

reflector. γ' is the angle which will be measured on the plate, γ the angle we want. Call,

S , the distance between the points on which the rays strike the reflector.

A , the angle which the line joining the points makes with the plane normal to the axis of the telescope.

D , mean distance of the mirror from the objective.

$\delta\gamma = \gamma' - \gamma$, the error produced by the curvature of the mirror in the result of the angular measurement.

Then, $S = D \sin. \gamma \sec. A$.

$$\delta\gamma = \frac{2S}{\rho} = \frac{2D \sec. A}{\rho} \sin. \gamma.$$

Sec. A may be supposed to be unity. Since it is desirable that the error of $\angle\gamma$ should not exceed $\frac{1}{40000}$ of its value, it is desirable that we have $\frac{\rho}{D} > 80,000$; and since it is necessary that the error should certainly be within a limit four times as great as this, we must have $\frac{\rho}{D} > 20,000$.

It will probably be found that at most of the stations the reflector can be placed within a foot of the objective. If so, the limit outside of which the radius of curvature of the reflecting surface will be unimportant, will be 80,000 feet, and that within which it will be inadmissible will be 20,000 feet.

As to the second effect, that on definition, if the curvature of the reflector cannot be kept within the limit of 80,000 feet radius, or if any small deviations without it cannot be determined with certainty, a serious and fatal objection will arise to the proposed plan. The practicability of attaining this desideratum is the first thing to be determined, and it can only be determined by trial and experiment. The most necessary precaution is that the reflector should be exposed to full sunlight only at the moment of taking the picture. When it is found necessary to use the reflected light for adjustment, the heat rays must, as far as possible, be cut off by a blue or green glass. The necessary time of full exposure of the mirror need not be more than half a second, or a second at most, for each picture.

The most perfect arrangement for moving the reflector would be that of the "siderostat" of Foucault, in which the mirror is moved round two axes in such a manner that the reflected rays remain parallel as the sun passes along its parallel of declination by its diurnal motion, the change due to refraction excepted. The adjustment of the reflector must be made so that the direction of the reflected ray shall vary from that of the telescope as little as possible during the transit. The motion of the mirror must be free from all vibrations, and every instrument must be carefully tested for this condition before being used. To avoid all serious danger of vibration, Prof. Newcomb proposes that no toothed wheels shall be allowed in the moving machinery, but that all motion shall be communicated by fine and well-oiled tangent screws. Whether the mirror should be of plain glass, silvered glass, or speculum metal, is a question to be settled by experiment.

Prof. Newcomb then proceeds to give some valuable suggestions as to the objective, the tube, arrangements at the focal points, the exposing of the plate, determination of the planet's position on the sun's disc, and the angle of position. These are an admirable *résumé* of and criticism on the best results that have been hitherto arrived at on these points. His concluding remarks are worth quoting:—"The determination of the solar parallax from measures of photographs of the sun taken during the transit of Venus is beset with this serious difficulty. That the required element appears only as a minute difference between two comparatively long arcs, much longer, in fact, than are often measured with a micrometer. In order that the solar parallax may thus be determined with

a precision exceeding that attained by other methods, it is necessary that the arcs in question be measured with a precision considerably exceeding any ever attained in the astronomical measurement of an arc of similar length. The difficulties of the operations are greatly aggravated by the direction and motion of the body to be photographed, which require the apparatus to be mounted on moving axes, and demand either an instrument of unwieldy proportions, or the use of an enlarging lens. In Prof. Winlock's apparatus the diurnal motion is thrown entirely upon the revolving mirror, so that all the advantages of a fixed horizontal sun are obtained. The apparatus is all firmly mounted on stone piers, thus admitting of exact measurement of all its parts, and avoiding all danger of changing the adjustments by the photographic manipulations. It seems to be that the advantages are all greatly in its favour."

☉ We hope that the Commission will very soon be able to publish an equally, if not more, interesting and valuable collection of papers, containing the results of their own independent inquiries and experiments. We only hope that the preliminary work will be as efficiently done in other countries as there is every promise of its being done in the United States.

