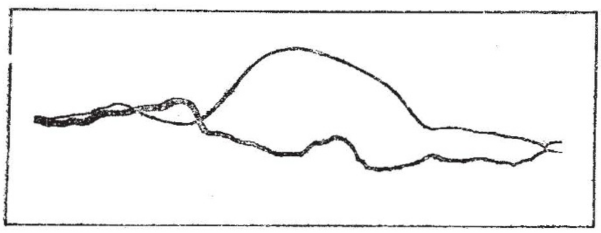
miles per second, takes to pass over a few feet, is *required* to prove to us that lightning is not absolutely instantaneous. Wheatstone has shown that it certainly lasts less than a millionth part of a second. Take this, along with Swan's datum, which I have just given you, and you see that the apparent brightness of the landscape, as lit up by a lightning flash, is *less than one hundred thousandth part* of what it would be were the lightning permanent. We have thus rough materials for instituting a comparison between the intrinsic brightness of lightning and of the sun.

Transient in the extreme as the phenomenon is, we can still, in virtue of the duration of visual impressions, form a tolerably accurate conception of the form of a flash; and in recent times instantaneous processes of photography have given us permanent records of it. These, when compared with photographic records of ordinary electric sparks, bear out to the full the convictions at once forced by appearances on the old electricians, that a flash of lightning is merely a very large electric spark. The peculiar zig-zag form, sometimes apparently almost doubling back on itself, the occasional bifurcations, and various other phenomena of a lightning flash, are all shown by the powerful sparks from an electric machine. [These sparks were exhibited directly; and then photographs of some of them were exhibited.]

The spectroscope has recently given us still more convincing evidence of their identity, if any such should be wanted.

The bifurcations of a flash can puzzle no one who is experimentally acquainted with electricity, but the zig-zag form is not quite so easily explained. It is certainly destroyed, in the case of short sparks, by heating the air. [Photographs of sparks in hot and in cold air were



exhibited. One of each kind is shown in the woodcut. The smoother is that which passed through the hot air. The other passed through the cold air nearer the camera, and is therefore not quite in focus.]

Now heating in a tube or flame not only gets rid of motes and other combustible materials but it also removes all traces of electrification from air. It is possible, then, that [the zig-zag form of a lightning flash may, in certain cases at least, be due to local electrification, which would have the same sort of effect as heat in rarefying the air and making it a better conductor.

A remark is made very commonly in thunderstorms which, if correct, is obviously inconsistent with what I have said as to the extremely short duration of a flash. The eye could not possibly follow movements of such extraordinary rapidity. Hence it is clear that when people say they *saw* a flash go upwards to the clouds from the ground, or downwards from the clouds to the ground, they must be mistaken. The origin of the mistake seems to be a *subjective* one, viz., that the central parts of the retina are more sensitive, by practice, than the rest, and therefore that the portion of the flash which is seen directly affects the brain sooner than the rest. Hence a spectator looking towards *either* end of a flash very naturally fancies that end to be its starting-point.

(*To be continued.*)

OBSERVATIONS ON ARCTIC FOSSIL FLORAS WITH REGARD TO TEMPERATURE

THE first feelings of surprise caused by the discovery of remains of warmer-temperate, sub-tropical, and even tropical plants within the Arctic circle, of, geologically speaking, comparatively recent age, have now died away, and we no longer find that their presence there forms so favoured a theme for speculation. The time appears to have arrived when we may critically examine the botanical evidence upon which estimates of the past degree of warmth enjoyed by the Arctic regions have to be formed. The method open to us is very simple: we have, it seems, only to first set aside determinations that are clearly little more than guesses; then ascertain the minimum mean temperature required by the remaining groups of plants to flourish at the present day; and the sum of these temperatures should furnish reliable results for each period.

I am not yet able myself to carry this inquiry beyond the ferns and conifers, but the determinations of these are probably so very much more accurate than those of the higher orders of plants as to comprise most of the safer data, and they are sufficiently numerous for the purpose.

