THURSDAY, SEPTEMBER 18, 1890.

THE ABORIGINES OF TASMANIA.

The Aborigines of Tasmania. By H. Ling Roth. (London: Kegan Paul, Trench, Trübner, and Co., 1890.)

MR. H. L. ROTH has written an honest, unpretentious, and therefore most useful book on "The Aborigines of Tasmania." He gives us on pp. 2–8 a very complete bibliography of all works treating of his subject, and he then proceeds to place before us the quintessence distilled from that little library. Why he should have printed two hundred copies only of his work, is difficult to understand, and does not speak well for the study of anthropology. No serious student of human palæontology can be without this book, and we should have supposed that the public at large also would have much preferred a trustworthy description of the life and manners of this now extinct race to the ever-varying theories of what a savage is supposed to have been or not to have been, to have done or not to have done, which abound in some of the most popular works on anthropology and sociology. In the fourteen chapters of his book Mr. Roth treats of the country, the form and size of its inhabitants, the psychology of the natives, their wars, their knowledge of fire, hunting, and fishing, their nomadic life, their personal habits, their scientific and artistic acquirements, their manufactures, their trade, their customs, good and bad, their language, their osteology, and lastly their origin.

It would be impossible to give an idea of the wealth of information on all these subjects which Mr. Roth has rendered accessible in this volume. It is well arranged, and all his statements can readily be verified, for he always give his references, and a complete index renders its use easy at all times. The illustrations also show great care and cleverness.

Perhaps not the least important lesson which anthropologists might learn from this book is the extremely uncertain character of the accounts which visitors of Tasmania, and even persons long settled in the island, have given us of its inhabitants. This is a sore point with the students of sociology, but it is high time that it should be thoroughly probed. We shall confine our remarks to one subject only, the Tasmanian religion, and, with the help of Mr. Roth, we shall undertake to show that there is not one essential point in the religion of the Tasmanians on which different authorities have not made assertions diametrically opposed to each another.

No Religion.—Nothing staggers a savage—perhaps even an educated man—so much as when he is asked what his religion is. No wonder that many of the Tasmanians, when asked that question, answered, with a broad grin, "Don't know." What should we say if we were asked whether we believed in *Raegoo Wrapper* or *Namma?* Widowson, however, assures us that the Tasmanians had really no religion at all. "It is generally supposed," he says, "that they have not the slightest idea of a Supreme Being." Briton adds: "They do not appear to have any rites or ceremonies, religious or otherwise."

Dualism.—That the Tasmanians were Dualists, believing, like the followers of Zoroaster, in a good and an evil spirit, is attested by numerous authorities. Leigh says:—"Their notions of religion are very obscure. However, they believe in two spirits: one, they say, governs the day, whom they call the good spirit; the other governs the night, and him they think evil. To the good spirit they attribute everything good, and to the evil spirit everything hurtful." Jeffreys says:—"They have but a very indistinct notion of their imaginary deity, who, they say, presides over the day, an evil spirit making its appearance in the night. This deity, whosoever it is, they believe to be the giver of everything good." He adds, however, that they appear to acknowledge no more than one God, thus furnishing an exact parallel to the Parsis, who, though they admit two spirits, acknowledge Ormasd only as their true god. Milligan confirms this view. He admits that the Tasmanians believed in many spirits, but he adds that "they considered one or two spirits to be of omnipotent energy, though they do not seem to have invested even these last with attributes of benevolence." Robinson maintains that "they were fatalists (whatever that may mean in their language), and that they believed in the existence both of a good and evil spirit. The latter they called *Raegoo Wrapper*, to whom they attributed all their afflictions, and they used the same word to express thunder and lightning."

Nature-Gods.—That the Tasmanians derived some of their ideas of the godhead from the great phenomena of Nature we have seen already from their identifying day and night with their good and evil spirits. Thunder and Lightning were their names for the evil spirit, or their devil, as some observers call him. Besides day and night, thunder and lightning, the moon also is mentioned as an object of their worship. Thus, Lloyd tells us "that it was customary among the aborigines to meet at some time-honoured trysting-place at every full moon, a period regarded by them with most profound reverence." Indeed, he adds, "judging from their extraordinary gestures in the dance, the upturned eye and outstretched arm, apparently in a supplicating spirit, I have been often disposed to conclude that the poor savages were invoking the mercy and protection of that planet as their guardian deity."

Devil-worship.—We now come to the testimony in support of an exclusive devil-worship. Davies asserts that the aborigines certainly believed in the existence of an evil spirit, called by some tribes Namma, who has power by night. Of him they are much afraid, and never will willingly go out in the dark. But, he adds, "I could never make out that they believed in a good deity, for although they spoke of one, it struck me that it was what they had been told; they may, however, believe in one who has power by day."

Backhouse speaks in the same hesitating tone:—

"These people," he says, "have received a few faint ideas of the existence and superintending providence of God; but they still attribute the strong emotions of their minds to the devil, who, they say, tells them this or that, and to whom they attribute the power of prophetic communication. It is not clear that by the devil they mean anything more than a spirit; but they say he lives in their breasts, on which account they shrink from having the breast touched."

If we could fully trust this statement, and it is confirmed to some extent by Horton, it would be most important as showing the germs of moral ideas among the Tasmanians. To believe in a devil, not simply with horns and hoofs, but living within our own hearts, is an advance which, even in Europe, has as yet been made by a small minority only. The majority of Tasmanians evidently represented their devil in a more material form. Thus Dove says that, "while they had no term in their native language to designate the Creator of all things, they stood in awe of an imaginary spirit who was disposed to annoy and hurt them. The appearance of this malignant demon in some horrible form, was especially dreaded in the season of night."

Monotheism.—But while some authorities seem inclined to reduce the Tasmanian religion to a belief in a devil only, others seem to look upon it as almost monotheism. Thus Jeffreys, though he admits that the Tasmanians (like most Agnostics) have a very indistinct notion of their imaginary deity, relates that they have a kind of song which they chant to him. He knows that they believe in a good and an evil spirit, but he adds, that they believe the good spirit to be the giver of everything good, and that they do not appear to acknowledge any more than one God. That good spirit had, as we saw, no name, and this, which to some may seem to be a serious defect, is again a feature which the Tasmanian religion shares in common with the religion of far more advanced races.

Spirit-worship.—Those who hold that religion began everywhere with a belief in spirits may likewise find some support for their theory in the accounts given of the Tasmanians. Henderson states:—

"A common belief prevails in Tasmania and New South Wales regarding the existence of inferior spirits, who conceal themselves in the deep woody chasms during the day, but who wander forth after dark, with power to injure or even to destroy. Their rude encampments are frequently alarmed by these unearthly visitors, whose fearful moanings are at one time borne on the midnight breeze, and at another are heard mingling with the howling tempest."

This does not prove as yet that these spirits are always believed to be the spirits of the departed. Milligan, however, after telling us that the Tasmanians were polytheists—that is, that they believed in guardian angels or spirits, and in a plurality of powerful but generally evil-disposed beings, inhabiting crevices and caverns of rocks, and making temporary abode in hollow trees and solitary valleys, adds "that the aborigines were extremely superstitious, believing most implicitly in the return of the spirits of their departed friends and relations to bless or injure them, as the case might be. To their guardian spirits, the spirits of their departed friends or relations, they gave the generic name *Warrawah*, an aboriginal term signifying shade, shadow, ghost, or apparition."

Immortality of the Soul.—One point on which nearly all witnesses seem to agree is the belief of the Tasmanians in the immortality of the soul. They evidently had not yet advanced so far as to be able to doubt it. Milligan had ascertained that the aborigines of Tasmania, previous to their intercourse with Europeans, distinctly entertained the idea of immortality, as regarded the soul or spirit of man. Robinson, who was present at the burning of a dead body, received the following explanation from a native:—"Native dead, fire; goes road England, plenty natives England." What he meant to say was that when a black fellow was dead and had been burnt, he went to England, where there are many black fellows. The name of England, *Dreany*, as a distant country, and the home of white people, had become with them the name of a new Elysium. Others expected to reappear on an island in the Straits, and to jump up white men. They anticipated in another life the full enjoyment of what they coveted in this. Backhouse declares that they have some vague ideas of a future existence. Dove remarks that they were persuaded of their being ushered by death into another and happier state, and he considers this as almost the only remnant of a primitive religion which maintained a firm abode in their minds. However, as if to show that no account of their religious persuasions should go uncontradicted, Davies remarks that, "though it is hard to believe that the natives have no idea of a future state, yet from every inquiry, both from themselves and from whites most conversant with them, I have never been able to ascertain that such a belief exists."

Prayers.—Of course those who maintain that the Tasmanians have no religion, maintain at the same time that they have no kind of worship, no sacrifices, no prayers. But Leigh tells us that, "when any of the family are on a journey, they are accustomed to sing to the good spirit for the purpose of securing his protection over their absent friends, and that they may be brought back in health and safety." Jeffreys relates that it frequently happens that the sealers . . . are compelled to leave their native women for several days together. On these occasions these affectionate creatures have a kind of song, which they chant to their imaginary deity.

Charms.—It is known also that the Tasmanians carried charms, mostly a bone or even the skull of their relatives and friends. In some cases they ascribed healing powers to these bones, or at all events they put them by their side or on their head when they felt sick. This after all is no more than our preserving a lock of hair, and looking at it when we are in trouble or grief.

Negative evidence is always less trustworthy than positive. Still it may be taken for what it is worth, that observers seem never to have discovered idols (p. 69), totems (p. 75), or fetishes, among the natives of Tasmania.

Such is the nature of the evidence bearing on the religious ideas of the Tasmanians, which Mr. Roth has collected so carefully and so conscientiously. Nothing can be more full of contradictions, more doubtful, more perplexing. Yet with such materials our best anthropologists and sociologists have built up their systems.

The Tasmanians, being reputed the lowest of savages, were represented as the children of Nature, and whatever the children of Nature were supposed to have been, when emerging from a purely animal into a more or less human state, the Tasmanians and other savages were called up as witnesses to confirm every kind of psychological speculation.

We saw that there is hardly any kind of religion which could not be proved to have been the original religion of the Tasmanians. How then can we wish for more

pliant witnesses in support of any theory as to what the primordial religion of mankind must have been? If it were desired to prove that, prior to the advent of Europeans, they were atheists, without any religious ideas or ceremonial usages, we have several excellent witnesses to prove it. We could prove equally well that they believed in a devil only, that they were Dualists, believing in a good and an evil spirit, that they had deified the powers of Nature, that they had arrived at a belief in one God, that they were polytheists, that they believed in ghosts, in the return of the spirits of their friends, in the immortality of the soul, and in the efficacy of prayers and charms. Nay, if it were desired to produce perfectly unprejudiced evidence in favour of the descent of man from some higher animal, Lord Monboddo might have appealed to the Tasmanians. For, according to Mr. Horton, they believed "that they were formed with tails and without knee-joints, by a benevolent being, and that another descended from heaven, and compassionating the sufferers, cut off their tails, and with grease softened their knees."

Dr. E. B. Tylor, F.R.S., the Reader in Anthropology at Oxford, has written a short preface, in which he expresses his general approval of the work.

F. MAX MÜLLER.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

British Association Procedure.

THERE is one point on which I am unable to agree with Prof. Tilden's letter in your issue of September 4 (p. 456), viz. that concerning the work and constitution of the Sectional Committees. I can only speak in terms of Section A, but I believe that whatever cynical doubt may be expressed as to the utility of the proceedings of the Section there is none as to the utility of its proceedings in Committee. Here matters of moment are brought forward, suggestions made, new researches encouraged or the reverse; and here, as Mr. Shenstone implies, younger members become acquainted with those whom they have long revered at a distance. A sectional committee is not, and should not be, a small executive body, but a large, representative, and suggestive body comprising all the real workers in the particular subject present at the year's gathering, and by no means excluding those younger men who, though now retiring and inconspicuous, will have at some future time to take a prominent place.

Prof. Tilden speaks, however, of the *demand* for election upon the sectional committees.

If there is anything of this sort, and I believe that to some extent there is, it is an abuse to be checked with vigour.

I should like to propose a general agreement that any direct demand or solicitation to be placed on any committee should be accepted as at once disqualifying for that year. But all the more would it be incumbent on accustomed members to see that no real original worker was accidentally excluded from the healthy and stimulating conference with his seniors which these meetings may afford.

OLIVER J. LODGE.

The Mode of Observing the Phenomena of Earthquakes.

Forwarded by Dr. John Marshall.

HAVING seen in NATURE, of the 28th ult. (p. 414), your remarks, on the uncertainty of the evidence to be obtained from a narration of the subjective impression of movements of the earth and surrounding objects, in obtaining information with regard to earthquakes, and that you also remark that, "possibly, some evidence on this subject might even now be obtained," I venture to say that I was in a first storey room of Wickham Place, near Witham, Essex, during the earthquake that occurred somewhat severely in part of Essex a few years back; and that I was sitting against a partition wall, facing a window to the east, during the whole time of its duration. A hill about 1½ miles away formed the horizon, the outline of which passed across this window about half way up, from my point of view. I saw this outline apparently rise up to the top of the window, and sink down again, a displacement which, if it had been due to the movement of the hill itself, must have meant a great deal; but although this was really due, no doubt, to the motion of the house itself, yet the appearance was so deceptive that it produced entirely the idea, at the time, on my senses, that it was the hill that moved.

At Guy's Hospital last year, about 14 months ago, while I was in bed, at somewhere about eight o'clock, I fancy, I felt nothing, but saw the other parts of the building, through the windows, sway slowly, and the sight of it gave me a more or less dizzy feeling. There was a friend sitting on the bed at the time, but he felt nothing. Until I drew his attention to the fact that the bed curtains were swaying, he saw nothing of it.

These impressions make me think that such are of no value in a house except to determine very slight shocks.

I made notes at the time of these points, but they are not to hand just now. I scarcely think such evidence can be of any use to you, but on the chance that it may be, I send it.

HAROLD G. DIXON.

Nelson House, Shanklin, Isle of Wight, September 3.

THE BRITISH ASSOCIATION.

SECTION F.

ECONOMIC SCIENCE AND STATISTICS.

OPENING ADDRESS BY PROF. ALFRED MARSHALL, M.A., F.S.S., PRESIDENT OF THE SECTION.

Some Aspects of Competition.

I UNDERSTAND that the function of an opening address to a section of this Association is to give an account of the advances made in some part of the field of study with which that section is specially concerned. The part of our field to which I would direct your attention to-day is the action of competition. We cannot, in the short space of time allotted to us, make an adequate study of the progress that has been made even in this part of our field; but we may be able to go some way towards ascertaining the character of the changes that are going on in our own time in the mode of action of competition, and in the attitude of economists towards it.

I do not now speak of changes in the moral sentiments of economists with regard to competition—though these, also, are significant in their way—but of changes in their mental attitude towards it, and in the way in which they analyse and reason about its methods of action. Of these changes, the most conspicuous and important is the abandonment of general propositions and dogmas in favour of processes of analysis and reasoning carefully worked out, and held ready for application to the special circumstances of particular problems relating to different countries and different ages, to different races and different classes of industry.

This movement may, perhaps, best be regarded as a passing onward from that early stage in the development of scientific method, in which the operations of Nature are represented as conventionally simplified for the purpose of enabling them to be described in short and easy sentences, to that higher stage in which they are studied more carefully, and represented more nearly as they are, even at the expense of some loss of simplicity and definiteness, and even apparent lucidity. To put the same thing in more familiar words, the English economists of fifty years ago were gratified, rather than otherwise, when some faithful henchman, or henchwoman, undertook to set forth their doctrines in the form of a catechism or creed; and the economists of to-day abhor creeds and catechisms. Such things are now left for the Socialists.

It has, indeed, been an unfortunate thing for the reputation of the older economists, that many of the conditions of England

at the beginning of this century were exceptional, some being transitional, and others, even at the time, peculiar to England. Their knowledge of facts was, on the average, probably quite as thorough as that of the leading economists of England or Germany to-day, though their range was narrow. Their thoroughness was their own, the narrowness of their range belonged to their age; and though each of them knew a great deal, their aggregate knowledge was not much greater than that of any one of them, because there were so few of them, and they were so very well agreed. In these matters we economists of to-day have the advantage over them.

Their agreement with one another made them confident; the want of a strong opposition made them dogmatic; the necessity of making themselves intelligible to the multitude made them suppress even such conditioning and qualifying clauses as they had in their own minds: and thus, although their doctrines contained more that was true, and new, and important than those promulgated by almost any other set of men that have ever lived—doctrines for which they will be gratefully remembered as long as the history of our century retains any interest—yet, still, these doctrines were so narrow and inelastic that, when they were applied under conditions of time and place different from those in which they had their origin, their faults became obvious and created a reaction against them.

Perhaps the greatest danger of our age is that this reaction may be carried too far, and that the great truths which lie embedded in these too large utterances may be neglected because they are not new, and men are a little tired of them; and because they are associated with much that is not true, and which has become, not altogether unjustly, repugnant to men's sentiments.

The most important instances of this kind are, perhaps, to be found in connection with the relations between competition and combination in trade and industry. But I will first refer briefly to the relations between protection and free trade in foreign commerce, because these have a longer and more fully-developed history.

It is a constant source of wonder to Englishmen that protection survives and thrives, in spite of the complete refutations of protectionist arguments with which English economists have been ready to supply the rest of the world for the last fifty years or more. I believe that these refutations failed chiefly because some of them implicitly assumed that whatever was true as regards England, was universally true; and if they referred at all to any of the points of difference between England and other countries, it was only to put them impatiently aside, without a real answer to the arguments based on them. And further, because it was clearly to the interests of England that her manufactures should be admitted free by other countries, therefore, any Englishman who attempted to point out that there was some force in some of the arguments which were adduced in favour of protection in other countries, was denounced as unpatriotic. Public opinion in England acted like the savage monarch who puts to death the messenger that comes running in haste to tell him how his foes are advancing on him; and when John Stuart Mill ventured to tell the English people that some arguments for protection in new countries were scientifically valid, his friends spoke of it in anger—but more in sorrow than in anger—as his one sad departure from the sound principles of economic rectitude. But killing the messengers did not kill the hostile troops of which the messengers brought record; and the arguments which the Englishmen refused to hear, and therefore never properly refuted, were for that very reason those on which protectionists relied for raising a prejudice in the minds of intelligent and public-spirited Americans against the scientific soundness and even the moral honesty of English economics.

The first great difficulty which English economists had, in addressing themselves to the problems of cosmopolitan economics, arose from the fact that England was an old country—older than America in every sense, and older than the other countries of Europe in this sense, that she had accepted the ideas of the new and coming industrial age more fully and earlier than they did. In speaking of England, therefore, they drifted into the habit of using, as convertible, the two phrases—"the commodities which a country can now produce most easily," and "the commodities which a country has the greatest natural advantages for producing," that is, will always be able to produce most easily. But these two phrases were not approximately convertible when applied to other countries; and when List and Carey tried to call attention to this fact, Englishmen did little more than repeat old arguments, which implicitly assumed that New England's inability to produce cheap calico had the same foundation in natural laws as her inability to produce cheap oranges. They refused fairly to meet the objection that arguments which prove that nothing but good can come from a constant interchange of goods between temperate and tropical regions, do not prove that it is for the interest of the world that the artisans who are fed on American grain and meat should continue always to work up American cotton for American use three thousand miles away. Finding that their case was not fairly met, the protectionists naturally thought it stronger than it was, and honestly exaggerated it in every way. One of my most vivid recollections of a visit I made in 1875, to study American protection on the spot, is that of Mr. Carey's splendid anger, as he exclaimed that foreign commerce had made even the railways of America run from east to west, rather than from north to south.

