

of symmetry. The first-order lights, Anvil Point (Dorset), the Eddystone, and the Minicoy (Indian Sea), were constructed on this principle at Birmingham (1880-83). In the case of the Eddystone, two apparatus exactly alike were employed by the Trinity House—one superposed on the other, and each lighted by its own lamp, the whole height of optical glass exceeding 12 feet. The plan of superposed lenses was first suggested, in 1859, by Mr. J. W. D. Brown, of Lewisham, and first practically set forth, in 1872, by Mr. John R. Wigham, an engineer of conspicuous ability, in connexion with his large gas flames for Irish lighthouses; and it has been since fully approved and adopted by the Trinity House. The great lights of Galley Head, Howth Bailey, and Rockabill attest the excellence of this arrangement of lenses, and the Eddystone biform (1881) is not less successful.

The enhancement of illuminating power through the amplification, vertical and horizontal, of lenticular panels has been described. But a more emphatic change, associated with the name of Stevenson, has recently been consummated. The radius or focal distance of Fresnel's first-order light is 920 millimetres. The Fresnel of our time proposed a radius of 1330, and such a lens has been already constructed in France. The name "hyper-radiant," given to it by Mr. Stevenson, seems hardly so accurately formed as "hyper-radial," which was independently suggested by the writer in 1885, although the new lens will be excellently adapted to the large flames of the day, at once utilizing their volume and not suffering from their heat. In the lights for the Bishop Rock and Round Island (Scilly) now (1887) being prepared by Messrs. Chance for the Trinity House, the apparatus will be of the hyper-radial type, and it will have a vertical angle of  $80^\circ$ , with glass all of the usual refractive index. There will be for each lighthouse a biform structure 15 feet high, the Bishop having lenses for white double flashes arranged in a pentagon of five groups, each lens subtending  $36^\circ$  horizontally, with an eight-wick burner; and the Round Island having lenses for red single flashes, each lens subtending  $60^\circ$  horizontally, with a ten-wick burner. Petroleum will be used in both cases. The latter apparatus would seem to mark the maximum limit of dimension, with regard to optical agents and to illuminants, compatible with the present conditions of lanterns and towers. Hyper-radial apparatus is also being prepared in Paris for the Tory Island and Bull Rock lights in Ireland.

But the true maximum of power or intensity for lighthouses must ever be sought in the electric light. This application of the branch of physical science that has perhaps more than any other distinguished the Victorian epoch had its experimental beginnings, under the auspices of Faraday, at Dungeness and the South Foreland. The apparatus used at Dungeness was of 150 millimetres radius. In 1881 the apparatus for Macquarie was constructed of 920 millimetres radius. Six large electric lights have been established in Britain since 1862, all the work of Messrs. Chance, and all of their design except the Isle of May, which was planned by Mr. Thomas Stevenson. The Souter Point light, revolving, of second and third order elements, dates from 1871; the South Foreland, High and Low, fixed, of the third order, from 1872; the Lizard fixed lights, of the third order, from 1877; and the Isle of May, which gives a fourfold flash, and is of first and second order radii, from 1886. In addition, there have been designed by Dr. Hopkinson, and made at Birmingham, the Macquarie (Sydney), a first-order revolving, the most powerful light in the world, and the Tino (Spezia), a second-order triple group-flashing light. It is needless to give details of these apparatus, which are throughout distinguished by skilful optical combinations and the utmost precision of workmanship. They have all been, with the exception of the Isle of May, the subject of elaborate papers and exhaustive dis-

cussion before the Institution of Civil Engineers. An apparatus of the second order is being prepared at Birmingham for the new electric light of St. Catherine's (Isle of Wight). It is composed of refractors only, extended to  $97^\circ$  of vertical angle, and with certain special arrangements for divergence. The carbons will be of 50 millimetres diameter and of a novel and perfect form.

There has been during the past fifty years, but especially since 1861, with regard to lighthouse characteristics, a selective process in operation by which the fittest have survived. Not only has the optical apparatus been perfected in curvature, finish, and adjustment to nautical conditions, and the intensity of light increased threefold, but the weaker forms of distinction have been suppressed, and the better forms retained and multiplied. Fixed lights for the most part have been discontinued, and, in this country at least, lights composed of fixed and revolving portions. Long periods in revolving lights have been altered to short periods, the uncertain aid of colour largely abandoned, the varieties of the group-flashing system invoked, and the quick contrasts of light and dark resorted to in occulting or intermittent apparatus, although the very ingenious but too complicated plan of Babbage, with its rhythmical longs and shorts, has not prevailed. The enhanced speed of steam-vessels, the multiplication of all kinds of vessels, the improvement of shore-lights, and the spread of commercial enterprise, by which new ports are opened and new coasts explored, have naturally effected these changes. And, *pari passu*, striking improvements in the mechanism of revolving carriages and of clockwork both with weights and springs, in occulting-cylinders and gun-metal framing of apparatus, have resulted from the combined efforts of our best lighthouse engineers.