My present remarks are limited to the Komeschichten, a horizon supposed in the "Flora Fossilis Arctica," to represent in Greenland the Urgonian or Neocomian of Central Europe. In this Komeschichten two genera of ferns occur which deserve especial consideration, for Prof. Heer makes use of their presence to infer that at that period the Arctic regions were favoured with a sub-tropical or even tropical climate. These genera are *Gleichenia* and *Oleandra*. The correctness of the determination of the supposed Arctic Oleandra is doubtful, and it is best for the present to place them among the guesses. The very sparse indications of sori are not satisfactory, and there are no less than twelve widely-distinct genera possessing species with approximately the same venation. Oleandra is a small genus with but six species, almost confined to the tropics, but two of them grow in Northern India at altitudes of 6,000 and 7,000 feet.

It is quite otherwise with the remains of *Gleichenia*, for these preserve every characteristic of that genus. But while it is perfectly obvious that these are really fragments of Gleichenias, neither the number of species into which Prof. Heer has divided them, nor the inferences as to climate which he draws from them, can be admitted. He has quite unnecessarily, it seems to me, separated the fragments from the Komeschichten into fourteen species, and to these has added two from the Ataneschichten. The prevailing species, *G. Zippei*, if considered to represent the type in its average size, might be made to embrace eight or ten of them without even then approaching the limits of variation seen in the corresponding existing species. *G. Giesekiana* receives the rather larger pinnæ and *G. gracilis* the smaller, and many others seem separated on trifling or fancied peculiarities, as *G. acutipennis*, which is merely a small, indistinct fragment, with a few rounded depressions, conjectured to mark sori, but which, from their position on the mid-rib, could not well be such. *Gleichenia* is a particularly variable fern. Berkeley mentions (Introd. to "Crypt. Bot.," p. 516, Fig. 110, *b*) that he had seen at Kew the minute pinnules of one of them expanded to three times its normal length, and the margins unfolded by exposure to a warm damp atmosphere. In two full-grown specimens of *G. dichotoma* from Khasia, in the Kew Herbarium, the longest pinnules respectively are one and nine centimetres in length. The Arctic species are, however, closely represented by *G. glauca* (*G. longissima*, Hook., "Syn. Filicum"), and in this species the pinnules in different plants vary, from a single locality, between 25 and 2 mm. in length. In making species out of fragments of fossil plants the greater or less liability of the living forms to vary should, it seems to me, be kept in mind, and for general convenience the greatest possible number, if from one locality and horizon, be included together.

There are not wanting altogether, however, indications of other species, and among them *G. rigida*, *G. rotula*, and *G. micromera* seem to be distinct, but the great majority are simply pectinato-pinnatifid, and possess no really distinctive specific characters. In addition to this, fourteen species from one locality and horizon appear a very unlikely number to have existed together, for although the plants are sociable and grow massed together, but few species are ever met with living together in the same vicinity. The whole of America, which is the richest continent in species, contains but nine, the varied lands grouped as the Malayan region but seven, New Zealand five, Australia four, &c.; the total number recognised by Hooker in the "Synopsis Filicum" being but twenty-three. The greatest number growing in a restricted area is in North Caledonia, where there are four; but I am not aware whether these are actually associated together.

These Gleichenias are repeatedly alluded to by Prof. Heer as indicating a tropical nature for the Arctic cretaceous flora, but so far as their presence goes, they by no means imply that a high temperature prevailed. Although no Gleichenia now ranges into high northern regions, they flourish south in the rigorous climates of the Magellan and Falkland Isles, S. lat. 53°, which have an isotherm of less than 45°, and are also found on the high mountains of Tasmania and on the Andes at 10,000 feet, which is, according to Humboldt, the level of gentians and near the limit of arborescent vegetation. The group of Gleichenias from the colder regions of South America all resemble each other in much the same degree as those of the Arctic regions did, and all possess small, hard, rigid, pectinato-pinnatifid pinnæ. Among them are *G. pedalis*, *G. cryptocarpa*, and *G. quadripartita*, all of which, but especially the former, vary considerably, being either long or shortly pectinate. It is a suggestive fact that the existing representative of these Arctic Gleichenias is the only one that still ranges into northern temperate regions, such as China and Japan, while the representative of the English Eocene species is an essentially tropical form.

