If a vessel is to remain at rest for a considerable period, an anti-fouling composition which exfoliates rapidly, and which also contains poisons known to act on germ life, must be used, the amount of such poison depending on the seasons and the waters in which the ship is to be; whilst if a vessel is to be continually running, then a slowly exfoliating composition must be employed, and a very small percentage of poison is all that is required, as skin friction and the comparative absence of the germs and spores in deep water will do the rest.

Our ships represent an enormous capital, and any trouble or care which will prolong their existence is well worth taking and will be amply repaid, and at the present time a heavily corroded and foul vessel means either ignorance or negligence on the part of those who have the responsibility of deciding on the compositions to be used; and, finally, it must be clearly borne in mind that there is no anti-fouling composition which ever has been made, or probably ever will be made, that will answer for all cases, and that, until this is clearly recognized, the present unsatisfactory condition of the question will exist.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, March 28.—"The Diurnal Variation of Terrestrial Magnetism." By Arthur Schuster, F.R.S., Professor of Physics; with an Appendix by H. Lamb, F.R.S., Professor of Mathematics, Owens College, Manchester.

In the year 1839, Gauss published his celebrated memoir on "Terrestrial Magnetism," in which the potential on the earth's surface was calculated to twenty-four terms of a series of surface harmonics. It was proved in this memoir that if the horizontal components of magnetic force were known all over the earth the surface potential could be derived without the help of the vertical forces, and it is well known now how these latter can be used to separate the terms of the potential which depend on internal from those which depend on external sources.

The use of harmonic analysis to separate internal from external causes has never been put to a practical test, but it seems to me to be specially well adapted to inquiries on the causes of the periodic oscillations of the magnetic needle.

If the magnetic effects can be fairly represented by a single term in the series of harmonics as far as the horizontal forces are concerned, there should be no doubt as to the location of the disturbing cause, for the vertical force should be in the opposite direction if the origin is outside from what it should be if the origin is inside the earth.

In any case, the differences between the two results will be of the same order of magnitude as the vertical force itself. If it were then a question simply of deciding whether the cause is outside or inside, without taking into account a possible combination of both causes, the result should not be doubtful even if we have only an approximate knowledge of the vertical forces.

Two years ago I showed that the leading features of the horizontal components for diurnal variation could be approximately represented by the surface harmonic of the second degree and first type, and that the vertical variation agreed in direction and phase with the calculation on the assumption that the seat of the force is outside the earth. The agreement seemed to me to be sufficiently good to justify the conclusion that the greater part of the variation is due to causes outside the earth's surface. Nevertheless, it seemed advisable to enter more fully into the matter, as in the first approximate treatment of the subject a number of important questions had to be left untouched. I now publish the results of an investigation which has been carried out as far as the observations at my disposal have allowed me to do. My original conclusions have been fully confirmed, and some further information has been obtained, which I believe to be of importance.

I have made use of the observations taken at Bombay, Lisbon, Greenwich, and St. Petersburg. The horizontal components of the diurnal variation during the year 1870 were in the first place reduced to the same system of co-ordinates and to the same units. If we remember that experience has shown the diurnal variation to be very nearly the same for places in the same latitude, except near the magnetic pole, and also that it is symmetrical north and south of the equator, we may for a given time of day assume the horizontal components known over eight circles of latitude, four of which are north and four south of the equator.

From the horizontal components, the potential was calculated in terms of a series of surface harmonics. It was found that in order to represent both the summer and the winter effect with sufficient accuracy thirty-eight terms were necessary. In this calculation the vertical forces were not made use of at all.

From the potential, as calculated from the horizontal components, we can deduce the vertical force, either on the assumption that the variation is due to an outside cause, or that it is due to an inside cause; and compare the vertical forces thus found with the vertical forces as actually observed.

If we put both into the form

$$r_n \cos n(t - t_n),$$

we can obtain an idea of the agreement as regards amplitude and phase for each harmonic term. The following tables give the results for $n = 1$ and $n = 2$—that is, for the diurnal and the semi-diurnal variation:—

TABLE I.

