about a fortnight, and have been up the Binué as far as Loko, about 100 miles, where I got some birds. Altogether up to the present I have seen or got about 80 species of birds, including *Scopus*, *Plotus*, *Indicator*, and *Rynchops*; as yet no *Podica*, *Irrisor*, or Musephagidæ. Of Hornbill I have seen 3 or 4 species, but they are very shy, and as yet I have not shot one. Ploseine birds are the feature here; about 1-3rd of the species are of that family, and some I have are good ones, especially *Estrelda nigricollis* and *E. rara*, both of them discovered by Heuglin. These and other things make me fancy that we are out of the true West African region here; the antelopes seem also eastern. There are 4—5 here, including a brown *Hippotragus*, and what I fancy is *Alcelaphus tora*. I have skins and horns of these, and shall get others. *Bos brachyceros* is common here, but as yet I have only seen spoor, not the beast itself. We saw lots of Hippopotamuses coming up, and I killed the second I shot at, but could not recover the body.

I have also killed a large crocodile, 15 feet long, apparently *C. acutus*. I have also a few fishes and reptiles, and shall get more I hope. Butterflies are not very numerous at present, and the country is too open for them, being, generally speaking, a large grassy plain, with lots of isolated trees, not very big, and bushes. There is no regular thick forest up here at all, and even in the lower river, in the delta, it is nothing like the Neotropical forests. The weather has been very dry, and the river is still rising. After leaving Bidda our plans are uncertain. Mr. M. talks of going on to Sokoto, if he can get away from his stock-taking, and if he goes I shall probably go too. If not, I shall try and stay some time at Ischunga, a station a little off the river above Egga.

We are happy to be able to add that Mr. Forbes was in excellent health at the date of his letter.

WORK IN THE INFRA-RED OF THE SPECTRUM

IT is with a certain amount of dread of boring the readers of NATURE, that I have taken up my pen to write on the method of photographing with rays of very low refrangibility, since it ought to have passed the limits of novelty. And yet I suppose it has not altogether done so, since almost weekly, I have inquiries made as to where the method is described, and am questioned as to how to succeed with it, when my correspondents know where to find its description. The Editor, also, has asked me to write on the subject, so I propose to put as concisely as I can what plan to adopt. It is almost too well worn a scientific adage to repeat that unless you can obtain a sensitive salt which will absorb the rays to be used photographically, you cannot hope for success; and the method which I shall describe presently fully secures this desideratum. To photograph the red and dark rays then a sensitive salt must be procured which shall absorb the red and ultra-red rays. The colour of the salt to aim at then is a bluish green, which gives a continuous absorption at the least refrangible end of the spectrum. The salt employed is bromide of silver in a modified molecular state, a state I may say which is very easy to obtain when the formula below is strictly carried out, but very easily missed if the experimenter is self-inspired to make improvements in the method of procedure. I don't know whether it is something peculiar to photographic minds that there is in them such a large amount of self-assurance, but my frequent experience is that those who try a formula for a photographic preparation invariably try to improve on it before giving the original one a chance of success: and then when failure occurs they blame everything and everybody except their own conceptions. May I ask those who read this and endeavour to prepare the sensitive compound alluded to, to follow out strictly the directions as I described them in the Bakerian Lecture for 1880.

The following is the mode of preparation. A normal collodion is first made according to the formula below:—

Pyroxyline (any ordinary kind) . .	16 grains
Ether (·725 Sp.)	4 oz.
Alcohol (·820)	2 oz.

This is mixed some days before it is required for use, and any undissolved particles are allowed to settle, and the top portion is decanted off. 320 grains of pure zinc bromide are dissolved in ½ oz. to 1 oz. of alcohol (·820) together with 1 drachm of nitric acid. This is added to 3 ozs of the above normal collodion, which is subsequently filtered. 500 grains of silver nitrate are next dissolved in the smallest quantity of hot distilled water, and 1 oz. of boiling alcohol ·820 added. This solution is gradually poured into the bromized collodion, stirring briskly while the addition is being made. Silver bromide is now partially suspended in a fine state of division in the collodion, and if a drop of the fluid be examined by transmitted light it will be found to be of an orange colour.

