very high temperature, and therefore converted the drops of water into the spheroidal state. There they bounded and danced and rolled about like pith balls under an excited electrical receiver. Their constant rotation and well-known rippling motion gave them an opaque appearance which caused them to resemble closely a fine fall of hail. In fact, those to whom I pointed out the phenomenon likened their appearance to a fall of dusty snow at the mouth of a furnace. The sight was very striking and interesting. The workmen had taken these spheroids to be particles of scale and dust swaying about in the currents of air at the mouth of the furnace.

I have seen many times the experimental illustration of "Leidenfrost's phenomenon" at the mouth of a furnace, but I had never before seen its practical, though accidental, development, and in the incident which I have narrated above the interest chiefly attaches to the great antithesis of the fact and its appearance—snow at the mouth of a fiery furnace.

W. H. PREECE

The American Eclipse Expedition

I DEEM it but proper and just that I should correct a mistake that has just met my eye in Dr. Schellen's excellent work on Spectrum Analysis.

On page 332 of the 2nd German edition we find "Die erstere Expedition wählte unter der Anführung von Professor Morton die Stationen im Staate Iowa.

"(1) Burlington mit den Beobachtern Professor Mayer, Kendall, Willard, Phillips, und Mahoney, denen sich der als gewandter Spectroskopist bekannte Dr. C. A. Young, Professor am Dartmouth College (Hanover), und *Dr. B. A. Gould für die photographischen Aufnahmen hinzugestellen.*"

In the English translation, edited by Mr. Huggins, the above reads, "The first expedition, under the guidance of Professor Morton, selected stations in the State of Iowa as follows :—

"(1) Burlington, where its observers were Professor Mayer, and Messrs. Kendall, Willard, Phillips, and Mahoney, together with Dr. C. A. Young, Professor of Dartmouth College (Hanover), well known as an experienced spectroscopist, and Dr. B. A. Gould, to whose charge the photographic department was committed."

Dr. Gould had no connection with the photographic expedition, but placed himself under Professor Coffin's general organisation, so that he could have facilities for making observations on the corona, and in searching for the suspected intermercurial planet.

The Burlington station of the Philadelphia eclipse expedition was placed under the direction of Dr. Mayer, and the photographs pointing page 337 of Dr. Schellen's work are two of the five plates secured by him during totality.

Also the diagram on page 338 is from Dr. Mayer's report on the eclipse (published October 1869), an abstract of which, with accompanying copies on glass of the original negatives, was presented by M. Delaunay to the Institute of France. The Rev. T. W. Webb laid them before the Royal Astronomical Society, when the report and the photographs were discussed at length at the meeting of November 12, 1869.

HENRY MORTON, President
Stevens Institute of Technology, Hoboken, New Jersey

Mr. Spencer and the Dissipation of Energy

WILL you permit me to inquire, for the instruction of the many who are familiar with Mr. Herbet Spencer's "Doctrine of Evolution," and especially in regard to "First Principles," sec. 58, referred to by Mr. Spencer in his paper in your number for February 1, if the theory of the "Dissipation of Energy" does not upset a very considerable and significant portion of Mr. Spencer's "First Principles"? WILLIAM SMYTH

Maidstone, February 12

THE AURORA OF FEBRUARY 4

ON Sunday, the 4th inst., was witnessed one of the most magnificent displays of aurora which have been seen in Europe within the past twenty or thirty years. To most observers in this country it appeared equal in magnificence to the two fine auroræ seen on Oct. 24 and 25, 1870, and which were especially grand in England; but foreign observers could only compare it with those seen in 1831 and 1836. But if we take all the attendant phenomena into consideration, it will appear that, whilst others may have equalled this one in grandeur and beauty, there is not one which can compare with it either as to the wide extent of country over which it was visible, or as to the strangeness of many of the phenomena by which it was accompanied. The numerous letters which have appeared in these columns the last two weeks show how universally it was noticed in England, Scotland, and Ireland; but in addition to these, the letters and telegrams which have appeared in the daily and weekly papers—both English and foreign—show that it excited attention over a still larger area. It is difficult to trace the exact limits of this area; but when we mention Paris, Cologne, Berlin, Malta, Constantinople, Egypt, and India, it will be seen what a large extent of country is embraced. So far we have seen no account of it as having been visible in the extreme north of Europe, as in Iceland, Norway, Sweden, St. Petersburg, &c., where most auroræ boreales are so well displayed; but, on the contrary, many of the cities in which it was noticed are those which are commonly supposed to be too far south for such phenomena to be seen. The importance of this point will appear later on.