Observed and calculated Values of the Coefficients t_1 and t_2 of Vertical Force, when expressed in the form $r_1 \cos (t - t_1) + r_2 \cos 2(t - t_2)$, on the supposition that the Disturbing Force is *inside* the Earth.

	t_1.			t_2.		
	Calc.	Obs.	Diff.	Calc.	Obs.	Diff.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
Bombay	23 02	11 13	+11 49	9 55	4 23	+ 5 32
Lisbon	22 35	10 40	+11 55	11 42	5 50	+ 5 52
Greenwich	22 06	8 42	+11 54	11 32	5 56	+ 5 36
St. Petersburg, 1870	21 16	3 10	− 5 54	10 48	7 05	+ 3 43
,, 1878	...	7 05	− 9 49	...	6 12	+ 4 36

TABLE II.

Observed and calculated Values of the Coefficients t and t_2 when expressed in the form $r_1 \cos (t - t_1) + r_2 \cos 2(t - t_2)$, on the supposition that the Disturbing Force is *outside* the Earth.

	t_1.			t_2.		
	Calc.	Obs.	Diff.	Calc.	Obs.	Diff.
	h. m.	h. m.	h. m.	h. m.	h. m.	h m.
Bombay	11 10	11 13	− 0 03	3 47	4 23	− 0 36
Lisbon	10 37	10 40	− 0 03	5 46	5 50	− 0 04
Greenwich	10 03	8 42	+ 1 21	5 38	5 56	− 0 18
St. Petersburg, 1870	8 52	3 10	+ 5 42	4 38	7 05	− 2 27
,, 1878	...	7 05	− 1 47	...	6 12	− 1 34

In Table I. the comparison of the observed phases is made with the values calculated on the assumption that the disturbing force is inside the earth. In Table II. the same comparison is made on the alternative hypothesis. There is complete disagreement in Table I. between the observed and calculated values, and nearly complete agreement in Table II. It is seen how both at Lisbon and Bombay the time of maximum displacement agrees within three minutes of time for the diurnal variation, and at Lisbon within four minutes of time also for the semi-diurnal variation. Considering that Lisbon is the most important station, not only on account of its geographical position, but also because the observed vertical forces apply to the same year as the calculated ones, the result is strikingly in favour of the outside force. The results for Greenwich argue in the same direction. As regards St. Petersburg, the results for 1870 neither agree with one nor with the other hypothesis. The observations for 1870 are, however, doubtful, but the results for 1878 agree well with the hypothesis of an outside disturbing force.

The observed amplitudes are found in all cases to be considerably smaller than the calculated ones.

If we then take it as proved that the primary cause of this variation comes to us from outside the earth's surface, we are led to consider that a varying magnetic potential must cause induced currents within the earth, if that body is a sufficiently good conductor. These induced currents might be the cause of the apparent reduction in amplitude. As my colleague, Prof. Lamb, has given considerable attention to the problem of currents in a conducting sphere, I consulted him, and he

gave me the formulæ by means of which the induced currents can be calculated. This investigation is given in an appendix to the paper. The result is very interesting. If the earth is treated as a conducting sphere, the observed reduction in amplitude is accounted for, but that reduction should be accompanied by a change of phase which is not given by observation. We can reconcile all facts if we assume, as suggested by Prof. Lamb, the average conductivity of the outer layers of the earth to be very small, so that the reduction in amplitude is chiefly due to currents induced in the inner layers. If the conductivity inside is sufficiently large, a considerable reduction in amplitude would not be accompanied by a sensible change of phase. We have arrived, therefore, at the following result :—

The vertical forces of the diurnal variation can be accounted for if we assume an outside cause of the variation, which induces currents in the earth, and if the earth's conductivity is greater in the lower strata than near the surface.

Prof. Balfour Stewart's suggestion that convection currents in the atmosphere moving across the lines of the earth's magnetic forces are the causes of the daily variation, gains much in probability by this investigation. If the daily variation of the barometer is accompanied by a horizontal current in the atmosphere similar to the tangential motion in waves propagated in shallow canals, and if the conductivity of the air is sufficiently good, the effects on our magnetic needles would be very similar to those actually observed. The difficulty as to the conductivity of the air is partly met by the author's investigation of the behaviour of gases through which electric discharges are passing.

