

chirus peregrinus) from Australia, two Nicobar Pigeons (*Calanus nicobarica*) from the Indian Archipelago, purchased; a Reticulated Python (*Python reticulata*) from Malacca, received in exchange; a Thar (*Capra jemlaica*, ♀), a Red Deer (*Cervus elaphus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

OCCULTATION OF REGULUS.—On June 26 there will be an occultation of Regulus, magnitude 1.5. The disappearance will take place at 8.4 p.m., while the sun is still above the horizon, and the star will reappear at 8.56—that is, about 37 minutes after sunset at Greenwich. The point of disappearance will be at an angle of 147° from the north point towards the east, and of reappearance at 275° reckoned in the same direction. The age of the moon will be a little less than 4 days.

THE RECURRENCE OF ECLIPSES.—A new period of the recurrence of eclipses, which promises to be of great use in the discussion of ancient eclipses, has been investigated by Prof. J. M. Stockwell. (*Astronomical Journal*, No. 346.) He points out that 372 tropical years are very nearly equal to 4601 lunations; and also very nearly equal to twenty revolutions of the moon's node; thus:

372 tropical years	= 135870.10348 days.
4601 lunations	= 135870.23425 "
20 revolutions of node	= 135870.700 "

During this period, the change of mean longitude of the sun and moon at the time of new moon is $-5^{\circ}05'$, of the longitude of the moon's perigee $+11^{\circ}46'$, and of the longitude of the ascending node $+0^{\circ}02'$. The precession of the equinoxes during 4601 lunations amounts to $5^{\circ}13'68''$, so that the mean longitude of the sun and moon when referred to the movable equinox only changes by $0^{\circ}07'97''$ in a period of 372 years. From this it follows that if an eclipse happened on a given day of the tropical year, there would be another eclipse on the same day of the tropical year 372 years afterwards.

As an example of the application of this new cycle, Prof. Stockwell gives particulars of an inquiry into an eclipse of the sun which is said to have been observed in China on the day of the autumnal equinox during the twenty-second century B.C. According to Oppolzer, an eclipse occurred at the autumnal equinox in the year B.C. 1039, October 3, and going back three periods of 372 years, the year 2155 B.C. is deduced; other eclipses about this time are found by adding multiples of nineteen years to that date. The discussion of the conditions shows that the eclipse which satisfies the tradition occurred on October 10, 2136 B.C.; this would be visible as a partial eclipse over nearly the whole of China. According to a well-known story, the astronomers Ho and Hi were put to death for having failed to predict this eclipse.

VARIABILITY OF NEBULÆ.—One of the best authenticated cases of a variable nebula is that discovered by Hind in 1852 in the constellation Taurus. The nebula was then easily seen in ordinary telescopes, but D'Arrest was quite unable to see it in October 1861, though it was detected shortly after as an exceedingly faint object in the Pulkowa refractor, and in the following year was seen a little brighter with the same telescope. In 1868, however, the nebula was invisible to Struve, but another nebula was discovered 4' preceding. Struve's nebula was subsequently observed by D'Arrest, who testified to its absence in previous observations of the neighbourhood; it was seen also by Tempel in November 1877, but was not visible to him a month later. The interest attaching to this region was increased when, in 1890, Mr. Burnham found that τ Tauri was involved in nebulosity; this was confirmed by Prof. Barnard, who also observed that Hind's nebula was only just visible with the Lick telescope, while Struve's nebula was not perceptible. In a paper recently communicated to the Royal Astronomical Society, Prof. Barnard states that on February 25 of the present year he found Hind's nebula to be an easy object, while Struve's nebula was absent, and the nebulosity round τ Tauri had practically faded to invisibility. Further observations on March 24 showed that Hind's nebula was again scarcely visible, while τ Tauri was distinctly nebulous, and a faint nebula was suspected in the position assigned to Struve's nebula (*Observatory*, June).

