indicated by small red dots. In spare spaces to the north of the chart, small inset maps have been drawn to give the completion of the geography in the Polar areas, and upon these will be found, indicated by colour, the average summer limit of open water as far as known. The curves of equal magnetic variation are also shown upon these small maps, and the spots known as the magnetic poles are named. The northern limit of woods, beyond which trees are unknown, is shown upon the small map of the Arctic regions. The principal ocean mail routes are shown by broken black lines, and upon the longer lines the names of ports of departure and arrival are named. The number of days, the average of numerous voyages is noted on each line, and the distances in nautical miles from port to port are also given. The submarine telegraph cables are shown by strong black lines with dots at short intervals, and the various cables to the United States are identified by having their dates attached. The land is coloured politically giving the most recent territorial divisions, and a bright red colour is reserved for British possessions, which enables the reader to see easily how frequent are the stepping stones of British territory over the face of the earth. Altogether it will be seen this map is well calculated to serve a great variety of useful purposes; its execution is all that could be desired.

DR. NACHTIGAL has received a telegram from Malta to the effect that Herr Gerard Rohlfs's expedition, having reached and explored the Kufara Oasis, was there set upon and plundered. Herr Rohlfs and Dr. Anton Stecker were consequently compelled to return to Benghazi, though they hoped to receive help and compensation from the Turkish Provincial Government.

TRÜBNER AND CO. will shortly publish a new work on Madagascar, under the title of "The Great African Island: Chapters on Madagascar," by the Rev. James Sibree, jun The work will contain a popular account of recent researches in the physical geography, geology, and exploration of the country, and its natural history and botany; and in the origin and divisions, customs and language, superstitions, folk-lore, and religious beliefs and practices of the different tribes. It will contain physical and ethnographical maps.

GEOLOGISTS will be glad to learn the appearance of a trustworthy map of mines in Russia in Europe by Prof. W. Möller, "Carte des Gites miniers de la Russie d'Europe."

WE notice in the last number of the *Bulletin* of the Belgian Geographical Society a paper on the colour of eyes and hair in Belgium, by M. Vanderkindere, with maps: on the Zambeze, by M. Wauters; and the quarterly report on the demographical and medical statistics.

THE Church Missionary Society a short time back entertained the idea of establishing a sanatorium on the west coast of Africa, and the matter, it may be remembered, caused some discussion between their adviser, Capt. R. F. Burton, and the Rev. T. J. Comber, a Baptist missionary, at one of the Geographical Society's meetings last session. It was proposed to place the sanatorium on Mount Cameroons, which rises to a height of over 13,000 feet, just in the angle of the Gulf of Guinea, opposite Fernando Po. Two agents of the Society accordingly proceeded thither in the missionary steamer *Henry Venn*, and ascended the mountain to the highest peak. Their report was favourable to the suitability of a spot some 7,500 feet high, known as Mann's Spring, but to build a residence there and cut a road to it would, it appears, cost more than the Society can afford in order to recruit the health of their missionaries.

UNDER the heading of ethnography, a paper by Père Petitot, on the Asiatic origin of the Indians of Arctic America is commenced in the current number of *Les Missions catholiques*.

THE great work undertaken by the Russian Geographical Society under the title of "Works of the Ethnographical and Statistical Expedition to South-Western Russia" is now completed. The whole work consists of seven volumes, in nine fascicules, or nearly 4,800 pages, and it contains abundant most useful information as to those countries which afford so great an interest by the variety of their population.