It will be interesting to follow out the investigation, especially with a view of examining the influence of sun-spot variation. The question of magnetic disturbances is more complicated, but as magnetic observatories are being established in many countries, the time may not be far distant when we shall be able to bring the irregular disturbances within the reach of calculation.

The author acknowledges the help he has received from Mr. William Ellis in some of the reductions ; he has also to thank his assistant, Mr. A. Stanton, for much labour bestowed on making and checking numerical calculations.

Royal Meteorological Society, April 17.—Dr. W. Marcet, F.R.S., President, in the chair.—The following papers were read :—On the deaths caused by lightning in England and Wales from 1852 to 1880, as recorded in the returns of the Registrar-General, by Inspector-General R. Lawson. The total number of deaths from lightning during the twenty-nine years amounted to 546, of which 442 were of males, and 104 of females. In consequence of their greater exposure, the inhabitants of rural districts suffer more from lightning than those of towns. It appears also that vicinity to the west and south coasts reduces the chances of injury by lightning, and that distance from the coast and highland seems to increase them.—The diurnal range of the barometer in Great Britain and Ireland, by Mr. F. C. Bayard. The author has reduced the hourly records of the barometer at the nine Observatories, Aberdeen, Armagh, Bidston, Falmouth, Glasgow, Greenwich, Kew, Stonyhurst, and Valencia, during the years 1876–80. The curves of inland places are smoother than those of places on the sea-coast, and the curves of places to the westward are more irregular than those of places to the eastward. As we go from south to north the general tendency of the curve is to get flatter with a lessened diurnal range.—Note on a working model of the Gulf Stream, by Mr. A. W. Clayden. The author showed this interesting model at work ; it has been constructed to illustrate the formation of ocean currents in general and of the Gulf Stream in particular.—On the rime-frost of January 6 and 7, 1889, by Mr. C. B. Plowright. The author gives an account of the very heavy rime which occurred in the neighbourhood of King's Lynn on these days, when the fringe of crystals upon twigs and branches of trees was about 2 inches in length. The weight was so great that nearly all the telegraph wires were snapped and an immense number of branches of trees broken off.

Zoological Society, April 16.—Dr. A. Günther, F.R.S., Vice-President, in the chair.—The Secretary exhibited a pair of a fine large Buprestine Beetle of the genus *Julodis* (*Julodis ffinchi*), obtained by Mr. B. T. Ffinch near Karachi ; and a Mole-cricket (*Gryllotalpa vulgaris*), sent by Mrs. Talbot from Bagdad.—Mr. Sclater made some remarks on the animals he had noticed during a recent visit to the Zoological Gardens of Rotterdam, Amsterdam, and Antwerp.—A communication was read from Mr. A. H. Everett, containing remarks on the zoo-geographical relationships of the Island of Palawan and some adjacent islands. In this paper it was contended that Palawan and the other islands intervening between Borneo and Mindoro form an integral portion of the Bornean group, and do not naturally belong to the Philippine Archipelago, with which they have hitherto been treated. The writer founded his contention upon the grounds (1) that the islands in question are connected with Borneo by a shallow submarine bank, while they are separated from the Philippines by a sea of over 500 feet depth ; and (2) that a comparison of the Bornean and Philippine elements in the fauna of Palawan, so far as it is known, shows a marked preponderance of the former over the latter element ; while the Philippine forms are also more largely and more profoundly modified than the Bornean species. This fact indicated that they had been longer isolated, and consequently that the fauna of Palawan was originally derived from Borneo, and not from the Philippines, though a considerable subsequent invasion of species from the latter group had taken place.—A communication was read from Mr. Oldfield Thomas, containing an account of the mammals of Kina Balu, North Borneo, from the collections made on that mountain by Mr. John Whitehead in 1887 and 1888. The species represented in Mr. Whitehead's collection were 21 in number, of which six had proved to be new to science.—Mr. G. A. Boulenger read the second of his communications on the fishes obtained by Surgeon-Major A. S. G. Jayakar at Muscat, on the east coast of Arabia. The two collections recently received from Mr. Jayakar contained examples of 80 species not included in Mr. Boulenger's former list.

PARIS.

