on a journey of exploration into Upper Assam, and the regions lying between this and Burmah.

THE latest official information concerning Dr. Wilhelm Junker, the African traveller, comes from Zanzibar. It reports that while he was staying with the King of Unyoro, the latter was attacked and defeated by the King of Uganda. The King of Unyoro and Dr. Junker succeeded, however, in making their escape. Dr. Junker lost all his collections, but saved his journals.

AT the March meeting of the Geographical Society of Stockholm it was decided not to distribute the *Vega* medal—the greatest honour the Society can confer—this year. Only three travellers have as yet received it, viz. Nordenskjöld, Pallander, and Stanley. The *Vega* fund was awarded to Dr. F. Svenonius, for explorations in the Lapland highlands during the summer.

A RECENT number of the *Verhandlungen* of the Berlin Geographical Society (Band xiii. No. 5), contains an important paper on Corea, by Dr. Gottsche, who travelled widely over the peninsula on behalf of the Japanese Government. During two journeys he traversed all the eight provinces of the country, and visited 80 of the 350 district towns. The general features are already tolerably well known to English students from Mr. Carles's reports laid before Parliament, and his paper in the *Proceedings* of the Royal Geographical Society, but as Dr. Gottsche is a geologist, and travelled specially for scientific observation, he supplements Mr. Carles's papers in this direction. The climate, he shows by meteorological tables, lies between that of Japan and of North China, while in the North the climate in winter is of almost Siberian rigour. As for the geological formation, granite, gneiss, and crystalline schists play a predominant part. Here and there these are broken by the older volcanic formations, as diabase and quartz porphyry; palæozoic strata occur rarely, and the later sedimentary formations not at all. Active volcanoes do not exist on the mainland, and earthquakes have been unknown within the memory of man. The only metal in which Corea is rich is iron; the belief that gold abounds is a delusion. The fauna is rich, and of much interest, for palæarctic and sub-tropical types meet here. With regard to the flora, unfortunately a large portion of Dr. Gottsches' collection was lost, and the remainder was handed to Dr. Engler of Breslau for examination and report. In conclusion, he says that though Corea may never be popular with the ordinary traveller for pleasure, it will well repay the visitor on scientific objects intent. Prof. Enting, who travelled in the interior of Arabia in 1883-84 on an antiquarian mission, especially in search of inscriptions, gives a long and comprehensive account of the regions through which he went.

THE new number (Heft ii. Bd. 9) of the *Deutsche Geographische Blätter*, the organ of the Geographical Society of Bremen, contains the conclusion of Dr. Oppel's paper on the Congo basin. The present instalment refers to the explorations of past years, the lower, central, and upper Congo region, north and south of the stream, the climate, meteorology, botany, zoology, ethnography, &c. It will thus appear that the paper is an encyclopædic one on the great West African river. The next paper is a continuation of Herr Valdau's account of his journey to the north of the Cameroons, especially around Lake Mbu, and between that and Balundu, and the coast. Herr Steinvorth gives a most interesting account of a little Slav colony or oasis in Hanover called the Hanoverian Wendtland, where the people down to this day have in great part preserved their original speech, customs, and other peculiarities. The writer describes all these in some detail, and comes to the natural conclusion that here we have not a pure Wendt people, but one largely mixed with Germans, and thinks, after discussing the peculiarities of the dialect spoken, that this colony is worthy of the attention of the student of comparative language. This is followed by a general article (which is anonymous) on the new Chilian province of Tarapaca, dealing especially with the silver mines and saltpetre industry. Herr Seelstrang supplies a paper of more direct geographical interest on the region about the source of the Rio Chubut, hitherto one of the least-known parts of the Argentine Republic. The rest of the number (which is of considerable size) is occupied by geographical intelligence, reviews of books, &c.