WE notice the appearance of the following important works recently published by the Russian Geographical Society:—(1) The eighth volume of its *Memoirs* (*Zapioki*), which contains a "General Sketch of a Theory of Constant Marine Currents," by Colonel Schilling, and a "Note on the New Map of Persia," by General Stebnitzky, with the map itself, which is one of the most important acquisitions to the exact cartography of Asia during recent years.—(2) The fourth volume of the translation of Ritter's "Asia," being the description of the Altay and Sayan Mountains within the limits of the Russian Empire, with a very important appendix (far larger than the original work itself), by MM. Potanin and Semenoff, being a *résumé* of all new information acquired from 1832 to 1875.—(3) "The Kashgar Land" (*Kashgaria*), an historical and geographical sketch, of the country, of its military forces, industry, and trade, by M. Kuropatkin, with additions of General Stubendorff and M. Sreznevsky.—(4) "A Journey to the Holy Land of the Prince Radzivil-Sirotka during the Years 1582 to 1584," published and annotated by M. Hildebrandt; and (5) The two first volumes of a "Catalogue of the Library of the Geographical Society," containing books on mathematical, physical, and general geography. The importance of this catalogue will be realised by all those who know what a number of works appear in Russian on the geography of Russia and Asia, and how difficult it is to know them. We notice with pleasure that the catalogue contains detailed indexes of all papers that have appeared in the publications of the Geographical Society. An important work, being the description of M. Potanin's journey to north-western Mongolia is already in the press.

CELESTIAL PHOTOMETRY

THE volume of the annals of the Harvard Observatory just issued is one of great importance to astronomical science, as the new director, Prof. Pickering, has included in it the photometric observations which have lately been carried on with so much vigour. The first chapter is devoted to a description of the forms of instruments—many of them new—which have been employed, and in this notice we shall limit ourselves to an analysis of this part of the volume.

The first instrument employed was constructed by attaching a Nicol to a double-image prism in such a way that it could turn freely around its axis. By a graduated circle and index, the angle could be measured to tenths of a degree. When two bright objects were viewed through this instrument, two images of each were formed by the double-image prism, either of which, by turning the Nicol, could be made as faint as was desirable. Whatever their relative light, the faint image of the brightest could thus always be reduced to equality with the bright image of the faint object. The true relative brightness is then deduced from the angle through which the Nicol is turned.

This form of photometer may be used without a telescope in the comparison of bright stars which are sufficiently near each other, but the loss of light is large. By Fresnel's formula for the reflection of light, each of the four surfaces of the prisms will reflect four per cent. The amount they would transmit, were there no other losses, would therefore be $(\cdot 96)^4 = \cdot 849$. This supposes that the faces of the Nicol are perpendicular to its axis. If made of the usual form, the loss would be still greater. The unavoidable defects of the surface, dust, absorption, and the reflection at the surface of the balsam cementing the prism, reduce still further the transmitted light. About ·80 will remain under favourable circumstances. Since the prism forms two equal images, only one half or ·40 can pass into each, and when the two images are reduced to equality, their brightness will be only ·20 or ·40 of that of the fainter object. For any but the brightest of the heavenly bodies, it is accordingly necessary to increase the light by means of a telescope.

The following general remarks occur on this form of instrument.

"Since the relative positions of the Nicol and double-image prism are unimportant, either might be placed in front of the object-glass, between the object-glass and the field-lens, between the field-lens and eye-lens, or between the eye-lens and the eye. Unless the double-image prism is placed in front of the object-glass, two images of the latter will, in general, be formed, giving two emergent pencils, both of which must pass without loss into the eye. There is danger that on moving the eye one or other of these pencils will be partially cut off, thus reducing the brightness of one of the objects. If the two images to be compared are brought very near together, this is less likely to occur. On the other hand, at least one of the images of a double-image prism is not achromatic; and, if the prism is placed in front of the object-glass, the colour becomes very marked. In this case, also, it becomes difficult to obtain a prism having such flat surfaces that the images will not be distorted, since any irregularities are

magnified by the full power of the telescope. If the two images are separated by a distance *d*, any two stars at about this interval may be brought together, so that any star may be compared with all those on the circumference of a circle having a radius *d*. With a large prism in which *d* equalled about 3°, an attempt was made to compare β and ρ *Persei* and β and γ *Lyræ* by placing the prism in front of the objective of a telescope having an aperture of about 10 cms. A direct measure of the variations in brightness of the above-named variable stars might thus be obtained. This plan was abandoned, owing to the colour of the images.