Besides the suspended silver bromide, the collodion contains zinc nitrate, a little silver nitrate, and nitric acid, and these have to be eliminated. The collodion emulsion is turned out into a glass flask, and the solvents carefully distilled over with the aid of a water bath, stopping the operation when the whole solids deposit at the bottom of the flask. Any liquid remaining is carefully drained off, and the flask filled with distilled water. After remaining a quarter-of-an-hour the contents of the fla k are poured into a well-washed linen bag, and the solids squeezed as dry as possible. The bag with the solids is again immersed in water, all lumps being crushed previously, and after half-an-hour the squeezing is repeated. This operation is continued till the wash water contains no trace of acid when tested by litmus paper. The squeezed solids are then immersed in alcohol ·820 for half-an-hour to eliminate almost every trace of water, when after wringing out as much of the alcohol as possible the contents of the bag are transferred to a bottle, and 2 ozs. of ether (·720) and 2 ozs. of alcohol (·805) are added. This dissolves the pyroxyline and leaves an emulsion of silver bromide, which when viewed in a film is essentially green-blue by transmitted light.

All these operations must be conducted in very weak red light—such a light, for instance, as is thrown by a candle shaded by ruby glass, at a distance of twenty feet. If a green light of the refrangibility of about half way between E and D could be obtained it would be better than the faint red light transmitted by ruby glass, since the bromide is less sensitive to it than to the latter. The light coming through green glass after being filtered through stained red glass is almost the best light to use. It is most important that the final washing should be conducted almost in darkness. It is also essential to eliminate all traces of nitric acid, as it retards the action of light on the bromide, and may destroy it if present in any appreciable quantities. To prepare the plate with this silver bromide emulsion all that is necessary is to pour it over a clean glass plate, as in ordinary photographic processes, and to allow it to dry in a dark cupboard.

It has been found advantageous to coat the plate in red light, and then to wash the plate and immerse it in a dilute solution of HCl, and again wash, and finally dry. These last operations can be done in dishes in absolute darkness; the hydrochloric acid renders innocuous any silver sub-bromide which may have been formed by the action of the red light, and which would otherwise cause a heated image.

Let me here give warning, tnat the emulsion formed will be very grainy in appearance, and requires vigorous shaking to cause it to emulsify proper. If it requires a little plain pyroxyline, say about two grains to the fluid ounce should be added to give greater consistency. One thing is certain, if it be not coarse-grained under the microscope it will not be sensitive to the required region, and moreover it will be found that on an average it should be about twice as coarse as the average form of bromide which is generally obtained in collodion emulsion. Here let me interpolate a remark. It has been assumed that because an emulsion in gelatine has a bluish colour after it has been boiled, that in this case we have the same form of bromide as that described above. It is a very different form : let me show how. Suppose we throw a spectrum on a gelatine plate it will be found that G requires about $\frac{1}{5}$ of a second with a very narrow slit, whereas to obtain B it will require the best part of a minute, and to obtain rays of lower refrangibility very much more ; and that any amount of exposure will not make an impression much below A. With the blue-green bromide in collodion to obtain an impression about G will take some eight or ten seconds, and it will be found that at the same time we have an impression of B. A minute's exposure to the prismatic spectrum will under similar circumstances give an impression as much below A as D is above it, measured not in wave-lengths but along the photograph. I point out this because a leading continental photographic experimentalist has expressed himself satisfied as to the identity of the two forms of sensitive salt. They are totally distinct as if he tried to work with a gelatine plate in the infra-red region he will soon own. Now in reference to the coarseness of grain it is right to call attention to its disadvantages. Its advantage we know. In spectrum work we often come across close pairs of lines. Now suppose each pair happened not to be separated by a larger interval than the grain of the sensitive salt, we shall be unable to resolve such a pair, for the action of either component of the pair, and much more both, if they fell on it would be to cause, on development, a reduction to metallic silver of the whole grain. Thus evidently such a close pair would be unresolved.