IN the *Bollctino* of the Italian Geographical Society for May, Signor Sommier describes the excursion which he made with Signor G. Cini to Cape North in January 1885. Some interes. attaches to this journey, which is the first made across Lapland and Finland in midwinter for purely scientific purposes. The travellers proceeded by train from Christiania to Throndhjem, and thence by steamer in darkness and storm to Hammerfest and Skarsvaag, in the island of Magerö, the northernmost group of habitations in Europe, and the nearest permanent settlement to Cape North. Here they received a friendly welcome from the local "Landelsmand," and reached the goal of the expedition on foot with much greater ease than had been anticipated. The weather was unusually calm and mild, with a temperature of only -2° C. At some points the evergreen lichens and other growths (*Betula nana*, *Empetrum nigrum*, *Diapensia lapponica*, &c.) were visible through some centimetres of transparent ice clothing the surrounding rocks. The only animals seen, besides the eider and other water-fowl, were the raven, crow, magpie, Arctic fox, and frankoline, the latter (*Lagopus mutus*) everywhere present in large numbers. Several photographs were taken, and after a stay of eleven days in the neighbourhood, during which the glass never fell below -16° C., the travellers returned by water to Hammerfest and Bossekop, at the head of the Alten fjord. Thence the route was continued overland under great hardships—eastwards to Lake Enare, southwards through Kittilä to Haparanda, and round the west side of the Gulf of Bothnia to Sundsvall, whence Stockholm was reached by train. At Karasjok, on the road between Bossekop and Enare, the travellers made the acquaintance of the same Lapp family that visited London last year, and much valuable information was collected on the Lapps, Quäns, and northern Finns. This forms the subject of two communications sent by Stephen Sommier to the *Archivio per l'Antropologia e l'Etnologia* (xvi., 1, 1886), and separately printed under the title of "The Lapps and Northern Finns." The account of the trip to Cape North has also been issued in separate form by the Italian Geographical Society (Rome, 1886).

THE LUNAR SURFACE AND ITS TEMPERATURE

A MONOGRAPH by the writer, relating to the temperature of the lunar surface, read before the American Academy of Science, September 1869, contained the following:—"Are we not forced to dissent from Sir John Herschel's opinion that the heat of the moon's surface, when presented to the sun, much exceeds that of boiling water? Raised to such a high temperature, our satellite, with its feeble attraction, could not possibly be without an envelope of gases of some kind. Indeed, nothing but the assumption of extreme cold offers a satisfactory explanation of the absence of any gaseous envelope round a planetary body, which, on account of its near proximity, cannot vary very much from the earth as regards its composition. The supposition that this neighbouring body is devoid of water, dried up and sunburnt, will assuredly prove one of the greatest mistakes ever committed by physicists." This assertion was based on demonstrations showing that the circular walls of the great "ring mountains" on the lunar surface are not, as supposed, composed of "mineral substances originally in a state of fusion." The height and diameter of these walls being recorded in "Der Mond," computations based on the safe assumption that the areas of their transverse sections cannot be less than the square of their height, establishes the important fact that the contents of the wall of, for instance, Tycho, the circumference of which is 160 miles, height 2·94 miles, amounts to $2{\cdot}94 \times 160 = 1382$ cubic miles. The supposed transfer of this enormous mass, in a molten state, a distance of 25 miles from the central vent imagined by Nasmyth, and its exact circular distribution at the stated distance, besides its elevation to a vertical height of nearly 3 miles, involve, I need not point out, numerous physical impossibilities. Other materials and agencies than those supposed to have produced the "ring mountains" must consequently be sought in explanation of their formation. A rigid application of physical and mechanical principles to the solution of the problem proves conclusively that water subjected successively to the action of heat and cold has produced the circular walls of Tycho. The supposition that these stupendous mounds consist of volcanic materials must accordingly be rejected, and the assumption admitted that they are inert glaciers which have become as permanent as granite mountains by the action of perpetual intense cold.