"There is one other position of the prism, that where the eye-piece forms its image of the objective, in which the emergent pencil will remain undivided. This is, however, the exact point at which the eye should be placed; and, moreover, the

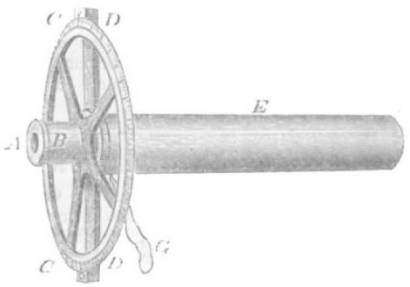

FIG. 1.

interval between the images cannot, in this case, be altered. Good results were obtained by placing the prism a little nearer the eye-piece, as in the first of the instruments described below. The advantage of placing the prism between the eye-lens and field-lens is that it is less likely to reduce the field of view. As this plan is open to the double objection of dividing the emergent pencil and keeping the images always at the same distance apart, it has not been employed in the following observations.

"The fourth position for the prism is between the field lens and objective. It then separates the emergent pencils by an amount increasing with its distance from the objective, but, on the other hand, the interval between the images is proportional to its distance from the focus. Whatever, therefore, is the interval between the two stars, within certain limits, their images may always be made to coincide by first turning the prism and

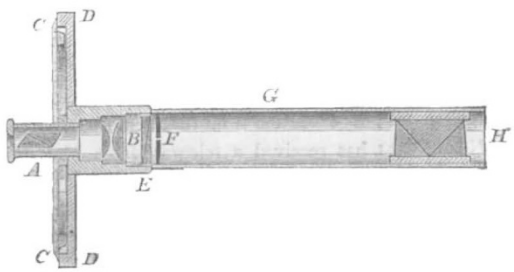

FIG. 2.

then sliding it along the axis of the telescope to the proper distance from the focus. A prism may therefore be used, in which the separation is small, and thus the two images of the objective may be rendered nearly coincident.

"The position of Nicol is comparatively unimportant. Since it must turn without moving the double-image prism, it is more convenient to place it between the latter and the eye. It was, accordingly, sometimes placed between the eye-lens and the eye, and sometimes between the field-lens and eye-lens."

We now come to the instruments.

The first observations were made with an eye-piece having a Nicol between its two lenses and with the double-image prism between this eye-lens and the eye. The observations made with this apparatus are regarded as preliminary; a second photometer was constructed, in which the Nicol and double-image prism were both placed in front of the eye-lens, the Nicol being next the eye. One marked advantage of this instrument, was that the circle instead of the index, turned with the Nicol. The labour of reading was thus much reduced. The Nicol was also replaced by a double-image prism, with the advantage that the field of view was less obstructed. With this form, however, the great number of images formed by successive reflections, when a bright object was observed, rendered it sometimes difficult to determine which should be compared.

A much simpler arrangement was used later. It consisted of two concentric tubes, one carrying a graduated circle, the other two indices. In the first of these tubes, a double-image prism was inserted; the other, which was held next the eye, carried a Nicol. This photometer was used without a telescope

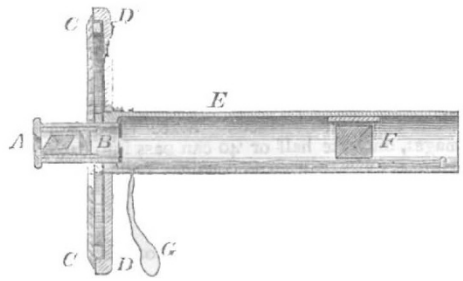

FIG. 3 (Scale ½).

to compare the relative brightness of Saturn and Mars, and Jupiter and Venus. A tube was attached to this photometer, so that the light should always pass nearly normally through the prisms. When the objects were sufficiently bright, and within a few degrees of one another, good results were thus obtained, but the colour of the images, and their want of symmetry, was a serious objection when a great difference in light was to be measured.

