checking its present thriftless use. Prof. Perry pointed out a few weeks ago to the members of the British Association for the Advancement of Science that the best steam engines are utilising only one-twelfth of the energy available by the combustion of the fuel, while the ordinary steam engines utilise a far less proportion. Whether our coal supply is sufficient to last for some centuries, or whether, as is the opinion of many competent authorities, a serious coal famine will begin to be felt within the lives of the present generation, economy in the use of coal is unquestionably of the utmost importance, and the investigation of the best means of effecting such economy would repay even a large expenditure, whether by the Government or by industrial corporations and technical societies. If the result of such inquiry were merely to effect an economy of one per cent. in the consumption of coal this would mean an annual saving to the coal consumers of this country of nearly 1⅔ million tons, worth at last year's prices about £625,000.

Such an investigation might also deal specially with the question of the supply of coal for the Navy. At present certain classes of coal, which with little or no effort on the part of the stoker can be burned without the production of smoke, are specially used for steamships and are often known by the name of "steam coal." If any means can be devised, by investigation and experiment, by which other classes of coal can be burned smokelessly, as is surely possible, our ships will no longer be dependent upon one class of fuel, the naval coal bills will be lessened, and the danger of the failure of coal available for naval purposes will arise only when the total coal supply of the country approaches the point of exhaustion.

Another matter of interest in the present statistics is the increase of the exportation of coal. The quantity of coal exported in 1899 (exclusive of coke and patent fuel) was more than 41 million tons—an amount more than the whole output of coal in any country in the world except the United States and Germany. Of this export more than three-sevenths in quantity and almost half in value is from the South Wales ports. In 1898 and also in 1897 the export was only a little over 35 millions. For the purpose of comparison it is better to take the year 1897, as the quantities dealt with in 1898 were disturbed by the coal strike. Compared with the former year there has been an increase of nearly 6 millions in the total export, and this increase is almost entirely in the export to foreign countries, the export to the British Colonies and Possessions having increased by only 200,000 tons. The countries whose purchases of coal show the largest increase are Russia (which has increased its purchase by nearly 1½ millions), France (more than 1 million), Sweden (¾ million), Italy and Holland. The exports to Germany, Spain, Egypt and South America show only a small increase. The export to the United States is inconsiderable, amounting only to 119,000 tons, chiefly to ports on the Pacific. Among the British Colonies and Possessions there is a considerable increase in the export to India, and some increase in that to South Africa; elsewhere the tendency is rather to decrease.

It must not be assumed that the whole of the coal exported to foreign countries was consumed by foreign nations. Some of it was merely shipped to foreign ports and there utilised for recoaling English steamers. What proportion was so employed does not appear from any statistics that are available, though possibly some indication may be gathered from the amounts sent to Malta, Gibraltar, and Aden, whieh in 1899 were respectively 418,000, 326,000, and 176,000 tons.

As regards minerals other than coal, the increasing importance of aluminium may be noted. The output of this metal now amounts to 550 tons, with a value of 71,125*l*. The output thus approaches in quantity nearly to that of copper, while the value is considerably greater. In spite of higher prices, copper, lead and tin show diminished outputs.

The total value of all minerals raised approaches 100,000,000*l*. sterling, the increase of 20,000,000*l*. compared with 1898 being mainly due to the enhanced value of coal. With our present output, a rise of one penny in the price of coal represents nearly one million of money.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—An election to an Isaac Newton Studentship in astronomy and astronomical physics will be held next term. The studentship is worth 200*l*. a year for three years. Candidates must be Bachelors of Arts who are under twenty-five on January 1, 1900.

Mr. H. F. Baker, F.R.S., of St. John's College, has been appointed University Lecturer in Mathematics.

At the biennial election to the Council of the Senate on November 7, the following new members were returned: Dr. Ryle, Dr. Taylor, Prof. Ridgeway, Mr. R. F. Scott, St. John's.

Science states that a bronze medallion with a likeness of Prof. Sylvester will hereafter be awarded as a mathematical prize at the Johns Hopkins University.

DR. LORENZ, of the University at Halle, has been made director of the physical and technological institute of the University of Göttingen.

THE following appointments have recently been made at University College, Sheffield. Dr. S. R. Milner, late junior demonstrator in physics at Owens College, to be demonstrator and assistant lecturer in physics. Dr. T. S. Price to be additional demonstrator in chemistry.

MR. E. J. RUSSELL, assistant lecturer and demonstrator at the Owens College, has been appointed lecturer in chemistry at the South-Eastern Agricultural College in succession to Mr. H. H. Cousins, who has been appointed agricultural chemist to the Government of Jamaica.