It thus appears that there are really three variable nebulae in this region, and the observations rather suggest that there is a connection between them. In 1890, Prof. Keeler found that the

nebulosity round τ Tauri was probably of the bright-line type, but nothing seems to be at present known as to the spectra of Hind's and Struve's nebulae. On the meteoritic hypothesis, changes in the brightness of nebulae are due to the interpenetration of nebulous streams and sheets.

THE ZI-KA-WEI OBSERVATORY.—The Zi-ka-wei (or Sicawei) Observatory, near Shanghai, was founded in 1873 by the French Roman Catholic Mission of Kiang-nan, and provided with the instruments necessary for the study of meteorology and terrestrial magnetism. Since that time, excellent service to commerce and to science has been rendered by the Observatory, by the daily publication of weather bulletins, and the issue of a number of important memoirs. Up to the present, however, astronomy has received little attention at Zi-ka-wei. Twelve years ago, the Municipal Council of the French Settlement furnished the Observatory with a small transit instrument for time determinations in connection with the time-ball service then established, but that instrument represents the whole astronomical outfit. Recognising this deficiency, Father Chevalier, the Director of the Observatory, has made an appeal for funds to purchase a good equatorial telescope. The English Settlement at Shanghai has voted a sum of £400 towards the cost of the instrument, and the French Settlement has granted a like amount. The shipping companies at Shanghai have also promised a sum of about £400, so that £1200 may be taken to be already available. But Father Chevalier wishes to have an instrument with an aperture of about twenty inches, and for this the money already subscribed is insufficient. He has therefore appealed to friends of science in France, America, and England for a sum of about £1000 more. If this is contributed, he hopes to have erected a great equatorial, and to accomplish valuable work with it.

THE ROYAL SOCIETY CONVERSAZIONE.

THE rooms of the Royal Society at Burlington House were filled last Wednesday evening, when the annual conversazione to which ladies are admitted took place. Some of the exhibits were shown at the conversazione on May 1, and have already been described in these columns. Following our usual custom, we only give descriptions of new exhibits.

Perhaps the most striking feature of the evening was the telephonic communication with Edinburgh, Glasgow, Belfast, and Dublin, practically shown by the Postmaster-General. The line used is the first link of the great Trunk Telephone System erected by the Post Office, which will eventually place the chief towns in the British Isles in direct communication with each other. The wires to Ireland extend through Leeds and Carlisle to Portpatrick, thence by cable across the North Channel to Donaghadee, and thence to Belfast and Dublin, the distance by this route from London to Dublin being 467 miles. The lines are so carefully laid that it was easy to converse with persons at the places connected by them, without being disturbed by the foreign sounds usually associated with telephonic communications.

An electograph for indelible linen marking was shown by Messrs. Nalder Bros. and Co. The instrument is used as follows: the fabric is damped and a current is passed for about two seconds from a silver die, carrying silver into the fabric wherever the die touches. The current is then reversed for three seconds, which reduces the silver in the fabric; the final result being the same as with ordinary marking-ink, viz. that metallic silver is deposited in the tissue. Plain water can be used, but a salt solution is preferable, as the result is much more quickly obtained.

Models illustrating Lewis and Hunter's patent coal shipping system, as in use at the Bute Docks, Cardiff, were exhibited by the Bute Docks Company. With this system the coal is shipped in very much better condition than with the old systems; and owing to the construction of the carrying-boxes, with a cone valve or bottom, which is only released to let the load out when it is lowered down into the hold of the vessel, within some 18 inches of the flooring of the ship or the cargo, as the case may be, the breakage is greatly reduced. Each crane is capable of loading 300 tons per hour.

Prof. C. V. Boys illustrated the projection of ripples, and showed a logarithmic chart of wave and ripple velocities and frequencies. Ripples produced by tuning-forks are so small, and travel so quickly, as to be invisible unless illuminated either instantaneously or intermittently at the proper rate. They are then visible, and the relations of velocity and frequency can be

illustrated. Both tuning-forks and a mechanical device were employed to produce the ripples. By the use of "scale lines," the logarithmic chart was made more comprehensive than usual. The lines were employed to illustrate the effect of all possible variations of gravity and of surface tension divided by density upon velocities and frequencies of waves and ripples.

