existing non-condensing plant can be more than doubled by the simple application of an exhaust steam turbine and condenser. Such installations are now in use all over the country, and from being absolutely a waste product exhaust steam has become a most valuable by-product in many works. In many cases the exhaust steam is intermittent, such as the exhaust steam from a winding engine of a colliery. Such intervals, if not too long, can be bridged over by a thermal accumulator. The principle of thermal storage is itself a comparatively old idea in connection with steam boilers, having been proposed by Druitt Halpin in 1891–2, but the best-known form of accumulator for use in connection with exhaust steam turbines is that of Prof. Rateau, where a tank containing water has the exhaust steam blown through it so that alternately the exhaust steam is partly condensed, and the water in the tank boils, and thus the supply given to the turbine is constant.

In many cases, however, the stops are too long to be bridged over by any form of thermal accumulator, and in such cases what are called "mixed pressure" turbines have been introduced, in which there is a high-pressure part revolving idly when exhaust steam is used, but when the exhaust steam supply fails, by an automatic arrangement this high-pressure part is supplied with live steam, and thus the turbine continues to be driven.

The first applications of the steam turbine to driving machinery were in the driving of electrical machinery, and on land this still continues to be the greatest use for steam turbines, and a full account of turbo-alternators and dynamos is given.

An important development during the past few years has been the application of the steam turbine for driving air compressors. An ordinary steam turbine when driven backwards does not act as an air compressor, but if the blades are suitably shaped it forms a very efficient one, and this fact has led to a large development in the application of steam turbines.

Such turbo-blowing engines are largely used for blast furnaces, the blast pressures required ranging generally from 10 lb. to 16 lb. per square inch.

It may be mentioned that the weight of a turbo-blowing engine complete is 25 tons, and the weight of a reciprocating engine of the same power 430 tons, or seventeen times heavier than the turbine.

For producing pressures higher than 25 lb. per square inch, the design of the blowing engine is usually of the centrifugal type, and consists of a number of centrifugal fans specially constructed to withstand the stresses caused by the high speed of revolution.

In the third lecture an account is given of the greatest development of the steam turbine, that for marine propulsion.

The large and increasing amount of horse-power, and the greater size and speed of the modern engines, tend towards some form which shall be light, capable of perfect balancing, and economical in steam. The marine engine of the piston type does not fulfil these requirements. This led to the well-known *Turbinia* being built, which proved the success of the steam turbine for marine propulsion. After the *Turbinia*, the *Viper* and *Cobra*, torpedo-boat destroyers, followed, but the next great step was the *King Edward*, built in 1902. The arrangement of the turbines was altered considerably from that of the *Turbinia* in order to get increased manœuvring power. Three shafts were still retained, with two screws on the wing shafts and one on the centre shaft, which revolved at rather lower speed; but, instead of all the three turbines being in series, the steam passed first through the centre high-pressure one, and then was divided between two low-pressure turbines, port and starboard. In the same casing as these low-pressure turbines, and at the exhaust end, the stern turbines were incorporated. This gave much better manœuvring power than with the arrangement in the *Turbinia*, as when manœuvring the high-pressure turbine was cut out and steam admitted direct to either or both of the low-pressure turbines or to the astern turbines, thus giving as good manœuvring power as in the case of a twin-screw ship with reciprocating engines.

The success of the *King Edward*, together with that of the *Viper* and *Cobra*, led the Admiralty to have turbines fitted into one of four third-class cruisers, and the vessel chosen was the *Amethyst*. Extensive trials were carried out between her and her sister ship, the *Topaz*, with reciprocating engines, each being 350 feet long and of 3000 tons displacement. The result was that at all speeds above 14 knots the turbine was the more economical, being 15 per cent. better at 18 knots, 31 per cent. better at 20½ knots, and 38 per cent. better at 22·1 knots.

With cross-Channel boats it has been found that the turbine vessels use 25 per cent. less coal per passenger, and travel 2 knots faster, than those with reciprocating engines, and the *Lusitania* has been shown by Sir William White to be 16 per cent. more efficient than the great German reciprocating liners.

The application of the steam turbine to the propulsion of slow-speed ships, that is, ships of below 15 to 18 knots, has up to the present been difficult, owing to the low speed of revolution of the screws making the turbines large and heavy, as well as not economical. This difficulty has now been got over by the use of an arrangement patented by Mr. Parsons some years ago, viz. the combination of reciprocating engines and exhaust turbines, similar to what was described before for land work. Here each utilises the part of the expansion for which it is best suited—the reciprocating engine for the high-pressure part of the range and the turbine for the low-pressure where the volume of steam is large.