CALENDARS of University Colleges are all built upon much the same pattern, but each has some noteworthy characteristics. For instance, we see that the Durham College of Science, Newcastle-upon-Tyne, like one or two similar institutions, has a marine biological laboratory available for its students at Cullercoats. The agricultural department has been well organised, and is entrusted with the scientific direction of the farm acquired for the purpose of demonstration and experiment by the County Council of Northumberland. Opportunity is afforded to qualified students to undertake original work in all departments, and the students are permitted to visit chemical and other works in the district. Prof. Louis is to deliver a special course this session for the instruction of persons proceeding to any of the gold-fields. The course will deal with prospecting for gold, the methods of extraction of gold from its ores, and the assaying of gold ore and bullion. A scheme is on foot for the establishment of a new northern university based on the Durham College, on the model of that founded at Birmingham upon Mason College.

A SCHEME of agricultural education, which Mr. A. N. Pearson has drawn up for Victoria, in connection with the Royal Commission on Technical Education, is founded on the principles which are now accepted to form the only permanent basis for scientific instruction: viz. that natural knowledge only comes by individual experience in the school of nature. Many elementary facts of agriculture lend themselves readily to educational purposes, and by employing them in a proper way it is possible to give young pupils an intelligent view of natural processes which will be of value in the practical work of later life. With a few seeds it is easy to study germination and the growth and structure of root and stem. Simple examinations of soils may follow, and then determinations of the composition of plants. After this, there would be but a short step to an elementary knowledge of the chemical composition of soils and of commercial plant foods, and the pupil could make intelligent use of the latter, either in growing pot plants, or in cultivating small garden plots. Mr. Pearson gives in his report a scheme for the education of youths in agricultural colleges and farm-schools, and he shows that he is inspired with the spirit of true education. By adopting such a scheme of work as he suggests, the Government of Victoria will show foresight for the future welfare of the colony, and will make its methods of agricultural instruction equal to the best.

FATHER A. L. CORTIE, S.J., discoursed on the teaching of science in Catholic Schools at the last conference of Catholic Colleges on Secondary Education; and his paper is given in full in the official report just received. The fundamental note of his remarks is that classics and mathematics ought to be the foundation of our educational structure, and the "finish and polish of a course of science" should be put upon it afterwards. It is suggested that scientific men wish to oust the classics, and substitute a merely commercial and scientific education as the mental training of the boy intended for trade and the practical walks of life. This, however, scarcely expresses the real state of the case, for many scientific men are familiar with classical literature and would be sorry to see it neglected. But can the same be said of classical men as a rule: are they inclined to give science a proper place in their educational curricula? A glance at the Time Table of any Public School, and of most Grammar Schools, or at a list of scholarships available at Universities, will show that science is the Cinderella in secondary schools, and its presence is more tolerated than encouraged. When science (rationally taught, of course) takes so many hours of a boy's school work as classics, it will be time to suggest that the languages of ancient Greece and Rome are being ousted. Father Cortie's views as to the plan and method of science teaching may be judged from the final remarks from his paper:—"Our aim in teaching science, as in teaching every other subject to the boys committed to our charge, ought to be chiefly directed to training the mind, and not to the imparting of a number of isolated and disconnected facts. I would advocate in the first place a preliminary course of classical and literary training before joining the science classes, and secondly that in the science course itself the training should be neither wholly didactic, nor yet wholly experimental, or Heuristic, to employ the term so much in fashion at present, but a judicious mixture of both. A cultured mind should be the outcome of our training, in science, as in other subjects. And for true culture, a knowledge of facts, in lieu of knowledge of principles and methods, is worthless."

