Astronomical Possibilities at Considerable Altitudes.*

As considerable attention has been directed of late to mountain observatories, and as the Boyden Station is, I believe, the highest astronomical observatory in the world having such an extensive equipment for the study of the heavens, a brief description of the atmospheric conditions found in this locality may be of general interest.

The Boyden Station of the Harvard College Observatory is situated two miles from the city of Arequipa, Peru, in latitude 16° 24′ south, and longitude $4^h\ 45^m\ 30^s$ west from Greenwich, and at an altitude of 8060 feet (2457 metres) above the sea-level. As an account of this station and its equipment will be given later in the 'Sidereal Messenger,' the present article will be confined strictly to a description of the atmospheric conditions under which the work is carried on. As we arrived here at the end of January 1891, it is impossible at present to give a complete account of the year's climate. Apparently, however, it may be described as follows:—The rainy season begins at the end of January and lasts through March, with a rainfall of about three inches. It is then clear, with comparatively small interruption from clouds, until the following November. A cloudy season then sets in, lasting a month, during which there was this year a rainfall amounting to 0·01 inch on two successive days. During the two remaining months we expect clear weather perhaps half of the time. The thermometer here rarely falls below 40° Fahrenheit, and rarely exceeds 75°. The extreme fluctuations of the barometer amount to rather less than 0·2 inches.

The Observatory is situated upon the crest of a hill overlooking the valley, and at an altitude of 400 feet above the city. It is overshadowed by three extinct or nearly extinct volcanoes, rising to altitudes varying from 18,500 to 20,000 feet above sea-level, but in no case exceeding 12° altitude as seen from the Observatory. Towards the south-west the horizon is clear, down to a level with the eye.

The first fact which strikes the attention of an observer coming from a sea-level station in the temperate zones is the brilliancy of the stars. Night after night 6·5 magnitude stars are picked out with the naked eye without the slightest effort. The eleven Pleiads can always be counted when the Moon is not too bright. The Andromeda nebula, seen with difficulty at home, is here a much more brilliant object, appearing larger than the Moon. 3·0 magnitude stars have been seen to disappear below the horizon where the latter was on a level with the eye, while 4·0 magnitude stars disappear at perhaps half a degree higher up. Every night the faint hazy light of the zodiacal arch spans the horizon from east to west, yet is so conspicuous that on pointing

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it out to one of our Peruvian assistants, with the request hat he should observe it, he remarked that he had often noticed it, and supposed it was part of the Milky Way. The Gegenschein is readily seen any evening after nine o'clock, and we have on several occasions used it as a convenient reference-mark to determine roughly whether a celestial body has reached opposition with the Sun or not. One of my assistants, Mr. A. E. Douglass, thought one evening that for a short time it was as bright as the Lesser Magellanic Cloud. One advantage of our location is that if a difficult phenomenon is observable one night, we know that it will in general be equally visible night after night, with but little interruption, for weeks at a time. In the case of the Gegenschein, however, a certain irregularity in its brilliancy seems to occur.

The same atmospheric transparency is noted with the 13-in. Clark refractor. As an illustration of this, while in the temperate zones little can be seen of the great Orion nebula that is not figured in Bond's drawing, here the whole of the photographic region, first shown in the Harvard photographs of 1887, and exhibited at the meeting of the first Astrophotographic Congress, is clearly visible to the eye, and could not escape detection even by one wholly unfamiliar with its conformation. This addition more than doubles its apparent area, and renders it indeed the most splendid object in the stellar universe.

Nor is it only in atmospheric transparency and uniformity from night to night, that a gain is made by ascending to a moderate altitude in the tropics. The stars appear here with a steadiness and lack of fluctuation, which is a very severe test upon the optical qualities of an instrument. A scale of steadiness of seeing has been adopted, on which 3 indicates that the brighter stars are surrounded by numerous diffraction rings, but that they are broken and impossible to count. 4 indicates that they are complete and may be counted, and that the central point of light is readily separable from the inner ring, while 5 indicates that each ring is perfect and immovable. As it is impossible to detect any improvement upon the latter condition, I have denominated it as "perfect" in my records. Usually half a dozen rings may be seen about the brighter stars; but when the seeing is "perfect," as many as twelve have been counted around α Centauri. This condition it should be stated has been noted on but two or three occasions this year; but then much of the work has been done at a considerable distance from the zenith, and visual observations were carried on for but little over three months. At the end of that time the crown lens was reversed, and the instrument used for photographic purposes. The seeing is generally divided between 3 and 4, and certain subdivisions have also been formed. It is so rarely inferior to 3, that no distinct definitions have been given to the lower numbers of the scale; but when the star images increase in size beyond mere points, or otherwise indicate inferior definition, the instrument has been closed or turned to other uses.