THE "HASSLER" EXPEDITION

WE are again indebted to the *New York Tribune* for the following account of the final labours and total results of Prof. Agassiz's expedition:—

SAN FRANCISCO, CAL., Sept. 2.—The steamer *Hassler* reached Acapulco on Sunday evening, Aug. 4, and remained 70 hours. The fishermen of the place were very active, and our own scientific party were not behindhand in diligence, so that these 70 hours yielded the Professor as rich a harvest as he has gathered in almost any port. Acapulco is a lovely Sleepy Hollow; its quiet little bay completely enclosed by beautiful mountains; its environs adorned with a profusion of tall cocoa-nut palms; the promenade from the town to the fort, half a mile distant, shaded by magnificent old lime trees; the town itself clean, old-fashioned, quiet; only three or four vessels in the port. If it had not been for the heat, we should have voted it the loveliest imaginable retreat. Two of the vessels in port were English, and I had one or two pleasant interviews with their captains. As we were parting, I mentioned to one of them that I had long wished to visit England. His answer was pre-eminently English:—"He thought a visit to England would be useful to me; it might remove some prejudices and hard feelings." Now, as I am absolutely certain, and do positively know, that I had not betrayed to him in any way or manner the least shade of prejudice or hard feeling toward the mother country, I must explain his remark by supposing that he was himself conscious of hard feelings toward the United States; and therefore presumed that I felt them toward England. The confidence with which an Englishman applies his English foot-rule to measure the universe is a very marvellous thing; it is as if he thought that the laws and customs of his little island are universal laws of humanity, and he seems incapable of supposing it otherwise.

We left Acapulco August 7. The scenery as we went out of the bay, passing between the islands and the main land, and for several miles after emerging into the Pacific, was exquisitely beautiful. The high hills behind the town reminded me of paintings which I have seen of Hymettus seen from the hill of the Museum. We have hardly seen on the whole voyage anything more picturesque and beautiful. The evening closed with a magnificent sunset. South of the sun were long streamers of golden clouds, and just north of it was a patch of the

bluest imaginable sky, broken by three or four projections of brilliant cloud. Our views toward the north were lovely beyond description; the sea nearer to us was the deepest blue, toward the shore becoming purple; then came a long golden beach; behind that deep green hills; behind these a line of purple hills; still farther back blue mountains, and then over all a series of clouds of varying shades. On the evening of the 9th, off Cape Corrientes, we had a heavy shower, a thing that six weeks in the rainy season had rendered familiar to us. But the next morning we were in a different climate, cool, dry, and pleasant; and gliding on smooth seas, we reached the western edge of the Gulf of California on the evening of the 11th. By noon of the 12th we had a strong head-wind which seemed positively cold after the sweltering heats of Panama and Acapulco. At sunrise on the 13th we anchored in Magdalena Bay, where we remained thirty hours, seeing only the two great islands which form the outer defences of this magnificent harbour. We found here a small colony gathering orchilla, a lichen (*Rocella*) from which cudbear is made. The plant only grows in comparatively rainless regions, and grows very slowly, so that the gathering of a crop leaves the field barren for many years. The bushes on which this lichen grows are of but few species, and most of them of very odd appearance. The animals in the sea were very interesting, and our thirty hours yielded us a rich harvest.

Good weather and favourable winds brought us into the harbour of San Diego by noon on Sunday, August 18. We had not been here long before a telegram ordered the *Hassler* to return to the Mexican coast and sound for a rock reported to have been seen in a certain place. The *Hassler* obeyed, and was gone several days, searching for a rock which probably does not exist, the scientific party meanwhile remaining in San Diego. It was a delightful place for the naturalists and for us all. It was our own country, and we were at home; and among hospitable people who at once made us feel at home. A few Chinese (washers and ironers and fishers) seemed to be the only low people in the place, if we except a few Indians in tents in the adjoining fields. All the rest—I speak of the new town—seemed to be industrious, respectable Americans, Germans, or Spanish. The harbour is a long crescent. The protection is from a long range of hills running southward in a promontory to the west, and two flat islands on the south connected with each other and the continent on the east by a narrow strip of sea beach. On the north side of this crescent are numerous little villages, two of which, Old San Diego and New San Diego, are of considerable importance. In the new town two daily papers are published, and a steamer leaves five times a month for San Francisco. While we were there the town was intensely excited over the arrival of Col. Scott and other railroad magnates, to make arrangements for the commencement of work on the western division of the Texas and Pacific Road. The town has been built in faith that a railway communication with the Atlantic must at no distant day be opened with this the best harbour in the southern part of California. But hope deferred had begun to make the heart sick. Those who had not means of living had begun to consider the expediency of retreating to some place of greater activity. But the visit of Col. Scott, and the arrangement made by him with the citizens of the town, have put every one at San Diego into high spirits, and they look forward now, I think reasonably, to the rapid growth of their city.