England had passed through the stage of having to import her teachers from other lands. But her genius for freedom had attracted to her shores the pick of the skilled artisans of the world; she had received the best lessons from the best instructors, and seldom paid them any fee, beyond a safe harbour from political and religious persecution. And modern Englishmen could not realize, as Americans, and even Germans, could, fifty years ago the difficulties of a manufacturer taking part in starting a new industry, when he came to England to beg or steal a knowledge of the trade, and to induce skilful artisans to come back with him. He seldom got the very best; for they were sure of a comfortable life at home, and were perhaps not without some ambition of rising to be masters themselves. He had to pay their travelling expenses, and to promise them very high wages; and when all was done, they often left him to become the owners of the 160 acres allotted to every free settler; or, the bitterest pill of all, they sold their skill to a neighbouring employer who had been looking on at the experiment, and, as soon as it showed signs of prosperity, stepped in, improved on the first experiments, and reaped a full harvest on a soil that had been made ready by others.

Again, the pioneer manufacturer had to bring over specialized machinery, and specialized skill to take care of it. If any part went wrong, or was superseded, the change cost him ten times as much as his English competitor. He had to be self-sufficing: he could get no help from the multitude of subsidiary industries, which in England would have lent him aid at every turn. He had a hundred pitfalls on every side: if he failed, his failure was full of lessons to those who came after; if he succeeded, the profits to himself would be trivial, as compared with those to his country. When he told the tale of his struggles, every word went home to his hearers; and when the English economists, instead of setting themselves to discover the best method by which his country might help him in his experiment, said he was flying in the face of Nature, and called him a selfish schemer for wanting any help at all, they put themselves out of court.

But the failure of English economists to allow for the special circumstances of new countries did not end here. They saw that protective taxes in England had raised the price of wheat by their full amount (because the production of wheat obeys the law of diminishing return; and in an old country, such as England, increased supplies could be raised only at a more than proportionately increased cost of labour); that the high price of bread had kept a large part of the population on insufficient rations; that it had enriched the rich at the expense of a much greater loss to the rest of the nation; and that this loss had fallen upon those who were unable to lose material wealth without also losing physical, and even mental and moral strength; and that even those miseries of the overworked factory women and children, which some recent German writers have ascribed exclusively to recklessness of manufacturing competition in its ignorant youth, were really caused chiefly by the want of freedom for the entry of food. They were convinced, rightly, as I believe, that the benefits claimed for protection in England were based, without exception, on false reasoning; and they fought against it with the honest, but also rather blind, energy of a religious zeal.

Thus they overlooked the fact that many of those indirect effects of protection which aggravated then, and would aggravate now, its direct evils in England, worked in the opposite direction in America. For, firstly, the more America exported her raw produce in return for manufacture, the less the benefit she got from the law of increasing return as regards those goods

that she manufactured for herself; and thus her case was contrasted with England, who could manufacture them more cheaply for her own use the more of her manufactures she sent abroad to buy raw produce; and for this and other reasons a protective tax did not nearly always raise the cost of goods to the American consumer by its full amount. And, secondly, protection in America did not, as in England, tax the industrial classes for the benefit of the wealthy class of landlords. On the contrary, in so far as it fell upon the exporters of American produce, it pressed on those who had received large free gifts of public land; and there was no *primâ facie* injustice in awarding to the artisans, by special taxation, a small part of the fruits of that land, the direct ownership of which had not been divided between farmers and artisans, as it equitably might have been, but had been given exclusively to the former.

I have touched on but a few out of many aspects of the problem. But perhaps I may stop here, and yet venture to express my own opinion on the controversy. It is, that fifty years ago it might possibly have been not beyond the powers of human ingenuity to devise schemes of protection which would, on the whole, be beneficial to America, at all events if one regarded only its economic and neglected its moral effects; but that the balance has turned strongly against protection long ago. In 1875 I walked up and down some of the streets of nearly all the chief American cities and said to myself as I went—The adoption of free trade, so soon its first disturbances were over, would strengthen this firm, and weaken that; and I tried to strike a rough balance of the good and evil effects of such a change on the non-agricultural population. On the whole, it seemed to me the two were about equally balanced. Taking account, therefore, of the political corruption which necessarily results from struggles about the tariff in a democratic country, and taking account also of the interests of the agricultural classes, I settled in my own mind the question as to which I had kept an open mind till I went to America, and decided that, if an American, I should unhesitatingly vote for free trade. Since that time the advantages of protection in America have steadily diminished, and those of free trade have increased; I can see no force in Prof. Patten's new defence of protection as a permanent policy. I have already implied that I believe that many of those arguments that tell in favour of protection as regards a new country tell against it as regards an old one. Especially for England a protective policy would, I believe, be an unmixed and grievous evil.

But this expression of my own opinion is a digression. My present purpose in discussing protection is to argue that, if the earlier English economists had from the first studied the conditions of other countries more carefully, and abandoned all positions that were at all weak, they could have retained the controversy with their opponents within those regions where they had a solid advantage. They would thus have got a more careful hearing when they claimed that, even though labour migrated more freely between the west and the east of America than between England and America, yet it was unwise to spend so much trouble on protecting the nascent industries of the East against those of England, and none on protecting the nascent industries of the west against those of the east; or, again, when they urged that, the younger an industry was, and the more deeply it needed help, the more exclusively would its claims have to stand on its own merits; while its older and sturdier brothers could supplement their arguments by a voting power which even the most honest politicians had to respect, and by a power of corruption which would tend to make politics dishonest.

Had the English economists been more careful and more many-sided, they would have gradually built up a prestige for honesty and frankness, as well as for scientific thoroughness, which would have inclined the popular ear to their favour, even when their arguments were difficult to follow. Intellectual thoroughness and sincerity is its own reward; but it is also a prudent policy when the people at large have to be convinced of the advisability of a course of action against which such plausible fallacies can be urged as that "protection increases the employment of domestic industries," or that "it is needed to enable a country in which the rate of wages is generally high to carry on trade with another in which it is generally low." The arguments by which such fallacies can be opposed have an almost mathematical cogency, and will convince, even against his will, any one who is properly trained for such reasonings. But the real nature of foreign trade is so much disguised by the monetary transactions in which it is enveloped, that a clever sophist has a hundred opportunities of throwing dust in the eyes of ordinary people, and especially the working classes, when urging the claims of protection as affording a short cut to national prosperity; and, to crown all, he contrasts America's prosperity with English prophecies of the ruin that protection would bring on her.

It is true that Ricardo himself, and some of those who worked with him, were incapable of supposing that a doctrine can be made more patriotic by being made less true; and, so far as their limits went, they examined the good and evil of any proposed course, and weighed the good and evil against one another in that calm spirit of submissive interrogation with which the chemist weighs his materials in his laboratory. But they were few in number, and their range of inquiry was somewhat narrow; while many of those Englishmen who were most eager to spread free trade doctrines abroad had not the pure scientific temper.

Now at length, however, there seems to be the dawn of a brighter day in the growth of large numbers of many-sided students, in England and other countries, and notably in America itself, where the problems of protection can be studied to most advantage—students who are not, indeed, without opinions as to what course it is most expedient to follow practically, but who are free from party bias, and have the true scientific delight in ascertaining a new fact or developing a new argument, simply because they believe it to be new and true, and who welcome it equally whether it tells for or against the practical conclusion which, on the whole, they are inclined to support.

But I must leave the subject of competition from outside a nation, and pass to that of competition within. Here the past counts for less; the present and the future have to work for themselves without very much direct aid from experience. For, rapid as are the changes which the last few years have seen in the conditions of foreign trade, those which are taking place in the relations of different groups of industry within a country are more rapid still, and more fundamental. The whirligig of Time brings its revenges. It was to England's sagacity and good fortune in seizing hold of those industries in which the law of increasing return applies most strongly that she owed in a great measure her leading position in commerce and industry. Time's revenge was that that very law of increasing return furnished the chief motive to other countries, and especially America, to restrict their commerce with her by protective duties to home industries. And Time's counter-revenge is found in this—that England's free trade has prevented the law of increasing return from strengthening combinations of wealthy manufacturers against the general weal here to the same extent as it has in countries in which protection has prevailed, and notably America.

The problem of the relations between competition and combination is one in which differences of national character and conditions show themselves strongly. The Americans are the only great people whose industrial temper is at all like that of the English; and yet even theirs is not very like. Partly because of this difference of temper, but more because of the differences in the distribution of wealth and in the physical character of the two countries, the individual counts for much more in American than in English economic movements. Here, few of those who are very rich take a direct part in business; they generally seek safe investments for their capital; and again, among those engaged in business the middle class predominates, and most of them are more careful to keep what they have, than eager to increase it by risky courses. And lastly, tradition and experience are of more service and authority in an old country than in one which, like America, has not yet even taken stock of a great part of her natural resources, and especially those mineral resources, the sudden development of some of which has been the chief cause of many recent dislocations of industry.

In England, therefore, the dominant force is that of the average opinion of business-men; and the dominant form of association is that of the joint-stock company. But in America the dominant force is the restless energy and the versatile enterprise of a comparatively few very rich and able men, who rejoice in that power of doing great things by great means that their wealth gives them; and who have but partial respect for those who always keep their violins under glass cases. The methods of a joint-stock company are not always much to their mind; they prefer combinations that are more mobile, more elastic, more adventurous, and often more aggressive. For some

purposes they have to put up with a joint-stock company; but then they strive to dominate it, not be dominated by it. Again, since distances in America are large, many local monopolies are possible in America which are not possible in England; in fact, the area of a local monopoly there is often greater than that of the whole of England. A local coal combination, for instance, means quite a different thing there from what it does in England, and is more powerful every way.

Again, partly, but not solely, because they are so much in the hands of a few wealthy and daring men, railways, both collectively and individually, are a far greater power in America than in England. America is the home of the popular saying that, if the State does not keep a tight hand on the railways, the railways will keep a tight hand on the State; and many individual railways have, in spite of recent legislation, a power over the industries within their territories such as no English railway ever had: for the distances are great, and the all-liberating power of the free ocean befriends America little.

It is this change of area that is characteristic of the modern movement. In Adam Smith's time England was full of trade combinations, chiefly of an informal kind, indeed, and confined to very narrow areas; but very powerful within those areas, and very cruel. Even at the present day the cruellest of all combinations in England are, probably, in the trades that buy up small things, such as fish, and dairy and garden produce in detail, and sell them in retail; both producers and consumers being, from a business point of view, weak relatively to the intermediate dealers. But even in these trades there is a steady increase in the areas over which such combinations and partial monopolies extend themselves. New facilities of transport and communication tell so far on the side of the consumer, that they diminish the *intensity* of the pressure which a combination can exert; but, at the same time, they increase the *extension* of that pressure, partly by compelling, and partly by assisting, the combination to spread itself out more widely. And in England, as in other Western countries, more is heard every year of new and ambitious combinations; and of course many of them remain always secret.

But it is chiefly from America that a cry has been coming with constantly-increasing force for the last fifteen years or more, that in manufactures free competition favours the growth of large firms with large capitals and expensive plants; that such firms, if driven into a corner, will bid for custom at any sacrifice; that, rather than not sell their goods at all, they will sell them at the prime cost—that is, the actual outlay required for them, which is sometimes very little; that, when there is not enough work for all, these manufacturers will turn their bidding recklessly against one another, and will lower prices so far that the weaker of them will be killed out, and all of them injured; so that when trade revives they will be able, even without any combination among themselves, to put up prices to a high level; that these intense fluctuations injure both the public and the producers; and the producers being themselves comparatively few in number, are irresistibly drawn to some of those many kinds of combinations to which, nowadays, the name trust is commonly, though not quite accurately, applied; and that, in short, competition burns so furiously as to smother itself in its own smoke. It is a Committee of the American Congress that reports that "combination grows out of, and is the natural development of, competition, and that in many cases it is the only means left to the competitors to escape absolute ruin."

The subject is one on which it would be rash to speak confidently. We of this generation, being hurried along in a whirl of change, cannot measure accurately the forces at work, and it is probable that the best guesses we can make will move the smiles of future generations; they will wonder how we could have so much over-estimated the strength of some, and under-estimated the strength of others. But my task is to try to explain what it is that economists of this generation are thinking about competition in relation to combination; and I must endeavour to reproduce their guesses, hazardous though this may be.

To begin with, I think that it is the better opinion that popular rumour, going now as ever to extremes, has exaggerated some features of the movement towards combination and monopoly, even in America. For instance, though it is said that there are a hundred commodities the sale of which in America is partly controlled by some sort of combination, many of these combinations turn out to be of small proportions, and others to be weak and loose. Again, the typical instances which are insisted on by those who desire to magnify the importance of the movement are nearly always the same, and they have all had special advantages of more or less importance.

This is specially true of the only trust which can show a long record of undisputed success on a large scale—the Standard Oil trust. For, firstly, the petroleum in which it deals comes from a few of Nature's storehouses, mostly in the same neighbourhood: and it has long been recognized that those who can get control over some of the richest natural sources of a rare commodity are well on their way towards a partial monopoly. And, secondly, the Standard Oil Trust has many of those advantages which have been long recognized as enabling large railway companies to get the better of their smaller neighbours; for, directly or indirectly, it has in some measure controlled the pipe lines and the railways which have carried its oil to the large towns and to tidal water.

On the other hand, we must remember that the future of a young and vigorous movement is to be measured, not so much by what it has achieved, as by what it has learnt; and that every unsuccessful attempt to hold together a trust has been a lesson as to what to avoid, taught to men who are wonderfully quick to learn. In particular, it is now recognized that a very large portion of the failures in the past have been due to attempts to charge too high a price; that this high price has tempted those on the inside to break faith, and has tempted those on the outside to start rival works, which may bleed the trust very much unless it consents to buy them up on favourable terms; and, lastly, that this high price irritates the public: and that, especially in some States, public indignation on such matters leads to rapid legislation that strikes straight at the offenders, with little care as to whether it appears to involve principles of jurisprudence which could not be applied logically and consistently without danger. The leaders in the movement towards forming trusts seem to be resolved to aim in the future at prices which will be not very tempting to any one who has not the economies which a large combination claims to derive, both in producing and in marketing, from its vast scale of business and its careful organization; and to be content with putting into their own pockets the equivalent of these economies in addition to low profits on their capital. There are many who believe that combinations of this kind, pursuing a moderate policy, will ultimately obtain so great a power as to be able to shape, in a great measure, the conditions of trade and industry.

It may be so, but these eulogists of trusts seem to claim for them both that individual vigour, elasticity, and originating force which belong to a number of separate firms, each retaining a true autonomy, and that strength and economy which belong to a unified and centralized administration. Sanguine claims of this kind are not new; they have played a great part in nearly all the bold schemes for industrial reorganization which have fascinated the world in one generation after another. But in this, their latest form, they have some special features of interest to the economic analyst.

They have a certain air of plausibility, for the organizers of trusts claim that they see their way to avoiding the weak points in ordinary forms of combination among traders, which consist in the fact that their agreements can generally be evaded without being broken. For instance, the most remarkable feature in the history of English railways during the present generation is, not their tendency to agree on the fares and freights to be charged over parallel lines—for that has long been a foregone conclusion—it is the marvellously effective competition for traffic which such railways have maintained, both of a legitimate kind, by means of improved conveniences offered to the public as a whole, or of an illegitimate kind, by means of those special privileges to particular traders which we are now, at last, seriously setting ourselves to stop by law.

It is difficulties of this kind which the modern movement towards trusts aims specially at overcoming. Trusts have very many forms and methods, but their chief motive in every case is to take away from the several firms in the combination all inducements to compete by indirect means with one another; and in every case the chief instrument for this purpose is some plan for pooling their aggregate receipts, and making the gains of each depend on the gains of all, rather than on the amount of business it gets for itself. But here the dilemma shows itself. If each establishment is left to its own devices, but has very little to lose by bad management, it is not likely long to remain well managed, and anyhow the trust does not gain much of the special economy resulting from production on a very large scale.

For this a partial remedy can sometimes be found in throwing as much of its work as possible on to those establishments which are best situated, have the best and most recent appliances and the ablest management, and, perhaps, closing entirely some of the others. But when once the pooling has begun, the combination is on an inclined plane, and every step hurries it on faster towards what is virtually complete amalgamation and consolidation. The recent history of trusts shows a constant tendency to give a more and more absolute power to the central executive and to reduce the heads of the separate establishments more and more nearly to the position of branch managers. In some cases the only substantial difference between such a trust and a consolidated joint-stock company is that it is nominally left open to the several parties contracting to claim their separate property after the lapse of a certain number of years, while some are already preparing to dissolve and reconstitute themselves formally as joint stock companies.

This tendency has been helped on by the action of the legislature and the law courts, and since this action can be traced back in some measure to the imperfect analysis of competition in the older economic writings, it has a special interest for us here. There seems to have been set up a false antithesis between competition and combination. For instance, if 100 workmen agreed to act together, as far as possible, in bargaining for the sale of their labour, they were denounced as combining to limit freedom, even when they did not interfere in any way with the liberty of other workmen, but merely deprived the employers of the freedom of making bargains with the 100 workmen, one by one. But the employer himself was allowed to unite in his own hands the power of hiring a hundred or twenty hundred men, and if he had not enough capital of his own he might take others into private, if not into public, partnership with him. Now, no trades union was likely to be as compact a combination, governed by as single a purpose, as a public or private firm, still less as an individual large employer; and therefore, there was not only a class injustice, but also a logical confusion, in prohibiting combinations among workmen, on the ground that free competition was a good, and that combination, being opposed to free competition, was, for that reason, an evil.

It was an additional grievance to the workmen that employers had all manner of facilities for combination, of which they made full use, as is vigorously urged by Adam Smith, to whom the working classes owe more than they know. And it was this social injustice, rather than the logical inconsistency of economists and legislators, that led workmen to claim—and for the greater part successfully—that nothing should be illegal if done by workmen in combination which would not be illegal if done by any one of them separately—a principle which works well practically in the particular case of workmen's combinations if applied with moderation; though it has no better claim to universal validity than the opposite doctrine.

But at present it is with the latter that we are concerned—the doctrine, namely, that a use of the rights of property which would be "combination in restraint of competition" if the ownership of the property were in many hands, is only a free use of the forms of competition when the property is all in a single hand. This doctrine has resulted in prohibitions of pooling between railways which were allowed to amalgamate, and in the prohibition of combination on the part of a group of traders to coerce others to act with them, or to drive others out of the trade, though all the while no attempt was made to hinder a single very wealthy firm from obtaining the despotic control of a market by similar means.

But to the economists of to-day the whole question appears both more complex and more important than it seemed to their predecessors, so they are inquiring in detail how far it is true that the looser forms of combination are specially dangerous in spite of their weakness, and even to some extent because of their weakness; how far the greater stability and publicity, and sense of responsibility and slowness of growth, of a single consolidated firm make it less likely to extend its operations over a very wide area, and less likely to make a flagrantly bad use of its power; and, lastly, how far it may be expedient to prohibit actions on the part of loose combinations, while similar actions on the part of individuals and private firms are allowed to pass in silence, because no prohibition against them could be effectual.

It is a sign of the times that the American Senate passed, on April 8 last, a Bill of Senator Sharman's, of which the second Section begins thus: "Every person who shall monopolise, or attempt to monopolise, or conspire with any other person or persons to monopolise, any part of the trade or commerce among the several States, or with foreign nations, shall be deemed guilty of a misdemeanour." This clause is interesting to the constitutional lawyer on account of the skill with which it avoids any interference by the central authority with the internal affairs of the separate States; and though, partly for this reason, it is perhaps intended to be the expression of a sentiment that may help to guide public opinion, rather than an enactment which will bear much direct fruit, yet it is of great interest to the economist as showing a tendency to extend to the action of individuals a form of public criticism which has hitherto been almost confined to the action of combinations.