After an experience of some months with these instruments, certain improvements suggested themselves, and still another photometer was constructed, represented in perspective in Fig. 1, and in section, on a scale of one-fifth, in Fig. 2. In both figures, B represents the eye-piece, in front of which is

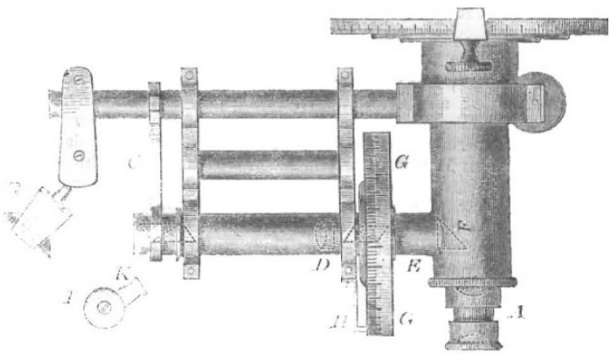

FIG. 4 (Scale ½).

inserted a Nicol, A. A circle, divided into degrees, is attached, and turns with the eye-piece. The indices D D are fastened to the tube E, which slides into the telescopes. F is a rochon prism, which was used instead of a double-image prism of spar. As it consisted of quartz, the separation of the images amounted to somewhat less than 1°, so that the emergent pencils overlapped each other by nearly three quarters of the diameter of each. The apparatus had, moreover, the great advantage that the images were precisely alike and nearly achromatic. The prism was placed in a tube, which could be drawn towards or from the eye-piece by a cord G. Attaching this photometer to a telescope, and directing it towards a star, the latter appeared double; and the interval between the components might be altered at will.

These photometers could only be used for comparing objects very near together, as double stars, or satellites. For greater intervals, another device was tried. Two achromatic prisms of small angle were placed in front of the telescope, so as to cover the central portion of its object-glass. Two images of any object would thus be formed, separated by an interval dependent on the angle of the prisms and on their relative positions. By turning one or both of the prisms, the directions of the two images may be altered at will, and their distance varied between the sum and the difference of the angular deviation of the prisms.

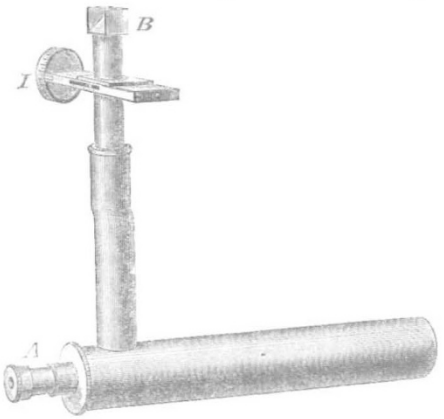

FIG 5.

After bringing the images near together, they could be compared by one of the photometers described above. This method was tried with two circular prisms, having a diameter of 4·4 cms., and producing a deviation of about 1°·3. A telescope was used having an aperture of 10 cms. The light of any objects nearer than 2°·6 could be measured with this instrument. The constant, or proportion of the light transmitted by the prisms, was easily determined by comparing, by the photometer, the two images of the same object. This instrument, like those previously described, has the great advantage that both objects are seen under the same magnifying power, and therefore closely resemble

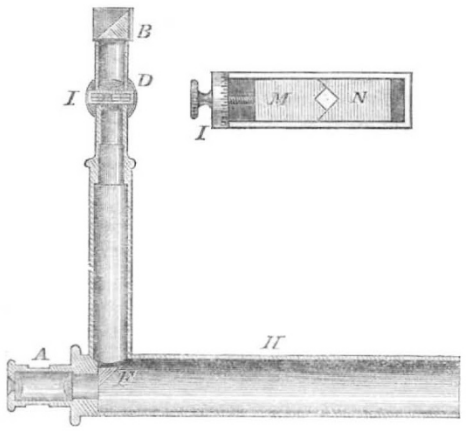

FIG. 6.

each other, even when the condition of the air is not good. This plan cannot be used for large intervals, since, if the angles of the prisms are large, the images will be coloured by the secondary spectrum, and it would also be difficult to find the objects. With a large telescope, the prisms could not be reached easily by the observer, and the large diameter required would be an objection to their use.

