THE PALOMAR STORY

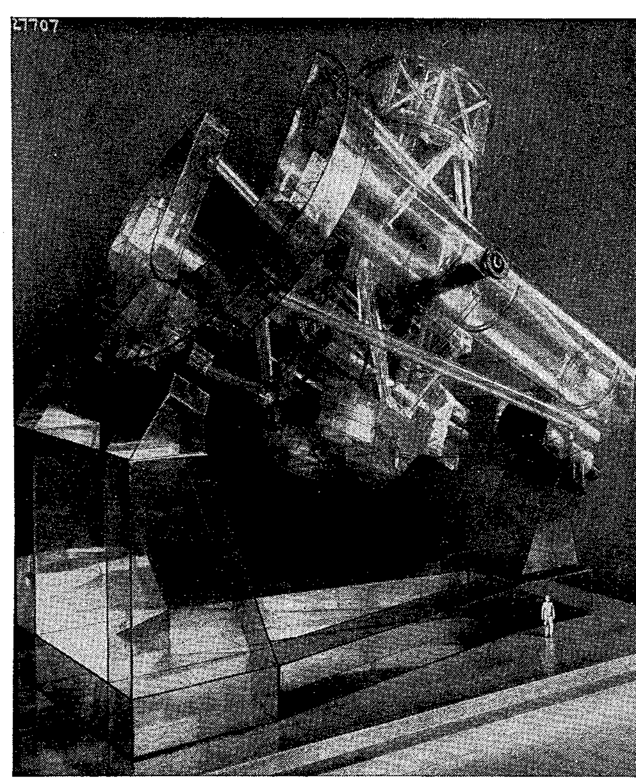
AFTER decision was finally reached to attempt a telescope larger than the 100-inch Hooker, it was necessary to decide on the exact size. The three problems of cost, construction, and transportation were the limiting factors. First consideration was given to a 300-inch reflector, until a survey showed that it would be impossible to transport such a mirror by any existing means and would necessitate building the disk on the observatory site. It was finally decided that 200 inches was the maximum size feasible. Dr. George Ellery Hale, who was fathering the project, estimated a construction cost of six million dollars and set about locating such a sum. Dr. Wickliffe Rose, president of the General Education Board of the Rockefeller Foundation, had shown interest in Hale's project, and in 1928 pledged the necessary amount to the California Institute of Technology. It was agreed with the Carnegie Institution that its Mt. Wilson staff would be available for consultation, and the facilities of the Observatory and Caltech would combine to produce the new telescope. Futher endowments from other sources guaranteed sufficient funds to carry the cost of operations at least for a time after construction, and the Observatory Council turned its attention to organization and actual building details.

Forming the Council in the beginning were Dr. Robert A. Millikan, chairman of the California Institute's Executive Council, Dr. Alfred A Noyes, professor of chemistry, Henry M. Robinson, chairman of the Security First National Bank of Los Angeles, and Dr. Hale. In an advisory capacity were top scientists in America and Europe, including astronomers from every American observatory. As executive head of the project, Hale named Dr. John A. Anderson, Mt. Wilson's chief optical expert for the previous 15 years. Russell W. Porter was brought West to design facilities for developing the new observatory, including Caltech's Astrophysical Laboratory.

The problems of casting a 200-inch mirror were first taken on by General Electric, where Professor Elihu Thompson experimented with a disk of fused quartz. The excessive cost of working with this material led the Council to reject it in favor of a Pyrex casting. This work was done by Corning Glass Works under the direction of Dr. George McCauley. After his own share of difficulties and near-failures, McCauley's task was completed in 1935, and the disk was carefully packed and shipped by rail to the optical shop at the California Institute for grinding and polishing.

When it was assured that the mirror would be cast successfully, other construction problems had to be met. One was the choice between a fork- and yoke-type mounting for the 55-foot telescope tube. The former would permit the instrument an unhampered view of any part of the sky, but at the same time it would be required to support the 125-ton tube in the middle, placing tremendous stresses on the arms of the fork and bearings. The yoke mounting alternative, on the other hand, would give the required rigidity but at the same time, as was the case with the 100-inch Hooker at Mt. Wilson, would stop the telescope 34° short of sighting on the Polar Star. In working out a compromise between these two designs, a third type was evolved which eventually solved both problems. With a basic yoke-type design, the new plan used a 46-foot horseshoe-shaped bearing at the north end of the yoke, which permitted full declination of the telescope tube.

After settling on the design there arose the problem of actual construction. The telescope mounting, with the observer's cage and auxiliary fixtures, was to weigh 125 tons. The yoke with its horseshoe bearing would weigh some 300 tons, and the combination had to be so mounted that it could be turned as nearly without friction as possible. Westinghouse Electric Corporation was given the contract, and four of its leading engineers, Hodgkinson, Ormondroyd, Froebel, and Kroon, took on the problem. As a check for paper calculations, a one thirty-second-inch scale working model was constructed of celluloid, and deflec-