To return, then, to the tendency of trusts towards consolidation. It is probable that the special legislative influences by which it has been promoted may be lessened, but that other causes will remain sufficiently strong to make a combination, which has once got so far as any sort of permanent pooling, tend almost irresistibly towards the more compact unity of a joint stock company. If this be so, the new movement will go more nearly on old lines than at one time seemed probable; and the question will still be the old one of the struggle for victory on the one hand between large firms and small firms, and on the other between departments of the Government, imperial or local, and private firms. I will then pass to consider the modern aspects of this question, ever old and ever new, but never more new and never more urgent than to-day.

To begin with, it is now universally recognized that there is a great increase in the number and importance of a class of industries, which are often called monopolies, but which are perhaps better described as *indivisible* industries. Such are the industries that supply gas or water in any given area, for only one such company in any district can be given leave to pull up the streets. Almost on the same footing are railways, tramways, electricity supply companies, and many others. Now, though there are some little differences of opinion among us as to the scale on which the owners of such undertakings when in private hands should be compensated for interference with what they had thought their vested rights, we are all agreed that such right of interference must be absolute, and the economists of to-day are eagerly inquiring what form it is most expedient for this interference to take. And here differences of opinion show themselves. The advantages of a bureaucratic government appeal strongly to some classes of minds, among whom are to be included many German economists and a few of the younger American economists who have been much under German influence. But those in whom the Anglo-Saxon spirit is strongest, would prefer that such undertakings, though always under public control, and sometimes even in public ownership, should whenever possible be worked and managed by private corporations. We (for I would here include myself) believe that bureaucratic management is less suitable for Anglo-Saxons than for other races who are more patient and more easily contented, more submissive and less full of initiative, who like to take things easily and to spread their work out rather thinly over long hours. An Englishman's or an American's life would involve too much strain to make them happy, while the Englishman would fret under the constraints and the small economies of their lives. Without therefore expressing any opinion as to the advantages of the public management of indivisible undertakings on the Continent, the greater part of the younger English and American economists are, I think, inclined to oppose it for England and America. We are not sure that we could exchange our own industrial virtues for those of the Continent if we wished to, and we are not sure that we do wish it. And though we recognize that the management of a vast undertaking by a public company has many of the characteristics of bureaucratic management, yet we think the former is distinctly the better suited for developing those faculties by which the Anglo-Saxon race has won its position in the world. We believe that a private company which stands to gain something by vigorous and efficient management by promptness in inventing, as well as in adopting and perfecting improvements in processes and organization, will do much more for progress than a public department.

Again, inferior as is a public company to a small private firm in its power and opportunities of finding out which among its employés have originating and constructive ability, a public department has much less still. And lastly it is more liable to have the efficiency of its management interfered with for the

purpose of enabling other persons to gain the votes of their constituents on questions in which it has no direct concern ; and as a corollary from this, it tends to promote the growth of political immorality, and it suffers from that growth.

There is certainly a growing opinion among English and American economists that the State must keep a very tight hand on all industries in which competition is not an effective regulator ; but this is the expression of a very different tone of thought from that which is leading so many German economists towards what is called State Socialism. In fact, so far as I can judge, English economists at all events are even more averse to State management than they were a few years ago ; the set of their minds is rather towards inquiring how the advantages claimed for State management, without its chief evils, can be obtained even in what I have called indivisible industries ; they are considering how a resolute intervention on the part of the State may best check the growth of *Imperia in Imperio*, and prevent private persons from obtaining an inordinate share of the gains arising from the development, through natural causes, of what are really semi-public concerns, at the same time that it leaves them sufficient freedom of initiative and sufficient security of gain by using that freedom energetically to develop what is most valuable in the energy and inventiveness of the Anglo-Saxon temper.[1]

But, though we dislike and fear the present tendency towards a widening of the area of public management of industries, we cannot ignore its actual strength. For more forethought and hard work are needed to arrange an effective public control over an undertaking than to put it bodily into the hands of a public department ; and there is always a danger that in a time of hasty change the path of least resistance will be followed.

By way of illustration of the inquiries that have had their origin in this fear of public management, as contrasted with public control and public ownership, I would here mention a notion which has been suggested partly by the relations of some municipalities to their tramways, gas and water works. At present it is in a very crude form, and not ready for immediate application ; but it seems to have occurred independently to a good many people, and it may have an important future. It is that a public authority may be able to own the franchise and, in some cases, part of the fixed capital of a semi-public undertaking, and to lease them for a limited number of years to a corporation who shall be bound to perform services, or deliver goods, at a certain price and subject to certain other regulations, some of which may perhaps concern their relations to their employés ; and, further, that competition for the franchise shall turn on the price or the quality, or both, of the services or the goods, rather than the annual sum paid for the lease. Competition as to quality is, from the consumer's point of view, often just as beneficial as competition is to price, and sometimes more so. And in industries which obey the Law of Increasing Returns, as very many of these indivisible industries do, a reduction of price or an improvement of quality will confer on the consumer a benefit out of all proportion to the extra cost involved.[2]

But I have lingered too long over those industries which I have called indivisible, and I must pass to those in which competition exerts a pretty full sway. The first point to be observed is that competition in bargaining and competition in production stand in very different relations to the public interest ; and that one of the great advances in modern analysis consists in the emphasis which it lays on the distinction between the two. Competition in bargaining constitutes a great part of competition in marketing, but is not the whole of it. For under marketing is included the whole of the effective organization of the trade side of a business ; and most of this performs essential services for the public, and is, in fact, of the same order as production commonly so called. But a great part of marketing consists of bargaining, of manœuvring to get others to buy at a high price and sell at a low price, to obtain special concessions or to force a trade by offering them. This is, from the social point of view, almost pure waste ; it is that part of trade as to which Aristotle's dictum is most nearly true, that no one can gain except at the loss of another. It has a great attraction for some minds that are not merely mean ; but nevertheless it is the only part of honest trade competition that is entirely devoid of any ennobling or elevating feature. A claim is made on behalf of large firms and large combinations that their growth tends to diminish the waste, and on the whole perhaps it does. The one solid advantage which the public gain from a combination powerful enough to possess a local monopoly is that it escapes much waste on advertising and petty bargaining and manœuvring. But its weakness in this regard lies in the fact that to keep its monopoly it must be always bargaining and manœuvring on a large scale. And if its monopoly is invaded, it must bargain and manœuvre widely in matters of detail as well as in larger affairs.

Still less can we fully concede, without further proof, the claim which has been urged on behalf of such combinations, that they will render industry more stable and diminish the fluctuations of commercial activity. This claim, though put forward confidently and by many writers, does not appear to be supported by any arguments that will bear examination. On the one hand some industries which are already aggregated into large and powerful units, such as railway companies, give exceptionally steady employment ; and others, such as the heavy iron and the chemical industries, exceptionally unsteady. And when combinations succeed in steadying their own trades a very little, they often do it by means which diminish production and disturb other trades a very great deal. The teaching of history seems to throw but little light on the question, because the methods of regulation which are now suggested have not much in common with those of earlier times, while the causes which govern variations in prices have changed their character completely.

Let us then next turn to the economies of production on a large scale. They have long been well known, and our forefathers certainly did not underrate their importance. For, though the absence of any proper industrial census in England prevents us from getting exact information on the subject, yet there seems no doubt that the increase in the average size of factories has gone on, not faster, but slower than was thought probable a generation or two ago. In many industries, of which the textile may be taken as a type, it has been found that a comparatively small capital will command all the economies that can be gained by production on a large scale ; and it seems probable that in many industries in which the average size of businesses has been recently increasing fast, a similar position of maximum economy will shortly be attained without any much further increase in size.

Those reductions in the expenses of production of commodities which have been claimed by the eulogists of trusts and other large combinations, as tending to show that their gains are not at the expense of the public, turn out generally to have been at least equalled by the reductions in the expenses of production in similar industries in which there was no combination. And this count in their eulogy, though it may truly stand for something, seems to have been much exaggerated.

After all, what these very large public firms and combinations of firms have done has generally been only to turn to good account existing knowledge, and not to increase that knowledge. And this brings us to the main reason for regarding with some uneasiness any tendency there may be towards such consolidations of business. Observation seems to show, what might have been anticipated *à priori*, that though far superior to public departments, they are, in proportion to their size, no less inferior to private businesses of a moderate size in that energy and resource, that restlessness and inventive power, which lead to the striking out of new paths. And the benefits which the world reaps from this originality are apt to be underrated. For they do not come all at once like those gains which a large business reaps by utilizing existing knowledge and well-proven economies ; but they are cumulative, and not easily reckoned up. He who strikes out a new path by which the work of eight men is rendered as efficient as that of ten used to be, in an industry that employs 100,000 men, confers on the world a benefit equal to the labour of 20,000 men. And this benefit may in many cases be taken as running for many years. For though his discovery might have been made later by some one else of equal inventive power, yet this some one else, starting with that discovery in hand, is likely to make another improvement on it.

[1] Among the younger English economists who have written on the subject of combinations, trusts, and Government interference, I would specially refer to Mr. Rae and Prof. Foxwell. Most of the other young American economists have written on it instructively from various points of view, and in Mr. Baker's "Monopolies and the People," to which I am myself much indebted, the English reader will find condensed into a short compass an account of the general position of these questions in America, together with some bold and interesting suggestions for reform. Some useful documents relating to trusts have recently been published in a Consular Report by our Foreign Office [5896-32].

[2] This belongs to a class of questions relating to monopolies, &c., the more general and abstract aspects of which can be best shown by the diagrammatic method.

I believe that the importance of considerations of this kind is habitually underrated in the world at large; and that the older economists, though fully conscious of them, did not explain with sufficient clearness and iteration the important place which they take in the claims of industrial competition on the gratitude of mankind.

The chemist in his laboratory can make experiments on his own responsibility: if he had to ask leave from others at each step he would go but slowly, and though the officials of a company may have some freedom to make experiments in detail, yet even as regards these they seldom have a strong incentive to exertion; and in great matters the freedom of experimenting lies only with those who undertake the responsibility of the business.

It may indeed be admitted that some kinds of industrial improvements are getting to depend on the general increase of scientific knowledge rather than on such experiments as can only be made by business men. And this, which is an important fact so far as it goes, may be used as a convenient introduction to the next point that I want to make in the analysis of competition. It is that the motives which induce business men to compete for wealth are not altogether as sordid as the world in general, and I am forced to admit, economists in particular have been wont to assume.

The chemist or the physicist may happen to make money by his inventions, but that is seldom the chief motive of his work. He wants to earn somehow the means of a cultured life for himself and his family, but, that being once provided, he spends himself in seeking knowledge partly for its own sake, partly for the good that it may do to others, and last, and often not least, for the honour it may do himself. His discoveries become collective property as soon as they are made, and altogether he would not be a very bad citizen of Utopia just as he is. For it would be a great mistake to suppose that the constructors of Utopias from the time of Plato downwards have proposed to abolish competition. On the contrary, they have always taken for granted that a desire to do good for its own sake will need to be supplemented by emulation or competition for the approbation of others.

But business men are very much of the same nature as scientific men; they have the same "instincts of the chase," and many of them have the same power of being stimulated to great and even feverish exertions by emulations that are not sordid or ignoble. This part of their nature has however been confused with and thrown into the shade by their desire to make money. The chief reason why the scientific man does not care much for money is that in scientific work the earning of much money is no proof of excellence, but sometimes rather the reverse. On the other hand, in business a man's money-earning power, though not an accurate test of the real value to the world of what he has done, is yet often the best available. It is that test which most of those, for whose opinion he cares, believe to be more trustworthy than the highly-coloured reports the world hears from time to time of the benefits which it is just going to derive from a new invention or plan of organizing that is just going to revolutionize a branch of industry. And so all the best business men want to get money, but many of them do not care about it much for its own sake; they want it chiefly as the most convincing proof to themselves and others that they have succeeded.

These are the very men for whom the older economists were most eager to claim freedom of competition as needful to evoke them to do fully their high work for the world. But they seem to have made the error of running together and treating as though they were one, two different positions.

The first is that industrial progress depends on our getting the right men into the right places and giving them a free hand, and sufficient incitement to exert themselves to the utmost. And the second position is that nothing less than the enormous fortunes which successful men now make and retain would suffice for that purpose. This last position seems to be untenable.

The present extreme inequalities of wealth tend in many ways to prevent human faculties from being turned to their best account. A good and varied education, freely prolonged to those children of the working classes who showed the power and the will to use it well, an abundance of open-air recreation even in large towns, and other requisites of a wholesome life—such things as these might, most of us are inclined to think, be supplied by taxes levied on the rich, without seriously checking the accumulation of material capital; and with the effect of increasing rather than diminishing the services which competition renders to society by tending to put the ablest men into the most important posts, the next ablest into the next most important, and so on, and by giving to those in each grade freedom sufficient or the full exercise of their faculties.

It is quite true that where any class of workers have less than the necessaries for efficiency, an increase of income acts directly on their power of work. But when they already have those necessaries, the gain to production from a further increase of their income depends chiefly on the addition that it makes, not to their power of working, but to their will to exert themselves. And all history shows that a man will exert himself nearly as much to secure a small rise in income as a large one, provided he knows beforehand what he stands to gain, and is in no fear of having the expected fruits of his exertions taken away from him by arbitrary spoliation. If there were any fear of that he would not do his best; but if the conditions of the country were such that a moderate income gave as good a social position as a large one does now; if to have earned a moderate income were a strong presumptive proof that a man had surpassed able rivals in the attempt to do a difficult thing well, then the hope of earning such an income would offer to all but the most sordid natures, inducements almost as strong as they are now when there is an equal hope of earning a large one.

On all this class of questions modern economists are inclined to go a little way with the socialists. But all socialist schemes, and especially those which are directly or indirectly of German origin, seem to be vitiated by want of attention to the analysis which the economists of the modern age have made of the functions of the undertaker of business enterprises. They seem to think too much of competition as the exploiting of labour by capital, of the poor by the wealthy, and too little of it as the constant experiment by the ablest men for their several tasks, each trying to discover a new way in which to attain some important end. They still retain the language of the older economists, in which the employer, or undertaker, and the capitalist are spoken of, as though they were, for all practical purposes, the same people. The organ of the German school of English socialists prints frequently in thick type the question, "Is there one single useful or necessary duty performed by the capitalist to-day which the people organized could not perform for themselves?" It would be just as reasonable to ask if there is a single victory to which Julius Cæsar or Napoleon conducted their troops, which the troops properly organized could not have equally well won for themselves; or whether there is a single thing written by Shakespeare which could not have been equally well written by any one else who, as Charles Lamb said, happened to "have the mind to do it." It is quite true that many business men earn large incomes by routine work. It is just in these cases that Co-operation can dispense with middlemen and even employers. But the German socialists have been bitter foes of Co-operation; though this antagonism is less than it was.

The world owes much to the socialists, as it does to every set of enthusiasts among whom there are honest men; and many a generous heart has been made more generous by reading their poetic aspirations. But before their writings can be regarded as serious contributions to economic science, they must make more careful and exact analysis of the good and the evil of competition; and they must suggest some reasonably efficient substitute for that freedom which our present system offers to constructive genius to work its way to the light, and to prove its existence by attempting difficult tasks on its own responsibility, and succeeding in them. For those who have done most for the world have seldom been those whom their neighbours would have picked out as likely for the work. They must not, as even Mr. Bellamy and other American socialists do, in spite of their strong protestations to the contrary, assume implicitly a complete change of human nature; and propound schemes which would much diminish the aggregate production, but which they represent as enabling every family to attain an amount of material well-being which would be out of reach of the aggregate income if England or America were divided out equally among the population.

But though the socialists have ascribed to the virtues inherent in the human breast, and to the regulating force of public opinion, a much greater capacity for doing the energizing work of competition than they seem really to have; yet, unquestionably, the economists of to-day do go beyond those of earlier generations in believing that the desire of men for the approval of their own conscience, and the esteem of others, is an economic force of the first order of importance, and that its strength is steadily increasing with the increase and the diffusion of knowledge, and

with the constant tendency of what had been regarded as private and personal issues to become public and national.

Public opinion acts partly through the Government. The enforcement of the law in economic matters occupies the time of a rapidly increasing number of people; and though its administration is improving in every way, it fails to keep pace with the demands resulting from the growing complexity of economic organization, and the growing sense of responsibility of public opinion. A part of this failure is due to a cause which might easily be remedied; it is that the adjustment of punishment to offences is governed by traditions descending from a time when the economic structure of England was entirely different. This is most conspicuous with regard to the subtler, or, as they are sometimes called with unconscious irony, the more gentlemanly forms of commercial fraud on a large scale; for which the punishment awarded by the law courts is often trivial in comparison with the aggregate gains which the breakers of the law, whose offences can seldom be proved, make by their wrongdoing; and it is still more trivial in comparison with the aggregate injury which such wrongdoing inflicts on the public. Many of the worst evils in modern forms of competition could be diminished by merely bringing that part of the law which relates to economic problems of modern growth into harmony with that which relates to the old-fashioned and well-matured economic questions relating to common picking and stealing. And somewhat similar remarks apply to the punishments for infringements of the Factory Acts.

But at best the action of the law must be slow, cumbrous, and inelastic, and therefore ineffective. And there are many matters in which public opinion can exercise its influence more quickly and effectively by a direct route, than by the indirect route of first altering the law. For of all the great changes which our own age has seen in the relative proportions of different economic forces, there is none so important as the increase in the area from which public opinion collects itself, and in the force with which it bears directly upon economic issues.

For instance, combinations of labour on the one side, and of employers on the other, are now able to arrange plans of campaign for whole trades, for whole counties, for the whole country, and sometimes even beyond. And partly on account of the magnitude of the interests concerned, partly because trade disputes are being reduced to system, affairs which would be only of local interest are discussed over the whole kingdom.

The many turbulent little quarrels which centred more often about questions of individual temper than of broad policy, are now displaced by a few great strikes, as to which public opinion is on the alert; so that a display of temper is a tactical blunder. Each side strives to put itself right with the public; and requires of its leaders above all things that they should persuade the average man that their demands are reasonable, and that the quarrel is caused by the refusal of the other side to accept a reasonable compromise.

This change is increasing the wisdom and the strength of each side; but the employers have always had fairly good means of communication with one another; it is the employed that have gained most from cheap means of communication by press, by railway, and by telegraph, and from improvements in their education and in their incomes, which enable them to make more use of these new and cheaper facilities. And while the employers have always known how to present their case to the public well, and have always had a sympathetic public, the working classes are only now beginning to read newspapers enough to supply an effective national working class opinion, and they are only now learning how to present their case well, and to hope much from, or care much for, the opinion of those who are neither employers nor of the working classes.

I myself believe that in all this the good largely predominates over the evil. But that is not the question with which I am specially concerned at present. My point is that, in the scientific problem of estimating the forces by which wages are adjusted, a larger place has to be allowed now than formerly to the power of combination, and to the power of public opinion in judging, and criticizing, and aiding that combination; and that all these changes tend to strengthen the side of the employés, and to help them to get a substantial though not a great increase of real wages; which they may, if they will, so use as to increase their efficiency, and therefore to increase still further the wages which they are capable of earning, whether acting in combination or not.

And thus public opinion has a very responsible task. I have spoken of it as the opinion of the average man; and he is very busy, and has many things to think about. He makes great mistakes, but he learns by all of them. He has often astonished the learned by the amount of ignorance and false reasoning which he can crowd into the discussion of a difficult question; and still more by the way in which he is found at last to have been very much in the right on the main issue. He is getting increased power of forming a good and helpful opinion, and he is being educated in mind and in spirit by forming it, and by giving it effect. But in the task which he is undertaking there are great difficulties ahead.

In an industrial conflict each side cares for the opinion of the public at large, but especially for that of those whose sympathy they are most likely to get: in the late South Wales strike, for instance, the railway companies were specially anxious about the good opinion of the shippers, and the engine drivers about that of the colliers. And there is some fear that when party discipline becomes better organized, those on either side will again get to care less for any public opinion save that of their own side. And if so, there may be no great tendency towards agreement between the two sides as to what are reasonable demands.