The idea suggested itself to Prof. Pickering, that such photometers might be used to compare the colours of the components of double stars, by measuring *the relative light of different portions of their spectra*. A combined spectroscope and photometer, shown in Fig 3, was devised. A is a Nicol, placed in front of the eye-piece B. The graduated circle C C is attached directly to the tube carrying the Nicol; and the indices D D are fastened to the tube G, which slides into the telescope. H is a direct-vision prism, by which the images of the stars are converted into linear spectra. F is a diaphragm placed at the focus, and having a slit in it ·02 cms. broad, parallel to the edges of the prism. It is, therefore, perpendicular to the spectra, and permits a short portion of each to pass through. These appear as two stars, of a colour which may be varied with the position of the objects observed, as regards the axis of the telescope. Their relative light was measured by forming two images of each, by a plate of Iceland spar, E, which was used instead of a double-image prism, since the rays were not parallel. The light was then measured by turning the Nicol.

All of the photometers described above are open to the objection that the loss of light is very great. Under the most favourable circumstances only ·20 to ·40 of the light is used; so that, with the large telescope of aperture 38 cms., faint objects appear no brighter than with a telescope having an aperture of 18 to 24 cms., with a common eye-piece. To remedy this objection which was greatly felt during the observations of the satellites of Mars, a class of photometers of wholly different form was tried.

In these the image of some bright object, assumed as a standard, is reflected into the field of the telescope, and its light reduced by a known amount, until it is no brighter than the object to be measured. An unobstructed view of the latter is obtained meanwhile, with an eye-piece of the usual form. The first of these instruments is represented in Fig. 4.

The image of the faint object formed by the telescope is viewed by the eye-piece A. The light of the bright star taken as a standard, passes outside the telescope, and falls upon the prism B, by which it is reflected through the objective D of a small auxiliary telescope, and falling on the prism F, is brought into the field of view. The faint object is thus seen in one half of the field with the full aperture of the telescope; while the bright standard appears in the other half of the field, its image being formed by the small telescope. C and E are two Nicols, of which E may be rotated, and the light passing through it reduced at will. G G is a graduated circle, attached to the tube carrying D and E, and measuring the reduction of the light by an index H, which is fixed. The whole photometer may be turned around the axis of the large telescope, the tube carrying the prism enables the latter to rotate around the axis of the auxiliary telescope, and, finally the prism may be tipped around an axis parallel to its edges. Either two of these motions enable the observer to bring any object into the field of view of the small telescope. Practically, the second and third motions were used for the purpose. The first of these movements was reserved almost exclusively for the purpose of placing the prism so that it would conceal the bright star or planet with which the faint object was to be compared, when their distance apart was small. Otherwise, its light as seen in the large telescope, would be so intense as to interfere with the proper estimate of the light of the faint object. I is a lamp, by which the half of the field covered by the prism F may be illuminated, so as to render it as bright as the other half of the field. A piece of blue glass, K, served to vary the colour of the light.

