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60 Ocean View Avenue,
Santa Barbara, California,
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Filing Room ✓ Telegram

Mr. Trevor Arnett,
President International Education Board,
61 Broadway,
New York.

Dear Mr. Arnett:

Thank you for your telegram received yesterday. As I lack the necessary data to answer your question fully, I telephoned to Professor Seares in Pasadena, who at once prepared the enclosed memorandum. We can give you from the Annual Reports the number of nights of observation and the quality of the "seeing" (sharpness of definition) on Mount Wilson for every night during the past fifteen years or more if you wish them, but other observatories rarely or never publish such figures, so you would have nothing with which to compare them. Professor Seares' memorandum, though without these data, admirably summarizes the case, but some additional remarks may be useful.

Professor S. W. Burnham's telescopic tests of the atmospheric conditions at Mount Hamilton (near San Jose), first drew the attention of astronomers to the advantages of high altitude stations near the southern half of the Pacific coast. They showed such marked superiority over all other observatory sites that Mount Hamilton was selected by the Lick Trustees, acting with the advice of Professor Simon Newcomb, as the best possible location for the Lick 36 inch telescope, the largest refractor of its day. After 1888, when the severe tests made possible by this powerful instrument began to be applied, Mount Hamilton (altitude about 4200 feet) was regarded by astronomers the world over as the finest of all observatory sites. Thus when the 40 inch Yerkes refractor was initiated a few years later, Professor Newcomb thought it should be established in California. But the University of Chicago could not consider a site more than a hundred miles from its campus, and Lake Geneva was finally selected.

In 1903, when the Carnegie Institution began to consider the erection of a large observatory, no restriction as to site was imposed. The committee (of which Professor Campbell of the Lick Observatory, Professor Lewis Boss, and I were the members) selected Professor Hussey of the Lick Observatory to make an extensive series of telescopic tests in California, Arizona, and in the southern hemisphere. He did not find favorable conditions in the southern hemisphere (Australia), but recommended Mount Wilson as the best possible site. As compared with Mount Hamilton, it has the advantage

of greater altitude (5886 feet), much lower wind velocity, and greater distance from the center of the typical cyclonic storms, which enter the Pacific coast in or near Oregon (I am writing from memory, without reference books) and move eastward across the United States. Their diameter is so great that they extend down through the central part of the country, but except in winter,* they do not reach the Mount Wilson region. Such storms affect telescopic observation, not merely in the regions of rain, snow, or cloudiness, but even in their outer zones, where they disturb the air and thus the sharpness of star images.

Our tests at Mount Wilson for twenty four years, made not only with the largest existing telescopes but also with the 20 foot Michelson interferometer, indicate that it is unsurpassed as an observatory site. We photograph the sun on about 300 days in the year, and the average record for the last 15 years shows that observations were made all night on 189 nights and during a part of 95 additional nights. Throughout the long dry season, unbroken by storms, high winds, or clouds for month after month, an enormous amount of observing is done. Moreover, the average sharpness of celestial images, which is the most vital factor in exacting work, is much above that of eastern observatories. The chief question about Mount Wilson as a site for the 200 inch telescope results from the rapid growth of Los Angeles and the surrounding towns and the great increase in the illumination of the night sky caused by the countless lights in the San Gabriel Valley. In 90 percent of our work (all classes of spectroscopic, bolometric, and visual observations, and direct photography with moderate exposures) the conditions are as good as ever, but for very long exposures on faint nebulae with the 200 inch telescope the illumination of the sky may be sufficient to make trouble. We are therefore making a very rigorous test of several mountain sites away from ~~the~~ cities or populous regions, and the results thus far obtained point to Palomar as the most promising, as the "seeing" is distinctly better than at Mount Wilson, while the sky is much darker and purer. However, a long series of tests, both telescopic and meteorological, will be required to settle this important question.

We are not leaving Arizona out of account, but, as I remarked in my last letter, the summer rainy season (from which California is exempt) and the very cold winter nights in the most promising region, are serious objections. Here, again, a most careful study of all the conditions must be made before any decision is reached.

