What may be the end of this research? One may speculate, but the end should surely include an orderliness, a co-ordination of parts, and a relationship of functions which should make for greater prosperity and for greater stability and freedom from temporary over- or under-production of agricultural commodities. It is not suggested that the exchange of commodities should be intra-Imperial. Even if that were desirable it is not possible. The trade of the Empire is shared almost equally between the Dominions and foreign countries. It is not that the Empire may be a self-contained and self-supporting quarter of the globe that I make these suggestions. To succeed in such an aim would be to end nowhere or to end in destruction. I make these suggestions because the nations which make up the British Empire form a political body which faces an opportunity open to no other system of governments in the world. This opportunity is the possibility that by taking thought and by organising the acquisition and the application of knowledge, the wealth of the Empire can be greatly increased, and thereby, and necessarily, the wealth of the rest of the world will be increased also.

It is a far cry to an organised Empire, but if the object is worth it, the initial step is to adopt the 'view-point' described by General Smuts. With the view-point and the mental field surrounding it come the creative ideas which in the end realise the dream. What I plead for then is the 'view-point'. Even in the prosaic occupation of agriculture, of the earth earthy, I suggest that the Imperial view-point is stimulating and creative.

The conception of an organised agriculture based upon science should, I think, be part of the mental equipment of every statesman and administrator. The same vision should inspire every research worker if, in the words of the late Lord Morley, he is to weave the strands of knowledge into the web of social progress.

If the vision is keen enough, the conception wide enough, the energy enduring, and the courage un-failing, is it not possible that the group of free nations which constitute the British Empire may demonstrate the means and lead the way to that wider world government to which every generous and contemplative mind would look?

The Progress of the Motor Ship.

By Engr. Capt. EDGAR C. SMITH, O.B.E., R.N.

IN NATURE on Mar. 9 a short review was given of the progress of the steamship, and attention was directed to the advances made in the use of high steam pressures, water tube boilers, pulverised coal, and other means by which the efficiency of steam machinery is being improved. It was then stated that of 65,159,413 tons of shipping included in Lloyd's Register Book, 50,045,048 tons were driven by reciprocating steam engines, 9,682,063 tons by steam turbines, and 5,432,302 by oil engines.

The history of the ocean-going steamship extends over a period of about a century; the first turbine vessel was the famous little *Turbinia* of 1894, while the first vessel driven by the modern heavy oil engine was probably a small canal barge built in 1903. In the case of the marine oil engine, as in that of the marine steam turbine, there was much pioneering work to be done before the new machinery secured the favourable opinion of shipbuilders and shipowners, and the development of the motor ship belongs almost entirely to the last twenty years. Of its growing popularity, however, there is no question, and for certain classes of vessels and for certain trades it will probably retain its position whatever advances are made in steam practice.

In 1914 the tonnage of motor ships was only 234,000, but by 1922 this had increased to 1,542,000, and the latest returns of Lloyd's Register show that no less than 40 per cent of the tonnage under construction will be driven by oil engines, and that larger and larger vessels are being supplied with oil engines. Of ships of 8000 tons and upwards now under construction, 27 will be driven by steam and 59 by oil; of ships of 15,000 tons and above, 7 will be steam ships and 14 motor ships. Though

no motor ship yet equals in size the *Majestic*, *Berengaria*, *Leviathan*, *Olympic*, or *Aquitania*, the Italian liners *Augustus*, *Vulcania*, and *Saturnia* are of 32,650, 25,000, and 23,940 tons respectively, the four British ships *Alcantara*, *Asturius*, *Carnarvon Castle*, and *Bermuda* range from 22,181 tons to 19,086 tons, and the new White Star liner *Britannic*, the largest British motor ship, launched on Aug. 6 by Messrs. Harland and Wolff, Ltd., is 680 feet long and has a gross tonnage of 26,840.

All large oil engines as found in motor ships have been developed from the independent inventions of Rudolph Diesel and Herbert Akroyd Stuart, both of whom patented engines in which the compression of the air in the cylinder caused its temperature to rise to the ignition point of the oil. Stuart's patent was taken out in 1890; Diesel's in 1892. Stuart's first engine was made in 1891, Diesel's in 1893, and in that year Diesel published his memoir, "The Theory and Construction of a Rational Heat Motor".

Both inventors used the four-stroke cycle as introduced by Nikolaus Otto. In the Stuart engine fuel oil was sprayed into the air at the end of the compression stroke and was automatically ignited by a hot bulb extension to the cylinder end which was heated previously to the engine being started, but was afterwards kept hot by the explosions. In the Diesel engine, on the other hand, the air was more highly compressed and the fuel oil was injected by compressed air. No previous heating of the cylinder end was required, but the engine was started by compressed air.

The manufacture of engines working according to Stuart's plan, or the 'Akroyd' cycle, was taken up by Messrs. Hornsby, and they were placed upon the market as Hornsby-Akroyd engines. The Diesel

engine was developed on the continent and always bore the inventor's name, and for some reason Diesel's name came to be applied also to engines working on the Akroyd cycle, and are even to-day known as 'semi-Diesel' engines.