The early rivalry between the catoptric and the dioptric systems has wholly ceased, the latter having, by the weight of its general and well-tried superiority, displaced the old system in all directions save in one or two revolving sea-lights of exceptional merit, like Beachy Head or St. Agnes, and save in all light-vessels where the excellent 21-inch reflectors, with the two-wick Douglass burners, often send out beams of 20,000 candles over the shoal-beset waters.

There were in the United Kingdom, in 1886, 202 sea-lights, of which 147 were dioptric and 55 catoptric, and, in addition, about 450 small lights of all kinds, making, with the 74 light-vessels, a total of about 730. Surely this is a noble growth of lighthouse illumination, even in the long period under review. It compares not unfavourably with the United States, the first country to adopt the lenticular system on a bold and comprehensive scale, or even with the country of Fresnel himself and of his brother Léonor, where the elucidations and experiments of Allard and of Reynaud, and the practical work of Lepaute, Sautter, Barbier and Fenestre, have done much to promote science and benefit humanity.

J. KENWARD.

(To be continued.)

#### THE OBSERVATORIES AT OXFORD AND CAMBRIDGE.

THE following is the Annual Report of the Rev. Prof. Pritchard, the Savilian Professor of Astronomy at Oxford, to the Board of Visitors of the University Observatory; read June 8, 1887:—

I. *Lectures.*—The statutory lectures have been given, and the Observatory and its instruments have been freely accessible to the students during every day of Term time. For next Term I offer a course of elementary lectures expressed as far as possible in untechnical language. I desire to add also two public lectures on the development of astronomy during the last century.

II. *Instruments*.—As a matter of practical convenience, portions of both the equatorial instruments have been within the last day or two placed in the hands of the opticians, with a view to modifications or repairs which shall render them applicable to the entirely new departure which is now in progress in respect of the processes and methods of practical astronomy. The De la Rue equatorial, which has long possessed an historical value, has been rehabilitated mainly at the expense of Dr. De la Rue in certain of its more delicate working parts, and this has been so advantageously completed that Dr. De la Rue has been induced to introduce still further renovations, whereby that instrument will be placed in a condition probably equal to that in which it first left its designer's hands.

The mounting of the large equatorial refractor, originally supplied at the expense of the University, is now required for some experimental inquiries suggested by the Photographic Committee of the Royal Society. Dr. De la Rue has supplied two mirrors of 15 inches aperture of different focal length, and these are to be mounted alternately on the tube of the refractor, together with a camera as arranged by Mr. Grubb. The expense of these valuable additions is borne by the Royal Society and by Dr. De la Rue. The delicacy of the projected inquiries necessitates the electrical control of the driving-clock.

The transit-circle recently presented to the University by Mr. Barclay has realized my expectations of its excellence. I find it to be thoroughly stable, and sufficient for all the purposes required, whether for University instruction or for accurate meridional observations. In the latter respect it completes the Observatory equipment. The electrical illumination of the circles and other necessary parts has proved entirely successful, and the general aspect of the instrument as it stands on its massive piers is such as to suggest confidence.

III. *Buildings*.—The fabric of the building and its complicated roofs and domes are in excellent substantial repair, and will require no outlay that I can foresee during the present year.

IV. *Astronomical Work*.—The somewhat hazardous enterprise of attempting for the first time in the history of astronomy to obtain the distance of the fixed stars from our earth by the aid of photography has been attended with success. The final results of the investigation have been placed in my hands only during the writing of this Report. The first observation was obtained on May 26 of last year, and the last was effected on May 31 of the present year. The intermediate computations were systematically continued during the interval. They involved the reduction of no less than 30,000 bisections of star images, or 330 photographic plates, procured on 89 nights. Eight independent determinations of the parallax of the two components of 61 Cygni resulted from all this work, and these happily indicate a substantial agreement between themselves, and afford other necessary proof of reliability.

By a happy coincidence, on the very day when the final results of these investigations were evolved, I had the pleasure of a visit from Her Majesty's Astronomer at the Cape of Good Hope, a practical observer whose experience in parallactic investigations is probably unrivalled. His remarks, after critical examination of the entire work, have encouraged and gratified me. Astronomical photography is hereby placed on a secure basis as an efficient and exact exponent of the highest form of astronomical science.

Simultaneously with these observations, similar work has been in progress for the determination of the parallax of  $\mu$  Cassiopeiæ and Polaris. These observations will now be treated on a less laborious scale. Photographic plates of the Pleiades have also been taken with the view of obtaining the accurate relative positions of about one

hundred stars therein. The necessary triangulations have been commenced.