Mr. J. Norman Lockyer, C.B., had three exhibits. One was a photograph of apparatus employed for collecting the gases obtained from minerals by the distillation method. A small retort containing the mineral is connected with an end-on spectrum tube joined on to a Sprengel pump. After exhaustion, the mineral is heated to redness, and the spectra of the gases evolved at the various stages, as exhibited by the spectrum tube, are both observed and photographed. The gases are collected in a "steeple" at the foot of the fall tube of the pump, and they can then be observed at atmospheric pressure. The second exhibit consisted of photographs of the spectra of Bellatrix, and of a part of the solar chromosphere, showing coincidences with the lines photographed in the spectra of the gases obtained from uraninite. The photographs showed a close relation of the new gas or gases to solar and stellar phenomena. They appear to point to the *vera causa*, not of two or three, but of many of the lines which so far have been classed as "unknown." The spectrum of Bellatrix was photographed at South Kensington with a 6-inch prism of 45°, and that of the solar chromosphere with the same instrument during the total eclipse of the sun, 1893. Mr. Lockyer also exhibited photographs of the spectra of the new gases. In the preliminary experiments, the new gases have not been separated from the known gases which come over with them, so that the spectra exhibited contained many known lines. The photographs illustrated: (a) The presence of the yellow line (D_3) in some instances with the blue line 4471, and in others without it. (b) The presence of the yellow line in some spectra with an ultra-violet line at 3889, and in others without it.

Dr. A. A. Common exhibited the following silvered glass mirrors: (1) 21-inch convex mirror, 54-inch radius, being the small mirror of an oblique Cassegrain reflecting telescope. (2) 20-inch concave mirror, 90-inch radius, spherical curve. (3) Two 16-inch plane mirrors for heliostats to be used at the 1896 total solar eclipse.

Mr. A. E. Tutton exhibited an instrument for cutting, grinding, and polishing accurately orientated plates and prisms of crystals of every degree of hardness. The instrument combines an accurate reflecting goniometer with a diamond-edged cutting disc and grinding and polishing laps. The adjusting segments of the goniometer are graduated, in order that the crystal may be adjusted so that the desired direction in it can immediately be brought parallel to the cutting disc or grinding lap. Numerous interchangeable laps are provided suitable for all classes of crystals, and the interchange may be effected with great readiness. A counterpoising arrangement is also provided which enables the pressure with which the crystal bears upon the lap to be nicely adjusted, according to the strength of the crystal. The instrument may either be driven by hand or by means of any form of small motor.

Mr. A. P. Trotter showed a model illustrating the relation of volts, amperes, and length of electric arc. The model was made from the diagrams in Prof. Ayrton's paper, read before the Chicago Congress, and described in Mrs. Ayrton's article in *The Electrician*. Drawings of the electric arc were shown by Mrs. Ayrton. The drawings were in sepia, and ten times the full size. They showed the form of the arc produced with a current of 20 amperes between a positive carbon 18 millimetres in diameter, and a negative one 15 millimetres in diameter, when the arc was respectively 4, 7 and 18 millimetres long. From the drawings it could be seen that using a *coiled* positive carbon *diminishes* the visible part of the arc, and, when the arc is long, causes the central portion to become gourd-shaped.

The Applied Mathematics Department of University College showed a series of diagrams, calculated and prepared by Miss Alice Lee, to illustrate the time-decay of the field due to a Hertzian oscillator. The late Prof. Hertz prepared four diagrams to illustrate the nature of the field in the neighbourhood of an oscillator giving a stable wave train. His theory requires modification, owing to every Hertzian oscillator really giving a rapidly damped wave train. Miss Lee's diagrams illustrated the changes in the field during 6½ complete oscillations. Four systems of curves gave the points of the field with relative strengths 50, 30, 10 and 1. The decadence of the field was repre-

sented not only by the gradual change of shape of the curves, but by the complete disappearance of the curves of greater strength. When the series is complete, it is proposed to reduce it by photography and use it in a "wheel of life," to illustrate the decadence of an oscillator-field.