Stuart, who was born in 1864 and died in 1927, published many documents to establish his claim as an original inventor, and by his will left £700 to the Institute of Marine Engineers for a biennial prize for the best paper on "The Origin and Development of Heavy Oil Engines". In an obituary notice of him it was said that he "belonged to that rather tragic fraternity of inventors whose achievements have not secured from the world at large the recognition they merited". Without detracting in the least from the merits of the work of Diesel, it is undoubtedly true to say that Stuart was the first to bring out an engine with high compression and with timed injection of the oil fuel, while his method of spraying the oil into the cylinder, sometimes called 'solid' injection or more properly 'airless' injection, is used in many of the big engines for motor ships.

Diesel, it may be recalled, was born in 1858 and died in 1913. He apparently fell overboard while on passage between the Continent and England, but the mystery of his disappearance has never been cleared up. He lived long enough, however, to see Diesel engines at work in land stations all over the world, and also the beginning of their adaptation to ships.

The first boat driven by a Diesel engine was a canal barge fitted with an engine in 1903 by the Paris firm of Sautter Harle and Co. Five years later the *Delo*, of 4000 tons, fitted with an engine of 1250 h.p., was placed on service on the rivers of Russia. It is, however, with the *Vulcanus*, of 1900 tons, built at Amsterdam in 1910, that the history of the ocean-going motor ship begins. This vessel had a Werkspoor Diesel engine of 500 b.h.p. The next year the *Toiler*, built by Messrs. Swan, Hunter and Wigham Richardson, fitted with an engine constructed by the Aktiebolaget Diesels Motorer, of Stockholm, went from the Tyne to Halifax, N.S., and was thus the first motor ship to cross the Atlantic. At about the same time, the East Asiatic Company of Copenhagen built the *Sealandia* and *Jutlandia*, ships of 7500 deadweight carrying capacity, and these were equipped with engines of 2500 i.h.p., by Messrs. Burmeister and Wain. By 1914 there were about three hundred motor ships at sea, but while the War led to great activity in the construction of Diesel engines for submarines, it proved unfavourable for the development of such engines for merchant ships, and it is only during the last ten years that the large Diesel engine has become a familiar sight in our marine engineering shops.

Unlike the various types of reciprocating steam engines used in the past, all marine oil engines bear the names of the firms by whom they have been developed. Thus we have the Burmeister and Wain, the Werkspoor, the Sulzer, the M.A.N. (Maschinenfabrik Augsburg-Nürnberg), the Fullagar, and the Doxford engines. All these engines work on either

the four-stroke principle, which we owe to Otto, or the two-stroke principle first introduced by Sir Dugald Clerk. Sometimes they are single acting, as in the ordinary motor car engine, sometimes double acting, as in the reciprocating steam engine. At present, the majority of motor ships have engines of the four stroke, single acting type, which for small and medium power have proved most economical in fuel, lubricating oil, and repairs. The number of cylinders, of course, depends on the power required, 4, 6, 8, or 10 cylinders being used.

One of the most notable motor ships of last year was the Nelson liner *Highland Monarch*, of 14,450 tons, which had two 8-cylinder four-stroke double acting Harland-Burmeister and Wain engines of a total horse-power of 10,000, and the *Britannic* will have two similar engines, but with ten cylinders instead of eight.

With the assured reliability of the marine Diesel engine, the decision as to whether a new ship should be driven by oil engines or steam engines is now influenced solely by the considerations of the economics of the problem, except in the case of very fast ships, for which the steam turbine retains its supremacy.

With every important change in the design of marine machinery, difficulties have been met with, and the oil engine was no exception to the rule. Whatever scepticism there was as to the reliability of the marine Diesel engine has been removed by the successful motor ships now afloat, and seeing it is possible to construct petrol engines which enable aircraft to maintain endurance flights of a fortnight, there can be no doubt as to the possibility of eliminating such defects as do occur in the internal combustion engine in ships.

The economics of up-to-date steamships and motor ships was the subject of some interesting remarks by Mr. J. Johnson in his paper entitled "The Propulsion of Ships by Modern Steam Machinery", read to the Institution of Naval Architects on Mar. 21 last. Mr. Johnson was responsible for the design of the s.s. *Duchess of Bedford* and other interesting vessels for the Canadian Pacific Railway Company, which maintains services on the North Atlantic and North Pacific. Among the factors to be taken into consideration are first cost, fuel costs, weight of bunkers, and costs of repairs, and it was evident that for the particular services mentioned, Mr. Johnson held the view that the steam vessel was quite capable of holding its own against the motor ship. In some tables, he gave figures relating to two ships of 18,000 s.h.p. and 30,000 s.h.p. respectively. As regards the weight, the steam installations worked out at 4435 tons and 9640 tons, as against the 4765 tons and 9870 tons of the Diesel installations. In the steam ships the consumption of boiler oil was given as 0.63 and 0.60 per h.p. per hour, as against 0.48 in the motor ships. But owing to the much higher price of Diesel oil the daily fuel costs for the 18,000 s.h.p. ship on the Atlantic would, when running to Montreal, be £324 in the motor ship as against £262 in the steam ship, while the 30,000 s.h.p. motor ship on the Pacific would

have a fuel bill of £355 per day and the 30,000 s.h.p. steam ship £348 per day.