It is true that there is always the action of outside competition tending to visit with penalties either side, which makes excessive use of any tactical advantage it may have obtained. As we have just noticed, the shrewdest organizers of a trust are averse to raising the price of its wares much above the normal or steady competition price. And the first point which courts of conciliation and arbitration have to consider is, what are the rates of wages on the one hand and of profits on the other, which are required to call forth normal supplies of labour and capital respectively; and only when that has been done, can an inquiry be properly made as to the shares in which the two should divide between them the piece of good or ill fortune which has come to the trade. Thus the growth of combinations and partial monopolies has in many ways increased, and in no way diminished, the practical importance of the careful study of the influences which the normal forces of competition exert on normal value.

But it must be admitted that the direct force of outside competition in some classes of wages disputes is diminishing; and though its indirect force is being increased by the increased power which modern knowledge gives us of substituting one means of attaining our ends for another, yet on the whole the difficulty of deciding what is a reasonable demand is becoming greater. The principles on which not only the average man, but also an expert court of conciliation or arbitration should proceed in forming their judgment, are becoming, in spite of the great increase of knowledge, more and more vague and uncertain in several respects.

And there are signs of a new difficulty. Hitherto the general public has been enlightened, and its interests protected by the fact that the employers and employed when in conflict have each desired to enlighten the public as to the real questions at issue; and the information given on one side has supplemented and corrected that on the other: they have seldom worked together systematically to sacrifice the interests of the public to their own, by lessening the supply of their services or goods, and thus raising their price artificially. But there are signs of a desire to arrange firm compacts between combinations of employers on the one side and of employés on the other to restrict production. Such compacts may become a grievous danger to the public in those trades in which there is little effective competition from foreign producers: a danger so great that if these compacts cannot be bent by public opinion they may have to be broken up by public force.

It is, therefore, a matter of pressing urgency that public opinion should accustom itself to deal with such questions, and be prepared to throw its weight against such compacts as are injurious to the public weal, that is, against such compacts as are likely to inflict on the public a real loss much greater than the gain to that trade; or in other words, are of such a nature that if their principle were generally adopted in all trades and professions, then all trades and professions would lose as buyers more than they would gain as sellers.

I must now close this imperfect and fragmentary study. I have endeavoured to give some illustrations of the changes which are coming over economic studies. I believe that the great body of modern economists think that the need of analysis and general reasoning in economics is not less than our predecessors supposed, but more. And this is because we think economic problems

more difficult than they did. We are recognizing more clearly than they did that all economic studies must have reference to the conditions of a particular country and time. Economic movements tend to go faster than ever before, but, as Knies pointed out, they tend also to synchronize; and the economists of our western countries have much more to learn now than fifty years ago from the contemporary history of other countries; but in spite of the many great benefits which we are deriving from the increase of our historical knowledge, the present age can rely less than any other on the experience of its predecessors for aid in solving its own problems.

Every year economic problems become more complex; every year the necessity of studying them from many different points of view and in many different connections becomes more urgent. Every year it is more manifest that we need to have more knowledge and to get it soon in order to escape, on the one hand, from the cruelty and waste of irresponsible competition and the licentious use of wealth, and on the other from the tyranny and the spiritual death of an ironbound socialism.

SECTION G.

MECHANICAL SCIENCE.

OPENING ADDRESS BY CAPTAIN NOBLE, C.B., F.R.S., F.R.A.S., F.C.S., M.INST.C.E., PRESIDENT OF THE SECTION.

IN taking over the chair of this Section from my distinguished predecessor, I cannot but feel myself to some extent an intruder into the domain of mechanical science, and I am conscious that the office which I have the honour to hold would have been more worthily filled by one of the great mechanicians who have won for the town in which we hold our meeting so widespread a reputation.

I can truly say the claims on my time are so considerable that I should not have ventured to appear before you in the character of President of this Section had it not been for my desire to afford what little support might be in my power to my friend the President of the British Association, with whom for so long a period I have been associated by so many ties.

I believe I should have consulted best both my own feelings and your patience by merely opening the Section in a formal manner, and proceeding at once to the business of the meeting. One of my predecessors, however, has pointed out that Sir F. Bramwell, whose authority is too great to be disputed, has ruled that to depart from the time-honoured practice of an address is an act of disrespect to the Section—a ruling which has, without cavil, been accepted.

I therefore propose to direct your attention, by a few brief remarks, to that branch of mechanical science with which I am best acquainted. I shall endeavour to show the great indebtedness of the naval and military services to mechanical science during the period with which I have been more or less connected with them, and the complete revolution which has in consequence resulted in every department and in every detail.

But before commencing with my special subject, it is impossible that I should pass over in silence the great work which has excited so much interest in the engineering world, and which, since we last met, has, with formalities worthy of the occasion, been opened by H.R.H. the Prince of Wales.

It is in no way detracting from the merit of the distinguished engineers who have with so much boldness in design, with such an infinity of care in execution, with so much foresight in every detail, given to the country this great monument of skill, if I venture to point out that, without the great advance of mechanical and metallurgical science during the present generation, and the co-operation of a host of workers, a creation like that of the Forth Bridge would have been an impossibility.

The bridge has been so frequently and so fully described that it is unnecessary in this address I should do more than draw your attention to some of its main features.

The bridge, with its approach-viaducts, has a total length of 8296 feet, or nearly a mile and six-tenths; and this length comprises two spans of 1710 feet, two of 680½ feet, fifteen of 160 feet, four of 57 feet, and three of 25 feet.

The deepest foundation is 90 feet below high-water mark, and the extreme height of the central position of the cantilever is 361 feet above the same datum, making the extreme total height of the bridge 451 feet.

The actual minimum headway in the channels below the centre of the main spans at high-water spring tides is a little over 150 feet, and the rail level is about 6 feet higher.

The weight of steel, nearly all riveted work, is 54,076 tons, and the amount of masonry and concrete 4,057,555 cubic feet.

It is difficult, even for experts, fully to appreciate the stupendous amount of work indicated by these figures. During the Paris Exhibition the Eiffel Tower justly excited considerable admiration, and brought its designer into much repute; but that great work sinks altogether into insignificance when compared with the Forth Bridge.

Conceive, as I have heard described, the Eiffel Tower built, not vertically, but horizontally; conceive it further built without support, and at a giddy height over an arm of the sea. Such a work would do little more than reach half across one of the main spans of this great bridge.

Those only who have had work of a similar nature can fully appreciate the innumerable experiments that must have been made, and the calculations that must have been gone through to secure the maximum attainable rigidity both with respect to the strains induced vertically by the railway traffic and its own weight, and horizontally by the force of gales.

The anxiety as to the security of the erection might well daunt the most skilful engineer. We are told that, apart from the permanent work, many hundreds of tons of weight in the shape of cranes, temporary girders, winches, steam boilers, rivet furnaces, and riveting machines, miles of steel-wire rope, and acres of timber staging were suspended from the cantilevers. A heavy shower of rain would in a few minutes give an additional weight of about 100 tons; and in their unfinished state, while approaching completion, the force of any gale had to be endured.

I trust that, as the Forth Bridge has been a great engineering, it may likewise prove a financial success, and I feel sure that all who hear me are rejoiced that it has pleased Her Majesty to confer the distinguished honours she has awarded to Sir John Fowler and Sir B. Baker—honours, I may add, that have rarely been more worthily bestowed.

Let me turn now to the subject on which I propose to address you; and I shall first advert to the change which within my own recollection has taken place in that service which has been the pride and glory of the country in time past, and on which we must rely in the future as our first and principal means at once of defence and attack.

To give even an idea of the revolution which our navy has undergone, I must refer in the first instance to the navy of the past. I must refer to those vessels which in the hands of our great naval commanders won for England victories which left her at the close of the great wars supreme upon the sea.

A "first-rate" of those days (I will take the *Victory* as a type) was a three-decker 186 feet in length, 52 feet in breadth, with a displacement of 3500 tons, and she carried an armament of 102 guns, consisting of thirty 42- and 32-pounders, thirty 24-pounders, forty 12-pounders, and two 68-pounder carronades (the heaviest of her guns was a 42-pounder), and she had a complement of nearly 900 men. When we look at the wonderful mechanism connected with the armaments of the fighting-ships of the present day, it is difficult to conceive how such feats were accomplished with such rude weapons.

With the exception of a few small brass guns, the guns were mere blocks of cast iron, the sole machining to which they were subjected consisting in the formation of the bore and the drilling of the vent.

A large proportion of nearly every armament consisted of carronades—a piece which was in those days in great favour. They threw a shot of large diameter from a light gun with a low charge, and their popularity was chiefly due to the rapidity with which they could be worked. The great object of every English commander was, if it were possible, to bring his ship alongside that of the enemy; and under these circumstances the low velocity given by the carronades became of comparatively small moment, while the ease of working and the large diameter of the shot were factors of the first importance.

The carriages on which the rude weapons I have described were placed were themselves, if possible, even more rude. They were of wood, and consisted of two cheeks with recesses for the trunnions, which were secured by cap squares, the cheeks being connected by transoms, and the whole carried by trucks. The gun was attached to the vessel's side, and the recoil controlled by breeching. The elevation was fixed by quoins which rested

on a quoin bed, and handspikes were used either for elevating or for training.

It is obvious that, to work smartly so rude a machine, a very strong gun's crew was required. Indeed, the gun and its carriage were literally surrounded by its crew, and I may refer those who desire to acquaint themselves with the general arrangements of what was once the most perfect fighting-machine of the first navy in the world, to the frontispiece of a book now nearly forgotten—I mean Sir Howard Douglas's "Naval Gunnery."

The mechanical appliances on board these famed war-vessels of the past were of the simplest possible form, and such as admitted of rapid renewal or repair. There was no source of power except manual labour; but, when handled with the unrivalled skill of British seamen, the handiness of these vessels, and the precision with which they were manœuvred, was a source of never-ending admiration.

Those who have seen, as I have done, a fleet like the Mediterranean squadron enter a harbour, such as Malta, under full sail, and have noted the precision with which each floating castle moved to her appointed place, the rapidity with which her canvas was stowed, have seen a sight which I consider as the most striking I have witnessed, and infinitely more imposing than that presented under like circumstances by modern vessels, any one of which could in a few minutes blow out of the water half a dozen such men-of-war as I have been just describing.

I must not, however, omit to mention two advantages possessed by the old type of war-vessels, which, if we could reproduce them, would greatly please modern economists. I mean, their comparatively small cost, and the length of time the vessels remained fit for service.

When the *Victory* fought the battle of Trafalgar she had been afloat for forty years, and her total cost, complete with her armament and all stores, was probably considerably under £100,000. The cost of a first-rate of the present day, similarly complete, would be nearly ten times as great.

The most improved battle-ships of the period just anterior to the Crimean war differed from the type I have just described, mainly by the addition of steam power, and for the construction of these engines the country was indebted to the great pioneers of marine engineering, such as J. Penn and Sons, Maudslay Sons and Field, Ravenhill, Miller, and Co., Rennie Bros., &c., not forgetting Messrs. Humphreys and Tennant, whose reputation and achievements now are even more brilliant than in these earlier days.

Taking the *Duke of Wellington*, completed in 1853, as the type of a first-rate just before the Crimean war, her length was 240 feet, her breadth 60 feet, her displacement 5830 tons, her indicated horse-power 1999, and her speed on the measured mile 9·89 knots. Her armament consisted of 131 guns, of which thirty-six 8-inch and 32-pounders were mounted on the lower deck, a similar number on the middle deck, thirty-eight 32-pounders on the main deck, and twenty short 32-pounders and one 68-pounder pivot gun on the upper deck.

Taking the *Cæsar* and the *Hogue* as types of second- and third-rate line-of-battle ships, the former, which had nearly the displacement of the *Victory*, had a length of 207 feet, a breadth of 56 feet, and a mean draught of 21. She had 1420 indicated horse-power, and her speed on the measured mile was 10·3 knots. Her armament consisted of twenty-eight 8-inch guns and sixty-two 32-pounders, carried on her lower, main, and upper decks. The *Hogue* had a length of 184 feet, a breadth of 48 feet 4 inches, a mean draught of 22 feet 6 inches: she had 797 indicated horse-power, and a speed of 8½ knots. Her armament consisted of two 68-pounders of 95 cwt., four 10-inch guns, twenty-six 8-inch guns, and twenty-eight 32-pounders of 56 cwt.—sixty guns in all.

Vessels of lower rates (I refer to the screw steam frigates of the period just anterior to the Crimean war) were, both in construction and armament, so closely analogous to the line-of-battle-ships that I will not fatigue you by describing them, and will only allude to one other class, that of the paddle-wheel steam frigate, of which I may take the *Terrible* as a type. This vessel had a length of 226 feet, a breadth of 43 feet, a displacement of about 3000 tons, and an indicated horse-power of 1950. Her armament consisted of seven 68-pounders of 95 cwt., four 10-inch guns, ten 8-inch guns, and four light 32-pounders.

It will be observed that in these armaments there has been a very considerable increase in the weight of the guns carried. As I have said, the heaviest guns carried by the *Victory* were the 42-pounders of 75 cwt., but in these later armaments the 68-pounder of 95 cwt. is in common use, and you will have noted that the carronades have altogether disappeared. But as regards improvements in guns or mounting, if we except the pivot-guns, with respect to which there was some faint approach to mechanical contrivance to facilitate working, the guns and carriages were of the rude description to which I have alluded.

In one respect, indeed, a great change had been made. Shell-fire had been brought to a considerable state of perfection, and the importance ascribed to it may be traced in the number of 10-inch and 8-inch shell-guns which entered into the armament of the *Duke of Wellington* and the other ships I have mentioned. Moorsom's concussion fuse and other similar contrivances lent great assistance to this mode of warfare, and its power was soon terribly emphasized by the total destruction of the Turkish squadron at Sinope by the Russian fleet. In that action, shell-fire appears to have been almost exclusively used, the Russians firing their shell with rather long-time fuses in preference to concussion, with the avowed object of there being time before bursting to set fire to the ship in which they lodged.

It is curious to note in the bygone discussions relative to shell-fire the arguments which were used against it; among others it was said that the shell would be more dangerous to those who used them than to their enemies. There was some ground for this contention, as several serious catastrophes resulted from the first attempts to use fused shells. Perhaps the most serious was that which occurred on board H.M.S. *Theseus*, when seventy 36- and 24-pounder shells captured from a French storeship and placed on the quarter-deck for examination exploded in quick succession, one of the fuses having by some accident been ignited. The ship was instantly in flames; the whole of the poop and after-part of the quarter-deck were blown to pieces. The vessel herself was saved from destruction with the greatest difficulty, and forty-four men were killed and forty-two wounded.

This accident was due to a neglect of obvious precautions, which would hardly occur nowadays, but I have alluded to the circumstance because the same arguments, or arguments tending in the same direction, are in the present day reproduced against the use of high explosives as bursting charges for shells. To this subject I myself and my friend and fellow labourer, Mr. Vavasseur, have given a good deal of attention, and the question of the use of these shells and the best form of explosive to be employed with them is, I believe, receiving attention from the Government. The importance of the problem is not likely to be overrated by those who have witnessed the destruction caused by the bursting of a high explosive shell, and who appreciate the changes that by their use may be rendered necessary, not only in the armaments, but even in important constructional points of our men-of-war.

Shortly before the termination of the long period of peace which commenced in 1815, the attention of engineers and those conversant with mechanical and metallurgical science, seems to have been strongly directed towards improvements in war material. It may easily be that the introduction of steam into the navy may have had something to do with the beginning of this movement, but its further progress was undoubtedly greatly accelerated by the interest in the subject awakened by the disturbance of European peace which commenced in 1854.

Since that date—whether we have regard to our vessels of war, the guns with which they and our fortresses are armed, the carriages upon which those guns are mounted, or the ammunition they employ—we shall find that changes so great and so important have been made that they amount to a complete revolution. I believe it would be more correct to say several complete revolutions. It is at least certain that the changes which were made within the period of ten years following 1854, were far more important and wide-spreading in their character than were all the improvements made during the whole of the great wars of the last and the commencement of the present century.

Indeed, it has always struck me as most remarkable that during the long period of the Napoleonic and earlier wars, when the mind of this country must have been to so large an extent fixed on everything connected with our naval and military services, so little real progress was made.

Our ships, no doubt, were the best of their class, although, I believe, we were indebted for many of our most renowned models to vessels captured from our neighbours. They were fitted for sea with all the resources and skill of the first seamen of the world, and when at sea were handled in a manner to command universal admiration. But their armaments were of

the rude nature I have described, and so far as I can see possessed little, if any, advantage over those of nearly a couple of centuries earlier. It is not improbable that the great success which attended our arms at sea may have contributed to this stagnation.

The men who with such arms achieved such triumphs, may well be forgiven for believing that further improvement was unnecessary, and it must be remembered that the practice of engaging at very close quarters minimised to a great extent the most striking deficiencies of the guns and their mountings.

I need scarcely, however, remind you that were two vessels of the old type to meet, one armed with her ancient armament, the other with modern guns, it would be vain for the former to attempt to close. She would be annihilated long before she approached sufficiently near to her antagonist to permit her guns to be used with any effect.

It would be quite impossible, within reasonable limits of time, to attempt to give anything like an historical account of the changes which have taken place in our ships of war during the last thirty-five years, and the long battle between plates and guns will be fresh in the memory of most of us. The modifications which the victory of one or the other impressed on our naval constructions are sufficiently indicated by the rapid changes of type in our battle-ships, and by the number of armour-clads once considered so formidable, but seldom now mentioned except to adorn the tale of their inutility. The subject also requires very special knowledge, and to be properly handled must be dealt with by some master of the art, such as our Director of Naval Construction.

Let me now compare with the vessels of the past those of the present day, and for my purpose I shall select for comparison as first-rates the *Victoria* and the *Trafalgar*. The *Victoria* has a length of 340 feet, a breadth of 70 feet; she has a displacement of about 10,500 tons, an indicated horse-power of 14,244, and she attained a speed on the measured mile of 17½ knots; she has a thickness of 18 inches of compound armour on her turrets, a similar thickness protects the redoubt, and her battery-deck is defended with 3-inch plates. Her armament consists of two 16½-inch 110-ton guns, one 10-inch 30 ton gun, twelve 6-inch 5-ton guns, twelve 6-pounder and nine 3-pounder quick-firing guns, two machine guns, and six torpedo guns.

The *Trafalgar* has a length of 345 feet, or very nearly double the length of the *Victory*, a displacement of 12,000 tons, an indicated horse-power of 12,820, and a speed on the measured mile of a little over 17¼ knots. Her armament consists of four 68-ton guns, six 4·7-inch quick-firing guns, six 6-pounder, and nine 3-pounder quick-firing guns, six machine and six torpedo-guns.

Comparing the armament of the *Victoria* with that of the *Victory*, we find, to quote the words of Lord Armstrong—which when evaluating the progress we have made will bear repetition—that while the heaviest gun on board the *Victory* was a little over 3 tons, the heaviest on board the *Victoria* is a little over 110 tons. The largest charge used on board the *Victory* was 10 lbs., the largest on board the *Victoria* close on 1000 lbs.; the heaviest shot used in the *Victory* was 68 lbs., in the *Victoria* it is 1800 lbs. The weight of metal discharged from the broadside of the *Victory* was 1150 lbs., from that of the *Victoria* it is 4750 lbs. But having regard to the energy of the broadside, the power of each ship is better indicated by the quantity of powder expended than by the weight of metal discharged, and while the broadside fire from the *Victory* consumed only 355 lbs. of powder, that from the *Victoria* consumes 3120 lbs.

These figures show in the most marked manner the enormous advances that have in every direction been made in the construction and armament of these marine monsters; but it is when we come to the machinery involved in our first-rates that the contrast between the past and the present is brought most strongly into prominence.