A curious model for showing the gyroscopic properties of a wheel was exhibited by Mr. Killingworth Hedges. The wheel was represented by a rim, having within it a heavy inner disc which could be made to revolve rapidly on the axis of the wheel. When the wheel was allowed to roll slowly down an inclined plane, and the inner disc was made to revolve in the same direction as the wheel, they both assisted to keep the system upright. When, however, the inner disc revolved in the opposite direction to the wheel, the system was in a state of unstable equilibrium which caused a rapid revolution through 180°, when both the wheel and the inner disc revolved in the same direction, and so produced a state of stable equilibrium.

Four photographic views taken by Mr. W. Bartier, and illustrating the accumulation of ice on the river near the Beckton Gas Works, North Woolwich, in February of this year, were shown by Mr. G. J. Symons.

Photographs of curvilinear crystals of water were exhibited by Dr. Gladstone, F.R.S. The photographs were taken during the severe frost of last February, and showed the forms assumed by the vapour when frozen upon a shop window, and the glass roof of a photographer's studio. All the lines of the crystals were curved. Another exhibit by Dr. Gladstone consisted of a blue photograph showing the way in which a solution of sodium salts mixed with some earthy matter and water may be made to crystallise on evaporation. This specimen showed many spiral forms. It, and the original specimens, were prepared by Mrs. M. Watts Hughes.

Prof. A. G. Greenhill and Mr. T. I. Dewar exhibited an algebraical spherical catenary. By a special choice of the constants, depending upon the quinquisection of the period of the associated elliptic functions, the general equations of the spherical catenary, considered by Clebsch in Crelle, 57 were shown reduced so as to make the projection of the chain on a horizontal plane a closed algebraical curve of the tenth degree.

A number of interesting Japanese pictures, selected to illustrate the effects of time on the pigments used by the old painters of Japan (A.D. 1322 to the early part of the 19th century), were exhibited by Mr. W. Gowland. The chief pigments used in these pictures were as follows:—Greens and blues: carbonates of copper. Permanent blue: the mineral *Lapis lazuli*. Reds: red oxide of iron, vermilion, carmine. Permanent white: leigated oyster-shells. Black: soot prepared from the oil of *Sesamum Indicum*.

Tropical American butterflies, selected to show the existence of common colour-types among species associated in the same areas, were exhibited by Mr. W. F. H. Blandford. The phenomenon (*Homœochromatism*) is observed chiefly among species of the sub-families *Danainæ* and *Heliconiinae*, but frequently species of other sub-families conform to the prevailing colour-type. To a particular class of cases of colour-resemblance the term "mimicry" has been applied. The series shown comprised:—(1) Species of *Heliconius* associated in pairs, the colour-type varying with the distribution from north to south. (2) Species of different genera (*Tithorea* and *Heliconius*) associated in pairs, and sometimes mimicked by butterflies of other families. (3) Homœochromatic types from various districts represented by numerous species in different families, sub-families and genera.

Minutiae in finger-prints formed the exhibit of Mr. Francis Galton. The exhibit furnished an illustration of the exceptional trustworthiness of the finger-print method in determining questions of identity. It demonstrated that in a case of twins, whose portraits, classificatory measures, and finger-print formulae were closely alike, the finger-print minutiae were quite different. A second exhibit of Mr. Galton's was the print of the hand of a child eighty-six days old. An enlargement of this print showed the development of the ridges at that early age.

Mr. B. Harrison exhibited Eolithic implements from the chalk plateau of Kent. The implements were found by the exhibitor in pits, dug under the auspices of the British Association. Stones were shown which were thought to bear evidence of use as tools, naturally of suitable shapes, but improved upon by chipping round the edges where required.