To take England first. Mr. Allnatt sends to the *Times* a long description of the appearance of the aurora as seen by him at Frant, which shows that it was first noticed at 6 P.M. in the S.W., and that by 7 o'clock it had reached the zenith. It disappeared at 7.45, but reappeared for a short time at 10.50 in the N.; but "at 7.30 P.M. the whole heavens were pervaded by this abnormal southern aurora, that had now expanded universally and dipped its supplementary bands into the northern horizon." He also writes:—"The earth's electricity was so powerful, that the gold leaves of the electrometer remained diverged for a considerable time!" Other correspondents describe it as seen at Blackburn, in Lancashire, at 7, "embracing the whole southern sky from N.E. round to W.;" from Faversham, in Kent, as visible between 9 and 10 o'clock;" from Cambridge as having its maximum intensity about 10; at Swindon as commencing at 10 minutes past 7 and lasting till 10 o'clock, "and giving as much light as a full moon, every object being clearly visible." But many observers had noticed it at times considerably earlier than those just mentioned: thus, "J.S.H.," writing in NATURE last week from Gloucester, "observed it at 5.30, just in the twilight, but it was then confused with the rays of the setting sun; but as the darkness deepened the aurora came out alone, and was then extremely beautiful." But still earlier was it observed at Hartlepool, whence a correspondent writes, at 5 o'clock:—"The whole of the southern sky was tinged with a most beautiful rose colour, which, as darkness set in, extended towards the zenith, where it culminated in a brilliant corona." This very early manifestation of the aurora partakes very much of the nature of a "day aurora," the possibility of which has been so much discussed in these columns (*vide* NATURE, vols. iii. and iv.) To us there does not appear much difficulty in believing that these grand meteorological phenomena, whatever their cause may be, are independent of merely relative time, and that the reason why they are mostly observed at night is because the purely local circumstances are then most favourable to their observation. That an aurora should wait till night-time before it manifests itself hardly seems probable, whilst, on the other hand, that the more brilliant light of the sun should prevent auroral displays being seen in the day-time is not only probable but is borne out by what we know of the light of the stars and planets. No one believes that stars only shine at night-time, why then should there be a belief that auroral displays take place only at night-time, especially when it is remembered that the experiences of polar travellers in their sunless regions are distinctly against it? But this is a digression arising from the fact that in comparative daylight we have distinct and independent evidence of this aurora having been observed. In addition to those already

given, from Worcester we learn that it was noticed "shortly before 6 o'clock in the twilight, when thin fleecy clouds of a bright rose colour were observed in the South and East," whilst correspondents of the *Kölnische Zeitung* state that it was first noticed at Cologne about 6 o'clock, and at Bonn about "half-past 5, gradually becoming more and more marked till 6 o'clock, when do doubt was left as to its true auroral character." While there is thus clear evidence that the phenomena had commenced some time before 6 o'clock, there is, as might be expected, great diversity as to the time when it was last visible. That this should be the case is only natural, and is entirely dependent on purely local circumstances—the state of the weather, the cloudiness of the sky, &c. Thus, whilst in some the aurora first appeared at 6 o'clock, to others it was not visible till between 7 and 8; and whilst in some places it disappeared about 8 or 9, it was then in others in its most brilliant state. But, taken as a whole, it appears to have lasted the whole evening until quite late at night; thus a correspondent, writing to the *Pall Mall Gazette* from Autun, states that "at midnight the East was crimson, and it was so light that I could tell the time easily, although my watch has gold fingers, and strong shadows were cast in rooms whose windows faced the East."

