cumbering the ground, and that the remaining 10 per cent., if useful, are very imperfect. One instance of the evil done by such means will suffice. Sir Wm. Fairbairn, to whom is due the credit of being the earliest labourer in this field, experimented on certain single- and double-riveted joints, and found that the "proportion of strength" in the case of the former was 56 per cent., and in the latter 70 per cent. of the solid plate. These figures, which of course applied only to the particular designs tested, have been repeated in almost all manuals of engineering as if they were universally true; disregarding the obvious fact that a double-riveted joint could be made just as weak as a single-riveted one, by simply spacing the holes in the outside row at the same distance.

The Committee wisely determined to throw aside the voluminous labours of their predecessors, and begin *de novo* a connected series of experiments, based on the true and scientific method described above. We cannot find space to consider the many collateral points with which these experiments will have to deal, much less to give any account of the results which they are to supersede. These, as embodied in this Report, will remain a singular instance of the lamentable waste of money so continually incurred in engineering experiments. There can be little doubt that less than a tenth of this money, if applied on the scientific and proper method, would have set the whole question long ago at rest, and would now be saving the world, through increased economy of construction, many hundreds per annum for every pound so expended.

Friction.—The last of the three subjects under consideration is that of Friction at High Velocities, the Report on which has been prepared by Prof. Kennedy, of University College, London. This subject offers a curious instance of the influence exercised by a distinguished experimenter, and how his conclusions are pushed, by those who blindly follow his guidance, much further than he himself would attempt to go. About fifty years ago the late General Morin made an important series of experiments, from which the well-known "Laws of Friction" were deduced. One of these laws is that the friction between solid bodies in motion, or dynamical friction, is independent of the velocity. It was overlooked, by those who announced this law, that the experiments were only conducted with certain substances under small pressures and at moderate speeds. General Morin himself, in an interesting letter published in the present Report, expressly states that he had himself always regarded his results, "not as mathematical laws, but as close approximations to the truth *within the limits of the data of the experiments themselves.*" Unfortunately others did not imitate this caution: they asserted everywhere that the law was universal, and by many it is asserted to be so still.

That it is not universal has however been sufficiently proved. At the time of the launch of the *Great Eastern* the late Mr. Froude showed, by experiments on a large scale, that the friction of a vessel on the launching-ways decreased rapidly as the velocity increased. In 1851 Poirée and Bochet showed that the coefficient of friction of railway wheels sliding on rails diminished very rapidly with increase of speed (between limits of 900 and 3600 feet per minute). Recently Capt. Douglas Galton and Mr. Westinghouse made a long series of experiments on the friction of railway-brakes (cast-iron blocks on steel tyres), and their results showed a marked decrease of friction, with increase of speed, within the very large range of 400 to 5300 feet per minute. Prof. Kimball has made experiments at much lower speeds (about 1 to 100 feet per minute), both with pieces of wood and with wrought-iron spindles in cast-iron bearings; and he also finds a rapid decrease of friction with increase of speed. At the lowest possible speeds (0·012 to 0·6 feet per minute) Prof. Fleeming Jenkin finds a similar decrease, pointing to the supposition that the change from statical to dynamical friction is not sudden, but continuous. Lastly, Prof R. H. Thurston has made an elaborate set of experiments on the frictional resistance of lubricated bearings. He arrives at the conclusion that for cool and well-lubricated bearings the coefficient of friction decreases up to a speed of about 100 feet per minute, and afterwards increases with the speed approximately as its fifth root. The details of these experiments do not seem to have been published, so that it is not certain how far this curious result may be taken to hold.

It will be seen that none of these various experiments confirm the universal law deduced from Morin's results, viz. that dynamical friction is independent of velocity. On the contrary, it may be taken as proved for *unlubricated* surfaces (such as railway brakes) that the coefficient of friction diminishes rapidly with increase of velocity; although the exact law of variation and its relation to the pressure on the surfaces is not fully determined. With *lubricated* surfaces the same fact may be assumed to be true at speeds up to 100 feet per minute; but above this, if we accept Prof. Thurston's results, the result is the opposite. It seems clear that the question is ripe for further investigation, which might take the form, first of repeating and extending Thurston's experiments with lubricants, and secondly of ascertaining the law of variation with unlubricated surfaces more exactly than could be done by the aid of the experiments hitherto carried out.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—At the Downing College Examination in June, 1881, one Foundation Scholarship of the annual value of 80*l.* will be thrown open to all members of the University who have not kept more than six terms. The subjects of this Examination will be Chemistry (Theoretical and Practical), Physics (Heat, Electricity, and Magnetism), Comparative Anatomy, Physiology, and Botany. The Examinations for Minor Scholarships, which are open to all persons who have not entered at any college in the University or who have not resided one entire term in any such college, will be held in Downing College on Tuesday, May 31, and three following days. Further information will be given by Mr. J. Perkins or by the Rev. J. C. Saunders, tutors of the College.