I have alluded to the simplicity of the arrangements on board the old battle-ships, but no charge of this nature can be made against the present. The *Victoria* has no less than twenty-four auxiliary steam-engines in connection with her main engines, viz. two starting, two running, eight feed, eight fan, for forced draught, and four circulating water engines. She has in addition thirty steam engines unconnected with her propelling engines, viz. six fire and bilge engines, two auxiliary circulating engines, four fan engines for ventilating purposes, two fresh-water pumping engines, two evaporating fuel engines, one work-shop, one capstan, and five electric-light engines, four air-compressing and three pumping engines for hydraulic purposes.

She has further thirty-two hydraulic engines, including two steering engines, four ash hoisting engines, two boat engines, four ammunition lifts, two turret-turning engines, one topping winch, two transporting and lifting engines, two hydraulic bollards, and fourteen other engines for performing the various operations necessary for the working of her heavy guns, making a grand total of eighty-eight engines. This number is exclusive of the machinery in the torpedo and other steam-boats, and of the locomotive engines in the torpedoes carried, which are themselves engines of a most refined and delicate character.

At an earlier point in my address I alluded to the incomparable seamanship of our bygone naval officers. Seamanship will, I fear, in future naval battles no longer play the conspicuous part it has done in times past. The weather-gage will belong not to the ablest sailor, but to the best engineer and fastest vessel, but the qualities of pluck, energy, and devotion to their profession which distinguished the seamen of the past have, I am well assured, been transmitted to their descendants, and I am glad to have the opportunity of expressing my admiration of the ability and zeal with which the naval officers of the present day have mastered, and the skill with which they use, the various complicated, and in some cases delicate machinery which mechanical engineers have placed in their hands.

I pass now to a class of vessel—the fast protected cruisers—intended to take the place and perform the duties of the old frigates. Of these I will take as types H.M.S. *Medusa* and the Italian cruiser *Piemonte*. The *Medusa* has a length of 265 feet, a breadth of 41 feet, a displacement of 2800 tons, and her engines have 10,010 indicated horse-power. Her armament consists of six 6-inch breech-loading guns, ten 3-pounders, four machine guns, and two fixed and four turning torpedo tubes. The *Piemonte* has a length of 300 feet, a breadth of 38 feet, a displacement of 2500 tons, and her engines of 12,981 indicated horse-power developed on the measured mile a speed of 22·3 knots, or about 26 miles. Her armament, remarkable as being the first instance of an equipment composed altogether of quick-firing guns, consists of six 6-inch 100-pounders, and six 4·7-inch 45-pounders, all with large arcs of training, ten 6-pounder Hotchkiss, four Maxim-Nordenfelt machine-guns, and three torpedo guns.

These vessels have a steel protective deck, with sloping sides from stem to stern, protecting the vitals of the ship; above and below the armour-deck the vessels are subdivided into a large number of water-tight compartments, and a portion of the vessel's supply of coal is employed to give additional protection.

With respect to the *Piemonte* the engines (vertical triple expansion) were designed and constructed by Messrs. Humphreys, Tennant, and Co. They are, in order that they may be wholly below the water line, of exceedingly short stroke, (27 inches), and the behaviour of the engines, both on their trials here and in the very severe weather to which the vessel was exposed on her passage out, amply justify these eminent engineers in their somewhat bold experiment.

I might describe other cruisers, both larger and smaller than those I have selected, but I must not fatigue you, and will only in this part of my subject draw your attention to these triumphs of engineering ingenuity and skill, I mean the torpedo boats, which (whether or not locomotive, torpedoes continue to hold their own as engines of destruction), are destined, I believe, to play no insignificant part in future naval warfare.

Let me illustrate the marvels that have been achieved by the great English engineers who have brought these vessels to their present state of perfection by giving you a few particulars concerning one or two of them.

A first-class torpedo boat by Yarrow has a length of 135 feet, a breadth of 14 feet, a displacement of 88 tons, and with engines of 1400 indicated horse-power attains a speed of a little over 24 knots.

A slightly larger boat, built for the Spanish Government by Thorneycroft, has a length of 147 feet 6 inches, a breadth of 14 feet 6 inches, and with engines of 1550 indicated horse-power, has attained a speed of a little over 26 knots.

It is interesting to note that the engines of the first-named torpedo boat develop nearly exactly the same power as those of the 90-gun ship, the *Cæsar*, and the engines of the second-named but little less than that developed by the *Duke of Wellington*, two vessels which you will remember I have taken as types of the second- and first-rate men-of-war of thirty-five years ago.

The weight of the engines of the *Duke of Wellington* and the *Cæsar* would be approximately 400 tons and 275 tons, while that of the torpedo boats is about 34 tons.

But if these results are sufficiently remarkable, the economy attained in the consumption of coal is hardly less striking.

The consumption of coal in the early steam battle-ships was from 4 to 5 lbs. per indicated horse-power per hour, and occasionally nearly reached 8 pounds.

At the present time in good performances the coal consumption ranges from 1½ to 1¾ lbs. per indicated horse-power per hour under natural draught, and from 2 to 2¼ lbs. per hour with forced draught.

In war-ships the engines are designed to obtain the highest possible power on the least possible weight, and this for a comparatively short time, and, further, have to work at such various powers, that the question of economy must be a secondary consideration.

With the different conditions existing in the mercantile marine, more economical results may be expected, and I believe I shall not be far wrong in assuming that in special cases 1½ lbs. may possibly have been reached; but I have not been able to obtain exact information on this head.

Turning now to the guns, let me refer first to those which were in use thirty-five years ago, and which formed the armaments of the ships of those days, and of the fortresses and coast defences of the United Kingdom and colonies.

The whole of these, with the exception of a few very light guns, were made of cast-iron. I have already alluded to the small amount of machine work (not of a very refined character) expended on them. Although the heaviest gun in use was only a 68-pounder, there were no less than sixty different natures of iron ordnance. Of the 32-pounder alone there were as many as thirteen descriptions, varying in length and weight. Of these thirteen guns, again, there were four separate calibres ranging from 6·41 inches to 6·3 inches, and as the projectile was the same for all, the difference fell on the windage. This varied, assuming gun and projectile to be accurate, from about 0·125 to 0·250, so that it may easily be conceived the diversity of the tables of fire for this calibre of gun were very great. And although from the simple nature of the guns, and the absence of anything like mechanical contrivance connected with them, it was quite unnecessary to give to them the care and attention that are absolutely indispensable in guns of the present day, it must not be supposed that they were altogether free from liability to accident and other defects.

I had occasion recently to look into the question of the guns employed in the siege of Sebastopol, and found that in that great siege no less than 317 iron ordnance were used by this country. At the close of the siege it was found that 8 had burst, 101 had been condemned as unserviceable, while 59 were destroyed by the enemy's fire.

The 95 cwt. 68-pounder gun seems to have been about the largest gun that could safely be made of cast-iron, and that in it the limit of safety was nearly reached, was shown by the fact that a serious percentage of this calibre burst or otherwise failed. With the spherical shot the column of metal per unit of area to be put in motion by the charge was small, and to this the guns probably owed their safety.

When the same charge was used, and cylinders representing double, treble, or quadruple the normal weight of the shot were fired, the end was rapidly reached, the guns frequently bursting before cylinders four or five times the weight of the shot were employed.

But the fact that a stronger and more reliable material than cast-iron was necessary, was shortly to be emphasized in a much more striking manner. The great superiority of rifled to smooth-bored ordnance in every respect, in power, in range, in accuracy, in destructive effect of shrapnel and common shell, was in this country demonstrated by Lord Armstrong and others. This led to numerous attempts to utilize cast-iron for rifled ordnance. The whole of these efforts resulted in failure. Although the charges were feebler than with smooth-bored guns, these experimental guns burst one after the other with alarming rapidity, generally before many rounds had been fired. The matter was not made much better when the expedient was adopted of strengthening these guns by hoops or rings shrunk on externally. Failures with this arrangement were little less frequent, the cast-iron bursting under the jackets, and the only plans in which cast-iron was used with any success were those proposed respectively by Sir W. Palliser and Mr. Parsons, who inserted, the one a coiled wrought-iron, and the other a steel tube in a cast-iron gun block.

But the country that suffered most severely from the use of cast-iron was the United States. Their great civil war took place just when efforts were being made in every country to introduce rifled artillery. Naturally every nerve was strained to manufacture these guns, and naturally the resources that came most readily to hand were first employed.

A report presented by the Joint Committee on Ordnance to the United States Senate in 1869 gives the history of these guns, which were nearly all either cast-iron or cast-iron reinforced with hoops in the way I have described. I have heard the existence of internal strains disputed, but in this report we read that ten guns burst, that is, flew to pieces, when lying on chocks, without ever having had a shot fired from them, and 98 others cracked or became ruptured under like conditions.

In the "Summary of Burst Guns" in the same report, it is stated that 147 burst and 21 were condemned as unserviceable; 29 of them being smooth-bore and 139 rifled ordnance. But perhaps the most striking passage is that which relates that in the action before Fort Fisher *all* the Parrott guns in the fleet burst, and that by the bursting of five of these guns during the first bombardment, 45 men were killed and wounded, while only 11 men were killed or wounded by the enemy's fire.

The muzzle velocity given by the smooth-bored, cast-iron guns may be taken approximately at 1600 f.s., and at the maximum elevation with which they were generally fired their range was about 3000 yards. The 32-pounder, with a charge of one-third the weight of the shot and an elevation of 10°, gave nearly 2800 yards, and the 68-pounder, with a charge of about one-fourth, nearly 3000 yards. The same gun, with an eccentric shot, and an elevation of 24°, gave a maximum range of 6500 yards.

But it must not be supposed because the range tables gave 3000 yards as practically the extreme range of the ordnance of 35 years ago, that our guns possessed any high efficiency at that distance. At short distances, from 300 to 500 yards, dependent on the calibre, the smooth-bored guns were reasonably accurate, but the errors multiplied with the distance in so rapidly increasing a ratio, that long before a range of 3000 yards was attained the chance of hitting an object became extremely small.

It is desirable to give some idea of the accuracy, or, rather, want of accuracy, of these guns.

In 1858 I was appointed secretary to the first Committee on Rifled Cannon, and the early experiments showing how extraordinary was the accuracy of the new weapons, it became a matter of importance to devise some means of comparing in this respect the old and the new guns.

The plan I proposed was one which has since been followed by the artillerists of nearly all countries. It was to calculate the probable error in range and the probable error in deflection, and from these data the area within which it would be an even chance that any given shot would strike; or, in other words, that area within which, out of a large number of rounds, half that number would fall. This area was for the smooth-bored gun at a range of 1000 yards, 147·2 yards long by 9·1 yards broad, or 1339·5 square yards, while the similar area for the rifled gun at the same range was 23·1 yards long by 0·8 yards broad, or an area of 18·5 square yards. But the great decrease of accuracy due to an increase of range with the smooth-bore guns is especially remarkable. Experiments showed that with the smooth-bored gun an increase of range of only 350 yards more than doubled the error in deflection, and made the area selected for comparison 206 yards long by 20·2 broad, or 4161 square yards, as nearly as possible trebling the area for an increase in range of 35 per cent.

But I have not done yet. These experiments were made with the same lots of powder carefully mixed, and the irregularities in velocity would be such as are due to manufacturers' errors only. But the variations in the energy developed by the gunpowder employed have still to be considered. In 1860, being then an associate member of the Ordnance Committee, I carried on for the Government the first electro-ballistic experiments made in this country. My attention was early called to the great variation in energy developed by powders recently made and professedly of the same make, and I pointed out that in my experiments the variations between one lot of powder and another amounted occasionally to 25 per cent. of the total energy developed. It is unnecessary to say that on service, and when

powder had been subjected to climatic influences, the variations would have been much greater.

The variations in energy of new powder were chiefly due to the method of proof then in use, the Eprouvette mortar, than which nothing can be conceived better adapted for passing into the service powders unsuitable for the guns of that time.

But with the want of accuracy of the gun itself, and the want of uniformity in the propelling agent, it may easily be conceived that a limit was soon reached beyond which it was mere waste of ammunition to fire at an object even of considerable size, and we can appreciate the reasons which led our naval commanders, whenever possible, to close with their enemy.

When we come to consider guns of the present day, the first point that attracts our attention is the enormous increase in the size and weight of the larger natures. It may fairly be asked, indeed, if, weight for weight, the modern guns are so much more powerful than the old, and, if we have command of such great ranges, why such heavy guns should be necessary.

The answer to this, of course, is that it has been considered essential to have guns capable of piercing at short distances the thickest armour which any ship can carry, and this demand has led us from guns of 5 tons weight up to guns of 110 and 120 tons weight, and to the development of the important mechanical arrangements for working them, to which I shall presently refer.

On the principles which guide the construction of these large guns I shall say little, both because the subject is too technical to be dealt with in an address, and because the practice of all nations, though differing in many points of detail, in essentials is closely accordant.

On three points of construction we lay particular stress in this country. These points are: That the gun shall be strong enough to resist the normal working pressure, even if the inner tube or barrel be completely split. That whether we regard the gun as a whole, or the parts of which it is composed, the changes of form should be as little abrupt as possible, and that any sharp angle or corner must be absolutely avoided.

As in principles of construction, so in material employed, is the practice of the great gun-making nations closely agreed. The steel employed is ductile and subjected to severe specifications and tests, which differ slightly one from the other, but exact, in effect, qualities of steel substantially the same. So far as I know, the application of the tests in this country is more severe than in any other, and I take this opportunity of entering my protest against the statement which I have seen more than once in the journals of the day—that English gun-steel is in any way inferior to any that is produced in any part of the world. Sheffield has in no respect lost its ancient reputation in the art of steel-making, and to my certain knowledge has supplied large quantities of steel, admitted to be of the first quality, to gun-makers of the Continent. The steel made by Sir J. Whitworth & Co. has likewise long been in great repute both at home and abroad, and looking at the care devoted to the subject by the Government, and the eagerness with which improvements in the quality and mode of manufacture are sought for and acted on by the steel-makers, we may be absolutely certain that to the best of our knowledge the most suitable material is used in the construction of our guns.

As many of you are aware, the mild steel which is used for the manufacture of guns is after forging and rough-boring subjected to the process of oil-hardening, being subsequently annealed, by which process it is intended that any detrimental internal strain should be removed. This process of oil-hardening, introduced first by Lord Armstrong in the case of barrels, is now almost universally adopted for all gun forgings. Of late, however, there has been considerable discussion as to whether or not this oil-hardening is necessary or desirable; and while admitting the increase of the elastic limit due to the process, it is asked whether the same results would not be obtained by taking a steel with, for example, a higher percentage of carbon, and which should give the same elastic limit, and the same ductility. The advocates of oil-hardening urge that steel with low carbon, duly oil-hardened to obtain the elastic limit and strength desired, is more reliable than steel in which the same results are reached by the addition of carbon. Those who maintain the opposite view point to the uncertainty of obtaining uniform results by oil-hardening, to the possibility of internal strains, and to the costly plant and delay in manufacture necessary in carrying it out. The question raised is undoubtedly one of great importance, but it appears to me to be one concerning which it is quite within our power in a comparatively short time, by properly arranged experiments, to arrive at a definite conclusion.

Sir F. Abel has in his Presidential Address given us so masterly a *résumé* of the present state of the steel question in its metallurgical and chemical aspects that it is unnecessary for me to add anything on this head. I will only remark that in selecting steel for gun-making, individually I should prefer that which is on the side of the low limit, to that which is near the high limit, of the breaking weight prescribed by our own and other Governments. I have this preference because, so far, experience has taught us that these lower steels are safer and more reliable than the stronger—and in guns we do not subject, and have no business to subject, the steel to stresses in any way approaching that which would produce fracture.

Of course if our metallurgists should give us a steel or other metal which with the same good qualities possesses also greater strength, such a material would by preference be employed, but it must not be supposed that the introduction of such new material would enable us, to any great extent, to reduce the weight of our guns. As a matter of fact, the energy of recoil of many of our guns is so high that it is undesirable in any case materially to reduce their weight. As an illustration, I may mention that some time ago, in re-arming an armour-clad, the firm with which I am connected was asked if by using the ribbon construction it would be possible, while retaining the same energy in the projectile, to reduce the weight of the main armament by three tons per gun. The reduction *per se* was quite feasible, but when the designs came to be worked out it was found that, on account of the higher energy of recoil, no less than 4 tons weight per gun had to be added to strengthen the mounting, the deck, and the port pivot fastenings.

The chamber pressures with which our guns are worked do not generally exceed seventeen tons per square inch, or say 2500 atoms. It must not be supposed that there is any difficulty in making guns to stand very much higher initial tensions; but little would be gained by so doing. Not only can a higher effect be obtained from a given weight of gun if the initial pressure be kept within moderate limits, but with high pressures the erosion (which increases very rapidly with the pressure) would destroy the bores in a very few rounds.

In fact, even with the pressures I have named, the very high charges now employed in our large guns (1060 lbs. have frequently been fired in a single charge), and the relatively long time during which the high temperature and pressure of explosion are maintained, have aggravated to a very serious extent the rapid wear of the bores. In these guns, if the highest charge be used, erosion, which no skill in construction can obviate, soon renders repair or relining necessary. Reduced charges, of course, allow a materially prolonged life of the bore, and there is also a very great difference in erosive effect between powders of different composition, but giving rise in a gun to the same pressures. Unfortunately, the powder which has up to the present been found most suitable for large guns is also one of the most erosive, and powder-makers have not so far succeeded in giving us a powder at once suitable for artillery purposes, and possessing the non-eroding quality so greatly to be desired.

An *amide* powder made by the Chilworth Company, with which I have, not long ago, experimented, both gave admirable ballistic results, and at the same time its erosive effect was very much less than that of any other with which I am acquainted. It is by no means certain that the powder would stand the tests which alone would justify its admission into the service, but the question of erosion is a very serious one, and has hardly, I think, received the attention its importance demands. No investigation should be neglected which affords any prospect of minimising this great evil.

On the introduction of rifled artillery the muzzle velocities, which you will remember had been with smooth-bore guns and round shot about 1600 f.s., were, with the elongated projectiles of the rifled gun, reduced to about 1200 f.s. In the battle between plates and guns these velocities were with armour-piercing projectiles gradually increased to about 1400 f.s., and at about this figure they remained until the appointment by the Government of a Committee on Explosives. By the experiments and investigations of this committee it was shown that, by improved forms of gunpowder and other devices, velocities of 1600 f.s. could be obtained without increasing the maximum pressure, and without unduly straining the existing guns. Similar advances in velocity were nearly simultaneously made abroad,

but in 1877 my firm, acting on independent researches on the action of gunpowder made by myself in conjunction with Sir F. Abel, constructed 6-inch and 8-inch guns which advanced the velocities from 1600 to 2100 f.s., and this great advance was everywhere followed by a reconstruction of rifled artillery.

With the present powder the velocities of the powerful armour-piercing guns, firing projectiles considerably increased in weight, may be taken at from 2000 to 2100 f.s. The distance of 3000 yards, which I said practically represented the extreme range of smooth-bored guns, is attained with an elevation of only 2° in the case of the 68-ton gun, and of 3½° in the 4·7-inch quick-firing gun, while at 10° the ranges are 9800 and 5900 yards respectively, and, as an instance of extreme range, I may mention that with a 9·2-inch gun a distance of over 13 miles has actually been reached.

Nor is the accuracy less remarkable. Bearing in mind the mode of comparison which I have already explained, at 3000 yards range the 68-ton gun would put half its shot within a plot of ground 7·2 yards long by 0·3 broad, and the 4·7-inch gun within a plot 19 yards long by 1·3 broad; or, to put it in another form, would put half their rounds in vertical targets respectively 0·92 yards broad by 0·34 yards high and 1·3 yards broad by 1·6 yards high.

