the north-east of Aberdeen. The remaining vessels are light vessels, two acting for Holland, the other four, by courtesy of the Brethren of the Trinity, for the English department.

The observations will consist of current measurements made near both surface and bottom every hour night and day, throughout the fortnight, and in fine weather at other intermediate depths. Special attention will be paid to the submarine waves which are, it is expected, to be met with at the depth at which the heavier bottom water and the lighter surface water are in contact; but information will be obtained as to all layers. Specially devised current meters are used in this work, some depending for their operation on small propellers, resembling those of an anemometer and worked by the current, others upon the deflection of a wire from which a metal cylinder depends, caused by the force exerted by the current. The temperature and salinity of the various layers of the sea will also be ascertained in the course of the work, special water-bottles being employed to secure samples of the sea from any desired depth. Samples of the minute floating organisms which, directly or indirectly, constitute the food of all our food fishes will also be taken at various depths and at the extremes of the tide.

Some idea of the scale of the operations may be gathered by the fact that it is expected that some 8000 independent current measurements will be made from the English vessels alone.

The hydrographic operations are planned by a special committee of the International Council for the Exploration of the Sea. They are undertaken because a knowledge of the constitution and movements of the sea-water is essential to the understanding of the movements and even of the abundance of the fishes upon which our fishing industry depends. As a classical instance, the herring of the Kattegat and Skagerak may be cited. Its abundance or scarcity has been found to be connected directly with the amount of water which enters the Baltic from the North Sea; and, indeed, not only the herring fishery but other fisheries of southern Sweden have been shown to change with the ebb and flow of this layer of cold salt water. It is clear, in fact, that a state of knowledge of marine currents which would permit of prognostication as to their movements and volume at a later period would in the case of many fisheries permit the fishermen to reap the utmost harvest which the year would afford or to anticipate a time of scarcity and take such precautions as were possible to mitigate its effects.

A NEW METHOD OF COOLING GAS-ENGINES.

THE summer meeting of the Institution of Mechanical Engineers was held in Cambridge last week. Among the many papers read and discussed, that by Prof. Bertram Hopkinson, of Cambridge University, takes a prominent place; the subject of the paper was a new method of cooling gas-engines. The most important peculiarity of the gas-engine, that which determines the characteristic features of its design and operation, is the heat-flow from the hot gases into the cylinder walls. About 30 per cent. of the heating value of the fuel passes into the metal of the engine in this way. The method hitherto employed in removing this heat has been by the circulation of water in jackets, except in the case of small air-cooled engines. In large engines, the piston and exhaust valve have also been kept cool by circulation of water. The appliances necessary for the carrying out of this method have been responsible largely for the great weight and cost of large gas-engines.

Water circulation has secondary effects which tend to make a large engine untrustworthy in working. The cylinder walls in places may be 3 in. thick or more. To cause the heat to flow from the inner to the outer surface of the metal requires a temperature difference of the order of 50° C. per inch, and this may become serious with thick walls. It is also difficult in large engines to secure adequate circulation about all parts of the cylinder walls and piston, and some parts may be much hotter than others. Severe stresses may be set up in consequence of the unequal expansion, and the overheating of certain parts of the inner surface is apt to cause pre-ignition of the charge. In consequence of the dangers of overheating it has been found impossible to work gas-engines, especially of large size, continuously at the maximum power which they can develop.

In Prof. Hopkinson's method of cooling, water is injected internally in thin jets directed against the walls of the combustion chamber and the end of the piston. There is thus no heat flow through the metal and no difference of temperature between the inner and outer surfaces. The water is so distributed that each part receives it in proportion to the rate at which it receives heat from the hot gases. Practically uniform temperature all over is thus maintained, and the stresses due to unequal heating are eliminated. A simple single-walled casting can be used for the cylinder, resulting in a great saving in weight and cost and in improved trustworthiness on account of the elimination of casting stresses. Piston-cooling arrangements—a frequent cause of trouble—can be dispensed with. Finally, pre-ignitions are entirely prevented.

