nearly the same time that the latter completes 191 revolutions; the periods are 16,801 and 16,802 days respectively, and thus transits of Mercury must occur every forty-six years at the same node.

THE PERSEID METEORS.—In No. 4206 of the *Astronomische Nachrichten* (p. 81, October 16) Herr W. Milowanov, of the Kasan University Observatory, Russia, gives an account of the Perseid observations made at Kasan in August, 1906. Two hundred and seventy-two meteor-paths were recorded, by three sets of observers, on August 11, 12, and 13, forty-nine of which were not Perseids. The horary rate on August 11 was 21·5, and on August 12 25·4. The time of observation, the path and the magnitude of each meteor are given, together with a list of the variously estimated radiants; the centre of the radiant for 1906 is given as $\alpha = 43°\cdot 5$, $\delta = +55°\cdot 0$. The heights of twenty-four meteors are also given, the mean heights of appearance and disappearance being 111 km. (sixty-nine miles) and 73 km. (forty-five miles) respectively.

A RICH NEBULA REGION.—On a plate exposed in the Bruce telescope for three hours on July 16, 1906, Prof. Max Wolf found an extensive nebulous cloud having its centre some 1½ degrees north-east of ϵ_2 Sagittarii. Later observations show that the region is very rich in small nebulæ, a plate exposed on July 16 showing a large number of such objects over a region of forty-eight square degrees. Most of these nebulæ are of Prof. Wolf's class I_1, being round objects with central condensations (*Astronomische Nachrichten*, No. 4207, p. 109).

RAIN-GAUGE EXPOSURE AND PROTECTION.

WHEN during the nineteenth century rainfall observations by means of gauges began to be carried out upon an extensive and scientific system, it was soon discovered that gauges which stood in situations much exposed to the wind invariably indicated a smaller amount of rain than such as were protected from the wind.

The greater part of our knowledge regarding the effects of wind exposure upon the indications of rain-gauges was derived from a careful study of the diminution of recorded rainfall with the elevation of gauges, either upon buildings or poles, above the ground, and an abundance of experimental work carried out during the nineteenth century in many European countries, notably, perhaps, in England, as well as in the United States of America, left no doubt but that this indicated decrease of rainfall with height above the ground was only apparent, and due to the more imperfect catch of rain by the gauges consequent upon their increased exposure to wind.

The well-founded conclusion is that wind interferes with the proper catch of rain by eddying around the mouth of the rain-gauge, and that consequently a rain-gauge should on theoretical principles be protected from wind disturbance if we would know the true quantity of rain that falls upon the ground in its vicinity. Nothing is known as to the mode of formation or of the complexity of these wind eddies, and information respecting these questions could only be suggested through laboratory experiments. When a gauge is elevated above the ground upon a thin pole there is merely the augmented wind velocity to be considered in explanation of the decreased amount of rain it will receive as compared with a similar one upon the ground, but when a gauge is placed upon an edifice or close to the edge of a steep cliff or bank the case is far more complicated through new disturbances introduced by such obstructions themselves to the wind, which has the effect of causing a deficit of rain upon the windward side of buildings and a relative surplus upon the leeward side.

The whole subject, however, of decrease of recorded rainfall with height above the ground has been thoroughly investigated, as mentioned above, in its several relations, so that there offer themselves for discussion, more particularly the methods that have been adopted for protecting rain-gauges from, or of correcting their readings for, wind error.

It was about the year 1889 that Prof. Cleveland Abbe,[1] of the United States, made an exhaustive study of the data at that time available from different parts of the world with reference to the apparent decrease of rainfall with elevation above ground, and relating his data to a law known to meteorologists as Archibald's, connecting increase of wind velocity with square root of altitude for small altitudes above the surface of the earth, showed that the deficit of rain indicated by an elevated gauge was proportional to the square root of its altitude above the ground. From these results Abbe deduced for a rain-gauge in a free, open situation a numerical wind correction which may be explained as follows:—

If a second gauge, in all essential respects similar to the one for the readings of which the correction is to be applied, be placed twice as high above the ground as the latter, the quantity $E \times 2\cdot414 + R = C$, where E is the excess of the reading of the lower gauge above that of the upper, R is the reading of the lower gauge, and C is the corrected reading of the lower gauge; to state this in words, add to the reading of the lower gauge 2·414 times its excess above that of the upper, and the result is the amount of rain which the lower gauge would have caught in the absence of wind disturbances. The validity of this correction, which depends, of course, upon the extent to which for any particular occurrence of wind and rain the necessary assumption of Archibald's law is trustworthy, is doubtless such as to enable at least a close approximation to the true rainfall to be reached. But two conditions must be complied with before the records of two gauges placed at different heights above the ground can thus bear a simple relation to differences of wind velocity corresponding to different amounts of error through eddy action at the mouths of the gauges:—(*a*) the two gauges must be of the same form and dimensions; (*b*) if the lower gauge rests upon the ground, the upper one must be supported on a somewhat thin pole as may not induce, by offering an obstruction to the wind, other disturbances operating at the mouth of the rain-gauge in addition to those due to the gauge itself.