It is interesting to note that in the early days of the screw propeller the great difficulty was to make the engines run fast enough for the screw, and spur gearing was adopted in many cases in the first half of the last century. Gearing has been entirely dropped for the last fifty or sixty years, but now the difficulty in many cases is to make the turbine run slow enough for the screw, and once more gearing is being considered so as to make the turbine adaptable for use in slow-speed steamers, which, after all, constitute by far the greater part of the shipping of the world.

The combination system described above does this, but gearing a high-speed turbine to a slow-speed screw would also accomplish what is needed.

Eighty years ago there was nothing but primitive spur gearing, with generally wooden teeth in one member, but now we have steel gears accurately cut by modern machinery, often with helical teeth, and running in oil baths.

At the present date there are about 120 vessels actually on service fitted with turbines, representing about 1,250,000 horse-power, and these comprise practically all the high-speed ships which have been recently built. Some seventy more are under construction, representing another 1,000,000 horse-power, or a total of 2,250,000 horse-power, and the curve of progress as yet shows no sign of saturation.

THE OUTLOOK OF SCIENCE.[1]

PROBABLY there never was a time when the scientific spirit was more active than at the present moment. We see evidence of this on all hands. In the realms of abstract science we have researches dealing with profound questions as to the intimate nature of matter that were not within the sphere of thought only a few years ago. The theories of electrons which are founded on mathematical and physical investigation give us a glimpse into worlds of movement of which those before us had no conception, and of stores of energy that may one day be liberated in the service of mankind. That mysterious agency, electricity, is now seen to be probably at the basis of all phenomena, physical, chemical, vital, and a new interpretation is given of many actions going on all around us. The relation of matter to the circumambient æther also engages the speculations of men of science.

Researches at extremely low temperatures, down near to absolute zero, as carried out by Dewar, are enabling the physicist and chemist to criticise the properties of matter from a new point of view. The microscope, hitherto an instrument used mostly by the biologist, is now employed in the investigation of the molecular structure of metals and other substances, as these are modified

[1] From an address delivered to the associates and students of the Glasgow and West of Scotland Technical College on October 28 by Prof. John G. McKendrick, F.R.S.

by pressure and strain. The phenomena of radio-activity have opened up a new world, and no achievement of science is, to my mind, more wonderful than the way in which a modern physicist can measure the velocity and count the number of inconceivably minute particles that fly off from a morsel of radio-active matter.

For many purposes the steam engine has been outdistanced. The energy now available from modern engines is much greater than was at one time thought practicable. The best triple-expansion steam engines gave back as mechanical energy only 17 per cent. or 18 per cent. of the energy represented by the combustion of the fuel, the remaining 82 per cent. and 83 per cent. being lost, or, at all events, is mechanically inefficient, as heat. A human muscle gives as mechanical energy 25 per cent. of the energy of the food, but the remaining 75 per cent. of heat is necessary for the life of the muscle, so that, in this aspect, it is superior to the steam engine.

I have often been struck with the wonderful economy of nature. She attains her ends usually by the simplest and most direct method and with the smallest expenditure of matter and energy, and one cannot help thinking that future inventions—I mean inventions during the next two or three centuries—will be in this direction. The electric organ of an electric eel, at rest, may show so small an electromotive force as to require a good galvanometer to detect it, but a nervous impulse from nerve-cells in its spinal cord may suddenly raise a potential of many volts, and this with little heat and with so small an expenditure of matter as to defy the most expert chemist to weigh it. The electric organ is in no sense a storage battery, but rather a contrivance by which electrical energy is liberated at the moment it is required. The fire-flies, the glow-worms, and many deep-sea fishes can produce light without heat and at a cost which would make the price of a wax vesta an extravagant outlay. Plants, possibly aided by micro-organisms, or at all events by ferments (enzymes), can produce alkaloidal substances at a low temperature and by slow processes; but, on the other hand, to produce these synthetically the organic chemist requires all the resources of his laboratory, high temperatures, acids, and other potent agencies. Many other examples might be given of the economy of nature all establishing the truth that the principle of least action holds good everywhere—a principle which some have thought was a greater, at all events a wider, generalisation than that of the conservation of energy.