We have thus evidence of the aurora having commenced about 5 o'clock, and continuing at least till midnight, and probably later. But before proceeding to notice the other attendant phenomena, we would direct attention to a passage in the letter of the correspondent of the *Pall Mall Gazette*, before alluded to, which confirms the hypothesis that the accounts of "showers of blood," &c., mentioned in ancient chronicles were in reality only auroral displays. He writes, "all these signs and wonders produced a considerable effect upon the peasantry, who see in them warnings of a coming war; they always connect the idea of a red aurora with bloodshed." Comparing, then, all the varied accounts to which we have referred, we find very general agreement with regard to certain phenomena, some of which are of very remarkable character. The first of these is that when the aurora was noticed by those who observed it early in the evening, it appeared in the Southern and South-Western horizons, thence it seems gradually to spread, and finally appeared later on in the evening in the Northern and Eastern horizon. That this was the case is shown by the agreement of the accounts, some of which we have already quoted, and many more of which might be given. Thus at Bonn, "nothing remarkable was to be noticed on the northern horizon, whilst on the southern lay the dense, greyish bank of clouds, whence auroral streamers shortly ascended." There can also be little doubt that during the middle of the evening, and towards midnight the chief seat of the display was to the north and east, as shown in the letters of those who first observed the phenomena at about 7.30 to 9 o'clock, and continued to do so till towards midnight. The second well-marked phenomenon was that between 7 and 8. There appeared a brilliantly-coloured arch, extending across the heavens from S.W. towards the north and east. Thus at Autun we have described "a splendid and perfect arch, spanning the sky from a point on the south-eastern horizon to one on the south-western, and which lasted, more or less continuously, for two hours, whilst from 10 to 12 the sky became gradually less luminous in the south, and grew more and more splendid overhead. Till about 11 the two eastern and western auroras united in a vast arch overhead, with tongues of green flame darting through a suffused crimson." Similarly other accounts, with merely local variation. The third well-marked phenomenon appears to have been the formation of a "corona," nearly, if not quite, in the zenith, whence auroral rays streamed out in all directions. At some places this was more marked than at others, but is more or less universally noticed, both by English and foreign observers. Thus at Cardiff it is reported that "a corona, having rugged, sharply-defined edges, stood out prominently in the zenith, apparently on a parallel plane to the earth, and having its centre almost immediately over the head of the spectator, rays from which extended to the N.E. and N.W. horizons." If one may venture to say so, most auroræ visible in our latitudes appear to commence in general by an accumulation of cloud masses towards the magnetic north, then coloured masses slowly appear, and afterwards rays, or streamers, are sent up from this northern horizon towards the zenith. Sometimes the coloured masses themselves rise toward the zenith, and there the streamers pass in all directions. But in this aurora of the 4th of February, all the most marked phenomena are directly contrary to our ordinary experience, and should therefore be carefully noted. It is an extremely interesting inquiry to ascertain whether on the evening of the 3rd or 4th instant a brilliant Aurora Australis was visible in the southern hemisphere. If we consider the wide extent of country over which the aurora which we are describing was visible, the probability becomes very great that this will be found to be the case. The question then arises, Was the aurora of Feb. 4th, appearing as it did first in the southern horizon, an Aurora Australis or not? It is impossible to answer this question definitely; but we would throw out the following suggestion:—Knowing the ultimate connection that there is between northern and southern auroræ, and the fact that one of any magnitude rarely happens without the other, may we not have seen the last traces of a grand Aurora Australis, which gradually died away, whilst at the same time an Aurora Borealis was in process of formation, and which appeared in its full brilliancy in the northern and eastern horizon towards the latter part of the evening? We would make this suggestion with all due deference, but it seems to us to account in a fairly satisfactory manner for most of the very unusual and peculiar phenomena noticed, viz., the first appearance of the aurora in the south, the grand arch, the corona in the zenith, and the final disappearance in the north. We must also remember that in what is called the correspondence of northern and southern auroræ, there must be at least twelve hours difference as regards time. So that if there was an Aurora Australis on the same day, it would be dying out at the time our display was commencing.