But it cannot be assumed that we are at the end of progress. Already, with the amide powder we have obtained nearly 2500 f.s. in a 6-inch gun with moderate chamber pressures, and with the cordite originated by the Committee on Explosives, of which Sir F. Abel is president, considerably better results have been obtained. I have elsewhere pointed out that one of the causes which has made gunpowder so successful an agent for the purposes of the artillerist is that it is a mixture, not a definite chemical combination; that it is not possible to detonate it; that it is free, or nearly so, from that intense rapidity of action and waves of violent pressure which are so marked with nitro-glycerine and other kindred explosives.

We are as yet hardly able to say that cordite in very large charges is free from this tendency to detonation, but I think I may say that up to the 6-inch gun we are tolerably safe; at least, so far, I have been unable, even with charges of fulminate of mercury, to produce detonation. I need not remind you that cordite is smokeless, and that smokeless powder is almost an essential for quick-firing guns, the larger natures of which are day by day rising in importance.

I now come to the third part of my subject—the modes which are now adopted of mounting and working the ordnance I have described. I have alluded to the carriages, which, at the beginning of the century, were made of wood, and were worked solely by handspikes. Thirty-five years ago they were but little changed, although in the case of pivot guns screws for giving elevation, and blocks and tackle for training had been introduced, but timber was still the material employed. A strong prejudice long existed in both services against iron for gun carriages, as it was believed that iron carriages would be more difficult to repair, and that the effect on the crew of splinters would be much more serious.

But when the experiment of firing at both natures was made at Shoeburyness, with dummies to represent the crews, it was found both that the wooden carriage was far more easily disabled than the wrought iron, and that the splinters from the wooden carriages were far more destructive.

In all other respects, the superiority of wrought iron as regards unchangeability, durability, and strength, was so apparent, that iron, and later steel, rapidly displaced wood. No gun carriages, not even field, are now made of that material. It is impossible, within moderate limits, to give even a sketch of the various forms of mountings that have, as the science of artillery has progressed, been designed to meet the constantly changing conditions of warfare. I shall confine myself to the description of certain types of carriages, dividing these generally into three classes, viz., those for guns of the largest class, which require power to work them; those for guns of medium size, in which, by special arrangements, power is dispensed with; and those for guns of a smaller class, which are particularly arranged for extremely rapid fire.

With respect to the first class. On the adoption of heavily armed, revolving turrets of the Cowper-Coles type, in which the guns are trained for direction by revolving the turret, the first idea which naturally presented itself was to utilize steam power for this heavy work. It was, however, soon recognized that, on account of its elasticity steam did not give the necessary steadiness and control of movement essential for accuracy of aim, and water under pressure was employed as the means of transmitting the power from the steam-engine to the machinery for rotating the turret and working the guns.

On land, where an accumulator can be employed, a small steam-engine kept constantly at work is used; but at sea, where accumulators, whether made to act by the pressure of steam, air, or springs, are inadmissible, a very much larger engine is employed sufficiently powerful to supply water to perform all the operations ever carried on together. When little or no work is required, the engine automatically reduces its speed till it merely creeps, so that little or no power is consumed.

The mode of mounting the guns differs somewhat according as they are intended to be placed in a barbette or in a turret. Our guns have gradually been increased in length, and are now so long (our largest has a length of nearly 45 feet) that it is impossible to provide an armoured turret of sufficient size to protect the forward part of the gun, and under these circumstances it is a grave question whether it is worth while to devote so much armour to the protection of what is after all the strongest part of the gun.

Of the eight new battle-ships now building, seven are to have their guns mounted *en barbette*, and one is to be provided with armoured turrets. In either case the guns and their machinery are carried on revolving turntables of practically the same form. These turntables are placed in an armoured redoubt, and the guns, when horizontal, are entirely above the armour, but in the case of the ship provided with turrets the breech ends of the guns are covered in, with the turrets placed as an addition on the turntables.

The extra weight required thus to protect the breech ends of the guns is for this ship about 550 tons.

As the hydraulic machinery for these new ships differs but slightly from that fitted on ships of the *Rodney* and *Nile* classes, the same description will cover all these vessels. The armoured barbette battery at each end of the ship is made of a pear shape, in order to provide for a pair of ammunition hoists and hydraulic rammers at its narrower end.

These ammunition hoists come right up into the armoured barbette and descend to the shell-room and magazine decks, forming the channel by which the projectiles and charges are rapidly supplied to the guns; and it must be remembered that the weight to be lifted for a single round, including powder and projectile, with the necessary cases, considerably exceeds a ton. The cage in each hoist is worked by hydraulic cylinders with double wire-ropes, and in case of breakage, automatic safety gear is fitted to arrest and lock the cage.

While on the ammunition deck the cages are charged simultaneously from either side, and when hoisted to the battery-deck are automatically slowed, and then stopped at the proper position for loading the guns, much depends upon the service of ammunition by these hoists being protected from interruption, and in the event of derangement of the cage, independent tackle, worked by an hydraulic capstan, is provided to take its place, and a few rounds can also be stowed within the battery.

In intimate connection with the ammunition hoists are the hydraulic rammers on the ammunition deck for charging the cages, and in the battery for loading the guns. To reduce their length within reasonable limits they are made telescopic, and they are fitted with indicators to show when the charges are home.

In the shell-rooms hydraulic cranes and traversing bogies are fitted to convey the shell to the base of the ammunition hoist, so that a projectile is transported from the place where it is stowed to the shot-chamber of the gun without manual labour of any sort except that of moving the various levers to set the hydraulic machinery in motion. In the magazines hydraulic bollards are provided for hoisting and transporting the powder-cases by means of overhead runners. Hand-gear is provided as an alternative in both magazine and shell-rooms.

Each turntable carrying the guns and their fittings is rotated by a pair of entirely independent three-cylindered engines, each engine being of sufficient power to rotate the turntable at the speed of one revolution per minute. The gear for controlling them is worked from two or three look-out stations, at either or any of which the officer has to his hand the means of elevating, training, sighting, and firing either one or both guns. The turning-engines are fitted with a powerful spring break, which will hold in a seaway, but which is taken off automatically when the water is admitted to start the engines. Easy control is obtained by

the use of servo-motor valves, so that the handwheel is small and requires but little power to move it. It only remains to describe as shortly as possible the system of mounting the guns on the turntable. The guns are trunnionless, to allow them to be as close together as possible, with the view of reducing to the smallest possible size the diameter of the turntables. The carriages are cradles of steel grooved to correspond with rings turned on the guns, and with straps by which the guns are secured to the cradles. The carriages are mounted without rollers or wheels on slides formed of steel beams of great strength, pivoted at their front ends and supported on hydraulic presses, by which they are bodily raised or lowered to give the guns elevation or depression. In the case of the turret this system gives the smallest possible port. The loading of the gun is effected while the gun is at extreme elevation, a position which is easily determined by dropping the slide on to fixed stops, and which gives the best protection for the breech mechanism, for the hoist and rammers. The operations of unlocking the breech-block, withdrawing it, traversing it, inserting a loading tray, and, after completing the loading, performing the same operations in reverse order, are all done by hydraulic power, and the fittings are so devised that, unless the gun is properly locked and run out, it cannot be fired.

In certain foreign vessels provided with the hydraulic breech mechanism, a valve has been arranged which makes in their proper order, and in that order only, the eight or ten movements necessary to open and close the breech of the gun, but this system has not been adopted in our own navy.

The sights are carried on the top of the turntable, or, in the case of a turret, on the turret roof, and are worked automatically by an arc attached to the gun slide, gearing into cog-wheels, with shafting reaching to each sighting position.

The system of recoil press adopted on all these ships is that which lends itself most readily to employment also as a running-in-and-out press. It consists of a simple cylinder carried in the middle of the slide, having working in it a ram with piston, attached at the front end to the carriage. Spring-loaded valves are placed in the recoil ram piston and at the end of the cylinder, and by these the water escapes when the gun recoils. The water which passes through the cylinder valves runs to the exhaust-pipe, while that which passes through the piston valve remains in the front of the cylinder, and prevents the gun charging out again. When the recoil press is used to run the gun in and out, these valves are inoperative, as they are loaded much above the working pressure in the hydraulic mains. The high pressure of recoil does not enter the hydraulic mains, as the supply to the rear of the press, where alone the high pressure of recoil exists, is made backwards and forwards, through a valve which shuts itself automatically when not in use.

Before leaving the working by power of heavy guns, there is one example of mounting a pair of guns *en barbette* which, although it has many points in common with the system I have just described, has also some points of difference, which it may be worth while to note.

Objections have sometimes been urged to the fixed loading station on the ground that it is necessary to bring the guns to it and lock them there until sponged and loaded, thereby involving, not only a loss of time, but, under certain conditions, exposing them more to the enemy's fire.

In ships of the *Re Umberto* type, what is termed an all-round loading is obtained by bringing up the ammunition through a central hoist to the deck below the turntable. From this central hoist it is transferred to two other hoists, which are carried on the turntable behind the guns. The transfer is made by hand for the powder, and by sliding down a tray for the projectile, this work being performed by men on the deck below the turntable. The hydraulic rammers are fixed to the turntable, and are very much shortened by being made with more rams. In spite of this arrangement, however, the hoists are rather cramped, and the breech mechanism has to be made to pass from behind the gun, so as to permit the gun to recoil, and the gun is rather further forward than usual when run out.

With these reservations, however, the system has advantages: the reduction in the armour required to protect the turntable and its machinery is considerable, and the redoubt being round instead of pear-shaped, presents a smaller and stronger surface to the enemy when broadside on.

I very much doubt, however, whether with this system there can be any advantage in rapidity of fire. Training to the loading station is in our navy very quickly done, and the turntable is rotated while the guns are being run in or out.

It is hardly necessary to say that hydraulic machinery for guns was worked out by my friend and late partner Mr. George Rendel, and up to the end of 1881 all details connected therewith were made under his management.

I ought perhaps to give you some idea of the rate at which these heavy guns worked by power can be fired.

In the case of the *Benbow*, with the 110-ton gun the time from "load" to "ready" was 2½ minutes. In the firing trials of the *Trafalgar* four rounds were fired from one of her 68-ton guns in 9 minutes 5 seconds. In the *Colossus*, when under command of Captain Cyprian Bridge, the average from one round to another was 1 minute 45 seconds, and on one occasion, steaming at 8 knots per hour past a target at a distance of 1500 yards, she fired four rounds in six minutes, striking the target three times.

Of the mountings which are worked solely by manual power, the whole range for naval service is covered by the carriages of the type designed by Mr. Vavasseur. No single description can be made to cover all the varieties of these mountings which have been worked out to meet the diverse conditions which have arisen in the re-arming of old ships, and the fitting out of new vessels on modern and novel designs. The very general adoption of breech-loading ordnance brought with it the necessity for a mounting which would give easier access to the breech of the gun than was obtained with the long low gun-slide employed with the muzzle-loading guns. The main features of the type, therefore, are: a high slide, very short, so as not to project beyond the breech of the gun, a short low carriage carrying on either side the recoil presses, and a shield to afford protection both to the carriage and the gun crew.

The increased importance of rapid-fire guns has led in later carriages to a strong armour plate being built into the mounting as part of its structure, and to this must be added the shield above mentioned, so that the total protective thickness of plate is very considerable.

By means of a worm wheel sliding on a keyed shaft the movement of the gun for elevation or depression can be made up to the instant of firing—a decided and very important advance on the older methods.

The arrangement of the recoil-cylinders is peculiar. They are fitted with a pair of pistons with rotating valves, so adjusted as to be open when the gun is in the firing position, and to be gradually closed during recoil by studs running along rifled grooves in the cylinders; by this ingenious contrivance the area of the ports of the valves is increased and then decreased in proportion to the variation of the velocity of recoil, so that the liquid passes from one side of the piston to the other at as nearly as possible a constant velocity and under a constant pressure. The velocity of the flow through the ports, and therefore the pressure of the liquid, varies with the energy of the recoil of the gun, so that the length of the recoil is with all charges practically the same.

Even a blank charge produces nearly full recoil, and on one occasion caused one of these mountings to be reported as unserviceable, and unfit to fire a shotted round. Constant length of recoil has the advantage over constant pressure in the recoil-presses that, in the event of an unusually heavy recoil, a higher pressure in the recoil-press would in the former case be the only result, and would do no harm, as the pressure would still be much below the test-pressure; but in the latter case there would be an increased length of recoil, and, unless considerable margin were allowed, a possible destruction of the slide.

Most frequently the Vavasseur mountings are made with central pivots, and there is then little tendency for the movements of the vessel to affect the mounting, and as the weight is borne upon a ring of live rollers the greatest ease of training is obtained.

In the larger sizes the centre pivot is increased in size, and made hollow so as to provide for the passage through the centres of a powder hoist, which, after rising high enough, curves to the rear under the gun and delivers its charge at the point where it can most conveniently be drawn out for insertion in the gun. In this case a foot plate is also provided as a rear attachment to the slide, and from this the crew work the gun. This foot plate is provided with boxes for eight or ten projectiles, which are therefore ready for use at any moment and in any position of training. These mountings are fitted in the belted cruisers of

the *Orlando* class, one being carried at the fore and one at the after end of each ship.

As a sufficient proof of the value of these mountings and of the ability which has been displayed in their design, I may mention that practically all countries have adopted these carriages for modern guns, either without any alteration or with comparatively unimportant modification.

In discussing our modern ordnance I only alluded to quick-firing guns, because in their case the gun and mounting are so closely connected, the efficiency of the system depending as much upon the one as the other, that a separate description of either would be incomplete, and they are more easily described together. The great success which attended the small Hotchkiss and Nordenfelt three- and six-pounder guns led me to consider whether the same principle could not be applied to large guns, and we designed and made at Elswick the 4·7 inch and 5·5 inch quick-firing guns which were so successfully tried by the *Excellent* at Portsmouth. Subsequently, with the co-operation of Mr. Vavasseur, various improvements were made, and for the sake of uniformity in calibre a 6-inch was substituted for the 5·5-inch gun.

One of the peculiarities of these guns is in the form of the breech-screw which, while on the principle of the interrupted screw, is made conical, so as to simplify the action of opening and closing—the principle of the ordinary rifle cartridge has been extended to the ammunition for these guns. This not only allows extremely rapid loading, but secures safety from premature explosions in rapid firing. The cartridges are fired electrically, and, not having their own ignition, there is no danger of exploding them either when stowed in the magazine or if accidentally dropped in the handling.

To follow the rapid movements of a torpedo boat it is essential that there should be the most perfect control over the gun and mounting, and the most effective mode of rapid fire is to keep the gun always on the object aimed at, allowing the gun itself to fire as the breech is closed. The captain stands at the side of the gun, shielded by a guard-plate from the recoil, his shoulders braced against a shoulder-piece which is unaffected by the recoil; his eye aligns the sights; with one hand he works the elevating or training wheel, and with the other grasps the firing-trigger, or, for rapid firing, the training-wheel may be thrown out of gear, and direction given by the shoulder-piece alone. The mounting is a centre pivot, and, being on live rollers, turns with the least effort. The gun has no trunnions, but slides in a carriage which envelopes it like a sleeve. The trunnions are on this carriage, so that the two are together pivoted like an ordinary gun in a fixed lower carriage. There is no preponderance when the gun is in the forward position, and the recoil lasts for so short a time that the disturbance of the centre of gravity is not felt on the elevating-gear or shoulder-piece. The lower side of the carriage is formed into a recoil press, the piston-rod of which is attached to a horn on the rear of the gun.

There is also a spring-box, with rod attachments to the horn, by which the gun is instantly run out as soon as the recoil is expended. Efficient shields are provided to protect the crew. The revolving weight of the gun and mounting is 5 tons; yet, with the shoulder against the shoulder-piece, it can be swung through 90° in 2 seconds, and with the gear can be trained through the same arc in 5 seconds. It is possible to fire from this gun at the rate of 10 to 12 rounds per minute, and on one occasion 10 rounds were fired in 47 seconds; but perhaps the most striking experiment with the gun was made at Shoeburyness, when five rounds were fired in 31 seconds at a 6′ × 6′ target at 1300 yards, all of which struck the object aimed at.

A trial has also been recently made between two cruisers, the one armed with ordinary breech-loading, the other with quick-firing artillery, from which it appears that when firing at a target the latter, in a given time, was able to discharge about six times the quantity of ammunition fired by the former. I need not impress upon you the significance of these facts or the importance of quick-firing armaments, especially if firing shell, possibly charged with high explosives, against the unarmoured portions of cruisers or other vessels.

The accuracy and the shell power of rifled guns have naturally had their effect upon the mountings for the land service, experiments having conclusively shown that batteries armed with guns placed in ordinary embrasures would soon be rendered untenable. Among the expedients that have been adopted or suggested to meet the altered conditions, the system of making the gun disappear behind a parapet or into a pit, with which the name of Colonel Moncrieff has been so long and so honourably associated, is more and more coming into favour as the most effective mode of protection for the gun and its mounting, as well as for the gun detachment. During the last ten years much attention has been devoted to the designing of various mountings on this system for all weights of guns from 3 up to 68 tons.

In the earliest carriages of this type the gun was raised by the descent of a balance weight, but the most successful arrangement is that in which compressed air is employed for the purpose. The 9·2-inch and 10-inch hydro-pneumatic mountings are the largest sizes as yet adopted into the English service, and a description of them will serve for that of the type generally.

The gun on this system is raised by compressed air stored in several chambers, and acting through the medium of a fluid upon a recoil ram.

On the recoil of the gun the liquid is driven from the cylinder by the incoming ram into the lower parts of the air chambers, so that as much as is required of the energy of recoil is stored up by the compression of the air, and is used to raise the gun for the next round. The gun is raised up and lowered on two heavy beams pivoted to the lower carriage. Two long light elevating rods, pivoted at one end to the breech of the gun, at the other to the lower carriage, hold the gun in correct position as it rises or falls; the elevation is changed by moving the position of the lower ends of the elevating rods. This can be done when the gun is down without disturbing it, and consequently with very little labour. The effect of the change is apparent after the gun rises, when any slight correction can be made if desired. Generally these mountings have been made with overhead shields placed a little below the level of the top of the gun pit, and entirely closing it. There is an aperture through which the gun rises, but which can be closed when the gun is out of action.

In the case of the 10-inch gun the total weight of the revolving mass is 80 tons. Only two men are required at the hand-wheels to revolve it—in fact, it is within the power of *one* man to do the whole work. The ordinary speed of training is 90° in 1¼ minute, while the time required to raise the gun to the firing position is 20 seconds. The speed of rising might be considerably increased, but, taking the weight of the mass in motion into account, it does not appear to be desirable to accelerate it.

At Maralunga, Spezia, in March of the present year, the first 68-ton disappearing mounting, manufactured for the Italian Government, was tried with most satisfactory results. Fifteen rounds were fired in all, some of them being made to give greatly increased energy of recoil, with the view of proving the gun and mounting.

The gun was worked entirely by hand-power, and on land no difficulty is experienced in thus dealing with it, while the system possesses the advantage that it is always ready for use should it be required, but no great alteration is necessary to adapt the mounting for use with hydraulic power.

In this case the water from the recoil press is driven through spring-loaded valves instead of into air chambers. There is, therefore, no storing up of the recoil energy, and to raise the gun to the firing position, water pressure from an accumulator kept charged by a steam-pumping engine in the usual way is employed. These guns and mountings are too large to be easily covered by an overhead shield, but they are provided with shields at the front and rear to protect the gun detachments.

Another very successful mounting for land service has been made for guns when the site is such that it is permissible to place them *en barbette*. The gun is entirely above the parapet, but the detachment is protected while loading and working the gun by a broad sloping shield carried on the gun carriage and recoiling with it. The shield is inclined so that any splinters, &c., striking it, may be deflected in an upward direction.

The carriage runs back on a long slide inclined at 5°, and at the end of the recoil is caught by a spring catch, which retains it in the run in position until the loading is finished. To load, the gun is put at extreme elevation, so that the breech may be as much under protection as possible, the charge being rammed home with a hand rammer worked by rope tackle. The slide is mounted on front and rear rollers, and has an actual central pivot. The recoil is controlled by a single Vavasseur recoil cylinder placed in the centre of the slide, and giving a constant length of recoil for all charges, so that the spring catch to retain the gun at extreme recoil for loading is always reached.

