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by

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Solar System Studies with 16-inch Telescope

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1. Construction of Tumamoc Hill Observatory

Reference is made to the proposal to NASA under the above title dated March 13, 1964. The funding of this proposal was made July 1, 1964.

In the Introduction to the proposal it was stated: "The University of Arizona has agreed to the construction of a 16-inch telescope on Tumamoc Hill, 800 ft above the city of Tucson and 3200 ft above sea level, five and one-half miles due west of the Campus of the University of Arizona." The dome for this telescope was erected in October 1964. It was found, however, that the narrow and extremely rough access road to the summit over sheer lava blocks was too dangerous for normal use, even with a 4-wheel drive. Limited improvements to the road were made with available Laboratory funds but a much more drastic improvement was needed. Because of the appreciable construction cost involved ($23,000), no action could be taken in 1964, but the University Administration made the funds available by mid-1965 and an excellent road was constructed during the fall of 1965. The contribution of the University to the Tumamoc observatory has therefore been more than double the amount originally estimated and has been in excess of $40,000, telescope and dome included. The road problem, however, has delayed the completion of the project by one year and made necessary finding substitute solutions for the intervening period through the use of other telescopes. These telescopes are: the 36- and 84-inch telescopes of Kitt Peak (distance 56 miles); the 20-inch telescope of the Steward Observatory on the University Campus; the 12 1/2-inch telescope on Puu Poliahu, Maui, Hawaii; and the telescopes at the Catalina observatory (distance 36 miles). The results thus obtained are

reviewed in Section 2. While time was lost during the past year, the efficiency of the Tumamoc Hill installation has in the end much gained by the new plan.

Figures 1 and 2 show views of Tumamoc Hill with its new road; Figure 3, of the observatory and its trailer-laboratory which contains a photographic darkroom. This photograph was taken in March 1965. Since then a radio antenna for the reception of time signals has been added, as have telephone and, of course, electric power. Figure 4 shows part of the telescope mounting.

Because of the unexpected delays and problems, now overcome, this Final Report has also been delayed.

The telescope originally used a Cave telescope mounting and a light plastic tube. This combination was found not sufficiently stable and the tube was replaced by a much heavier tube by mid-1965. Ultimately, we shall want to use a heavier mounting as well, particularly for long exposures on comets, etc. A heavier mounting has been designed and will be constructed on University funds during 1966 partly in-house. With this also completed we shall have an excellent instrument on a surprisingly good site, less than six miles from the Campus. Mr. Aliks Herring has made numerous observations with his 12 1/2-inch telescope on the slope of Tumamoc Hill (near the Geochronology Laboratory, 300 ft above the floor of the valley) and has often found excellent seeing. On the 800-ft summit the seeing should be better. Mr. Herring believes that the seeing may compare favorably with that of the Catalina observatory (8300 ft elevation). If so, we may wish in time to install additional astronomical equipment on the site. The air currents over the Tucson valley differ appreciably from those over the high mountains. The valley has more clear weather.

2. Solar System Studies

Professor Van Biesbroeck has made all of his observations so far with the 84-inch Kitt Peak reflector, which he was able to use on 21 nights during the

calendar year 1965 and a number of nights the preceding six months. In fact, Dr. Van Biesbroeck had the honor of being the first guest astronomer to be assigned time on the large NSF telescope upon its completion. In addition to measuring well over a thousand double-star positions, he observed the comet Ikeya-Seki 1965 f. He found two nuclei on November 5, 1965, separated by 13".0 with a magnitude difference of 3 magnitudes. On October 21, 1965, he was a visual observer on the NASA flight based on Hawaii (40,000 ft elevation) to watch the close perihelion passage of comet 1965 f. Naked-eye observations during the day showed the comet and its curved tail within a radius of the sun. From the chosen site the comet set at the same time as the sun, but after dark the diffuse end of the tail could be seen protruding sidewise from the zodiacal light.

Dr. Van Biesbroeck also investigated the orbit of comet 1959 IX Mrkos using 62 measures covering its 298-day visibility period. He determined a "final orbit" after applying all planetary perturbations. The eccentricity came out slightly elliptical, showing that the object is a permanent member of the solar system but that the period is very long, of the order of a million years. The result will appear in the April 1966 issue of the Astronomical Journal.

Dr. Van Biesbroeck also has started on the nearly parabolic orbit on the comet Bester 1947 I, which had been under observation for two years. He has further assisted in the development of attachments to the 16-inch Tumamoc telescope telescope and the 61-inch NASA telescope, among others a filar micrometer and a plate holder.

Dr. Gehrels, assisted by two graduate students, especially Mr. David Coffeen, and a night assistant, has made numerous observations of polarization of the planets Venus and Mars in the wide range of wavelength 0.3-1.0 microns. Venus was observed between phase angles 20 and 150 degrees. The instruments used were the 20-inch telescope of the Steward Observatory on Campus and the telescopes at the

Catalina observatory. Ultimately, such observations will be made more efficiently and with less effort at the Tumamoc observatory. Much work remains to be done on Venus and Mars and no observations have yet been made on Mercury, Jupiter, and Saturn, and the brighter asteroids. Only occasional measurements of the moon have been made so far. Extensive laboratory studies have been performed by Mr. Coffeen in a program designed to compare the moon with laboratory materials over the full range of wavelengths reached photoelectrically and with the full range of phase angles.

Mr. A. E. Whitaker has spent nearly the entire report period on the Ranger program and on geophysical studies supporting the Ranger program (normally half his salary is derived from University funds; during one year of the report period one quarter of his total salary was charged to NsG-681). In addition, Mr. Whitaker assisted with various solar system observing programs both at Kitt Peak and, since October 1965, at the Catalina observatory.

Mr. D. W. G. Arthur during the report period (one-fourth covered by NsG-681) investigated the theory of lunar rotation and the related problems of selenodesy. He has discovered a major weakness in the lunar coordinate system used over the past 50 years, traceable to an arbitrary assumption by Franz. His work is now being prepared for publication.

The undersigned has spent a considerable fraction of the report period on the Ranger program in his capacity as Principal Investigator (normally his full salary is paid by the University). In addition, he has conducted solar system programs particularly on infrared planetary spectroscopy with both Kitt Peak telescopes; and on lunar photography with the 61-inch telescope after its completion. He has further served as Laboratory Director organizing the construction work on the 61-inch telescope, its extensive tests, and research program; and on the preparations for the Tumamoc observatory.

The supply and travel items budgeted for in the original application have been used in connection with the substitute programs referred to, on Kitt Peak, the Catalina observatory, and elsewhere.

I wish to express to NASA my appreciation for assisting the Lunar and Planetary Laboratory in carrying out its mission.

Fig. 1 View of the mesa-like Tumamoc Hill from its base showing Geochronology Lab. at 300 ft level and new continuing road plus power line to summit.