Of the various types of wind-shield for rain-gauges that have been suggested or tried, by far the most serviceable is the protecting funnel jacket[1] originally devised about the year 1879 by Prof. F. E. Nipher, of the United States. This is screwed on to the cylinder of the rain-gauge at such a height that the rim of its broad upper portion lies level with that of the mouth of the gauge, and consists usually of copper gauze for the purpose of preventing or minimising the splashing of water into the gauge from the inner surface. The efficiency of such a protector has been tested, not only by Nipher himself, but by Prof. R. Börnstein in Germany and Dr. H. Wild in Russia, with the result that the contrivance may, on the whole, be regarded as an appropriate means of eliminating, or at all events reducing, injurious wind eddies around the mouth of a rain-gauge, as will be shortly seen. Since the protecting jacket was invented by Nipher it has been improved in various ways, a comparatively recent modification, as used at some of the Russian rainfall stations under the direction of the Central Physical Observatory at St. Petersburg, being capable of being taken to pieces so as to facilitate packing for transport.

Another type of protection contrivance, more accurate than the Nipher jacket, was established about 1880 in St. Petersburg by Dr. H. Wild. This took the form of a rectangular fence enclosure composed of wooden slabs, 2·5 metres in height, at certain equal distances on each side from the rain-gauge, the mouth of which was 1 metre above the ground, and provided with a door for the entry or exit of the observer. A comparison of anemometer observations within and without such an enclosure shows that even during the prevalence of high wind the conditions within approximate nearly to those of a calm, so that a fence enclosure of the dimensions adopted by Wild may be taken as the standard of accuracy for wind-protection contrivances.

1 *Monthly Weather Review*, vol. xxii., 1894, p. 25, "The Reliability of the Rain-gauge"; *American Meteorological Journal*, vol. vi. p. 241, "The Determination of the Amount of Rainfall.'

1 *Zeitschrift der Osterreischischen Gesellschaft für Meteorologie*, Band xiv., 1879, s. 250, "Ueber die Bestimmung der wahren Regensmenge mittelst hochaufgestelltes Regensmesser, von F. F. Nipher; *Meteorologische Zeitschrift*, Band i., 1884, s. 381, "Ueber den von Nipher vorgeschlagenen Schutztrichter für Regenmesser," von R. Börnstein; *Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg*, v^e série, vol. iii., 1895, p. 193, "Kritische Untersuchung der Angaben freier und geschützter Regenmesser,' von Emil Berg.

Respecting the relative efficiency as protecting agents of the Nipher jacket and the Wild fence, experimental observations have been, and are apparently still being, conducted in Russia, a country, be it noted, where, owing to the large quantities of snow that fall during the colder months of the year, the sources of error in rain-gauge records through wind assume greater magnitude than they do, for instance, in England, where the winter precipitation consists largely of rain. It may be said that, while the Nipher protector is generally well adapted to its purpose for ordinary situations of rain-gauges, it may be with advantage replaced by the fence enclosure in the case of gauges which are unduly exposed to the full force of the wind in unsheltered locations. If the accuracy of the Wild fence be taken as 100, that of the Nipher jacket may approximate to 100 in more sheltered positions, but may be as low as 80 or even lower in such as are quite open to the violence of the wind. It should be added that a Nipher gauge ought to be fitted with some form of heating apparatus adequate to prevent accumulations of snow in winter upon the protecting jacket, from which into the rain-gauge portions of such accumulated snow are liable to be blown.

This brief abstract of the chief methods of diminishing or eliminating the wind error due to rain-gauges would be incomplete were it omitted to mention a process of calculation[1] by which the rainfall figures for a sufficiently long period, as indicated by a gauge at a place which suffers undue exposure to the wind in comparison with another gauge in the neighbourhood, say a few miles distant, at a more sheltered spot that may be regarded normal, may be corrected. The method depends upon the relation subsisting between the amounts of discrepancy in the records of two such gauges during periods of rain and of snow. If the rainfall for a specified time at the sheltered station be represented as 100, and that at the exposed station as $100-A$ for periods of rain and $100-A-B$ for periods of snow, the equation $K=\frac{x+A}{B}$, when solved for x, affords the correction required. The value of K, which for a few localities in Germany has been found to range from 0·13 to 0·22, must be empirically determined for a particular district by establishing two similar rain-gauges close together, or, if possible, side by side, one of which is fitted with an efficient wind-protection contrivance, the other being left free; for a pair of gauges in such close proximity x may be considered to vanish, so that K becomes $=A/B$. The value of K for the locality being thus found, x is solved $=KB-A$, which will, of course, be a *plus* or *minus* quantity according as the true rainfall is slightly greater or less at the exposed than at the sheltered station. This method of calculation, which is applicable in many instances, has been tested by another more direct one involving anemometer readings, whereby the measured quantities of precipitation could be reduced to equal mean wind velocities, and as the two have given most concordant results, it may be concluded that the one briefly delineated above is correct.