To run out after loading, the spring catch is released, and the

incline of the slide is sufficient to cause the gun to run out, which it does smartly, but is checked and brought to rest quietly by means of a controlling ram placed at the end of the recoil press.

But I must conclude. I trust I have said enough to satisfy you as to the indebtedness of the naval and military services to mechanicians and to mechanical science, but you will also understand that within the limits of an address it is impossible to give a complete survey of so large a subject, and that there are important fields I have left wholly untouched.

SECTION H.

ANTHROPOLOGY.

OPENING ADDRESS BY JOHN EVANS, D.C.L., LL.D., D.Sc., TREAS.R.S., PRES.S.A., F.L.S., F.G.S., PRESIDENT OF THE SECTION.

IN the year 1870 I had the honour of presiding over what was then the Department of Ethnology in the Biological Section of the British Association at its meeting in Liverpool. Since that time twenty years have elapsed, during the greater portion of which period the subjects in which we are principally interested have been discussed in a Department of Anthropology forming part of the organization of the Biological Section; although since 1883 there has been a new Section of the Association, that of Anthropology, which has thus been placed upon the same level as the various other sciences represented in this great parliament of knowledge. This gradual advance in its position among other branches of science proves, at all events, that, whatever may have been our actual increase in knowledge, Anthropology has gained and not lost in public estimation, and the interest in all that relates to the history, physical characteristics, and progress of the human race is even more lively and more universal than it was twenty years ago. During those years much study has been devoted to anthropological questions by able investigators, both in England and abroad; and there is at the present time hardly any civilized country in the world in which there has not been founded, under some form or another, an Anthropological Society, the publications of which are yearly adding a greater or less quota to our knowledge. The subjects embraced in these studies are too numerous and too vast for me to attempt even in a cursory manner to point out in what special departments the principal advances have been made, or to what extent views that were held as well established twenty years ago have had either to be modified in order to place them on a surer foundation, or have had to be absolutely abandoned. Nor could I undertake to enumerate all the new lines of investigation which the ingenuity of students has laid open, or the different ways in which investigations that at first sight might appear more curious than useful have eventually been found to have a direct bearing upon the ordinary affairs of human life, and their results to be susceptible of application towards the promotion of the public welfare. I may, however, in the short space of time to which an opening address ought to be confined, call your attention to one or two subjects, both theoretical and practical, which are still under discussion by anthropologists, and on which as yet no general agreement has been arrived at by those who have most completely gone into the questions involved.

One of these questions is: What is the antiquity of the human race, or rather what is the antiquity of the earliest objects hitherto found which can with safety be assigned to the handiwork of man? This question is susceptible of being entirely separated from any speculations as to the genetic descent of mankind; and, even were it satisfactorily answered to-day, new facts might to-morrow come to light that would again throw the question entirely open. On any view of probabilities, it is in the highest degree unlikely that we shall ever discover the exact cradle of our race, or be able to point to any object as the first product of the industry and intelligence of man. We may, however, I think, hope that from time to time fresh discoveries may be made of objects of human art, under such circumstances and conditions that we may infer with certainty that at some given point in the world's history mankind existed, and in sufficient numbers for the relics that attest this existence to show a correspondence among themselves, even when discovered at remote distances from each other.

Thirty-one years ago, at the meeting of this Association at Aberdeen, when Sir Charles Lyell, in the Geological Section, called attention to the then recent discoveries of Palæolithic implements in the Valley of the Somme, his conclusions as to their antiquity were received with distrust by not a few of the geologists present. Five years afterwards, in 1864, when Sir Charles presided over the meeting of this Association at Bath, it was not without reason that he quoted the saying of the Irish orator, that "they who are born to affluence cannot easily imagine how long a time it takes to get the chill of poverty out of one's bones." Nor was he wrong in saying that "we of the living generation, when called upon to make grants of thousands of years in order to explain the events of what is called the modern period, shrink naturally at first from making what seems so lavish an expenditure of past time. Throughout our early education we have been accustomed to such strict economy in all that relates to the chronology of the earth and its inhabitants in remote ages, so fettered have we been by old traditional beliefs, that even when our reason is convinced, and we are persuaded that we ought to make more liberal grants of time to the geologist, we feel how hard it is to get the chill of poverty out of our bones."

And yet of late years how little have we heard of any scruples in accepting as a recognized geological fact that, both on the Continent of Europe and in these islands, which were then more closely connected with that continent, man existed during what is known as the Quaternary period, and was a contemporary of the mammoth and hairy rhinoceros, and of other animals, several of which are either entirely or locally extinct. It is true that there are still some differences of opinion as to the exact relation in time of the beds of river gravel containing the relics of man and the Quaternary fauna to the period of great cold which is known as the Glacial period. Some authors have regarded the gravels as pre-Glacial, some as Glacial, and some as post-Glacial; but, after all, this is more a question of terms than of principle. All are agreed, for instance, that in the eastern counties of England implements are found in beds posterior to the invasion of cold conditions in that particular region, though there may be doubts as to how much later these conditions may have prevailed in other parts of this country. All, too, are agreed that since the deposit of the gravels considerable changes have taken place in the configuration of the surface of the country, and that the time necessary for such changes must have been very great, though those in whose bones the chill of poverty still clings are inclined to call in influences by which the time required for the erosion of the river valleys in which the gravels occur may be theoretically diminished.

On the other hand, there have been not a few who, feeling that the evidence of the existence of the human race has now been satisfactorily established for Quaternary times, and that there is no proof that what has been found in the ordinary gravels belongs to anything like the first phases of the family of man, have sought to establish his existence in far earlier Tertiary times. In the view that earlier relics of man than those found in the river gravels may eventually be discovered, most of those who have devoted special attention to the subject will, I think, concur. But such an extension of time can only be granted on conclusive evidence of its necessity; and, before accepting the existence of Tertiary man, the grounds on which his family-tree is based require to be most carefully examined.

Let me say a few words as to the principal instances on which the believer in Tertiary man relies. These may be classified under three heads[1]: (1) the presumed discovery of parts of the human skeleton; (2) that of animal bones said to have been cut and worked by the hand of man; and (3) that of flints thought to be artificially fashioned.

On most of these I have already commented elsewhere.[2] Under the first head I may mention the skull discovered by Prof. Cocchi at Olmo, near Arezzo, with which, however, distinctly Neolithic implements were associated; the skeletons found at Castelnedolo, of which I need only say that M. Sergi, who described the discovery, regarded them as the remains of a family party who had suffered shipwreck in Pliocene times; and the fossil man of Denise, in the Auvergne, mentioned by Sir Charles Lyell, who may have been buried in more recent times under lava of Pliocene date. On these discoveries no superstructure can be built. The Calaveras skull seems to have better claims

[1] See A. Arcelin, "L'Homme Tertiaire," Paris, 20 rue de la Chaise, 1889.

[2] Trans. Herts. Nat. Hist. Soc., vol. i. p. 145; "Address to the Anthrop. Inst., 1883," *Anth. Journ.*, vol. xii. p. 565.

to a high antiquity. It is said to have been found at a depth of 153 feet in the auriferous gravels of California, containing remains of mastodon, and covered by five or six beds of lava or volcanic ashes. But here again doubts enter into the case, as well-fashioned mortars, stone hatchets, and even pottery, are said to occur in the same deposits. In the same way the discoveries of M. Ameghino at the mouth of the Plata, in the Argentine Republic, require much further corroboration.

The presumably worked bones which I have placed in the second category, such as those with incisions in them from St. Prest, near Chartres, the cut bones of Cetacea in Tuscany, the fractured bones in our own crag-deposits, and numerous other specimens of a similar character, have, by most geologists, been regarded as bearing marks entirely due to natural agencies. It seems more probable that in bones deposited at the bottom of Pliocene seas, cuts and marks should have been produced by the teeth of carnivorous fish, than by men who could only have lived on the shores of the seas, and who have left behind them no instruments by which such cuts as those on the bones could have been produced.

As to the third category, the instruments of flint reported to have been found in Tertiary deposits, those best known are from St. Prest and Thenay, in the north-west of France, and Otta, in Portugal.

These three localities I have visited; and though at the two former the beds in which the flints were said to have been found are certainly Pliocene, there is considerable doubt in some cases whether the flints have been fashioned at all, and in others, where they appear to have been wrought, whether they belong to the beds in which they are reported to have been found, and have not come from the surface of the ground. Even the suggestion that the flints of Thenay were fashioned by the Dryopithecus, one of the precursors of man, has now been retracted. At Otta the flakes that have been found present, as a rule, only a single bulb of percussion, and, having been found on the surface, their evidence is of small value. The exact geological age of the beds in which they have occurred is, moreover, somewhat doubtful. On the whole, therefore, it appears to me that the present verdict as to Tertiary man must be in the form of "Not proven."

When we consider the vast amount of time comprised in the Tertiary period, with its three great principal subdivisions of the Eocene, Miocene, and Pliocene, and when we bear in mind that of the vertebrate land animals of the Eocene no one has survived to the present time, while of the Pliocene but one—the hippopotamus—remains unmodified, the chances that man, as at present constituted, should also be a survivor from that period seem remote, and against the species *Homo sapiens* having existed in Miocene times almost incalculable. The *à priori* improbability of finding man unchanged, while all the other vertebrate animals around him have, from natural causes, undergone more or less extensive modification, will induce all careful investigators to look closely at any evidence that would carry him back beyond Quaternary times; and though it would be unsafe to deny the possibility of such an early origin for the human race, it would be unwise to regard it as established except on the clearest evidence.

Another question of more general interest than that of the existence of Tertiary man is that of the origin and home of the Aryan family. The views upon this subject have undergone important modification during the last twenty years. The opinions based upon comparative philology alone have received a rude shock, and the highlands of Central Asia are no longer accepted without question as the cradle of the Aryan family, but it is suggested that their home is to be sought somewhere in Northern Europe. While the Germans contend that the primitive Aryans were the blue-eyed dolichocephalic race, of which the Scandinavians and North Germans are typical examples, the French are in favour of the view that the dark-haired brachycephalic race of Gauls, now well represented in the Auvergne, is that of the primitive Aryans. I am not going to enter deeply into this question, on which Canon Isaac Taylor has recently published a comprehensive treatise, and Mr. Frank Jevons a translation of Dr. Schrader's much more extensive work, "The Prehistoric Antiquities of the Aryan Peoples." Looking at the changes that all languages undergo, even when they have the advantage of having been reduced into the written form, and bearing in mind the rapidity with which these changes are effected; bearing in mind, also, our extreme ignorance of the actual forms of language in use among prehistoric races unacquainted with the art of writing, I, for one, cannot wonder a something like a revolt having arisen against the dogmatic assertions of those who have, in their efforts to reconstruct early history, confined themselves simply to the comparative study of languages and grammar. But, notwithstanding any feeling of this kind, I think that all must admire the enormous industry and the varied critical faculties of those who have pursued these studies, and must acknowledge that the results to which they have attained cannot lightly be set aside, and that, so far as language alone is concerned, the different families, their provinces, and mutual relations have, in the main, become fairly established. The study of "linguistic palæontology," as it has been termed, will help, no doubt, in determining still more accurately the affinities of the different forms of language, and in fixing the dates at which one separated from another, as well as the position that each should occupy on the family-tree—if such a tree exists. But even here there is danger of relying too much on negative evidence: and the absence in the presumed original Aryan language of special words for certain objects in general use ought not to be regarded as affording absolute proof that such objects were unknown at the time when the languages containing such words separated from the parent stock. Not only Prof. Huxley, but Broca and others have insisted that language as a test of race is as often as not, or even more often than not, entirely misleading. The manner in which one form of language flourishes at the expense of another; the various ways in which a language spreads even otherwise than by conquest; the fact that different races, with totally different physical characteristics, are frequently found speaking the same language, or but slightly different dialects of it—all conduce to show how imperfect a guide comparative philology may be so far as anthropological results are concerned. Of late, prehistoric archæology has been invoked to the aid of linguistic researches; but here again there is great danger of those who are most conversant with the one branch of knowledge being but imperfectly acquainted with the other. The different conditions prevailing in different countries, the degrees of intercourse with other more civilized nations, and local circumstances which influence the methods of life, all add difficulties to the laying down of any comprehensive scheme of archæological arrangement which shall embrace the relics, whether sepulchral or domestic, of even so limited an area as that of Europe. We are all naturally inclined to assume that the record of the past is comparatively complete. But in archæology no more than geology does this appear to be the case. The interval between the period of the river-gravels and that of the caves, such as Kent's Cavern, in England, and those of the Reindeer period of the south of France, may have been but small; but our knowledge of the transition is next to none. The gap between the Palæolithic period and the Neolithic has, to my mind, still to be bridged over, and those who regard the occupation of the Belgian caves as continuous from the days of the reindeer down to late Neolithic times seem to me possessed of great powers of faith. Even the relations in time between the *kjökkenmöddings* of Denmark and the remains of the Neolithic age of that country are not as yet absolutely clear; and who can fix the exact limits of that age? Nor has the origin and course of extension of the more recent Bronze civilization been as yet satisfactorily determined; and until more is known, both as to the geographical and chronological development of this stage of culture, we can hardly hope to establish any detailed succession in the history of the Neolithic civilization that went before it. In the meantime, it will be for the benefit of our science that speculations as to the origin and home of the Aryan family should be rife; but it will still more effectually conduce to our eventual knowledge of this most interesting question if it be consistently borne in mind that they are but speculations.

Turning from theoretical to practical subjects, I may call attention to the vastly improved means of comparison and study that the ethnologists of to-day possess as compared with those of twenty years ago. Not only have the books and periodicals that treat of ethnology multiplied in all European languages, but the number of museums that have been formed with the express purpose of illustrating the manners and customs of the lower races of mankind has also largely increased. On the Continent, the Museums of Berlin, Paris, Copenhagen, and other capitals have either been founded or greatly improved; while in England our ethnological collections infinitely surpass, both in the number of objects they contain and in the method

of their arrangement, what was accessible in 1870. The Blackmore Museum at Salisbury was at that time already founded, but has since been considerably augmented. In London, also, the Christy collection was already in existence, and calculated to form an admirable nucleus around which other objects and collections might cluster; and, thanks in a great degree to the trustees of the Christy collection, and in a far greater degree to the assiduous attention and unbounded liberality of the keeper of the department, Mr. Franks, the ethnological galleries at the British Museum will bear comparison with any of those in the other European capitals. The collections of prehistoric antiquities, enlarged by the addition of the fine series of urns and other relics from British barrows explored by Canon Greenwell, which he has generously presented to the nation, and by other accessions, especially from the French caverns of the Reindeer period, is now of the highest importance. Moreover, for purposes of comparison the collections of antiquities of the Stone and Bronze periods found in foreign countries is of enormous value. In the ethnological department the collections have been materially increased by the numerous travellers and missionaries which this country is continually sending forth to assist in the exploration of the habitable world; and the student of the development of human civilization has now the actual weapons, implements, utensils, dress, and other appliances of most of the known savage peoples ready at hand for examination, and need no longer trust to the often imperfect representations given in books of travel. But besides the collection at Bloomsbury there is another most important Museum at Oxford, which that University owes to the liberality of General Pitt-Rivers. It is arranged in a somewhat different manner from that in London, the main purpose being the exhibition of the various modifications which ornaments, weapons, and instruments in common use have undergone during the process of development. The skilful application of the doctrine of evolution to the forms and characters of these products of human art gives to this collection a peculiar charm, and brings out the value of applying scientific methods to the study of all that is connected with human culture, even though at first sight the objects brought under consideration may appear to be of the most trivial character.

So far as the museums more intimately connected with anthropology are concerned, the advance that has been made has been equally well marked. The osteological collections both at the Royal College of Surgeons and at the Natural History Museum have received important accessions, especially in the craniological department; and the notable addition of the Barnard Davis collection to that previously existing in Lincoln's Inn Fields has placed the Museum of the College in the foremost rank. The Museums at Oxford and Cambridge have also received most important accessions: the one, of the Greenwell collection from British barrows; the other, of the Thurnam collection of skulls.

The value of the small hand-book for travellers, issued under the title of "Anthropological Notes and Queries," has been proved by the necessity for a new edition, towards which the British Association has made a grant. Some delay in the publication of the new issue has taken place, but I hope that the report of the Committee in charge of the work may give assurance of the book being now in a forward state.

The feasibility of assigning trustworthy marks for physical qualifications in candidates for posts either in the military or civil departments of the State has now for some time been attracting more or less of public attention, and the subject has been taken up by the Council of this Association. The result of their communications on this subject with the Government has been made known in their Report, and I need not enter into the history of the correspondence that has passed upon the question. Whatever course may at the present time be adopted, we may, I think, feel confident that eventually due weight will have to be attached to physical capacity in selection for appointments in the military branch of the public service, for which, indeed, at the present time a medical examination has to be passed. Thanks to the ingenuity of Mr. Francis Galton and others, we have now instruments at our command, not only for testing muscular force, breathing capacity, and other bodily characteristics, but also for ascertaining the closeness and rapidity of connection between the organs of seeing and hearing, and the action of the muscles required to be brought into play. In these experiments nervousness, no doubt, is to some extent a factor, but perhaps the rough-and-ready test of the South American commander was, for ascertaining the presence or absence of nervousness, even more effective. When promotion of some officer was about to be made upon the field, the general caused all the possible candidates to be arranged around him, each armed with a flint and steel and a cigarette, and he who first was satisfactorily smoking was promoted then and there.

Connected with the question of general physical capacity is that of the proper appreciation of colours, the absence of which is a fruitful source of danger, both by land and at sea. It is, indeed, impossible to say how often an apparently inexplicable accident may not have arisen from some form of colour-blindness, such as the inability to distinguish red from green, in a person in charge of a ship, a train, or of points on a railway. True, there are some forms of examination to be gone through, both by mariners and railway officials, with the view of testing their powers and correctness of vision; but it is very doubtful whether the tests employed or the manner in which the examinations are conducted can be regarded as in all respects satisfactory. For the purpose of investigating the phenomena, and, if possible, the physical causes of colour-blindness and allied defects of vision, and also with the view of suggesting improvements in the methods of determining the existence of such defects in candidates for maritime or railway employment, the Council of the Royal Society has appointed a Special Committee. Its labours, however, are not yet finished, and no report has hitherto been received from the Committee. I mention the subject as one in which all anthropologists will be interested, and the importance of which must be universally acknowledged. The most singular feature in the case is that the subject, though carefully investigated by several private inquirers, should have waited so long before being submitted to some public or quasi-public body for investigation.

The subjects of an anthropological survey of the tribes and castes in our Indian possessions, and of the continued investigation of the habits, customs, and physical characteristics of the North-Western tribes of the Dominion of Canada, were both recommended for consideration to the Council of this Association by the General Committee at the meeting at Newcastle. We have heard from the Report of the Council what has been done in the matter. The rapidity with which the various native tribes in different parts of the world are either modified, or in some cases exterminated, affords a strong argument for their characteristics, both physical and mental, being investigated without delay.