The harbour is excellent. It needs some care to prevent the San Diego River from filling it with sand, to prevent the ocean from breaking the beach that connects the island, and thus obviate the present "scour" in the main entrance; and to prevent wharf and other "improvements" in the distant future from doing the same mischief. The situation of the town is fine, on a gentle slope, with a hard pan foundation for building. The climate is wonderfully

equable, it is rather too dry, but windmills are cheap; the direction of the wind is so uniform that the windmill need only be set for west winds; and with a windmill to irrigate one can raise any crop. Many plants, as olives, figs, grapes, &c., only need irrigation for a time and then strike root deep enough to reach perennial moisture. Frosts come only at intervals of many years and are then exceedingly light. We ate tomatoes gathered from bushes that had yielded fruit freely every week in the year for three years past. The melons were of an excellence surpassing anything I have ever tasted. The city is well laid out, and the nucleus of citizens already there is of sterling quality. The Horton House, which is the principal hotel, is admirably kept in the neatest and most comfortable style, with gas, water, and other conveniences, and a good table. One can make oneself at home there as well as in any city of larger size. I met also many persons in private at whose houses I had evidence that some of the best fruits of English and German, French and Spanish civilisation are acclimated here. In zoology our naturalists found a rich field. Fifty-three different species of fish, and sixty or seventy species of other animals, were added to their collections, many of these species being of very rare and valuable kinds, and several probably new. Most of these were found in such abundance that the Professor could take just as many as he chose, as many, that is, as he thought he could make useful at home.

On August 28 we parted with real regret from our new-made but most cordial and hospitable friends at San Diego, and, being again greatly favoured by the weather, we made the Golden Gate on the 31st at sunrise, and dropped our anchor in the harbour of San Francisco at 9 o'clock. The expedition proper here ended, but Prof. Agassiz, with Dr. Steindachner, will remain to gather what they can in this harbour before returning. Their success during the whole voyage in collecting valuable specimens of fish and other animals has been truly wonderful; new and unknown species have apparently been everywhere awaiting their arrival to reveal themselves; rare and valuable fishes have come freely and in numbers to give themselves up, and the more ordinary species have come into their nets in superabundance, so that we have thrown back living into the sea very frequently more than half of what the seine brought up. The whole number of fish brought home from the voyage will probably exceed 30,000, and the other animals of all descriptions will probably swell the number of specimens brought home to over 100,000. It is, however, the quality and kinds that give value to their collection rather than the mere numbers; and the *Hassler* Expedition will have prominent place in the history of zoology, because of the number of new species discovered, as well as for the valuable collection of materials on which original anatomical investigations may hereafter be made. In the history of physics the exhibition will also be remembered, not for the deep-sea dredgings which circumstances beyond the control of the officers of the vessel prevented it from making, but for the valuable geological observations made for the first time in the south temperate zone by an observer thoroughly conversant with the action of glaciers and the glacial sheet north of the equator; the observer who first detected the marks, now apparent to every eye, which demonstrate the existence of glacial sheets before the birth of the present glaciers, even in their most extended form. During nine months the little company have received the courteous attention of the officers of the *Hassler*, and enjoyed the rare privileges which the Superintendent of the Coast Survey and Secretary of the Treasury had granted; nine months of continuous and varied enjoyment. The *Hassler* came round South America to survey the Pacific coast of the United States, but the long voyage has not been idle. It has been employed incidentally in a manner not less valuable than the work to which the vessel is specifically devoted.