I should say that the experimental investigations required by the Photographic Committee of the Royal Society originated in the necessity of ascertaining what are the limits of accurate field obtainable from mirrors of different focal lengths: the inquiry had distinct reference to the questions which were open for discussion at the recent Paris International Conference. I deeply regret that I was unable to fulfil my intention of taking part (as invited by Admiral Mouchez) in that important meeting.

V. *Finance*.—The funds granted by the University have been sufficient, notwithstanding the continuous activity, which requires a corresponding continuity of outlay. This grant, hitherto triennial, expires on December 31 next. If the Board of Visitors see fit to request the University to continue this grant for five years, it would assist me in undertaking, for the University, a share in the production of a photographic map of the heavens, a valuable and extended class of work, which under other circumstances I should not be justified in contemplating.

The details given above testify without further words of mine to the unwearied perseverance and intelligence of my two able assistants, Mr. Plummer and Mr. Jenkins.

Prof. J. C. Adams has just presented the Report of proceedings in the Cambridge Observatory, from May 27, 1886, to May 26, 1887. From this Report we take the following extracts:—

The total number of observations made with the transit-circle during this interval, for determinations of right ascension and north polar distance, is 2253.

These include 726 observations of clock stars made on 151 nights; 68 observations of Polaris at the upper transit involving 169 circle readings, and 61 observations at the lower transit involving 149 circle readings; 1331 observations of zone stars made on 88 nights; and 67 observations of stars compared with the minor planet Sappho.

For instrumental adjustment, the nadir point was observed 218 times, the bisections of the declination wires with their images being in every case made in two positions of the observer, on the north and south sides of the tube respectively; the level and collimation errors were each observed 217 times.

At the request of Mr. Bryant, F.R.A.S., the planet Sappho was compared with adjacent stars 70 times on 7 nights from January 12 to February 2, by means of the Northumberland equatorial and square bar micrometer for differences of right ascension and declination. Before the end of February all the compared stars were repeatedly observed with the meridian circle; and in addition to this 9 stars which had been compared elsewhere with Sappho.

*State of the Reductions*.—The true right ascensions are obtained up to February 17, 1887, and the true north polar distances to April 27, 1887.

The mean right ascensions and north polar distances for January 1, of the standard stars are calculated to the end of 1886, as are also nearly all the observations of stars made in the present year for comparison with Sappho. The mean R.A. and N.P.D. of the zone stars are similarly reduced up to the end of 1881. The right ascensions of zone stars are reduced to the epoch 1875 as far as March 16, 1878, and the north polar distances to March 1880.

The collection of the observations of the zone stars for the Catalogue has been commenced.

A fresh determination of the intervals of the right ascension wires from 73 observations of Polaris, from 1885 November 17 to 1886 July 6, was completed on July 12. As no change seems to have taken place in the wires, the results were combined with those previously

obtained: so that the final determination rests on 145 observations of Polaris made from 1885 January 21 to 1886 July 6. These intervals were used till 1887 March 3, since which time another determination, from 78 observations of Polaris, from 1886 July 7 to 1887 April 27, has been used.

Sixty-five observed north polar distances of Polaris above the pole, deduced from observations made in 1886, with observed nadir point and assumed colatitude  $37^{\circ} 47' 8''.4$ , and corrected for flexure and errors of division, give a north polar distance less than that given in the *Berliner Jahrbuch* by  $0''.557$ : 68 observations below the pole, treated in the same way, give a polar distance greater than the Berlin one by precisely the same quantity. Thus our polar distance of Polaris for 1886 is exactly equal to the Berlin one, and the correction of assumed colatitude is  $+ 0''.557$ ; results very similar to those of previous years.

The observations of Polaris above the pole, direct and reflected, made by Miss Walker on 1886, April 8, May 3, 4, and 6, when corrected for errors of division and for refraction, give for the colatitude  $37^{\circ} 47' 8''.853$ . The mean for eight years, given in the last Report, is  $37^{\circ} 47' 8''.854$ .

579 observations of clock stars made by Mr. Graham in 1886, Mr. Todd in nearly every case reading the circle, give, as a mean value for reduction to the Berlin N.P.D.  $+ 0''.353$ ; or, if we take the means for each separate night as of equal weight,  $+ 0''.319$ . These have not been corrected for errors of division and flexure, which, for the limits of the zone,  $60^{\circ}$ - $65^{\circ}$  N.P.D., have probably a mean value of  $- 0''.26$  or thereabouts; this would have to be applied with an opposite sign to the above means: but the results for intervals of  $1^{\circ}$  show that the errors of division ought to be determined for each star, as they have been for Polaris and for the nadir point.

*Meteorological Observations.*—The meteorological observations continue to be communicated daily by telegraph to the Meteorological Office.

The sunshine recorder has been regularly employed, and the records are sent at intervals to the Office.