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, November 9.—Prof. A. W. Reinold, F.R.S., Vice-President, in the chair.—Dr. R. A. Lehfeldt read a paper on "Electro-motive force and osmotic pressure." This paper is an attempt to explain a difficulty in the interpretation of the ordinary logarithmic formula for the E.M.F. between a metal and solution, pointed out by the author at the Dover meeting of the British Association. An expression for the E.M.F. of a concentration cell is obtained thermo-dynamically upon the assumption that the electrolyte is only partially dissociated. A partition is used which is permeable to water but not to the salt or its ions, and the conclusion follows that the E.M.F. depends, not on the osmotic pressure of the metallic ions, but on that of the solution as a whole. A graphical representation is given plotting osmotic pressure against dilution, assuming Boyle's law to hold, and it is shown that the E.M.F. is not proportional to the integral $\int PdV$ but to the converse integral $\int VdP$. Assuming, further, that the osmotic pressure changes according to Van der Waals's equation, the E.M.F. is greater than that calculated from Boyle's Law. If the electrolytic solution pressure is calculated from the integral $\int PdV$ it comes out 10^{19} atmospheres; but if from the converse integral, the value obtained is about 20,000 atmospheres. A comparison between actual E.M.F.'s and those derived from the equation given by the author should afford, if the formula is correctly deduced from the assumptions made, a measure of how far the osmotic pressure deviates from that indicated by Boyle's law. Experiments upon concentration cells have been made by Helmholtz, Wright and Thomson, Moser, Lussana and Goodwin; but as their work was performed upon cells with migration of ions, the calculation of the osmotic pressure is rendered uncertain by the introduction of the transference ratio. Accordingly the author has measured the E.M.F.'s of cells without migration, using zinc as electrodes and chloride and sulphate of zinc as salts. The E.M.F. was measured by the compensation method, using a post office box through which a current was sent by an accumulator. The accumulator kept up a constant potential difference, and was standardised daily by means of a Clarke cell. The experimental results agree with the calculated over the range centi- to deci-normal, showing that the deviation from the value given by the logarithmic formula is accounted for by the incomplete dissociation of the salts. The osmotic pressures are then calculated from the E.M.F.'s and the values of PV plotted. They show irregularities due to the combined effect of the decreasing dissociation of the salt and the increasing departure from Boyle's Law. Dividing the product PV by Van 't Hoff's factor, determined from conductivity, values are obtained showing variations similar to those observed in the behaviour of gases when subjected to high pressure. Mr. Whetham said there was one form of membrane which is quite permeable to water and yet does not allow either salts or the ions to get through. He referred to the free surface of the solution itself. The water being volatile can get out, but the salt cannot. Dr. Donnan said the author seemed to have discovered things well known; for instance, the integral $\int VdP$ is generally taken as proportional to E.M.F. He expressed his interest in the explanation of the difficulty in the logarithmic formula. Dr. Lehfeldt, in reply, said Goodwin had used the integral $\int VdP$ but had not made any numerical calculations by means of it.—Mr. R. J. Sowter read a paper on "astigmatic lenses." An astigmatic lens is one which so acts on rays of light falling on it as to produce, in general, two focal lines in the refracted ray system. A lens derived from a quadric surface is the general elementary type of astigmatic lens, and in the paper an ellipsoidal lens is selected and considered. The focal lines are parallel to the elliptic axes, and correspond to the lens powers in these directions. These powers are proportional to the inverse squares of the axes. A curve drawn through all points on a lens where the material thickness is constant may be said to determine a natural aperture for that lens. A method of natura apertures is employed to establish the various relation set out in the paper. An ellipse is the natural aperture for an ellipsoidal lens, a circle for a spherical lens, and an infinitely long rectangle for a cylindrical lens. It is shown that two cylindrical lenses crossed at right angles are equivalent to an ellipsoidal lens, and the power of the combination in any direction is the same as that of the ellipsoidal lens in that direction. It is also shown that two obliquely crossed cylindrical lenses are equivalent to an ellipsoidal lens, or to two cylindrical lenses of definite powers crossed at right angles, or to a cylindrical and a spherical lens; for a spherical lens may be replaced by two equal cylindrical lenses crossed at right angles. Prof. S. P. Thompson said he had never seen the treatment of an ellipsoidal lens before, although the extreme case of a paraboloidal lens had been considered. The author's method was, as far as he knew, new, and would be very convenient to work with. Mr. A. Campbell then read the following papers:—(*a*) "On a phase-turning apparatus for use with electrostatic voltmeters." Electrostatic voltmeters are particularly insensitive at the lower parts of their ranges, the divisions closing in very much towards the zero point. When measurements of small direct-current potential differences have to be made, it is an easy matter to add to the voltage to be measured a constant voltage large enough to bring the deflection to an open part of the scale. If the small voltage to be measured is an alternating one, it is necessary that the auxiliary voltage should alternate with the same frequency, and be in phase with it. The apparatus described enables the phase of the auxiliary voltage to be turned until it agrees with the one to be measured. The phase difference referred to is not the time lag but the angle whose cosine is the power factor and may be called the power lag. The method is to get two independent equal voltages, U_1 and U_2, differing in power phase by $\frac{\pi}{2}$, and to add together suitable fractions of these, such as $U_1 \sin \phi$, $U_2 \cos \phi$. The resultant is equal to U_1, but with the power phase turned through ϕ. The unknown small voltage is connected in series with an auxiliary voltage and a voltmeter, and the phase of the latter voltage is turned until the maximum deflection is obtained. (*b*) "On a method of measuring power in alternating current circuits." The circuit in which the power is to be measured is connected in series across the supply circuit with a small non-inductive resistance. By means of a transformer the small voltage on this resistance may be transformed into one whose power phase is π behind the voltage on the resistance. This is added to the voltage on the circuit to be measured, and then reversed and added again. The difference of the squares of these effective resultants is shown to be equal to a constant into the power to be measured. If there is any direct current, it must be measured separately by a Weston voltmeter or other suitable instrument. (*c*) "Note on obtaining alternating currents and voltages in the same phase for fictitious loads." When testing instruments for the measurement of large amounts of electrical power or energy, it is usually desirable to do so by means of fictitious loads, or by applying to the instrument under test current and potential difference representing the required load. In order to obtain a fictitious non-inductive load with alternating currents, the potential difference and current should be in the same phase. The current for the