AT a special meeting of the Fellows of Gonville and Caius College, held on the 30th ult., Dr. Paget, F.R.S., Regius Professor of Physic in the University, and Mr. Pattison Muir, Hon. M.A. (Cantab.), were elected Fellows of the Society. Dr. Paget was formerly a Fellow of Caius College.

OXFORD.—In addition to the courses of lectures in Natural Science enumerated last week, the following courses will be held during this term in the University Museum:—Prof. Price will lecture on physical optics, and Prof. Westwood will lecture on the orders of the Arthropoda. In the absence of Prof. Rolleston, who is abroad on account of ill-health, Mr. Jackson will form classes for general catechetical instruction, while classes will be formed by Mr. Robertson for practical microscopy, and by Mr. Thomas for the study of the developing chick.

At the Botanical Gardens Prof. Lawson will lecture on elementary botany (development), and will continue his course on the dissection of plants.

In the Geological Department under Prof. Prestwich, lectures will be given on some of the secondary and quaternary strata. The Professor will have excursions to inspect the sections of the several formations around Oxford, commencing on Saturday, April 30, and to be continued through May. On each preceding Friday he will lecture on the subject of the following Saturday's excursion, or on some other subject of which notice will be previously given. Notice will also be given in the Gazette of the preceding week, and in the Museum, of the places to be visited, hours of meeting, &c.

In a congregation holden on Tuesday, May 3, the proposal to allow selected candidates for the Indian Civil Service to obtain the B.A. degree after two years' residence, was thrown out. An amendment to excuse selected candidates from responsions only was carried by 63 votes to 49.

THE scheme for the establishment of a University College in Liverpool is now almost matured, and it is expected that the College will open for its first session in October next. The donations have reached the sum of 100,000*l.*, and the task of drafting a constitution for the College is now being performed by a special committee. The Earl of Derby has accepted the office of president, the vice-presidents being Mr. Christopher Bushell and Mr. William Rathbone, M.P.

SCIENTIFIC SERIALS

Journal de Physique, April.—Theory of machines with alternating currents, by M. Joubert.—On radiophony (second memoir), by M. Mercadier.—Application of Talbot's fringes to determination of the refractive indices of liquids, by M. Hurion.—Apparatus for projecting images at any distance with a variable enlargement, by M. Crova.—Strong and constant voltaic pile, furnishing residues capable of regeneration by electrolysis, by M. Reynier.

Reale Istituto Lombardo di Scienze e Lettere, Rendiconti, vol. xiv. fasc. vi.—On Chætognatha, by Dr. Grassi.—On the stratigraphical position of the phyllitic zone of Rotzo, and the marine limestones which comprehend it, by S. Taranelli.—On a Cremonian quadratic correspondence between the elements of two ruled spaces, by S. Archieri.—The last introduction of fishes into our lakes, by Prof. Pavesi.—On a freshwater sponge new to Italy, by the same.

SOCIETIES AND ACADEMIES

LONDON

Photographic Society, April 12.—J. Glaisher, F.R.S., president, in the chair.—The following papers were read:—On a Swiss tour with gelatine plates, by W. Dillworth Howard.—On art and photography, suggestions for bringing them into closer connection, by H. B. Berkeley.—On the natural camera, and on uncorrected lenses in photography, by Capt. Abney, R.E., F.R.S. This paper described the natural camera as being the means of taking a photograph without an optical glass—a pin-hole producing the picture, although at a long focus—also that an uncorrected or non-achromatic lens, say an ordinary spectacle lens, if its aperture be reduced to one-fifth of an inch, would bring the wave-lengths of all colours into one perfect focus, but which, being very long, would necessitate prolonged exposures; at the same time this could be met by the use of the modern rapid gelatine plate.

Victoria (Philosophical) Institute, May 2.—A paper upon philosophy as advocated by Mr. Herbert Spencer was read by the Rev. W. Ground. The aim of the paper was to show that the philosophy in question is hopelessly illogical, the "analysis" in direct contradiction to the "synthesis."

GÖTTINGEN

Royal Society of Sciences, January 8.—On a proposition of the maintenance of the algebraic relation between the integrals of various differential equations and their differential quotients, by Herr Königsberger.—Report on the polyclinic for ear diseases, by Dr. Bürkner.—On the motion of an electric particle in a homogeneous magnetic field and the negative electric glow, by Herr Riecke.—On the quantity of electricity furnished by an influence-machine of the second kind and its relation to moisture, by the same.—Measurement of the force exerted by earth-magnetism on a linear current conductor capable of rotation, by the same.