The Curator of the Maidstone Museum showed a series of nine photographs (with map, ground plan, and section) of a

supposed Roman Mithræum or Mithraic temple discovered on the east bank of the river Medway at Wouldham, near Maidstone. The temple, or "cave," was found by workmen while engaged in removing sand for ballast, and excavated under the superintendence of the exhibitor. It had apparently been built into the bank, standing east and west, measuring 40 feet in length and 20 feet in width. Numerous fragments of tiles, samian and other pottery, animal bones, and a coin of Constantinopolis were found in the *filling*, but no statuary or inscriptions. So far this "cave" is the only one found south of the river Tyne.

Mr. G. F. Scott Elliot had on view photographs and objects illustrating his recent expedition to Ruwenzori. The photographs showed characteristic trees and shrubs of Taru, view of Kagera River, and of Ruwenzori. The objects consisted of Wandorobbo costume, sword, quiver, fire-stick, and arrows; Uganda pottery, bark cloths, &c.; banana meal, &c., in form, ready for export.

Mrs. Ellis Rowan exhibited Australian wild flowers in water-colours. The examples were from Northern Queensland and Western Australia.

A letter and original manuscript of Emin Pasha's last Ornithological Journal formed an interesting exhibit by Sir William H. Flower. The objects were found by the officers of the Congo Free State, after Emin had been murdered by the Arabs at Kinena, on or about October 28, 1892.

A series of cultures of various forms of the bacteria which had been isolated from the river Thames, and then cultivated by the methods employed in the laboratory, formed Prof. Marshall Ward's exhibit. The bacteria were grouped in sections corresponding to the different types, and characterised by differences as to the pigment-production, temperature of growth, capacity of forming spores, behaviour in different media, sizes, shapes, and power of movement, &c. Some of them belonged to common species; others were rare, or unknown, and not classified.

An instrument for describing parabolas by means of a combined sliding and link motion was exhibited by the inventor, Mr. H. Thomson Lyon.

Sir David Salomons showed new forms of "top" slides for the lantern, selenite and hot-water slide heated electrically; and illustrated the behaviour of a glow lamp in the magnetic field, &c.

Mr. F. Enock exhibited a living aquatic hymenopterous insect, *Polynema natans* (Lubbock), *Caraphractus cinctus* (Haliday), described by him in these columns a few weeks ago. This minute and most beautiful Hymenopteron was observed by Sir John Lubbock swimming or flying under water, crawling about weed, &c. The *Mymaridæ* (Hal.) all oviposit in the eggs of other insects; *Polynema natans*, according to Ganin, having been bred from eggs of a dragon fly, *Æschna*. The smallest of this family, *Camptoptera papaveris*, is but one eighty-fifth of an inch in length.

The bone structure in the dentary bone of *Gomphognathus*, a South African reptile, was illustrated by one of Prof. Seeley's exhibits. The bone structure in this fossil, which is of Permian age, is not distinguishable from the bone structure of a mammal, in the arrangement of the haversian canals and the lacunæ. Prof. Seeley also showed vertical sections through the maxillary and mandibular teeth from the same skull. This exhibit consisted of three vertical sections of the skull of *Gomphognathus* taken at the hinder termination of the hard palate, showing the conical forms of the single roots to the molar teeth, the flat transverse crowns to the teeth, and the way in which the mandibular teeth are opposed to those in the skull.

A sacred bone-trumpet, drum, and flute were exhibited by Dr. George Harley. The trumpet and tom-tom drum were from the temple of a Buddhist monastery in Tibet. They were made from the bones of priests—from their being supposed to be more religiously effectual. The trumpet when blown emits a rising and falling mournful wailing sound. The drum, when the knobs attached to its strings are rattled against the skins, gives a disagreeable harsh noise which is thought to drive the evil spirits out of the temple. The flute is a Carib Indian's, from Guiana, made from the tibia of a deer (*Coassus rufinus*). From it can be got the notes 1, 2, and 3, in the natural harmonic ratios of 6, 7, and 8, as in the French flageolet.