Independently of the foregoing demonstration, the fallacy of the volcanic hypothesis will be comprehended by its advocates on learning that the quantity of lava requisite to form the circular walls of Tycho would cover the entire surface of England and Wales to a depth of 125 feet.[1]

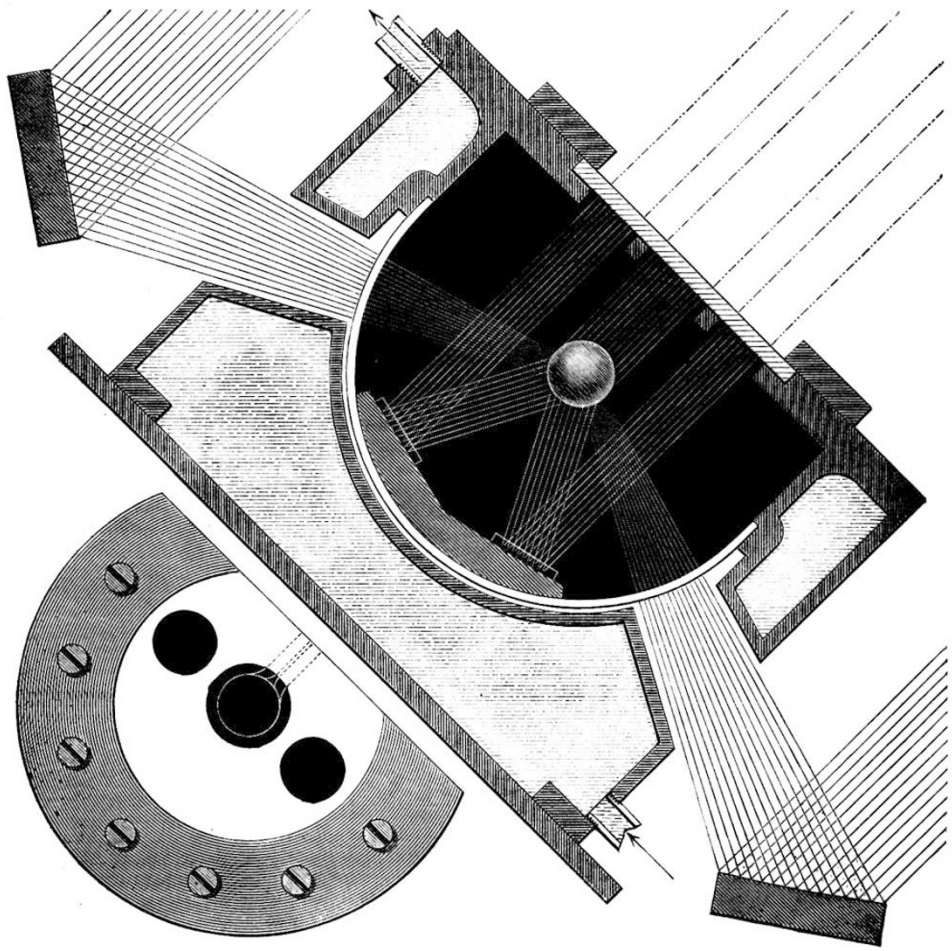
Before proceeding further with our demonstration it will be necessary to establish the maximum temperature which solar radiation is capable of imparting to the lunar surface. This temperature, of course, varies with the distance of the primary and its satellite from the sun. By means of an actinometer the bulb of whose thermometer receives an equal amount of radiant heat on opposite sides, I was enabled to determine with desirable accuracy, sixteen years ago, that, when the earth is in aphelion, solar radiation on the ecliptic imparts a maximum temperature of 67°·2 F., and that the retardation of the radiant energy occasioned by the want of perfect atmospheric diathermancy reaches 0·207. Consequently the temperature produced by solar radiation at the boundary of the terrestrial atmosphere is

$$67{\cdot}2 \times 1{\cdot}207 = 81°{\cdot}11 \text{ F.},$$

when the earth is in aphelion. Agreeably to observations during the winter solstice, compared with observations at midsummer, at equal zenith distance, the augmentation of solar intensity when the earth is in perihelion amounts to 5°·84 F. ; hence the temperature produced by solar radiation reaches

$$81{\cdot}11 + 5{\cdot}84 = 86°{\cdot}95 \text{ F.},$$

when the rays enter our atmosphere during the winter solstice. It should be observed that on theoretical grounds the increase of temperature, when the earth is in perihelion, will be in the



Captain Ericsson's Pyrheliometer.

inverse ratio of the *dispersion of the solar rays ;* hence, as the aphelion distance is to the perihelion distance as 218·1 to 210·9, it will be seen that the temperature produced by solar radiation when the earth is in perihelion will be

$$\frac{218{\cdot}1^2 \times 67°{\cdot}2}{210{\cdot}9^2} = 71°{\cdot}86 \text{ F.}$$

Adding 0·207 for retardation caused by imperfect atmospheric diathermancy, solar intensity during the winter solstice will be

$$71{\cdot}86 \times 1{\cdot}207 = 86°{\cdot}73 \text{ F.}$$

Calculation based on *observation*, as before stated, proves that the perihelion temperature is 86°·95, thus showing a trifling discrepancy between theory and observation.