When the contract for the s.s. *Duchess of Bedford* was placed, quotations showed that the cost of a motor ship of similar capacity would have been £100,000 more. The price of coal, oil fuel, and Diesel oil differs at the various ports of the world, and Mr. Johnson illustrated this by a map. He also gave a tabulated statement of the coal and oil deposits of the world as at present estimated.

This showed that whereas the coal deposits are equal to about 4000 or 5000 tons per head of population of the world, the deposits of oil are only equal to about 4 or 5 tons per head. It may be that superintending engineers of shipping companies at the present time are not influenced by these figures, but they have a direct bearing on the interesting question as to whether ocean transport in the future will depend on oil engines or steam engines.

Obituary.

SIR E. RAY LANKESTER, K.C.B., F.R.S.

WITH deep regret we record the death, on Aug. 15, of Sir E. Ray Lankester. For long he was the dominating figure among British zoologists, and he was recognised the world over as a great master in science owing to his achievements in biology and more particularly for his advancement of our knowledge of the morphology of animals. Those who met Lankester could not fail to see in him a man of exceptional intellectual power. His tall and commanding presence, his expressive face, his speech, all contributed to make up an impressive personality.

Edwin Ray Lankester was born in London on May 15, 1847, the eldest son of a well-known physician who became coroner for Central Middlesex. Educated in the classical tradition at St. Paul's School, London, he gained a scholarship at Downing College and went up to Cambridge at the early age of seventeen. Two years later, however, he migrated to the University of Oxford, where he entered Christ Church as a 'junior student'. Here he studied zoology, with his friend Moseley, under Rolleston, the first Linacre professor. Having graduated with first-class honours in natural science, and obtained the Burdett-Coutts scholarship in geology, and later the Radcliffe Travelling Fellowship, Lankester went to Naples in 1870, where he studied marine zoology with his friends Anton Dohrn, the founder of the famous zoological station, and Frank Balfour, the illustrious embryologist.

On his return to Oxford, Lankester was elected fellow and tutor of Exeter College, and began his teaching career. Two years later, in 1874, Lankester was chosen to fill the chair of zoology at University College, London. In 1882 he was appointed to the professorship of natural history in Edinburgh; but, finding the conditions of this post unsuitable, he resigned it within a fortnight, and was welcomed back to London, where he resumed the professorship at University College, which he retained until 1890. This was Lankester's best period, remarkable both for his success as a teacher and for the output of important original researches carried out in his laboratory by himself and his pupils.

In 1890, Lankester succeeded Moseley as Linacre professor of comparative anatomy at Oxford. Here, among his many activities, he greatly improved the laboratory facilities, and added a large modern building to his Department. He also devoted much attention to the reorganisation of the zoo-

logical section of the Museum, and the methods of displaying specimens with an eye to beauty and instruction. Of this experience he made full use when, in 1898, he was appointed Director of the Natural History Departments of the British Museum and Keeper of Zoology at South Kensington. These posts he occupied until his retirement at the age of sixty, in 1907.

Lankester's scientific work extended over the whole field of zoology. There is scarcely a group of animals he did not study, scarcely a problem he did not help to elucidate. Both his parents were cultivated people of intellectual interests. His father was a scientific man of distinction, a fellow of the Royal Society, interested more especially in microscopy, who contributed many papers to the *Quarterly Journal of Microscopical Science*, of which he was co-editor. In the congenial atmosphere of this family circle, where he met Huxley and other eminent men engaged in the controversies of those stirring days over the "Origin of Species", young Ray Lankester must have early developed that love of the wonders and beauties of Nature, that insatiable curiosity to know and understand, which inspired his work and lasted to the end of his career. Indeed, he began writing when a mere boy, and it is characteristic of the man that he never lost his interest in the subjects he took up; his enthusiasm and eagerness for fresh information were not blunted, nor did new interests crowd out old ones from his capacious mind. So we find that his first venture into print is a letter on *Pteraspis* (*Geologist*, 1862), beginning a series of contributions on a remarkable group of fossil fishes, and leading to the writing of the important monograph on "The Cephalaspidæ", published by the Palæontographical Society in 1868-70. This work is recognised as a classic on the subject. In 1863 appeared a note on the Gregarinidæ (*Quar. Jour. Mic. Sci.*, vol. 3), the prelude to a series of researches on parasitic Protozoa that won him a place of honour in the history of protozoology and parasitology.

The Protozoa had a peculiar fascination for Lankester, who was an expert in microscopy. Later in life he did much to promote the study of parasitic Protozoa in relation to disease at home and abroad, and the success of Minchin and others in this field owed much to his encouragement.

Lankester was only seventeen years of age when he wrote his first paper on the anatomy of the earth-worm (*Quar. Jour. Mic. Sci.*, vol. 4, 1864); this