#### NOTES.

IN the distribution of Jubilee honours the claims of science have not been forgotten. Among those who have been raised to the peerage we are glad to see the name of Sir William Armstrong, C.B., F.R.S. The honour of knighthood has been conferred upon Warington Smyth, Esq., F.R.S.; Dr. Garrod, F.R.S.; G. H. Macleod, Esq., Queen's Surgeon, Edinburgh; and J. Wright, Esq., C.B., late Civil Engineer to the Navy. Among the new Knights Commanders of the Bath are John Simon, Esq., M.D., C.B., F.R.S., late Medical Officer, Privy Council Office; and Capt. Douglas Galton, C.B., F.R.S.; Prof. W. H. Flower, F.R.S., British Museum, and Prof. Brown, Agricultural Department of the Privy Council, have been made Companions of the Bath.

THE names of the following gentlemen have been added to the list of the Tyndall Dinner Committee:—The Duke of Northumberland, President of the Royal Institution; Sir W. G. Armstrong, F.R.S., ex-President of the Society of Mechanical Engineers; Dr. Haughton, F.R.S., President of the Royal Irish Academy; E. H. Carbutt, Esq., President of the Society of Mechanical Engineers; and G. B. Bruce, President of the Institution of Civil Engineers.

MR. HARFORD J. MACKINDER, M.A., has been elected Reader in Geography at the University of Oxford.

IN the Report on the Oxford Observatory, which we print to-day, reference is made to important improvements effected, either wholly or in part, at the cost of Dr. De la Rue. We

may add to what is there stated that Dr. De la Rue generously offers £500 to convert the Oxford 12 $\frac{1}{4}$ -inch refractor into a Henry photographic telescope—practically, to buy a new object-glass.

THE annual general meeting of the Marine Biological Association will be held to-morrow in the rooms of the Linnean Society. The Laboratory on the Citadel Hill, Plymouth, erected by the Association at a cost of £9000, will be opened for work in the summer, and the Council are anxious to co-operate in the foundation and management of laboratories on other parts of the British coast.

MISS OLDFIELD has presented to the Herbarium of the Royal Gardens, Kew, the botanical collections made in Australia by her late brother, Mr. Augustus Oldfield. This gentleman was, as stated by Mr. Bentham in the preface to "The Flora of Australia," an acute observer as well as "an intelligent collector." His series of *Eucalypti* are especially good, as he took great pains to obtain the various forms of foliage characteristic of each species, as well as the fruiting and flowering stages. Sir Joseph Hooker used his Tasmanian plants in his "Flora" of that colony. Mr. Oldfield "made large additions to the West Australian plants previously known." These collections were placed at Mr. Bentham's disposal for the purposes of his "Flora Australiensis."

THE biennial Exhibition of Agriculture and Entomology in Paris will take place from August 27 next to September 29, at the Orangerie, one of the terraces of the Tuileries Gardens. The French Minister of Public Works is the President of the Society which organizes the display.

THE Pilot Chart of the North Atlantic Ocean for June, issued by the Hydrographic Department of Washington, states that Capt. Lassen, of the Norwegian barque *Petty*, while in lat.  $17^{\circ} 38' N.$ , long.  $46^{\circ} 34' W.$ , on April 1, experienced three distinct shocks of earthquake, diminishing in force, and accompanied by strong eruption of air-bubbles, covering the surface during the continuance of the shocks. The ice-reports show large numbers of bergs north of lat.  $42^{\circ}$ , and between long.  $47^{\circ}$  and  $53^{\circ}$ .

ON June 1, M. Hervé Mangon, President of the Council of the French Central Meteorological Office, read the ninth Annual Report of the work of the Office (see *NATURE*, vol. xviii. p. 96). It shows satisfactory evidence of continued energy and progress in all departments of the service. No less than 154 telegraphic reports are received daily from Europe and Algeria, and 41 telegraphic summaries and weather forecasts are issued, including one to a London daily paper. The success claimed for the forecasts is 88 per cent., and for the warnings of storms 82 per cent., being a greater success than in any previous year. There are 153 climatological stations (including 12 observatories) taking not less than 3 observations daily, in addition to a large number of minor stations. The Office is also actively engaged in collecting observations made at sea, and received upwards of 500 log-books during the past year. This branch is encouraged by the presentation of medals, awarded by the Association Scientifique to the best observers. M. Hervé Mangon reviewed the work of the various observatories, and referred especially to the investigations of M. Renou, at St. Maur, who has just completed an inquiry into the rainfall for the last 200 years, and is finishing a work on the climate of Paris, on which he has been engaged for 40 years. Reference is also made to the reports now received daily from America and the Atlantic, of which our own Meteorological Office bears half the cost. The telegrams are regularly published in the French *Bulletin International*. The other half of the expense of these telegrams is borne by a lady whose name is not generally known. M. Hervé Mangon spoke at great length of the damage