[1] Area of England and Wales, 58,320 square miles; contents of the walls of Tycho, 1382 cubic miles; hence $\frac{1382}{58320} \times 5280 = 125{\cdot}12$ feet.

Adopting 86°·73 as correct, it will be found that the yearly *mean* temperature produced by solar radiation when the rays enter the earth's atmosphere will be

$$\frac{81°{\cdot}11 + 86°{\cdot}73}{2} = 83°{\cdot}92 \text{ F.},$$

while the temperature produced by the sun's radiant heat is only 81°·11 during the summer solstice, as before shown. Hence the temperature of the lunar surface when presented to the sun while the earth is furthest from the luminary can only be augmented 81°·11 F.

The remarkable fact that the moderate heat produced by solar radiation is capable of increasing the temperature of bodies previously heated to a high degree demands consideration in connection with the subject under investigation ; also the nature of the device, before referred to, for ascertaining the temperature produced by solar radiation. The accompanying illustration

represents a combination of said device and a pyrheliometer differing materially from Pouillet's instrument, by showing the true intensity of the "fire" in the sun's rays.

The illustration presents a top view and a vertical section of the new instrument through the centre line. The upper part, composed of bronze, is cylindrical with a flat top, the bottom being semispherical, composed of ordinary glass. The top of the cylindrical chamber is provided with three circular perforations covered by a thin crystal carefully ground and polished. A thermometer having a spherical bulb is introduced through the side of the chamber, the bulb being central to the transparent semispherical bottom. A short parabolic reflector, shown in section on the illustration, surrounds the instrument, adjusted so that its focus coincides with the centre of the bulb of the thermometer. The compound cylindrical and spherical chamber is inclosed in a vessel containing water, appropriate openings at top and bottom being provided for maintaining constant circulation during experiments. Efficient means are also provided for exhausting the air from the internal chamber. The instrument is secured to the top of a substantial table which, during experiments, faces the sun at right angles by the intervention of a parallactic mechanism. Movable shades are applied, by means of which the sun's rays may be quickly cut off from, or admitted to, the parabolic reflector; while other shades enable the operator to admit or exclude the solar rays from the circular perforations at the top of the exhausted chamber. It will be readily understood that the parallel lines within the exhausted chamber, shown on the illustration, indicate the course of the solar rays passing through the crystal and the perforations at the top, while the converging radial lines indicate the rays reflected by the parabolic reflector. The upper hemisphere of the thermometric bulb, it will be seen, receives the radiant energy of the sun's rays which pass through the large central perforation; while the lower half of the bulb will be acted upon by the rays passing through the small perforations. These rays are reflected upwards by two inclined circular mirrors attached to the bottom of the exhausted chamber. It should be particularly observed that the areas of these inclined mirrors *together* should exceed the area of the great circle of the bulb of the thermometer sufficiently to make good the loss of radiant energy caused by the imperfect reflection of the said mirrors, and also to make good the loss attending the passage of the solar rays through the crystal. A capacious water cistern, connected by flexible tubes with the external casing of the pyrheliometer, enables the operator to maintain the exhausted chamber at any desirable temperature. Engineers of great experience in the application of heat for the production of motive power and other purposes deny that the temperature of a body can be increased by the application of heat of a lower degree than that of the body whose temperature we desire to augment. The soundness of their reasoning is apparently incontrovertible, yet the temperature of the mercury in the instrument just described raised to 600° F. by means of the parabolic reflector, increases at once when solar heat is admitted through the circular apertures, although the sun's radiant intensity at the time may not reach one-tenth of the stated temperature. It should be mentioned that the trial of this new pyrheliometer has not been concluded, owing to very unfavourable atmospheric conditions since its completion. For our present purpose the great fact established by the illustrated instrument is sufficient, namely that the previous temperature of a body exposed to the sun's radiant heat is immaterial. The augmentation of temperature resulting from exposure to the sun, the pyrheliometer shows, depends upon the intensity of the sun's rays.