In conclusion, the wide extent of country over which this aurora of the 4th February was visible, is easily shown. In Paris a "magnificent aurora" is reported, at Nancy and Chaumont there was a "brilliant display," while the Franco-German telegraph lines were greatly disturbed. At Constantinople one telegram states that "a splendid aurora, extending over half the heavens, was visible for several hours;" whilst another states that it was seen "from 10 till half-past 1." From Alexandria we hear that "a large space of the skies was illuminated for five hours." That it was visible at Malta, Suez, and Bombay, the following interesting account shows. It is supplied by Mr. George Draper, of the British Indian Submarine Telegraph Company, under date of Feb. 5th, and it also shows how powerful were the "earth currents" which were noticed in connection with this most brilliant aurora. He writes:—

"It may interest your readers to know that the brilliant aurora which was visible in London last night was also visible at Bombay, Suez, and Malta. Our electrician at Suez reports that the earth currents there were equal to 170 cells (Daniell's batteries), and that sparks came from the cable. These electrical disturbances lasted until midnight, and interrupted the working of both sections of the British Indian cable between Suez and Aden, and Aden and Bombay. Since Thursday last the signals on the British Indian cables have been very much interfered with by electrical and atmospheric disturbances, causing considerable delay in the transmission of messages, which all efforts failed entirely to overcome. Our superintendent at Malta also reports that there was a very severe storm there yesterday morning, so much so that they were compelled to join the cable to earth for several hours. He also reports the aurora as very large and brilliant. The electrical disturbances on the cables in the Mediterranean, and on those between Lisbon and Gibraltar, and Gibraltar and the Guadiana, were also very great. The signals on the land line between London and the Land's End were interrupted for several hours last night by atmospheric currents."

Taken, then, on the whole, this aurora of February 4th was one of the most brilliant, most interesting, and most widely visible which has been witnessed for many years past, and is probably one that will cause renewed attention to be paid to the still unsolved problem of their causes.

J. P. EARWAKER

[We have also received the following from J. W. Spengel of Berlin:—"At Berlin, the sky being covered by clouds, no one could see anything. But a young astronomer of our observatory told me that he had recognised the existence of a mighty aurora by means of the spectroscope. The magnets were also vehemently disturbed, and all the telegraphs failed for several hours. The following appears in the *Leipziger Allgemeine Zeitung* for Feb. 8:—'Freiberg, Feb. 6. The aurora observed by many on the evening of Sunday caused here a complete interruption of communication through the telegraph wires for some time. The intensity between 5·40 and 6·45 overcame the strength of the battery at this station, so that it was not possible to change the oscillations of the magnetic needle caused by the earth-stream. After the northern light had become fully developed the oscillations became stronger, and followed one another at short intervals until the phenomena entirely disappeared about 7 P.M.' At Warmbrunn in the Riesengebirge, the aurora was seen magnificently from 6 to 8·30. Towards 10 it had almost disappeared. The thermometer indicated 0° C., with a violent storm from the south-west. About 11 the storm suddenly subsided; the thermometer fell to − 1·5°, and the aurora appeared for the second time in the same manner and with the same uninterrupted play of colours as at 6. After 11·30 the storm recommenced, and the aurora disappeared soon after 12. The play of the aurora on the snow-covered mountains is described as one of the most magnificent sights that can be conceived."—ED.]

REFERENCE SPECTRUM FOR THE CHIEF AURORA LINE

WHILE Nature herself seems to delight in surrounding some questions with triple difficulties and mysteries almost inscrutable, there are other questions which she has made the easiest of the easy if men will only use the means which she has prepared. And amongst such easy questions, no more signal example can be quoted than the exact spectrum place, within very narrow limits indeed, of Angström's yellow-green aurora line, whenever any aurora at all appears.

This chief aurora line coinciding precisely (as I believe I may say from my own observations, though by means of the roughest of home-made apparatus) with the second line, at W.L. 5579, of the citron band of the blue base of flame, from any and every material used for artificial illumination by man, and having immediately on one side the 1st line, of the same strength with itself, at W.L. 5630, and on the other side the fainter 3rd line, at W.L. 5535, of the same citron band; the smallest variation of spectrum place in the aurora line can be instantly perceived by the eye on this chemical scale, without the aid of any mensuration apparatus.