When a photograph of the spectrum on the finest grained plate is examined under the microscope it will be found that the metallic image is composed of grains of silver and nothing else; and that instead of the lines having sharp edges as seen by the eye that they shade. Part of this shading is due to the grain, though the greater part is due to proper absorption, which the eye is incapable of distinguishing. The fineness of grain given by the different processes we may class as follows, in the order of coarseness, the coarsest grain being first :—

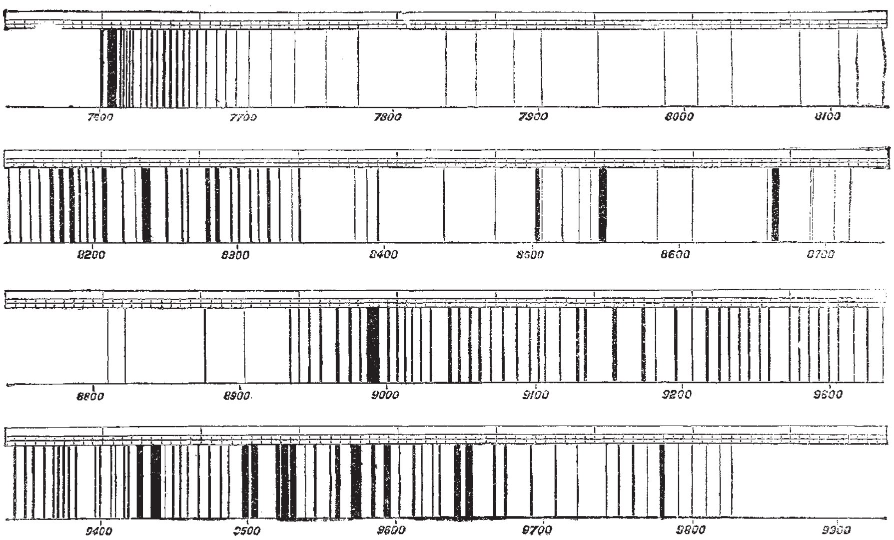

FIG. 1.

1. Wet plate developed by iron.
2. Special bromide emulsion, as before described.
3. { Ordinary collodion emulsion.
   { Wet plate developed by pyrogalic acid.
4. Gelatino-bromide plates.

It will thus be seen that for delicate work the dispersion with the wet plate process and the special bromide emulsion must be larger than when using a gelatine plate if equal resolving power be wished for. The above plate is an instance of this. In it we have the solar spectrum in approximate wave-lengths from Aλ (7,600) to about λ 10,500. The general impression to the eye is the extraordinary width of the lines compared with those in the visible spectrum. No doubt they are as a rule broader, but their breadth is also to be accounted for in other ways. First, the slit used was not quite as fine as might have been when the photographs were taken. Secondly, the dispersion used was the first order of a Rutherford grating 17,200 lines (about) to the inch, and a camera lens of a focus of about fifteen inches. In later photographs nearly all the broad lines have been resolved into pairs or triplets, as have also some of the lines of medium breadth. There are lines, however, like the 3 broad lines between 8500 and 8700 which remain unchanged whatever dispersion was used. This resolution was effected by using a finer slit and dispersion of the second order, the fine slit alone will not give it. If we take an example in the visible spectrum, and examine the B line with the eye, it will be found to be made up of a series of doublet flutings, each component being apparently of equal intensity. These pairs it is impossible to secure on the photographic plate, unless the second order of the grating spectrum is used ; but when secured it will be found that the more refrangible component is more intense, as is the case in certain hydro-carbon flutings. The sole reason why the first order is useless to cause resolution is that the pairs are so close they can both fall on the diameter of the grain of the sensitive compound. On the other hand, with a gelatine plate I have been able to see on one inch and a half every line and more than given in Angström's map from G to F. In this case the grain is almost invisible.