Great difficulty was experienced in obtaining good images of bright stars with the small telescope, on account of the Nicols used. Since the rays passing through E are convergent, aberration is caused by the obliquity of its faces, even if they are plane and parallel. Hence the Nicols were removed, and a new form tried. The lenses of a double-image micrometer being taken out, two V-shaped pieces of brass were attached to the slides carrying the divided lens. A square hole, or "cat's eye," was thus formed, whose dimensions could be altered at will, by turning the micrometer screw. This arrangement is shown in M N, Fig. 6. Placing it near the objective D, Fig. 4, the light was varied by changing the aperture of the small telescope. All these instruments, however, were heavy, difficult to adjust, and not easily removed and replaced. These defects were remedied by still another form, represented in perspective in Fig. 5, and in section, on a scale of one-fifth, in Fig. 6. The same letters are used as in Fig. 4, for the corresponding parts. The faint object is viewed with the eye-piece A, while the light of the bright object, passing outside of the telescope, is reflected by the prism B into the object-glass D, whose aperture

is varied by the screw I, which moves the plates M N. Finally, the prism F throws the light into the field of A. The whole is attached to the tube H, which slides into the end of the telescope. This photometer is light, can be easily removed, and by a suitable adapter may be attached to any telescope. As it forms a single piece, the adjustments are little liable to be disturbed.

In some observations, especially during twilight or moonlight, errors were apprehended from the comparative darkness of that half of the field covered by the prism F. This prism was replaced in other forms therefore by a piece of parallel glass. They were then called photometers E′ and J. The reflected stars they formed were much fainter, and double, one image being produced by each surface of the glass. Still these instruments had the advantage that the field was unobstructed, and the star to be measured might be placed in any desired position, as regards the standard.

The latter class of photometers can be used only in the measurement of faint stars. If the image of the object seen in the large telescope is brighter than that formed by the auxiliary telescope, no setting of the Nicols or micrometer screw will render them equal. This difficulty was obviated by using the photometer shown in Fig. 4, removing the Nicols, and replacing its eye-piece by the concentric tubes referred to in an early part of this analysis. The images of the same object, seen in the large and small telescope, were first compared, and the constant thus found was used in reducing the observations of other objects. The advantages of this photometer are that stars of greatly different brightness and in different parts of the sky may be compared; but the loss of light is great, and the images are seen under different magnifying powers.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The Board of Natural Science Studies have recommended a new set of regulations for the Natural Sciences Tripos, to take effect as regards the first part of the examination, in the Easter Term of 1881, and as regards the second part in Easter Term of 1882. In effect it is intended to provide for a class list in general natural science honours in June each year, founded on aggregate knowledge shown by candidates in the first part of the examination, provided no credit is given in a subject unless the candidate has shown a competent knowledge of that subject. Each of the three classes is to be arranged in alphabetical order. The general arrangement of subjects and practical work has already been settled, but the details will no doubt invite attention. The working of Regulation 6 is rather curious. "In the first part of the examination there shall be a practical examination, either written or *vivâ voce*, or both, in such subjects as the Board of Natural Science Studies shall from time to time determine, provided that in all those subjects in which there is no such practical examination, one or more of the questions in the printed papers refer to objects exhibited at the examination." Regulation 7 states that there is to be a practical examination either written or *vivâ voce*, or both, in each of the eight subjects of examination in the second part. Regulation 14 proposes that, in arranging the class-list for the second part of the examination, the examiners shall have regard to general knowledge and ability as well as to special proficiency in one or more subjects. No candidate shall obtain a first-class for proficiency in one subject unless he show a competent knowledge of some cognate subject. When Human Anatomy is taken as the principal subject, either Zoology and Comparative Anatomy, or Physiology, be taken as a necessary cognate subject. Regulation 15 includes the following:—In each case of giving a first-class in the second part of the examination, the examiners shall specify the subjects for which the candidate is so placed, or the reason for specially distinguishing him.—A discussion in the Arts School on the proposed regulations for the Natural Sciences Tripos (on October 31), was opened by Mr. Sedley Taylor expressing great doubts about the desirability of giving such a prominent place to human anatomy in an honours examination. He read to those present the opinions of three eminent physiologists and anatomists specially obtained by himself on this point, and they were, on the whole, against the proposed regulation as unnecessary, if human anatomy were to be taught in the only way in which it could fairly enter into the Tripos, for its general and not its professional value, while usually the memory work involved was enormous, and such as to be of quite technical character. Dr. Humphry strongly supported the regulations and the distribution of subjects, as a method of aiding in preserving a scientific study of human anatomy. Dr. Paget dissented strongly from this view, not as a means of discouraging the study of anatomy, but to lessen the strain of constant change by questions which went to the root of the matter. He believed no sufficient settlement could be expected unless or until the Tripos was divided into two—biological and non-biological; it was unwieldy and unmanageable in its present state. Surely it was not impossible to frame some division of subjects which might secure this and be found workable. Mr. Balfour did not agree with the way in which human anatomy was regarded as so far apart from the anatomy of all other animals as to gain such distinctive marks, while no such division was made in physiology. Mr. Trotter thought it would be quite impracticable to enter upon the discussion of the Tripos at present, and that it would be impossible to divide the subjects into biological and non-biological. The geologists would object. Mr. J. N. Langley testified to the difficulty men often found in choosing or combining their subjects. Mr. Bettany strongly supported Dr. Paget's projected division of the Tripos into two, but with this difference, that men who gained a degree in the first part of the Tripos, as now proposed, in the "comparatively elementary" parts of the subjects, should be allowed to gain their final class in either biological or non-biological subjects, without such complex and often uncertain or vague regulations to puzzle candidates.