The Arctic group of Gleichenia appears to have very little affinity with European fossil plants of similar age, except through *G. Zippei*. Heer connects one with *G. comptoniæfolia*, from Aix-la-Chapelle, although there is little discoverable resemblance between them. To do so he has to point out a discrepancy between the drawing and the description, and although he had never seen the specimens, prefers to rely on the drawing which Dr. De Bey now disclaims as incorrect. The Aix-la-Chapelle types are really quite different and more varied, and link them with our own eocene species. This latter is an essentially tropical type, and completely distinct from either the fossil Arctic group or the existing forms from the cold southern latitudes, since it closely approaches *G. dichotoma*, the only type of a well-defined section of the genus, now almost universally distributed over the tropical world.

The Gleichenias seem first to have appeared in the Jurassic, to have passed away from Europe before the close of the Eocene period, and to be now decidedly characteristic of the southern hemisphere—very few species crossing the equator, although the representative of the fossil Arctic species still extends as far north as Japan. It is obvious that we need not, from their presence, assign a very high mean annual temperature to the older cretaceous period in Greenland.

J. S. GARDNER

METEOROLOGY IN JAPAN

WE have read carefully and with great pleasure the *Memoirs* of the Science Department of the University of Tokio, Japan, vol. iii. Part i., which gives the report of the meteorology of Tokio for 1879, by Prof. T. C. Mendenhall. The observations, which are carried on in the west wing of the small observatory attached to the University, were commenced in January 1879, and this is the first report issued by the Observatory. The instruments are from Negretti and Zambra, and, with the exception of the thermometers, they appear to have been placed in suitable positions. The thermometers are mounted outside the north window of the second floor, and are separated from the observing room by glass doors, which are opened for observation. This position of the thermometer is in several respects objectionable, but particularly as it precludes any comparability, beyond a rough one, between the temperature observations at Tokio and at other stations which are or may be established in Japan.

The hours of observation are 7 a.m., 2 and 10 p.m., an arrangement of hours, it may be remarked, which states the mean temperature of the six warmest months of the year about three-fourths of a degree too high, and further does not approximate with the desired closeness to the important diurnal turning-points of the barometric pressure. It is however right to add that it is declared desirable to increase the number of the observations to at least five or six during the day as soon as the necessary arrangements can be made, and to institute a series of hourly observations for approximately determining several of the diurnal curves. An arrangement, if possible to be carried out, for the erection of continuously-recording instruments, would be an important gain to Japan meteorology.

The observations are published *in extenso*, and are illustrated with great fulness by excellent diagrams, which show in a clear manner the main results of the year's observations, the diagrams being lettered and numbered so as to serve for both the English and the Japanese editions which are issued.

The mean pressure for the year at 32° and sea level is given at 29·952 inches, the monthly maximum, 30·093 inches, having occurred in January, and the minimum, 29·809 inches, in August, thus showing a tendency in the atmospheric pressure to be assimilated to the annual march of pressure in the continent adjoining. There having occurred no typhoon during the year, the lowest barometer was only 29·087 inches, which happened on February 23, and the highest, 30·515 inches, on April 21, the range for the year thus being 1·426 inch. The mean diurnal range from 7 a.m. to 2 p.m. is large, being 0·059 inch for the year, regarding which Prof. Mendenhall remarks that "this same relation exists in each set of monthly means with two exceptions." These exceptions are May and September, the ranges for which being, as printed in the means, 0·028 inch and 0·019 inch. On comparing these ranges with those for the other months, they are at once seen to be physically impossible; but by averaging the observations themselves for these months these exceptionally low ranges turn out to be due solely to errors of computation. The true range given by the observations for May and September are 0·047 inch for each month. The exceptionally large range for July, viz., 0·085 inch, is also an error of computation; the true range was only 0·052 inch, the mean range at Tokio being, as in corresponding latitudes of the Atlantic, less in the summer than in the winter months.

The lowest temperature for the year was 24°·1 on January 2 and 7, and the highest 93°·0 on August 15. The temperature fell to or below freezing (32°) on 46 days, 27 of these days being in January, and rose to or above 90°·0 on 12 days, 7 of these days being in July and 5 in August. The mean annual temperature deduced from the 7 a.m., 2 and 10 p.m. observations was 58°·5, and from the maximum and minimum observations 58°·0, the higher temperature of the former being due to the 7 a.m. observations. If this were changed to 6 a.m. the hours of observation