Regarding the temperature prevailing during the lunar night, its exact degree is not of vital importance in establishing the glacial hypothesis, since the periodical increment of temperature produced by solar radiation is only a fraction of the permanent loss attending the continuous radiation against space resulting from the absence of a lunar atmosphere; besides, all physicists admit that it is extremely low. Sir John Herschel says of the night temperature of the moon that it is "the keenest severity of frost, far exceeding that of our Polar winters." Proctor says: "A cold far exceeding the intensest ever produced in terrestrial experiments must exist over the whole of the unilluminated hemisphere." The author of "Outlines of Astronomy" has also shown that the temperature of space, against which the moon at all times radiates, is −151° C. (−239°·8 F.), Pouillet's estimate being −142° C. (−223°·6 F.). Adopting the latter degree, and allowing 81°·11 for the sun's radiant heat, we establish the fact that the temperature of the lunar surface presented to the sun will be 223°·6 less 81°·1, or −142°·5 F., when the earth is in aphelion. It will be well to bear in mind that when the earth is in the said position, the sun's rays acting on the moon subtend an angle of 31′ 32″, hence the loss of heat by radiation against space will be diminished only 0·000021 during sunshine. Nor should Herschel's investigation be lost sight of, showing that stellar heat bears the same proportion to solar heat as stellar light to solar light. Stellar heat being thus practically inappreciable, the temperature produced by stellar radiation cannot be far from absolute zero—an assumption in harmony with the views of those who have studied the subject of stellar radiation, and consequently regard Pouillet's and Herschel's estimate of the temperature of space as being much too high.

Having disposed of the question of temperature, let us return to the practical consideration of the glacial hypothesis. The formation of annular glaciers by the joint agency of water and the internal heat of a planetary body devoid of an atmosphere and subjected to extreme cold is readily explained on physical principles. Suppose a sheet of water, or pond, on the moon's surface, covering the same area as the plateau of Tycho, viz. 50 miles diameter and 1960 square miles. Suppose, also, that the internal heat of the moon is capable of maintaining a moderate steam pressure, say 2 lbs. to the square inch, at the surface of the water in the pond. The attraction of the lunar mass being only one sixth of terrestrial attraction, while the moon's surface is freed from any atmospheric pressure, it will be evident that under the foregoing conditions a very powerful ebullition and rapid evaporation will take place, and that a dense column of vapour will rise to a considerable height above the boiling water. It will also be evident that the expansive force within this column at the surface of the water will be so powerful at the stated pressure that the vapour will be forced beyond the confines of the pond in all directions with great velocity. No vertical current, it should be understood, will be produced, since the altitude of the column, after having adjusted itself to the pressure corresponding with the surface temperature of the water, remains stationary, excepting the movement consequent on condensation from above. The particles of vapour forced beyond the confines of the pond, on being exposed to the surrounding cold, caused by unobstructed radiation against space, will of course crystallise rapidly, and in the form of snow fall in equal quantity round the pond, and thereby build up an annular glacier. As the radius of the vaporous column exceeds 25 miles, it will be perceived that, notwithstanding the rapid outward movement, before referred to, some of the snow formed by the vapours rising from the boiling pond will fall into the same, to be melted and re-evaporated.