Academy of Sciences, April 8.—M. Des Cloizeaux, President, in the chair.—Fixation of nitrogen by vegetable soil with or without the aid of leguminous plants, by M. Berthelot. The paper deals with a fresh series of sixty-four methodic experiments carried out during the year 1888, and fully described in the April number of the *Annales de Chimie et de Physique*. They form a sequel to the systematic researches begun by the author in 1883, and tend fully to confirm the views already announced by him on the fixation of free nitrogen in the ground effected either with or without the co-operation of luzern, vetches, and other leguminous plants. He considers the fixation now fully established, and finds in this fact the true interpretation of a multitude of phenomena highly important to agriculture.—Experiments on putrefaction and the formation of manures, by M. J. Reiset. The more recent experiments here described fully confirm the results of those undertaken by the author so far back as 1854, and show that, in the process of organic decomposition, nitrogen is not fixed, but liberated.—On the identity of erysipelas and acute lymphangitis, by MM. Verneuil and Clado. The researches of the authors in the Hospital de la Pitié show that these are not two distinct disorders, as is often assumed, but merely two forms of the same contagious, infectious, and parasitic disease, due to a special microbe easily recognized, isolated, cultivated, and inoculated in animals. This microbe, hitherto discovered in erysipelas alone, has now also been detected in acute lymphangitis with all its characters and biological properties.—On the influence of refraction in the reduction of the observations of a meridian transit, by M. G. Rayet. The conditions already described by the author in his communication on the influence of refraction in the reduction of the observations of the circumpolar stars (*Comptes rendus*, March 11, 1889), are here shown to be equally applicable to the reduction of the observations of transits at any declination.—Direct determination of the compressibility of glass, crystal, and metals, up to 2000 atmospheres, by M. E. H. Amagat. By direct determination is here meant a determination effected without employing any formula. The results already communicated in recent notes were for slight pressures only ; hence these further experiments have been undertaken for the purpose of ascertaining whether, under very high pressures, the compressibility of glass, crystal, &c., undergoes any considerable diminution. The process employed is that adopted by Mr. Buchanan, and afterwards by Prof. Tait in their researches.—On the intensity of telephonic effects, by M. E. Mercadier. During his researches on the theory of the telephone, the author has been led to study the causes to which is due the varying intensity of the effects produced by this instrument. Here he studies more particularly the influence of the thickness of the diaphragm for a telephone of well-defined form, and for a like variation of the magnetic

field. Some experiments are described with iron diaphragms, and it is generally inferred that for all telephones of a given magnetic field there is a given thickness of the iron diaphragm which yields a maximum effect.—On the solubility of salts, by M. H. W. Bakhuis Roozeboom. This is a reply to M. Le Chatelier's critical remarks (*Comptes rendus*, March 18, 1889) on the work recently published by the author on the conditions of equilibrium between the solid and liquid combinations of water with salts, more particularly with calcium chloride.—On methylacetanilide, by M. H. Giraud. It is pointed out that the scientific name of ortho-methylacetanilide given to the *exalgine* recently prepared by M. Brigonnet, can only be applied to the substance described by Beilstein and Kuhlberg under the name of aceto-orthotoluide. It is further shown that M. Brigonnet's preparation is not new, that it was described by Hofmann in 1874, and that its true name is methylacetanilide.

BERLIN.