THERE can be little doubt as to the health of Cambridge being good, and the increasing confidence in Cambridge as a place of education, in view of two facts, viz., that the death-rate during the Michaelmas quarter has been only at the rate of thirteen per thousand, per annum; including only six deaths from the seven principal zymotics; and that the entry of freshmen at the colleges this year is the largest ever known, having increased by at least one hundred. It is the more incumbent on the university or the colleges, to see that space for exercise, recreation, study, and sleeping are fully provided for every undergraduate, and to take an active part in preventing disorderly men from remaining to vitiate others; and it is equally the duty of every wise man not to tempt our youth into overstrain of body and mind.

MR. PATTISON MUIR, Caius Prælector in Chemistry, lectures on the Metals this term, and also on Advanced Systematic Chemistry to Tripos candidates. Professors Liveing and Dewar have issued a notice of great importance to those desirous of prosecuting researches in chemistry. The new rooms added to the Chemical Department will enable them to accommodate a limited number of students who have had the necessary training and are desirous of prosecuting chemical research or of acquiring skill in special branches of chemistry. Applications for permission to prosecute researches must be made personally to the Professors, and all investigations must be subject to their approval. Mr. A. Scott, B.A., Prof. Dewar's assistant, will have the general superintendence of this part of the laboratory.

A COURSE of practical instruction in Experimental Physics will be given in the Cavendish Laboratory during this term. The course will be adapted to the requirements of beginners, and demonstrations will be given daily at times to be arranged with the members of the class. Thus again one of the most necessary classes is to be provided, but we trust Mr. Garnett's energies in this department will not be overtaxed.

OXFORD.—In a congregation to be held on November 18, the amendments to the proposed statute respecting degrees in Natural Science will be considered. As the proposed statute now stands, scholars in the Faculty of Natural Science may offer for Responsions Greek and Latin, or Greek or Latin with either French or German, and shall also be examined in arithmetic, the elements of plane geometry and algebra up the binomial theorem. An amendment has been proposed by Prof. Rolleston to substitute the elements of deductive logic for algebra beyond proportion. In moderations (first public examination), Prof. Rolleston proposes to insert deductive and inductive logic as an alternative for algebra. Candidates will be obliged to offer either Greek or Latin, with either French or German, and will be examined in the theory of logarithms, Euclid, trigonometry as far as the solution of plane triangles, and elementary mechanics. The council have proposed amendments abolishing those clauses granting the rights of Masters of Arts to Masters of Natural Science, since counsel's opinion has given it to be beyond the power of the University to grant such privileges to a new faculty. The council will accordingly propose a decree authorising the Vice-Chancellor to take whatever steps may be necessary to ob ain