February 5.—Influence of heat on the optical properties of boracite, by Herr Klein.—On electrical shadows (third paper), by Herr Holtz.—New representation of spherical functions and related functions by determinants, by Herr Henn.—Remarks on a memoir, by Herr Warburg, on some actions of magnetic coercive force, by Herr Fromme.—Observations in the magnetic observatory, by Herr Schering.

March 5.—On the irreducibility of differential equations, by Herr Königsberger.—Contributions to a knowledge of the optical properties of analcim, by Herr Ben Saude.

PARIS

Academy of Sciences, April 25.—M. Wurtz in the chair.—The following papers were read:—On a question of ancient metrology; origin of the English mile, by M. Faye. He inquires into the error (long current) of supposing the mile equivalent in length to a terrestrial arc of one minute. The mile has been probably deduced from Ptolemy's measure, and the error of one-sixth seems to arise from the English geographers having supposed that Ptolemy used the Greek foot, which Eratosthenes used 400 years before, whereas he used the Phileterian foot, which is about 0·36m., the earlier one being 0·27m. Eratosthenes counted 700 stadia to a degree; Ptolemy only about 500.—Examination of materials from the vitrified forts of Craig Phadrick, near Inverness (Scotland), and Hartmannswillerkoff (Upper Alsace), by M. Daubrée. Like the forts in France, that at Craig Phadrick must have undergone heat intense enough for the mica to entirely disappear and the felspar to be in great part fused. The minerals produced at cost of the mica and felspar present evident similarities. The Alsace fort seems to have been composed of brown porphyry, but the crystalline products of heat are similar to those in the other case. The ingenious method of heating was probably transported, not invented independently in different countries. The phenomena elucidate metamorphism.—Meteorite which fell at Louans (Indre-et-Loire) on January 25, 1845, and the fall of which was not published, by M. Daubrée.—Researches on piperidine, by M. Hofmann.—Nodule of chromite in the interior of the meteoric iron of Cohahuila (Mexico), by Prof. Lawrence Smith. He obtained, on analysis, oxide of chromium 62·61, ferrous oxide 33·82. While chromite has long been known in association with meteoric stones, the form of its occurrence here is new. The meteorite contained distinct nodules of two chromiferous minerals.—Observations on phenomena of absorption in lower vegetable organisms, by M. Syrodot. Studying Batrachospermeæ, he has found the organs of absorption to present parallel phases to those better known in the higher groups.—M. Sire presented an instrument for demonstrating Foucault's law of the apparent deviation of the pendulum's plane of oscillation. The apparatus may be used in any latitude.—General theory of transmissions by metallic cables; practical rules, by M. Leauté. The author determines, *inter alia*, the coefficient of working (*fonctionnement*) in telodynamic transmissions, a coefficient which fixes the manner in which a cable behaves under a variation in the force exerted. The idea of equivalence of two transmissions as to working is thus reached. The limits of transmission of force by cables are investigated.—On the essence of licari kanali, or essence of female rosewood, by M. Morin. The composition of this essence from French Guyana appears to be identical with that of Borneo camphor.—On the winter-egg of phylloxera, by M. Mayet. About Montpellier the hatching of the egg has occurred during the whole month of April, and even in the end of March.—Results obtained in phylloxerised vines by a mixed treatment with sulphide of carbon and sulphocarbonate of potassium, by M. Laugier.—M. Faye, presenting the first volume of *Annales de l'Observatoire de Toulouse*, edited by M. Baillaud, said it marked a new era in the history of the provincial observatories, great activity being indicated. The researches of M. Tisserand (predecessor of M. Baillaud) on Saturn's satellites are given. M. Perrotin works out the theory of Vesta; while the zodiacal light, the eclipses of Jupiter's satellites, Saturn's rings, &c., are also studied.—On a class of linear differential equations with doubly periodic coefficients, by M. Appell.—Normal production of three systems of fringes of rectilineal rays, by M. Croullebois.—Causes of disturbance of telephonic transmissions, by M. Gaiffe. Two rods from the same piece of steel (capable of being strongly polarised without being tempered) were placed in a telephone circuit, one of them being first magnetised as much as possible. Striking them similarly produced strong currents from the magnetised rod, but very little current from the other.—On the renal origin of nefrogymase, by MM. Bechamp and Baltus.—On the absorption of mineral waters by the cutaneous surface, by M. Champouillon. The absorption of iron and manganese from the waters of Luxeuil was proved in examination of the urine. It is only after a period of mineral saturation that the minerals appear in the urine.—Remarks on the anatomy of pyrosoma, by M. Joliet.

CONTENTS