And yet in your last impression a respectable spectroscopist, after much labour, informs the Academy of Sciences in Paris, on Feb. 5, that Angström's yellow-green aurora line is somewhere close to Fraunhofer's solar line E, *i.e.* W.L. 5269; and in your previous impression a returning Indian observer considers the same Angström line to be somewhere near F, or W.L. 4860. Now, not only are these statements in error to the extent of from 30 to 70 times what they need be, but they cruelly drag us backwards in what should be the always onward course of science, and cause men to flounder once again in that slough of confusion they were immersed in a couple of years ago, when the chief solar corona line, at W.L. 5316, and Angström's grand aurora line, at W.L. 5579, were stated to be one and the same line, in the same place.

Excuse may, indeed, be proffered for these two observers, that they did not know of such a convenient night reference-spectrum as that which I have now alluded to; and then comes the question as to whose fault was that.

A full description of the method (after extensive trial for several months) was sent by me to the Royal Astronomical Society on May 30, 1871, with the particular request that the paper might be read at their June meeting and printed in the June Monthly Notice. This was mainly with the hope of supplying some possibly useful hints to the intending eclipse-corona-observers of December. The paper, however, though taken in, was neither read at the June meeting (if I am rightly informed) nor did it appear in the June Monthly Notice; but was handed over to secret referees, who simply sat upon it during six long months—or until the eclipse was safely past, and then they began to hint about possible objections being likely to be taken against some parts of the paper.

Of course I could not allow so admirable a society to run any risks of which they were afraid on my account; so I withdrew the paper thereupon, and am now engaged in publishing it myself, sustained in so doing by the hope that, although the eclipse for which it was mainly intended is irretrievably gone, its pages may yet be useful to some spectroscopists of aurora; and, in fact, that through their influence certain of both French and English observers will cease to attempt comparing the faint aurora's chief line with a bright solar spectrum, which they can never see in combination therewith (and if they could it has no coincident lines), but with a cheaply-procured chemical spectrum, which only comes well into view under the darkness of night, and is gifted by Nature in the spectroscope with an easily recognisable line in apparently absolute coincidence with the cosmical line of Angström.

C. PIAZZI SMYTH

15, Royal Terrace, Edinburgh, Feb. 16

*AMERICAN DEEP-SEA SOUNDINGS**

UNDER the title at foot a pamphlet of thirty-three pages, accompanied by a large chart, and illustrated by several diagrams and tables, has been issued. The school-ship *Mercury* is a vessel belonging to the commissioners having in charge the hospitals and prisons of New York city, and is employed for the purpose of training boys, committed by the magistrates for vagrancy and slight misdemeanours, to become thorough seamen. Instead of growing up to be a curse to the community, such boys are made into valuable men. The adventurous life has a special charm for them.

An essential feature of the discipline on this ship is to make long cruises, by which the boys are fitted quickly to enter into the service of the navy or mercantile marine. Of 258 boys carried out on this voyage, 100 were on the return of the ship, in the opinion of the captain, capable of discharging the duties of ordinary seamen.

The commissioners, in addition to the above object, desiring to advance the interests of science as far as lay in their power, instructed the captain, P. Giraud, to obtain a series of soundings on the line of or near the equator, from the coast of Africa to the mouth of the Amazon, to observe the set of the surface currents and the temperature of the water at various depths. He was also directed to bring home specimens of water and of the sea bottom.

The ship sailed on December 20, 1870, and arrived at Sierra Leone on February 14. On February 21 she left

* Cruise of the school-ship *Mercury* in the Tropical Atlantic, with a Report to the Commissioners of Public Charities and Correction of the City of New York on the chemical and physical facts collected from the deep-sea researches made during the voyage of the nautical school-ship *Mercury*, undertaken by their order in the Tropical Atlantic and Caribbean Sea, 1870–71. By Henry Draper, M.D., Professor of Analytical Chemistry and Physiology in the University of New York.