There is another department of science to which I must refer in this brief survey. I refer to bacteriology, a branch which deals with the life-history of minute organisms that play a very important part in the economy of nature. In the public mind there is a widespread impression that bacteria and other organisms are the enemies of man, but this is far from being the case with the great majority of these humble plants. Of the thousand or fifteen hundred species now known, probably only fifty or so are inimical to men. The others are highly beneficent. Some are engaged in taking nitrogen from the air for the use of the higher plants: others in splitting up complex substances existing in the bodies of dead plants and of dead animals, and in restoring simpler substances to the soil: others purify our rivers and lakes; even the ocean is the theatre of their activities: and others have to do with the varied phenomena of fermentation. A knowledge of the life-history of these microbes has enabled the physician and surgeon not only to do much in the way of preventive medicine, but to benefit mankind in the treatment of many diseases; and, what is probably of even greater interest, we now recognise that the *rôle* played by these living beings is of the greatest importance in many industries. Such are the industries connected with fermentations, brewing, distilling, baking; the processes of the dairy, as in butter-making and cheese-making; and the important industry of tanning or making leather. In those industries and in scientific agriculture the services of microbes are being more and more called to our aid. Bacteriologists can now make pure cultures of micro-organisms that are useful, and practical men may sow these in approximate media where they do their useful work. In this way the soil of the farmer may be enriched, the growth of particular cereals, leguminous plants, and roots may be facilitated, and the products of the dairy may be made more wholesome. There can be no doubt that in the future many industrial processes, such as these of tanning, paper-making, and others, will be improved as we are able to call these humble beings to our assistance. This, I think, is one of the fairy tales of scientific achievement.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Mr. W. G. Fearnsides has been appointed demonstrator of petrology, and Mr. F. J. M. Stratton assistant in astrophysics.

Mr. E. M. Wellisch has been elected to the Clerk Maxwell scholarship.

The general board of studies recommends that Mr. K. J. J. Mackenzie be appointed as university lecturer in agriculture for five years, and that he receive a stipend of 200*l*. a year, payable out of the agricultural education fund.

Dr. Stein will deliver a lecture in Cambridge on Thursday, January 20, at 5 p.m., on his explorations in Asia.

LONDON.—A new syllabus in chemistry is to come into force at the matriculation examination on and after January, 1911. In the new syllabus greater emphasis is attached to the theoretical basis of the science and to physical phenomena, such as the development of heat in chemical reaction. The general characteristics of the metals, including an elementary study of sodium, calcium, and iron, and their common compounds, are introduced, while the elementary organic chemistry and a part of what was termed the "chemistry of common life" has been taken out of the syllabus.

OXFORD.—The news of the impending retirement of Dr. E. B. Tylor, F.R.S., professor of anthropology, will be received with universal regret. It is perhaps not easy for the present generation to realise how much the science of anthropology owes to the unwearied labours of Prof. Tylor, continued for the space of full fifty years. The importance which the subject has now attained among the studies of Oxford is in large measure due to the energy and enthusiasm with which, on his appointment in 1883 as keeper of the university museum, and afterwards as reader and professor, Dr. Tylor threw himself into the work of arousing and maintaining interest in the scientific history of the arts and institutions of mankind. Under his careful management, and with the able help of the curator of the splendid Pitt-Rivers collection, Mr. H. Balfour, and of other younger workers, the study of anthropology in Oxford has during the last quarter of a century been completely transformed. Prof. Tylor's kindliness and geniality have secured to him the affection of a large circle of friends, whose good wishes will follow him into his retirement.

THE second annual dinner of the Old Students' Association of the Royal College of Science will be held on Friday, January 7, 1910. Tickets may be obtained from the secretary of the association, Mr. T. L. Humberstone, 3 Selwood Place, South Kensington. Sir Thomas H. Holland, K.C.I.E., F.R.S., has consented to nomination as president of the association for the year 1910, in succession to Mr. H. G. Wells.

SPEAKING at the Strand School, King's College, on December 10, Sir William White said that it is not putting a narrow or improper meaning on the word "education" to say that it must have relation, in the case of the vast majority of men and women, to their getting a livelihood. An examination which is passed by means of cramming is mischievous. In many cases boys crammed for an examination have obtained for themselves positions for which they are totally unfitted. Some men spoil their lives by cramming for examinations; they take away all the freshness of life by simply accumulating different kinds of knowledge for reproduction in a match against time. On the other hand, there are many excellent men who, directly they get into the examination room, can never do themselves justice. Examinations, therefore, do not always find