The development of the plate is greatly more difficult than the preparation of the emulsion. A strong developer it will not stand, and I may say also that a very new one is also inadmissible when using the ferrous oxalate development. To make the developer a saturated solution of neutral oxalate of potash is saturated in the cold, with ferrous oxalate: and then the deep red solution decanted off. When freshly prepared it is useless to attempt to develop a plate with it unless the precaution be taken of adding to it an equal part of a saturated solution of ferric oxalate in the oxalate of potash. Such a mixture may be employed by adding to it immediately before all an equal volume of a solution of potassium bromide (twenty grains of the salt to thirteen of water). The plate may then develop without fog or it may not: if it does fog, the developer must have more bromide solution added to it, and another trial made. On some days a clean picture seems an impossibility, whilst on others, every one will be perfect. It is not the emulsion that is in fault, since, on a "clear day" and on a "foggy day" the identical emulsion may be used, showing that the developer is at fault. This year this trouble seems to have increased, and I can only lay it down to the different preparations of the oxalates. Of one thing care should be taken, viz., that the developer never shows alkalinity; a drop of dilute sulphuric acid or nitric acid may be added to the developing cup just before development with advantage.

With prisms the photography with the rays of low refrangibility is simple, with one great drawback, and that is the difficulty of obtaining a true focus for the plate. This must all be done by guess-work, and plates exposed till the focus is obtained. When once obtained it is a good plan to mark the camera to show the focus, and at the same time accurately to mark the table on which it stands, so that the *same portion of the lens receives the same rays*. This is more particularly necessary to attend to when using an achromatic lens. I believe it to be easier to use the uncorrected lens than a corrected one, provided always that the camera has a proper horizontal swing back, which can be shifted through a very large angle at least 30° when using three prisms. If a spherical mirror be used in the collimator and in the camera instead of the lenses, the same difficulties of focusing do not present themselves. The disadvantage of this method is that the edges of the spectrum based are diffused and not straight, and this is awkward when making comparison of different spectra. With a grating nearly the same difficulty arises when using lenses, but not quite to such a degree. If "a" and A be got in focus at the end of the plate, the swing back being used till this results, and if the lens be placed close to the grating, the whole of the infra-red region will be fairly in focus. This of course only applies to my own grating which may have a slight curvature. In using the grating we must not forget that the second order overlaps the first order, and the third order the second order and so on: and if a plate were exposed without any artifice being adopted to get rid of this overlap the plate would show two or three spectra. There are several methods of accomplishing this separation, the simplest being to use the absorbing medium in front of the slit. At first I used stained red glass which cuts off all radiation above the green, leaving thus the tails of the different spectra intact. At present, when wishing to go no further down the scale than λ 10,000, I have found that a deep coloured solution of iodine of potassium in water about one-tenth of an inch in thickness is very excellent. The objection to the red glass is that it exercises a certain amount of general absorption in the infra-red region, but with the white glass of the cell holding the solution, and the solution itself, this general absorption is minimized. To get down still further, very thin stratum of a blue dye in tetrachloride of carbon is efficacious in conjunction with the iodine solution. With the above solutions λ 13,000 can be reached. Beyond this limit it is necessary to use other means of eliminating the higher orders of the spectrum. The simplest plan is to place behind the collimator a couple of prisms, and some two feet from the prisms, the grating so that it only receives those rays which it may be desired to impress. Thus one side of the grating may catch the limit of the red whilst the rest will be filled with the dark rays. The most difficult plan is to place a prism according (as Frauenhofer did) in front of the grating, in such a way that the axis of the prism is at right angles to the ruling and parallel to the plane of the grating; this causes a complete separation of all the different orders of spectra. But the resulting photographs are inconvenient to measure, since they are curved, and the position of the camera is also awkward. Another plan is to use a prism in front of the slit, but this too, I have found inconvenient for the same reasons as given above. For ordinary work the absorption method is decidedly the most elegant, but then it limits the operations with the spectrum. It was from photographs obtained in this manner that the above map of the solar spectrum was obtained, and as it is before us, it may be well to make a few remarks on it. As to