Physiological Society, March 27.—Prof. du Bois-Reymond, President, in the chair.—Dr. Klemperer spoke on the proteid needs of the animal economy in health and in certain pathological conditions. Voit's teaching, that the human body in health requires daily from 100 to 120 grammes of proteid in order to supply its nitrogenous needs, has been recently contested from many sides; and even if the experiments on which the attacks were based were not altogether free from some defects, they still sufficed to cast a good deal of doubt on Voit's theory. The speaker had endeavoured, working from the clinical point of view, to decide the question whether an increased proteid metabolism can be prevented or diminished by an increased ingestion of carbohydrates or fats. He carried out experiments on the nutrition of two healthy persons, in which the daily dose of proteids was very considerably diminished, even down to 40 grammes, while in compensation for the lessened proteids larger quantities of fats, sugar, and easily absorbed and oxidizable alcohol were administered. The nitrogen excreted in the urine was constantly less in amount than that taken in the food, thus showing that healthy, active men can be fed with largely diminished amounts of proteid without the occurrence of any destructive metabolism of their tissue-proteids. He next proceeded to investigate whether, in diseases which are characterized by an abnormally large breaking down of tissue-proteids, this increased nitrogenous metabolism could be lessened by the ingestion of an increased quantity of non-nitrogenous food. An increased nitrogenous metabolism occurs in dyspnœa, fever, anæmia, cancer, tuberculosis, diabetes, and Addison's disease. For dyspnœa, experiments were made on animals; while for anæmia, cancer, diabetes, and Addison's disease, observations were made on the human subject, and results were obtained which corresponded to the supposition under which the experiments were started. A very considerable reduction of the nitrogen excreted in the urine was observed when only moderate quantities of proteid were given, while at the same time increased amounts of carbohydrates, fats, and alcohol, were administered. It is impossible to enter here into the interesting details of these experiments, which were all carried out by very precise methods, or into a discussion of the hypotheses which were advanced in explanation of the phenomena which had been observed.—Prof. Rosenthal, of Erlangen, gave an account of calorimetric experiments with which he had been busied for the last few years. He employed in these an air-calorimeter of special construction. It consisted of a copper vessel, of easy ventilation, in which the animal was placed; this was surrounded by an air-tight envelope, filled with air and constituting the reservoir of an air-thermometer; external to this was a covering to shield the whole apparatus from any changes in the temperature of the surrounding atmosphere. When the animal gives up to the envelope of air, per unit of time, exactly the same amount of heat as the whole apparatus radiates into the surroundings, the temperature of the air in the envelope remains constant, as also its *pressure*: hence the heat produced and given off by the animal during any known time could be measured by means of a manometer. Notwithstanding that the dog used in the experiments was fed in exactly the same way at each meal, the quantities of heat produced varied very largely, and any considerable uniformity is only obtained by taking the mean of a long series of observations. Up to about the third hour after the meal the heat-production diminishes, then rises rapidly to a maximum, and from this point, at about the eighth hour, it begins to fall again slowly and with irregularities, until the next meal. Over the whole twenty-four hours the heat-production is more uniform during the second period of twelve hours than in the first; about 20 per cent. more heat is produced during the first than during the second half of the whole day. When an excess of food was given the heat produced was always less than that calculated out from the oxidation of the food itself; but with a uniformly constant diet the mean value of the heat produced corresponded to the heat calculated for the oxidation of the food. The amount of carbonic acid gas given off by the animal was found to correspond to the heat given off during the same period only in cases where prolonged intervals of time were taken into account. When the surrounding temperature varied between 5° and 25° C., all other conditions remaining the same, a minimal production of heat was observed at 15° C.: from this point it increased uniformly in both directions, not only when the temperature fell to 5° C., but also when it rose to 25° C.—Prof. Schweigger demonstrated several pieces of apparatus, which by the use of small incandescent electric lamps, could take the place of the ophthalmoscope, and even render a binocular examination possible. They also made the measurement of refraction in the eye both simple and exact.

BOOKS, PAMPHLETS and SERIALS RECEIVED.

The Useful Native Plants of Australia (including Tasmania): J. H. Maiden (Trübner).—The Psychic Life of Micro-organisms: A. Binet; translated by T. MacCormack (Chicago).—The Elements of Vital Statistics: Dr. A. Newsholme (Sonnenschein).—Catalogue of the Fossil Fishes in the British Museum (Natural History). Part 1: A. Smith Woodward (London).—Richtigstellung der in bisheriger Fassung unrichtigen Mechanischen Wärmetheorie und Grundzüge einer Allg. Theorie der Aetherbewegungen: A. R. von Miller-Hauenfels (Wien).—The Land of Manfred: J. Ross (Murray).—Bulletins de la Société d'Anthropologie de Paris, tome xi., 4e fasc. (Paris).—Mémoires de la Société d'Anthropologie de Paris, tome iv., fasc. 1 (Paris).—Journal of Anatomy and Physiology, April (Williams and Norgate).—Zeitschrift für wissenschaftliche Zoologie, xlviii. Band, 1 Heft (Leipzig).

CONTENTS.