To obtain success in this method of cooling, the water must be projected in comparatively coarse drops or jets directly against the surfaces to be cooled, so that it reaches these surfaces in the liquid form without much loss by evaporation on the way. Water which reaches the walls in the liquid form, and is there evaporated, absorbs, out of the heat given to the walls by the gas, the *whole* of its own heat of evaporation; there is no loss of thermodynamic efficiency because the heat used is waste heat, which in a jacketed engine would go to warm the cooling water. Any steam formed in this way is pure gain; and, if anything, there is an increase in the work done.

Further, if the cylinder walls are allowed to become and remain wet, they are destroyed rapidly by corrosion. This is due to the presence of sulphur dioxide in the gas, which forms sulphurous acid when dissolved in water. This difficulty has been overcome by regulating the amount of water injected in such a way that the temperature of the whole of the engine is kept well above 100° C. Under these conditions every drop of injected water is boiled when it reaches the walls, and no liquid can accumulate. It is found to be sufficient to inject water on to the surface of the combustion-chamber and the head of the piston only; the cooling of the barrel is effected by conduction into the piston. Thus no water falls on the sliding surfaces, where it would cause damage by the dissolved salts producing grinding.

Trials have been made on a Crossley engine fitted with a new cylinder embodying the principles explained above. The cylinder is $11\frac{1}{2}$ in. diameter by 21 in. stroke, and is rated at 40 brake horse-power at 180 revolutions per minute. The success of this engine, as compared with the original water-jacketed cylinder, has been remarkable. After considerable preliminary trials, the engine was put to drive a dynamo in a factory engine-room, at a speed increased to 195 revolutions per minute. It developed frequently 50 brake horse-power with coal gas for several hours together. Since then the engine has been taken to Cambridge, and is now engaged in regular service with a suction-producer, driving the workshops, and producing electric current for the engineering laboratory. It is left to itself like an ordinary gas-engine, giving no trouble at all, and has been in regular work for two years, the total time of running being 5000 hours.

Judging from the success which has so far been obtained, it seems likely that Prof. Hopkinson's method of cooling the cylinder will revolutionise the design and construction of large gas-engine cylinders.

RECENT PAPERS ON VERTEBRATE PALÆONTOLOGY.

A VERY remarkable announcement is made by Mr. J. W. Gidley in vol. lx., No. 27, of the Smithsonian Miscellaneous Collections, namely that an associated series of five upper cheek-teeth of a large ruminant from a Pleistocene cave-deposit near Cumberland, Maryland, U.S.A., indicate an antelope apparently closely related to the elands of Africa. So near, indeed, is the resemblance that the author deems himself justified in referring the fossil to the existing genus, under the name of *Taurotragus americanus*; and the plate showing these teeth alongside those of the existing *T. oryx* goes a long way in confirming his conclusion. It should have been mentioned that the present writer (see Cat. Siwalik Vert. Ind. Mus., part i., p. 1885) has provisionally referred certain teeth from the Indian Siwaliks to Taurotragus (=Oreas); and if the identification be correct, it would explain how eland might have reached America from Asia by the Bering Sea route. Mr. Gidley quotes the occurrence in the Pleistocene of Nevada of remains of certain ruminants described as Ilingoceros and Sphenophalus as corroborative evidence of the former existence of tragelaphine antelopes in America; but he omits to mention that although these genera were at first assigned to that group, they have been subsequently regarded as akin to the American family Antilocapridæ (Merriam, Bull. Dept. Geol. Univ. California, vol. vi., p. 292). If this be correct, is it quite impossible that the supposed eland represents another member of the same group?

In a second communication (*op cit.*, No. 26) Mr. Gidley records the occurrence of a toe-bone of a camel in a superficial deposit at the mouth of Old Crow River, in the Yukon Territory, in association with remains of mammoth, horse, and bison. The occurrence of the camel-bone confirms "the theory of the existence of a wide Asiatic-Alaskan land connection of comparatively recent date, which for a very considerable length of time served as a great highway for the free transmission of mammals between America and the Old World."