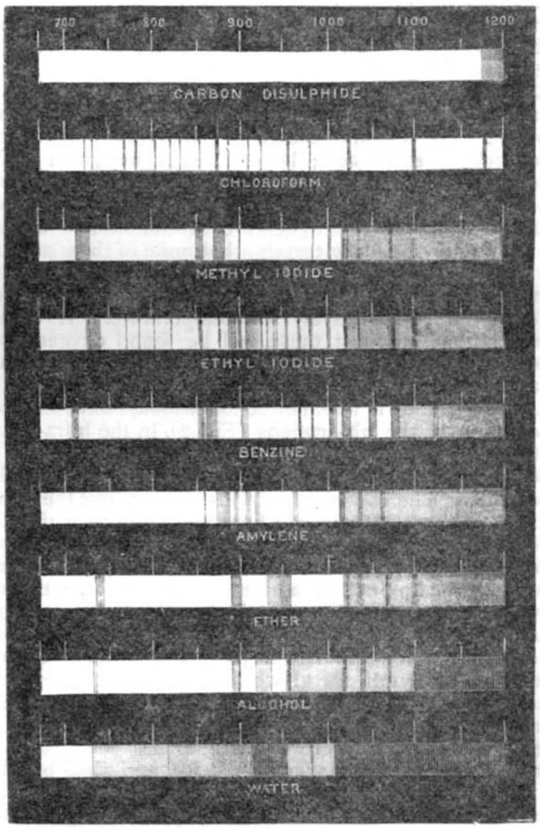

FIG. 2.

what the lines are due to we are at present absolutely uninformed, except as to some very few. A notable exception to this is the line lettered about 8600, which is one of the strongest lines in this part of the spectrum. Colonel Festing and myself found that this line coincided absolutely in position with what we call the radical absorption band of benzene, that is to say, that by diminishing a thin layer of benzene placed between the slit of the spectroscope and a source of light giving a continuous spectrum, this absorption-band, amongst many others, was the last to disappear, and that it also was the key-note as it were of the absorptions of all benzene derivatives.

A coincidence of this kind would not be fortuitous any more than that the vapour of sodium gives lines coincident with the D lines; and hence we were forced to ascribe this line to benzene or some of its derivations. When first we made this announcement it was facetiously remarked that we had been photographing London smoke; and no doubt had not other localities for photographing the spectrum been chosen, the reproach (for such it was) might have been just. My visit last June to the Riffel, 8,500 feet high, showed that not only was this said line present, but that it was more intense even than at the level of the sea. There was more unfolding of the spectrum at that high altitude, and lines faint indeed, which had almost escaped registration below, were well marked on the photographs obtained there. The brilliancy of this infra-red spectrum can scarcely be surpassed. When examined at an elevation of 10,000 feet, the general absorption due to water almost vanishes, and with the exception of two congeries of lines which lie beyond those given in the diagram, the whole of the lines shown are stronger than I have ever had them before.

Colonel Festing and myself have also shown the presence of some alcohol derivative, somewhere between ourselves and the sun, and the presence of the absorption lines at a high altitude place it outside our atmosphere. This I was not wholly prepared for, since lately we have been told that alcohol exists in rain water, and rain water can only derive it from the air. The fact, however, remains that it probably exists beyond the limits of our atmosphere. The region disclosed by photography has by no means been exhausted; beyond the region given in the diagram lies one in which we have a breadth of continuous spectrum, and beyond that again beautiful groups of lines, all of which require and deserve careful study. Of one thing we may be fairly certain, that none of them are due to metallic vapours, but are probably due to vapours of non-metallic compounds in some form or another, and these at a comparatively low temperature. It is not unlikely that amongst these will be found oxygen compounds, and if so it would be interesting in more ways than one.

As a suggestion in which direction to look, I have annexed a diagram of the absorptions (Fig. 2), in the infra-red of a few liquids, by which it will be seen, that by a study of these we may perhaps throw some light on the solar spectrum. The bands in some instances where the liquid is vaporized are split up into lines and flutings, whilst the radical bands, to which I have already drawn attention, seem to remain constant. When it is remembered that one-tenth of an inch of a liquid, such as benzene, will give a definite absorption, it will be seen that a manageable length of vapour may be placed between the slit and the source of light, for its proper investigation. Colonel Festing and myself are at work at it at the present, but the field of investigation is so large that it requires more workers before any general theory can be brought to bear on the subject. It is partly to aid such would-be workers that I have penned the above, and shall be glad if it stirs up some few to aid in this research, which not only has a bearing on solar physics, but even still more largely on physical chemistry.