It is a very fortunate fact that the region of the United States which is of suitable latitude (see the memorandum of Seares) and its removal from the path of the

* and then only in part,

typical cyclonic storms that move from west to east (and also those that move along the Atlantic coast) is a great natural laboratory and observatory, offering every variety of high altitude station from the extensive plateau of Arizona to the lofty peaks of San Jacinto and Mount Whitney. Such advantages have served, not only for telescopic observations, but for many other kinds of research, such as Millikan's studies of the cosmic rays. These studies demand, not only high altitudes, but the presence at various high levels of lakes free from radio-active particles in suspension and even of narrow canons, leading to the lakes, to shield his deeply immersed electrometers from the radiations from any part of the sky except, for example, the band of the Milky Way. Needless to say, Millikan's investigations with these great natural telescopes are closely related to the work on the constitution and transformations of matter to be made with the 200 inch reflector.

This brings us back to the argument so strongly emphasized by Dr. Rose as a reason for placing the 200 inch telescope and its auxiliary apparatus in close touch with the group of investigators centered in Pasadena. I wish it were possible for you to obtain his views on this subject, as I know how vital a factor it seemed to him.

Adams and Seares, who came up here last Sunday, have made a further study, in which they were aided by Hubble, of the relative advantages of the northern and southern hemispheres. Their conclusion fully confirms the statements made in my last letter. Thus the spectroscopic binary stars measurable with the proposed 40 foot interferometer can all be reached from Mount Wilson, while the two largest and most important spiral nebulae (Andromeda and Messier 33) lie high in the northern sky, out of reach of any suitable southern station. Moreover, the Magellanic Clouds, which are less important because they are not spirals (the typical form of the "island universes" beyond the Milky Way), can be well investigated with a 60 inch or, at most, a 100 inch telescope.

If I have not sufficiently answered your questions I can send additional data or come east if you wish me to do so.

Very sincerely yours,

George E. Hale

P.S. I am going to Pasadena to-morrow to see Millikan (due Friday) and others, but hope to return here and go home to stay on October 4.

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The selection of a site for a large telescope which shall perform with the greatest efficiency is greatly restricted by four limitations, geographical and climatic in character:

(1) Limitation in Latitude

(2) Limitation in Altitude

(3) Range in Temperature

(4) Freedom from Clouds

(1) The latitude should not be less than 30°, otherwise stars at the celestial pole cannot be satisfactorily observed. At the same time, the latitude should not be high, because stars south of the celestial equator, which otherwise would be within reach, would then be sacrificed. Three-fourths of the whole sky is accessible to observation from a station in latitude 30°, and no part of this fraction need ever be observed at altitudes above the horizon which are less than 30°. Conditions in latitudes up to 35° are only slightly less favorable.

(2) To obtain the transparency of sky so essential in photographing the faintest stars, the altitude should not be less than 5000 feet, and preferably should be a 1000 feet more. Still higher altitudes would be desirable except that adverse conditions, such as excessive snow fall, heated air rising from bare rocks above the timber line, etc. then begin to make their appearance.

(3) The range in temperature, both daily and annual, must be moderate. A large daily range is fatal to the finest observational results; deformations of the mirrors of the telescope and of sensitive parts of accessory apparatus, the prisms of spectrographs, for example, cannot be fully compensated against large and sudden changes in temperature. Large annual variations

mean low winter temperatures, which reduce enormously the efficiency of operation. Such temperatures imply bad seeing, arising from unsteadiness of the atmosphere, and a severe strain on the observer.

(4) The reason for freedom from clouds is obvious.

Application of these restrictions to North America at once eliminates all points except those in the southwest of the United States, or possibly a very narrow strip in northern Mexico. Locations in the mountainous region of the east are undesirable because of the latitude or the prevalence of clouds. The Rocky Mountain area is unfavorable because of the great range of temperature. These mountains are in the path of the great cyclonic storms that sweep across the continent. Latitude and other unfavorable conditions eliminate the northern mountains of the Pacific area. Only in the Southwest, Southern California and Arizona, or possibly the extreme north of Mexico, are the four fundamental conditions satisfied.

The conditions mentioned are by no means all that must be satisfied in selecting a suitable site. Steadiness of atmosphere (freedom from the quivering that appears in an exaggerated form on looking across a ploughed field on a hot summer's day) and low wind velocity, are also factors of vital importance, but less significant than those mentioned for general orientation. It need only be added that these conditions are known to be satisfied at various points in the Southwestern area.

(By Frederick H. Seares, Assistant Director of the Mount Wilson Observatory)