The rings indeed are usually so distinct, that they seriously interfere with the detection of the faintest companions to bright stars; but if the companion is bright itself, as in the case, for instance, of α Scorpii, we have perhaps six rings around the primary, and one intersecting them around the companion.

In examining surfaces, such as the bodies of the solar system, it was frequently impossible to detect any wavering whatever of the edges of the disc, even with a power of 400, which was the one always employed with the 13-in. Indeed, it was impossible to distinguish any difference in the sharpness of the limb as seen in the 13-in. and as seen in the 8-in. finder, with a power of 60. Until recently a one-half inch eyepiece was the shortest one in my possession, which explains why higher powers were not tested and employed.

Several facts have already been noted here which I believe to be new, but they cannot well be included within the scope of the present article. I will mention, however, an observation, which, while it brings out no new facts, will illustrate very well the character of the definition. Shortly after the telescope was erected about the middle of August, I was examining Jupiter's third satellite, which under the power employed appeared somewhat smaller than our own Moon with the naked eye, and nearly equally distinct. Near the centre of the disc, but not quite coincident with it, a small dark spot was observed, with rather hazy edges. This was at once set down to planetary detail, and careful drawings were made. The next night it was observed again, in the same place, but rather smaller, and again the following night. No motion of rotation, however, could be detected. The observations were continued, and the other satellites also observed. One particularly fine night the spot was very distinct and very small, appearing but little larger in proportion to the disc than the Mare Crisium does upon the Moon. On turning the telescope to the fourth satellite an exactly similar spot was seen, and similarly placed. Then it flashed upon me that what I was observing was a diffraction phenomenon, the size of the spot depending on the character of the seeing, and its non-coincidence with the centre of the disc being due to some slight lack of adjustment in the lenses. Some weeks later I was examining Jupiter. The seeing was very good, and the fourth satellite was in transit, appearing as a round dark spot. To my surprise I noticed that near the centre of its disc was a comparatively brilliant point of light. At first my other observations did not occur to me, but I presently saw that what I was now observing was merely the diffraction spot reversed, owing to the bright background of the planet. Indeed this same phenomenon has been frequently observed at the time of a transit of Mercury, but I do not know of its having been before noted in the case of a transit of Jupiter's fourth satellite. It is quite possible that these diffraction spots may in part explain the somewhat confused accounts of observed markings upon Jupiter's satellites. They are certainly much their most conspicuous features, since their surfaces are far more free from genuine planetary detail than is the case with our own Moon.

In closing this article I wish to express my opinion, that as the result of my experience with large refractors at altitudes varying from 6000 to 14,000 feet, among the mountains of Colorado, California, and Peru, that for transparent skies one must approach the tropics, and that for steady seeing one must have an extremely dry climate. Contrary to the not uncommon experience in localities when the seeing is poor, the thinnest haze here at once reduces the quality of our seeing, although perhaps still leaving it much better than it would be under similar conditions at home. For our very best seeing the stars must be brilliant, and there must not be the faintest trace of a cloud in the sky. In short, moderate altitude is, I think, a most desirable qualification for an observatory, but suitable latitude and habitual dryness of climate are still more important.

Arequipa, Peru,
1891, Dec. 9.

W. H. Pickering.

Nova Aurigæ and its Suggestions.

The one certain result of investigations into the late stellar outburst is that it was occasioned by the mutual disturbance of two cosmical masses rushing past each other at high speed. It can scarcely be maintained, however, that this conclusion applies exclusively to the single instance in which it has been demonstrated. There is, to say the least, a strong presumption that it holds good for all objects of the same class. But if for all Novæ, why not for variable stars as well? No really fundamental distinction can be established between one kind of phenomenon and the other. "New stars" approve themselves as such only negatively. The mere fact of the reappearance of any one of them would at once compel its transference to the ranks of variables. And the subsisting difference, such as it is, becomes still further attenuated on consideration of the abortive periodicity shown by Anthelm's Nova of 1670 in its twofold revival at annual intervals. Nor can spectroscopic tests be much relied upon, though some may, with qualifications, be indicated. Thus, the typical bands of the third stellar type, with superposed bright hydrogen-lines, characterize, perhaps unfailingly, stars subject to wide fluctuations of lustre in periods of many months; but shaded zones less regularly disposed were observed in the Nova of 1866, and are included with bright lines in the spectra of such variables as R Coronæ and R Andromedæ. Again, the vivid emergence of the solar chromospheric lines at 502 and 492, as well as of the calcium-lines H and K, does not appear, so far, to have been recorded in any but temporary stars;