W. DE W. ABNEY

NOTES

WE have received a communication from Prof. Hildebrandsson, director of the Meteorological Observatory, Upsala, so well known for his researches into the upper currents of the atmosphere, in which, with reference to the proposed observatory on Ben Nevis, he remarks that "the erection on Ben Nevis of a permanent meteorological observatory is of *the utmost importance* for the development of modern meteorology. No better situation for a mountain observatory can be imagined. I have for a special purpose discussed the few observations published from Puy de Dôme. They are of great importance, but unfortunately this mountain, as well as the station of Gen. Nansouty on the Pic-du-Midi, has a bad situation in relation to storm tracks, being almost constantly placed on the north-westerly or south-easterly slope of a high pressure. On the contrary, Ben Nevis is situated almost in the middle track of the depressions or storms of north-western Europe. Hence observations made there must be of far greater importance in their relation to the theory of cyclones than the mountain observations in the south of France. I hope the Scottish Meteorological Society will find the means of carrying on this work." With these views of Prof. Hildebrandsson we heartily concur, and hope that the Council of the Scottish Meteorological Society will succeed in the patriotic effort we understand that they are now making to raise the necessary funds, viz. 5000*l.*, for the erection and partial endowment of this truly national observatory.

WE are glad to learn that Sir Edward Reed is so far recovered that he may be able in the course of a few days to give occasional attendance in Parliament.

THE International Electrical Conference which has been sitting in Paris for the last fortnight, has, after passing several resolutions, adjourned to the first Monday of October, 1883. In regard to electrical units it was resolved that at present there is not a sufficient concord of view to enable the numerical value of the "ohm" in the mercurial column to be definitely fixed, and that all governments be appealed to by France to encourage further research on the subject. The section for "Earth Currents and Lightning Conductors" resolved that Government should be requested to favour regular and systematic observations of atmospheric electricity upon their telegraphic systems; that it is important for the study of storms to be extended to every country; that wires independent of the telegraphic system should be provided for the special study of earth currents; and that, so far as possible, the great subterranean telegraphic lines, particularly those running north and west, should be utilised for the same purpose, observations being instituted on the same day in the various countries. The section for fixing a standard of light expressed the opinion that the light emitted by a square centimetre of melting platinum would furnish an absolute standard. In closing the Conference M. Cochery, the Postal Minister, assured the Members that the French Government would endeavour to give effect to their Resolutions by representations to the various Governments concerned. It is hoped that the twelve months for which the Conference is adjourned will be sufficient for the searches in the various departments in question to be completed. England is indebted solely to the private enterprise and spirit of Sir William Thomson for being represented at all. Between the French Government, the Foreign Office, and the Science and Art Department a sad mess has been made. The Post Office Telegraph Department was never asked to send a representative, nor have any of those who took such an active part in the Conference last year been asked to take any part in this. A more disgraceful muddle has never previously distinguished our "how not to do it" system.

M. MIGNET, Perpetual Secretary of the Academy of Moral Sciences, has just resigned the office held by him from the reorganisation of the Academy in 1835, up to the present time. Having been born at the end of the last century, his plea of old age may be said to be fully justified. It is stated on good authority that he will be succeeded by M. Jules Simon, who is now temporarily filling the office of *secrétaire perpetuel*.

THE annual meeting of the five French Academies, sitting as one body in the capacity of the French Institute, was held on October 25. M. Dumas, as director of the Académie Française, was in the chair. He opened the proceedings by an address, which quite fulfilled the expectations that had been raised. M. Dumas gave an elaborate history of the several academies of Paris, of their suppression in 1793, and their reopening in 1795 as the five classes of the Institute. The regu-