As being only in part palæontological, brief notice must suffice for a paper, by Mr. K. S. Bardenfleth, on the form of the carnassial tooth in Carnivora, published in *Vidensk. Meddel. Dansk. naturh. Foren*, vol. lxv., pp. 67–111. After reviewing the various theories of the homology of tooth-cusps, the author proceeds to observe that in order to demonstrate that the simple reptilian tooth-cone is represented by the middle one of the three longitudinally arranged cusps of the Purbeck Triconodon, and that the tritubercular crown has been formed by rotation of the other two, indisputable evidence has yet to be furnished, "first, of the Triconodon-like forms being the ancestors of Dryolestes, &c.; second, of the supposed protocone and protoconid of these being really homologous with the median cusp of Triconodon. One can scarcely imagine how such a rotation could take place, and if Gidley is right in his interpretation of the molar cusps of Dryolestes, the rotation has not taken place, but the so-called protocone is a secondary acquirement; the true protocone is still to be sought in the central one of the three outer cusps. If this holds good the whole nomenclature and theory of Osborn falls to the ground; neither protocone nor protoconid are then identical with the reptilian cone."

Three papers, by Dr. R. Broom, form part 6 of vol. vii. of the Annals of the South African Museum, and relate to the extinct reptiles of the same country. In the first of the triad the author shows that while in Pariasaurus the digital formula is 2.3.3.4.3, in the allied Propappus it is probably 2.3.4.5.3. In the second he describes, as *Noteosaurus africanus*, a new genus allied to Mesosaurus, of which three of the known species are South African, while the fourth is Brazilian. The last paper comprises a classified list of the early Mesozoic reptiles of South Africa, which, apart from dinosaurs, crocodiles, rhynchocephalians, &c., are arranged in no fewer than nine ordinal groups, brigaded in three "superorders." R. L.

AN ALGEBRA FOR PHYSICISTS.[1]

THE principal novelties in Dr. Macfarlane's calculus are that a distinction is made between linear and cyclic successions of vectors, and that the commutative law of addition, as well as that of multiplication, is abandoned. To express what most vectorists write $\beta+\alpha=\alpha+\beta$, Dr. Macfarlane writes $\Sigma(\beta+\alpha)=\Sigma(\alpha+\beta)$. Thus $\alpha+\beta-\alpha$ is not the same as β, but either three sides of a parallelogram, or three coinitial vectors, according as we take linear or cyclical succession. By introducing some subsidiary and rather artificial rules, the author is able to get formulæ that are, in appearance, analogous to the binomial and exponential theorems, and so on.

The actual divergence from quaternion results is not very great, as may be easily shown by an example. Let x be a scalar, α a unit vector, and let $\exp(x\alpha)$ be defined to mean $\Sigma(x\alpha)^n/n!$. Then $\exp(x\alpha)=\cos x+\alpha \sin x$, and if y is another scalar, $\exp(x\alpha).\exp(y\alpha)=\exp(y\alpha)\exp(x\alpha)=\exp\{(x+y)\alpha\}=\cos(x+y)+\alpha\sin(x+y)$.

But, if β is another unit vector,

$$\exp(x\alpha)\exp(y\beta)=\cos x\cos y+\alpha\sin x\cos y+\beta\cos x\sin y+\alpha\beta\sin x\sin y,$$

which differs from $\exp(y\beta).\exp(x\alpha)$, while both, in general, differ from $\exp(x\alpha+y\beta)$: the latter, observe, being by definition the same as $\exp(y\beta+x\alpha)$. Dr. Macfarlane, after writing down his exponential formula, breaks it up into four parts, practically the same as the four given by the quaternion formula above, when written in the form—

$$\exp(x\alpha)\exp(y\beta)=(\cos x\cos y+\sin x\sin y\,S\alpha\beta)+\alpha\sin x\cos y+\beta\cos x\sin y+V\alpha\beta.\sin x\sin y.$$

It must be left to physicists themselves to decide whether Dr. Macfarlane's new algebra is superior to those already available; the need of a sign to express a resultant is a rather severe handicap. To the pure analyst it presents the appearance of a conglomerate, though possibly, with a change of notation, it could be fitted into a place in the family of linear associative algebras. One thing ought to be said: it is not, properly speaking, an "extension" of quaternions. Analytically, the calculus of quaternions is a linear algebra of a perfectly definite type,

[1] (1) "Account of Researches in the Algebra of Physics," I.–III. (Reprint from Journ. Wash. Ac. of Sc., 1912)
(2) "On Vector-analysis as Generalised Algebra" (Intern. Congress of Mathematicians, 1912.) By Dr. A. Macfarlane.