In connection with the foregoing explanation of the formation of annular glaciers, their exact circular form demands special consideration. An examination of Rutherford's large photograph of the lunar surface shows that, apart from the circular form of the walls, the bottoms of the depressions are in numerous cases smooth, rising slightly towards the centre uniformly all round. The precision observable proves clearly the action of formative power of great magnitude. Referring to what has already been explained regarding the vaporous column of 25 miles radius, calculation shows that a surface temperature exerting the moderate pressure of 2 lbs. to the square inch will produce an amount of mechanical energy almost incalculable. Practical engineers are aware that the steam rising from a surface of water 10 square feet, heated by a very slow fire, is capable of producing an energy of 1 horse-power; consequently a single square mile of the boiling pond will develop 2,780,000 horse-power. This prodigious energy will obviously be exerted *horizontally*, as the weight of the superincumbent column of vapour balances its *expansive* force precisely as the weight of our atmosphere balances its expansive force. But unlike the earth's atmosphere, which is restrained from horizontal movement by its continuance round the globe, the vapour of the column of 50 miles diameter is free to move beyond the confines of the pond. A very powerful horizontal motion, especially of the lower part of the vaporous mass, will thus be promoted, acting in radial lines from the centre, the principal resistance encountered being the friction against the water. Considering that the friction against the surface of the ocean, caused by the gentle trade-wind, is sufficient to produce the Gulf Stream, we need no figures to show the effect on the water in the boiling pond produced by the vaporous mass propelled by an energy of 2 lbs. to the square inch, in radial lines towards its confines. A circular tidal wave of extraordinary power, together with a return under-current towards the centre, will obviously be the result. But agreeably to the laws supposed to govern vortex

motion, these currents cannot be maintained in a radial direction. A rotary motion, rapidly augmenting, will take place, producing a vortex more powerful than any imagined by Descartes. The radial currents of the vaporous column having assumed a spiral course, will rapidly acquire a velocity exceed that of a cyclone. The practical effect of the powerful movement of the vortex, it is reasonable to suppose, will resemble that of a gigantic carving-tool whose thorough efficiency in removing irregularities has been proved by the exact circular outline presented by thousands of lunar formations. The terraces within the "ring mountains," indicated on Beer and Mädler's chart, it may be shown, were produced by evaporation resulting from low temperature and reduced energy after the formation of the main glacier.

There is another feature in the lunar landscape scarcely less remarkable than its circular walls and depressions. In the centre of nearly all of the latter one or more conical hills rise, in some cases several thousand feet high. Has the rotary motion of the boiling vortex any connection with these central cones? A brief explanation will show that the connection is quite intimate. The under-rated estimate that 10 square feet of surface under the action of slow fire is capable of developing one horse-power proves the presence of a dynamic energy exceeding 5,000,000,000 of horse-power at the base of the vaporous column resting on the boiling water of a pond as large as that of Tycho. No part of this power can be exerted vertically, as already explained, on the ground that the weight of the vapour restrains such movement. The great velocity of the vortex resulting from the expenditure of the stated amount of dynamic energy will of course produce corresponding centrifugal force; hence a maelström will be formed capable of draining the central part of the pond, leaving the same dry, unless the water be very deep, in which case the appearance of a dry bottom will be postponed until a certain quantity of water has been transferred to the glacier. It should be observed that the central part of the bottom, freed from water, will also be freed from the surrounding cold by the protection afforded by the vaporous mass. The quantity of snow formed above the centre, at great altitude, will be small, and of course diverged during the fall. Evidently the dry central part, prevented, as shown, from cooling, will soon acquire a high temperature, admitting the formation of a vent for the expulsion of lava, called for as the moon, whose entire dry surface is radiating against space, shrinks rapidly under the forced refrigeration attending glacier-formation. Lava-cones similar to those of terrestrial volcanoes, and central to the circular walls, may thus be formed, the process being favoured by the feebleness of the moon's attraction. The existence of warm springs on the protected central plains is very probable; hence the formation of cones of ice might take place during the last stages of glacier-formation, when those plains no longer receive adequate protection against cold.

In accordance with the views expressed in the monograph read before the American Academy of Science, continued research has confirmed my supposition that the water on the moon bears the same proportion to its mass as the water of the oceans to the terrestrial mass. I have consequently calculated the contents of the circular walls of the "ring mountains" measured and delineated by Beer and Mädler, and find that these walls contain 630,000 cubic miles. The opposite hemisphere of the moon being subjected to similar vicissitudes of heat and cold as the one presented to the earth, the contents of the circular walls not seen cannot vary very much from those recorded in "Der Mond"; hence the total will amount to 1,260,000 cubic miles. Allowing for the difference of specific gravity of ice, the stated amount represents 1,159,000 cubic miles of water. But "Der Mond" does not record any of the minor circular walls which, as shown by the large photograph before referred to, cover the entire surface of some parts of the moon. On careful comparison it will be found that the contents of the omitted circular formations is so great that an addition of 50 per cent. to the before-stated amount is called for. An addition of 25 per cent. for the ice-fields, whose extent is indicated by cracks and optical phenomena, is likewise proper. The sum total of water on the moon, therefore, amounts to 2,028,600 cubic miles.