The following exhibits, with demonstrations by means of the electric lantern, took place in the meeting-room of the Society.

Lantern slides, illustrating the ethnography of British New Guinea, by Prof. A. C. Haddon. The slides illustrated

the physical characters of different tribes inhabiting British New Guinea, some of the occupations of the people, several kinds of dances, and the distribution of dance-masks. A series of dwellings from one end of the Protectorate to the other was shown, and two types of canoes. Finally, illustrations of the decorative art of various districts were thrown upon the screen. Evidence was given in support of the view that British New Guinea is inhabited by true dark Papuans, and by two distinct lighter Melanesian peoples, one of whom may have come from the New Hebrides, and the other from the Solomon Islands.

Dr. J. Joly exhibited examples of colour photography, and described his method of obtaining them. The photographs were a realisation of composite heliochromy in a single image. The method of composite heliochromy requires three images superimposed by projection. In Dr. Joly's photographs the colour analysis and synthesis are carried out in the one image. The colours are the natural colours as they registered themselves upon the plate, and in no case altered after reproduction. The specimens shown were first attempts, produced with rough apparatus. The images showed a slightly grained appearance, but this is avoidable with proper appliances. The process of taking and reproducing the photographs differs in no way from ordinary photography upon the dry plate, save that the sensitive plate is exposed in the camera behind a screen lined in particular colours. The positive is subsequently viewed through a screen lined with three other colours; the three "fundamental colours," which upon the three-colour theory of vision are supposed to give rise to all our colour sensations.

ON THE TEMPERATURE VARIATION OF THE THERMAL CONDUCTIVITY OF ROCKS.¹

§ 1. THE experiments described in this communication were undertaken for the purpose of finding temperature variation of thermal conductivity of some of the more important rocks of the earth's crust.

§ 2. The method which we adopted was to measure, by aid of thermoelectric junctions, the temperatures at different points of a flux line in a solid, kept unequally heated by sources (positive and negative) applied to its surface, and maintained uniform for a sufficiently long time to cause the temperature to be as nearly constant at every point as we could arrange for. The shape of the solid and the thermal sources were arranged to cause the flux lines to be, as nearly as possible, parallel straight lines; so that, according to Fourier's elementary theory and definition of thermal conductivity, we should have

$$\frac{k(M, B)}{k(T, M)} = \frac{[v(M) - v(T)] \div MT}{[v(B) - v(M)] \div BM},$$

where T, M, B denote three points in a stream line (respectively next to the top, at the middle, and next to the bottom in the slabs and columns which we used); $v(T)$, $v(M)$, $v(B)$ denote the steady temperatures at these points; and $k(T, M)$, $k(M, B)$, the mean conductivities between T and M, and between M and B respectively.

§ 3. The rock experimented on in each case consisted of two equal and similar rectangular pieces, pressed with similar faces together. In one of these faces three straight parallel grooves are cut, just deep enough to allow the thermoelectric wires and junctions to be embedded in them, and no wider than to admit the wires and junctions (see diagram, § 8 below). Thus, when the two pieces of rock are pressed together, and when heat is so applied that the flux lines are parallel to the faces of the two parts, we had the same result, so far as thermal conduction is concerned, as if we had taken a single slab of the same size as the two together, with long fine perforations to receive the electric junctions. The compound slab was placed with the perforations horizontal, and their plane vertical. Its lower side, when thus placed, was immersed under a bath of tin, kept melted by a lamp below it. Its upper side was flooded over with mercury in our later experiments (§§ 6, 7, 8), as in Hopkins' experiments on the thermal conductivity of rock. Heat was carried off from the mercury by a measured quantity of cold water poured upon it once a minute, allowed to remain till the end of a minute, and then drawn off and immediately replaced

¹ A paper by Lord Kelvin, P.R.S., and J. R. Erskine Murray, read the Royal Society on May 30.