Thus at Karzig, in Neumark, the rainfall at an open, wind-swept spot on the outskirts of a forest, though indicated by a rain-gauge as considerably less than that of a glade more than 2 kilometres distant, was found by both processes of calculation to be actually 2 per cent. greater.

To summarise the contents of this article:—

(1) Experimental observations extensively carried out during the nineteenth century in many countries have established the fact that in the measurement of rainfall errors of considerable magnitude accrue from the presence of the rain-gauge during the prevalence of wind, and point to the conclusion that such errors arise from the eddying or rebounding of wind about or from the mouth of the rain-gauge.

(2) The readings of a rain-gauge in a free, open situation may be corrected by means of a method involving their comparison with those of another similar gauge placed at twice the height above the ground.

(3) The most efficient wind-protection contrivances for rain-gauges are the Nipher jacket and the Wild fence enclosure; the latter, though more accurate and advantageous in special circumstances, is generally less used than the former.

(4) The corrected rainfall for a sufficient length of time of a wind-swept spot may in many instances, if the rainfall for the corresponding period of a sheltered spot in the same neighbourhood, say a few miles distant, be known, be determined by means of an equation involving as known data (*a*) the relative amounts of discrepancy in the records of the gauges at the two places during periods of rain and of snow; (*b*) an empirically determined constant K.

L. C. W. BONACINA.

[1] *Meteorologische Zeitschrift*, Band xxiii., 1906, s. 444, "Wald und Niederschlag in Westpreussen und Posen und die Beeinflussung der Regen und Schnee-messung durch der Wind," von J. Schubert.

RECENT DEVELOPMENTS IN THE THEORY OF MIMICRY.[1]

THE remarkable resemblances that exist between certain insects belonging to widely different orders have long been known to naturalists. Wasps and hornets are imitated by the "clear-wing" moths, the resemblance being so close that it has sometimes deceived for the moment a skilled entomologist. Certain two-winged flies that inhabit the nests of humble-bees are scarcely to be distinguished from their hosts, and the handsome Xylocopas, or carpenter-bees, familiar objects in the tropics, are deceptively copied by two-winged flies found in the same regions.

But it is not only the bees and wasps that are so imitated, nor are the imitating insects to be found only in the ranks of moths and flies. An ichneumon fly in Borneo, belonging to the same order as the bees and wasps, though not in the same sense a stinging insect, is closely copied by a Reduviid bug.

Other instances are numerous. So long ago as the year 1836, the French entomologist Boisduval directed attention to the extraordinary resemblance that exists between certain butterflies which are not at all closely related to each other, belonging, indeed, to groups which are widely distinct. One of these butterflies is a member of the Danainæ, a group of which we have no resident representative in this country; a second is nearly related to our familiar "swallow-tail" of the Cambridgeshire fens; while the third is a Nymphaline, not far removed from our British "White Admiral." The structural differences between these butterflies show the want of real affinity between them in spite of their superficial resemblance. The "cell," for example, of the hindwing is open in the Nymphaline, while in the other two it is closed by a transverse vein. This illustrates the point that these resemblances affect only obvious characters; they are independent of affinity or blood relationship, and leave untouched such morphological features as do not readily meet the eye.

An insect thus resembled by another is spoken of as its "model," the imitating insect is called a "mimic," and the combination of model and mimic or mimics is known as a "mimetic pair" or "mimetic assemblage," as the case may be.

What is the meaning of these resemblances? Many of them were well known to the older naturalists, who, however, had nothing to offer by way of explanation but vague talk about "repetition" and "analogy" in nature. The well-known entomologists Kirby and Spence got so far as to suggest that in some cases the resemblance might be of advantage to the mimic, but in their day it was not likely that the subject should be treated from the evolutionary point of view, and the first really scientific explanation of the matter was given by Bates on his return from his famous visit to the Amazon, now nearly fifty years ago.

Bates had observed that in these cases of deceptive resemblance between butterflies, one member of the pair or of the group was often characterised by abundance of individuals, while the whole group was marked by slowness of flight, conspicuousness of appearance, and immunity from the attacks of insect-eating birds. On these grounds he put forward the suggestion that the mimicking species enjoyed protection from attack by their

[1] An evening discourse delivered at the Leicester meeting of the British Association on August 5 by Dr. F. A. Dixey.