Adopting Herschel's estimate of the moon's comparative mass, viz. 0·011364, and assuming that the oceans of the earth cover 130,000,000 square miles, it will be seen that the estimated quantity of water on the moon corresponds with a mean depth of 7250 feet of the terrestrial oceans.[1] This depth agrees very nearly with the oceanic mean depth established by the soundings for the original Atlantic cable, viz. 7500 feet; but the result of the *Challenger* Expedition points to a much greater depth. This circumstance is by no means conclusive against the supposition that the satellite and the primary are covered with water in relatively equal quantities. The correctness of Sir John Herschel's demonstration proving the tendency of the water on the lunar surface to flow to the hemisphere furthest from the earth must be disproved before we reject the assumption that the quantity of water on the surface of the moon bears the same proportion to its mass as the quantity of water on the earth to the terrestrial mass.

JOHN ERICSSON

[1] $\frac{2028600 \times 5280}{130000000 \times 0{\cdot}011364} = 7250$ feet mean depth of terrestrial oceans corresponding with water on the moon.

SCIENTIFIC SERIALS

Rendiconti del Reale Istituto Lombardo, May 27.—Determination of the heat of fusion in the alloys of lead, tin, bismuth, and zinc, by Prof. D. Mazzotto. By the cooling process usually adopted for determining the specific heat of liquids, the author finds the point of fusion and the heat of fusion for these various chemical alloys as under:—

	Point of fusion	Heat of fusion
	°	°
Tin and lead	181	10·29
Tin and zinc	196	16·20
Tin and bismuth	138	11·065
Bismuth and lead	126	4·744

Two of these coincide and two others differ little from the composition of the chemical alloys as given by Rudberg.—Education and crime in Italy, by S. Amato Amati. In order to ascertain the influence of public instruction on the criminal classes in the Peninsula, the author has compiled a number of comparative tables based on official returns ranging from the year 1871 to 1883 inclusive. For the last three years of this period the results are as under:—

	Criminals	Unlettered	Could read and write	Educated
1881 ...	8693 ...	5511 ...	3031 ...	151
1882 ...	7009 ...	4139 ...	2671 ...	199
1883 ...	6490 ...	3741 ...	2596 ...	153

According to the three last census returns the total percentage of unlettered was as under:—

	Males	Females	Total
1861 ...	65·47 ...	81·52 ...	73·50
1871 ...	60·16 ...	77·18 ...	68·64
1881 ...	53·89 ...	72·93 ...	63·45

—Meteorological observations made at the Brera Observatory, Milan, during the month of May.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 6.—"Further Discussion of the Sun-spot Spectra Observations made at Kensington." By J. Norman Lockyer. Communicated to the Royal Society by the Solar Physics Committee.

I have recently discussed, in a preliminary manner, the lines of several of the chemical elements most widened in the 700 spots observed at Kensington.

The period of observation commences November 1879, and extends to August 1885. It includes, therefore, the sunspot curve from a minimum to a maximum and some distance beyond.

It is perhaps desirable that I should here state the way in which the observations have been made. The work, which has been chiefly done by Messrs. Lawrance and Greening, simply consists of a survey of the two regions F—*b* and *b*—D.

The most widened line in each region—not the widest line, but the *most widened*, is first noted; its wave-length being given in the observation books from Ångström's map. Next, the lines which most nearly approach the first one in widening are recorded, and so on till the positions of six lines have been noted, the wave-lengths being given from Ångström's map, for each region.

It is to be observed that these observations are made without any reference whatever to the origin of the lines; that is to say it is no part of the observer's work to see whether there are metallic coincidences or not; this point has only been inquired into in the present reductions, that is, seven months after the