There are, indeed, now but few parts of the world the inhabitants of which have not, through the enterprise of travellers, been brought more or less completely within our knowledge. Even the centre of the dark African continent promises to become as well known as the interior of South America, and to the distinguished traveller who has lately returned among us anthropologists as well as geographers owe their warmest thanks. It is not a little remarkable to find so large a tract of country still inhabited by the same diminutive race of human beings that occupied it at the dawn of European history, and whose existence was dimly recognized by Homer and Herodotus. The story related by the latter about the young men of the Nasamones who made an expedition into the interior of Libya and were there taken captive by a race of dwarfs receives curious corroboration from modern travellers. Herodotus may, indeed, slightly err when he reports that the colour of these pygmies was black, and when he regards the river on which their principal town was situated as the Nile. Stanley, however, who states that there are two varieties of these pygmies, utterly dissimilar in complexion, conformation of the head, and facial characteristics, was not the first to rediscover this ancient race. At the end of the sixteenth century, Andrew Battel, our countryman, who, having been taken captive by the Portuguese, spent many years in the Congo district, gave an account of the Matimbas, a pygmy nation of the height of boys of twelve years old; and in later times Dr. Wolff and others have recorded the existence of the same or similar races in Central Africa. Nor must we forget that for a detailed account of an Acca skeleton we are indebted to the outgoing President of this Association, Prof. Flower. It is not, however, my business here to enter into any detailed account of African exploration or anthropology. I have made this incidental mention of these subjects rather from a feeling that in Africa, as well as in Asia and America, native races are in danger of losing their primitive characteristics, if not of partial or total extermination, and that there also the anthropologist and naturalist must take the earliest possible opportunities for their

researches. Already the day is past when the similitude drawn by Anaxilas between music and Africa holds good, and even Cornelius Agrippa could no longer maintain that he "sayeth not amisse: By God, sayeth he, Musicke is even like Affricke; it yearely bringeth foorth some straunge Beaste."[1]

I have, however, said enough on what I feel are somewhat vague and general topics, and will now ask you to devote your attention to the business of the Section, when, no doubt, many subjects of interest will be more particularly discussed.

NOTES.

WITHIN the next few days the National Association for the Promotion of Technical and Secondary Education will issue a brief "Guide to Evening Classes in London," which is the first attempt to give a systematic account of the educational work carried on in such classes throughout the metropolis. The Guide will be classified according to subjects and districts, so that an intending student can see at a glance the place, day, and hour at which classes are available in any particular subject in the district in which he lives, as well as the fee, name of instructor, and other details. The price will be 6*d.*, and the publishers will be Messrs. Cassell and Co.

THE following is a list, in brief, of subjects on which the Dutch Society of Sciences at Haarlem invite research:—A history of the mathematical and physical sciences in Holland; isomorphism; minerals in the river and dune sands on the Dutch coast; the accessory sexual glands in mammalia; heat liberated in solution of various salts in water; decomposition of water or other liquids by disruptive electric discharges within or on the surface; influence of compression in different directions on specific inductive power; determination of the form and position of the reticular micrometers used by Lacaille at the Cape of Good Hope; influence of volume of molecules on pressure of a gas; relation between density and chemical composition of transparent bodies, and the index of refraction; modification of reflected light by magnetization of some other metal than iron; methods of obtaining and fixing new varieties in cultivated plants; *rôle* of bacteria in filtration of portable waters through a layer of sand; bacteria and azotized combinations in the soil; healing after grafting.

THE Report of the Director of the Hong Kong Observatory for 1889 states that a self-recording anemometer, rain-gauge, and sunshine-recorder, have been erected by the Imperial Maritime Customs at the important station of South Cape, Formosa, and the observations are received monthly at the Observatory. Among the investigations in progress are: the collection of information respecting typhoons, from the logs of men-of-war stationed in those seas, and an investigation of the climate of Hong Kong from five years' observations; this latter work is nearly ready for press. The Report contains an interesting comparison of spectroscopic rain-band observations with the rainfall during the subsequent 24 hours; Dr. Doberck considers that the indications frequently foretold great thunderstorms which could not otherwise have been forecast from local observations. On May 29 and 30, 1889, the colony was visited by thunderstorms of unusual duration; above 22·5 inches of rain fell in 24 hours, causing floods and serious damage to property.

THE Journal of the Franklin Institute for September contains several interesting papers. Few can speak with more authority on "Precious Stones" than Mr. George F. Kunz, and his lecture delivered in February last, before the Franklin Institute, is replete with information respecting them. Under the heading "Electricity in Warfare," Lieutenant Bradley A. Fiske, U.S.N., comments upon the present condition of the art, indicates in what ways electricity is now actually employed, and what is the direction of progress. Mr. Joseph M. Wilson, the President of the Institute, continues his paper on schools, with particular reference to trades schools, and gives an account of the method of work set forth in the Science and Art Directory and in the Prospectus of the Normal School of Science. Among the other papers are the following: On fresh-water wells of the Atlantic beach, by Mr. Persifor Frazer. On the strength of gear teeth, by Mr. Samuel Webber; and on the electrolytic method as applied to palladium, by Messrs. E. F. Smith and H. F. Keller.

THE *Monthly Weather Review* issued by the Meteorological Service of the Dominion of Canada consists of telegraphic reports of observations received for the purpose of weather predictions and of reports of storms received by mail. Tables of temperature, pressure, wind, and precipitation are given, together with the records of sunshine and auroræ. The total number of storm warnings issued last month was 93, of which 77 or 82·8 per cent. were verified. Of the 77 warnings in connection with the direction of the wind, 66 or 85·7 per cent. were fully verified, and 72 or 93·5 partly verified. The steps made in the prediction of weather form an important factor nowadays in commercial life, and in Canada forecasts are posted up nightly at every telegraph station.

WE have received from America the summary of the weather during the last month, and also the forecast for September. The review shows that on the whole fine weather has prevailed, although occasionally disturbed by a few storms. The first storm of note was central on the 14th, about lat. 55° N., longitude 25° W., and was accompanied by moderate to strong gales, and high seas; the second moved from Southern New England to Nova Scotia on the 27th. The forecast indicates fine weather, with occasional gales north of the 35th parallel. Less fog will be found along the transatlantic steamship routes, and little ice will be encountered off the Grand Banks. An accompanying chart gives a brief but complete statement as regards these dangerous storms. A new series of storm signals at Havana were commenced in August, 1889, and this year night-signals have been added, details of these being given in an accompanying table. There is also a list of charts that have been published and corrected during the month of August, and information respecting dangerous obstructions to navigation along the coast.

WE have received from Mr. Edward Stanford, a *résumé* of the publications of the Ordnance Survey for England and Wales, with an introductory description of the survey by Major Francis P. Washington, R.E. The new 1-inch general map is reduced from the 6-inch maps, and will consist of 360 small sheets, 178 of which have been already published. This survey is well adapted for walking or driving purposes, and residential maps can be made up for 10, 15, or 20 miles round any centre. In this catalogue the particulars of each county are given in alphabetical order, and the mounting details will be found very useful to those who use maps to a great extent. At the end of the pamphlet there are some illustrations of various neat and handsome methods of mounting these maps for both library and schoolroom purposes.

A PAMPHLET on "Acoustics in Relation to Wind Instruments," by D. J. Blackley, consists of a series of lectures given by him to the students at the Royal Military School of Music, Kneller Hall, in May 1887. They have been revised and somewhat amplified, and now form a general sketch of the subject under consideration, and will be useful to those desirous of understanding the principles underlying the construction and use of wind-instruments, the illustrations of wave-motion given in them not being confined only to experiments with cylindrical tubes. There is an appendix on musical pitch, which has been

[1] "Vanitie of Sciences," cap. 17.

written with special reference to military and orchestral wind bands.

IN the number of *La Nature* for September 6 there is a detailed account of an ingenious application of the properties of iodide of nitrogen to photometry. The photometer, invented by M. Lion, is based on the fact that equal surfaces of iodide of nitrogen, preserved under its mother-liquor, and exposed for equal times to lights of equal intensities, evolve equal quantities of nitrogen. Two vessels are connected by a differential manometer, and when the rate of evolution of the nitrogen is the same in each, the manometer is unaffected. It is stated that the iodide of nitrogen, kept in the mother-liquors in which it has been prepared, is perfectly safe to handle. In practice, owing to the difficulty of exactly balancing the two halves of the apparatus, a method analogous to "weighing by substitution" is employed. The accuracy attainable in the measurements is not stated. In the same number another photometer of considerable theoretical interest is described. It is the invention of MM. Seguy and Verschaffel, and was described by them on September 1 at the Academy of Sciences, Paris. It is based upon the principle of Crookes' radiometer, but the disks, instead of being free to rotate, are suspended by a silk fibre, and with an indicating needle and divided circle, form a torsion balance. An alum cell is placed in front of the instrument, which, as a photometer, appears to be very sensitive, indicating 1–100th of a standard candle. Moreover, two instruments can be constructed, which with light of the same intensity give the same readings, an important practical advantage. So long as these instruments are used to compare lights of the same quality, there seems to be no doubt that they can both be made to yield results of practical value, and comparable with each other. It appears doubtful, however, whether the same figure would be obtained with the chemical and with the mechanical photometer, if used to compare the illuminating powers of two sources of light that differed much in character, such as an arc lamp, and a candle flame.

THE additions to the Zoological Society's Gardens during the past week include a Green Monkey (*Cercopithecus callitrichus* ♀) from West Africa, presented by Mrs. Roupell; a Sykes's Monkey (*Cercopithecus albigularis* ♀) from East Africa, presented by Mr. M. Tanner; two Bonnet Monkeys (*Macacus sinicus* ♂ ♀), a Toque Monkey (*Macacus pileatus* ♀), two Ring-necked Parrakeets (*Palæornis torquatus*) from India, presented by Mrs. Julie Rule; a Rhesus Monkey (*Macacus rhesus* ♀) from India, presented by Mr. W. Dodson; a Grey Ichneumon (*Herpestes griseus* ♂) from India, presented by Master Stanley Kerfoot; a Brush-tailed Porcupine (*Atherura africana*) from West Africa, presented by the Liberian Government Concessions and Exploration Co., Lt.; a Common Viper (*Vipera berus*) from Hampshire, presented by Mr. W. H. B. Pain; a Pig-tailed Monkey (*Macacus nemestrinus* ♂) from Java, deposited; two Vinaceous Turtle Doves (*Turtur vinaceus*) bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

OBJECTS FOR THE SPECTROSCOPE.

Sidereal Time at Greenwich at 10 p.m. on September 18 = 21h. 51m. 4s.

Name.	Mag.	Colour.	R.A. 1890.	Decl. 1890.
			h. m. s.	° ′
(1) G.C. 4695	—	—	21 40 2	− 9 20
(2) G.C. 4734	—	—	21 55 27	+17 12
(3) 73 Cygni	5	Yellowish-red.	21 35 52	+42 47
(4) α Aquarii	3	Yellowish-white.	22 0 6	− 0 51
(5) θ Pegasi	3	White.	22 4 24	+ 5 39
(6) 249 α Schj.	6	Red.	21 37 23	+35 1
(7) R Scuti	Var.	Red.	18 41 36	− 5 50

Remarks.

(1 and 2) No record has yet been made of the spectrum of either of these objects. The first is described in the General Catalogue as a nebulous star, or a very small cluster; the second as "pretty bright; pretty small; round; brighter in the middle to a nucleus; mottled as if with stars; star south preceding." No very bright nebulæ are near the meridian at 10 o'clock during the present week.

(3) The spectrum of this star is a very interesting one of Group II. Instead of the spectrum being totally discontinuous, as in α Herculis and others, the bands 2, 3, 7 are well marked, whilst 4, 5, and 8 are so feeble as to be hardly visible. This species of spectrum has been explained by supposing that the meteor-swarm is still sparse and the carbon radiation consequently bright. When the positions of the feeble bands are considered, it will be seen that the explanation is complete. Band 8 extends from about λ 503·5 to λ 496, and this will therefore be partly masked by the extremity of the brightest carbon fluting starting near λ 517. Bands 4 and 5 both come within the range of the second carbon fluting, starting near λ 564, and they also will be partly obliterated when the carbon flutings are wide. None of the other bands, however, will suffer from masking in this way, and they therefore should remain dark. It will be interesting if this explanation can be tested by a direct observation of an unusual width or brightness of the carbon flutings.

(4) This star has a spectrum of Group III., and may be observed as a study of criteria.

(5) A star of Group IV. (Vogel).

(6) This is a typical star of Group VI., showing in addition to the ordinary carbon bands no less than six of the secondary bands, namely 2, 3, 4, 5, 7, and 8. Dunér remarks that the two latter are undoubtedly bands, and not lines; their wave-lengths are 551 and 528 respectively, the latter almost agreeing with E of the solar spectrum. The general spectrum consists of four zones—that is, there is a certain amount of light beyond the carbon band commencing at 474. An observation of the precise character of this band would be interesting; in comets it sometimes ends abruptly at 474, sometimes fades away gradually on both sides at 468, and sometimes has two maxima, one at 468 and one at 474.

(7) Like S Vulpeculæ, referred to last week, this is a variable of comparatively short range and short period, but whereas the spectrum of the former is known to be one of Group II., that of the latter has yet to be determined. Although the period is but 168 days, we have not as yet any record of the light-curve of the star, which promises to be an interesting one from the fact that the maximum is stated as 4·7–5·7 and the minimum as 6·0–8·5 (Gore). If the spectrum be one of Group II. the shortness of the period suggests that the bands should be rather narrow, and this may be made a test observation. There will be a maximum about September 23. A. FOWLER.

THE URANIA GESELLSCHAFT.—An interesting account of the Urania Institution at Berlin appears in the publications of the Astronomical Society of the Pacific, vol. ii., No. 9. The account was originally written for Prof. Holden by Dr. M. Wilhelm Meyer, the director of the institution. It appears that Prof. Foerster, the director of the Berlin Observatory, first proposed the formation of an observatory that should be open to the public, and his proposition was afterwards modified so as to include other branches of natural science. The project was warmly supported by Herr von Gossler, the Prussian Minister of Public Instruction, a grant of land was made, and in March 1888 a sort of joint stock company was formed having for its object simply the diffusion of knowledge. The idea having thus taken tangible form, the work of construction was begun. On July 2, 1889, the institution was opened to the public, and at the end of the year had been visited by 60,000 persons.

The astronomical department has been the main attraction from the beginning. It contains a twelve-inch refractor equatorially mounted, and electrically controlled and illuminated. The instrument is provided with a filar micrometer, a polarizing telescope, and a complete set of eye pieces ranging in power from 70 to 1300 diameters. Unfortunately neither spectroscopic nor photographic accessories have yet been supplied. Five other telescopes are possessed by the Urania Observatory, viz. a six-inch refractor, a four-inch refractor, a six-inch reflector, a two and a half inch transit instrument, and a comet seeker of five inches aperture.

The lecture theatre which forms a part of this magnificent institution, is fitted with every convenience and provided with a lantern having a light of 6000 candle-power for the projection of views on a screen. The lectures that are delivered are not all, however, devoted to astronomy, but cover the other subjects within the scope of the institution.

The Physical Department is even better supplied with apparatus than the Astronomical, and it is so arranged that visitors, by pressing different buttons, may view the spectra of various substances, the phenomena of polarization, and many electrical effects. The recent presentation of two complete phonographs by Mr. Edison gives the science collection of this Department a still higher value. A Microscopical Department is also included, and affords instruction to many.

An exceedingly well-illustrated journal, *Himmel und Erde*, has been published monthly since the foundation of the institution, and is issued free to all the members. From the recently-published Report, it appears that the cost of production of this journal considerably exceeds the receipts from subscribers, but we are glad to know that the Urania Institution is too firmly established to need its discontinuance. The number of visitors during the 268 days on which the doors of the institution have been opened is 95,000. Three hundred and thirteen lectures of about ninety minutes long have been delivered, and five hundred and eighty-two of thirty minutes duration.

Prof. Holden points out that the Lick Observatory, like the Urania Institution, is devoted to the advance of scientific knowledge, and we hope with him that the success of the latter may lead to the establishment of similar institutions in Europe and America. The opening of observatories would be much appreciated by the general public, for doubtless the Urania Gesellschaft owes much of its popularity to this step in the right direction that its directors have taken.

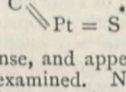
WASHBURN OBSERVATORY.—Mr. G. C. Comstock has issued the sixth volume of the "Publications of the Washburn Observatory," of which establishment he has been director since 1887. The first part contains observations with the meridian circle by Miss A. M. Lamb and Mr. Milton Updegraff. The second part is devoted to observations of double stars, by Mr. Comstock, and includes the measurement of double stars discovered at this observatory, and described in vols. i. and ii. of its Publications. The instrument employed for all of the measures was the 15½-inch Clark equatorial telescope. As soon as the necessary apparatus is ready, a determination of the constant of aberration will be made by Loewy's method.

NEW ASTEROIDS (297) AND (298).—Two new minor planets were discovered on the 9th inst. by M. Charlois of Nice Observatory. One of them may prove to be Aschera (214).

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 8.—M. Duchartre in the chair.—On a sulphocarbide of platinum, by M. P. Schutzenberger. By passing a current of dry nitrogen charged with the vapour of carbon bisulphide over spongy platinum contained in a glass tube heated to about 400° C., the carbon bisulphide was entirely absorbed, and the platinum converted into a finely divided black powder. An examination of the product showed that it had the composition Pt_2S_2C, which may be graphically represented thus :—



The powder is very dense, and appears entirely homogeneous when microscopically examined. Neither hydrochloric nor nitric acid have any action upon it, and even with *aqua regia* there is very little action. When heated to redness in dry oxygen the powder burns, with the formation of carbon dioxide, and sulphur monoxide and dioxide, leaving a residue of pure platinum.—New researches on the gadoline of M. de Marignac, by M. Lecoq de Boisbaudran. The results of a spectroscopic examination of gadoline are given. The substance is shown to have a characteristic spectrum, thus confirming the view held by M. de Marignac, viz. that it is a new element.—On a property of certain systems of forces, by M. L. Lecornu.—On the soluble ferment of urea, by M. P. Miguel. From various considerations the author has been led to believe that in ammoniacal fermentation, the microphytes always act on the urea by means of the soluble ferment discovered by M. Musculus (Annales de Micrographie, vols. 1 and 2), and that it is not necessary to adopt the hypothesis of the destruction of urea by an act of nutrition, in order to explain the alkaline fermentation of urine.—Post-embryonic development of the kidney of the *Ammocete* by M. L. Vialleton.—On modifications of ophitic rocks of Modon (Province de Séville) by M. Salvador Calderon.—On a carboniferous bed discovered at Quenon in Saint-Aubin-d'Aubigne by M. Bezier.—Revival of the activity of Vesuvius, by M. Wiet, Consul at Naples. This is an extract of a letter to the Foreign Minister, giving an account of the actual state of Vesuvius. Lava has been issuing from an opening formed last year, and is slowly descending the central cone. Prof. Maiorano has observed that the volcanic activity of the fumaroles has ceased, and that only a small column of smoke ascends from them. It is also noted that the smoke issuing from the various openings has a different appearance from the steam and vapour generally visible.—Additional note on the extension to Switzerland of the storm of August 19, by M. Bourgeat.

BRUSSELS.

Academy of Sciences, July 5.—M. Stas in the chair.—The following communications were made :—On the ten-monthly astronomical period, by M. F. Folie.—On the characteristic property of the common surface of two liquids, by M. G. van der Mensbrugghe. The author has previously studied the properties of the common surface of two liquids which do not mix, and now gives the results of a similar study of liquids having an affinity for each other, *e.g.* water and ether or alcohol.—On new observations of the canals of Mars, and on their duplication, by M. F. Terby.—Some observations made by Mr. Stanley Williams during April and May 1890 are shown to support Schiaparelli's conclusions with respect to the nature of the surface of Mars. A plate is given containing eight views of Mars made this year by the two above-named observers.—A coronula from the gulf of St. Lawrence, by M. P. J. Van Beneden.—The Actinozoa specimens obtained by Prof. Hensen in his Plankton expedition, by Edouard Van Beneden. A larva related to that found by Semper in 1867, by the same author.—On the constitution of benzopinacoline β, by M. Maurice Delacre.—On primary co-variants, by M. Jacques Deruyts.—On the biographical notice of G. A. Hirn, recently inserted in the *Bulletin de l'Académie*, by Prof. Dwelshauvers-Dery.—Contributions to the study of the Nebenkern, by Dr. E. Leclercq.

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