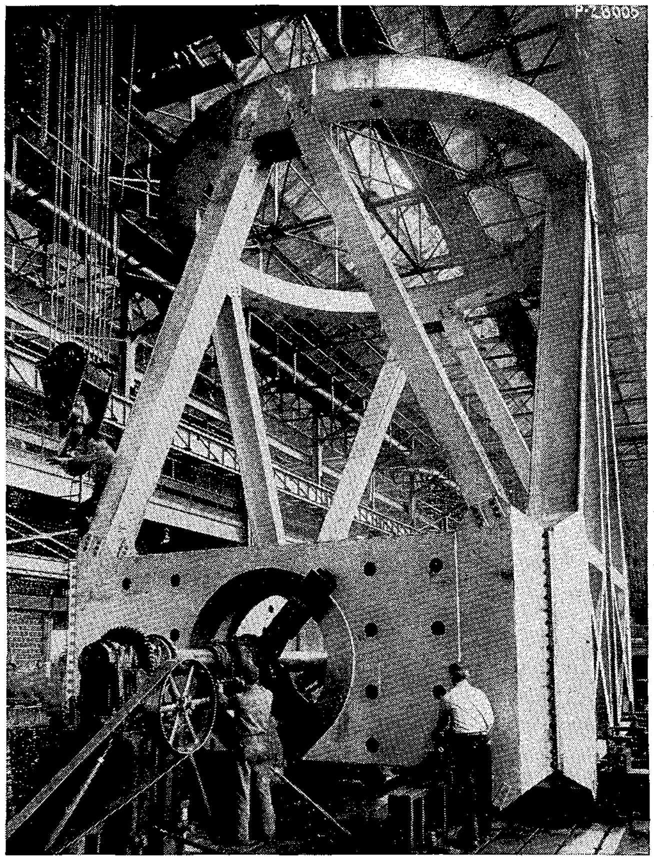
Completed plastic model of the 200-inch telescope, 1/32 actual size. The model, cemented together with acetone applied with a hypodermic needle, was built to test utility of design and points of stress. Places of strain were revealed by use of polarized light. Westinghouse photograph.

tions and distortions expected in the telescope mount were tested with ultra-sensitive micrometers electrically connected to a microammeter.

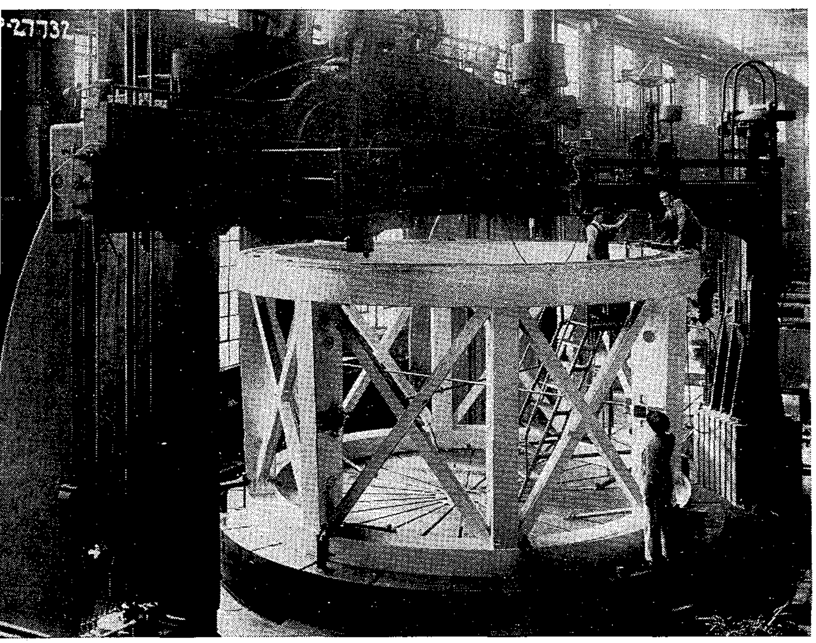
Most of the machining of the various parts was done on the regular tools in the Westinghouse turbine plant at Lester, Pennsylvania. However, the 46-foot horseshoe bearing had to be finished on a giant floor mill at Westinghouse's East Pittsburgh plant. And some pieces of the big telescope tube were so wide that a planer and a milling machine at Philadelphia had to be combined to achieve the necessary "reach".

Annealing of the fabricated parts presented another problem. All major parts were electrically welded, a process involving localized heating and resulting in internal strains in the surrounding metal. In order to remove these stresses, a special annealing oven was built and the parts brought to a maximum temperature of 1200° F and slowly cooled to 300° before removal.

The bearings on which the million-pound telescope turns to scan any visible portion of the sky consist of the 46-foot horseshoe at the north end, and a seven-foot spherical bearing at the south end. To



A section of the 125-ton telescope tube under construction. Westinghouse photograph.



Milling the cage that forms the upper end of the tube of the 200-inch telescope, at the South Philadelphia Works of Westinghouse Corp. Westinghouse photograph.

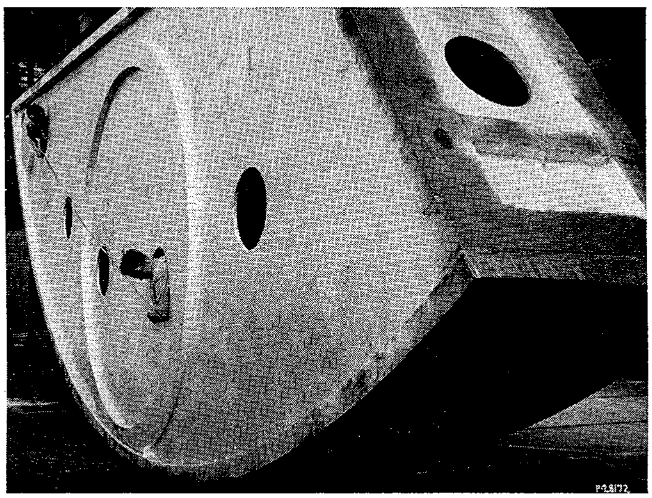
assure the desired accuracy, the use of roller bearings or mercury flotation was finally rejected in favor of an oil film bearing more commonly used in turbo-generators. By this device, a film of oil three thousandths of an inch thick is pumped under 300-pound pressure through orifices in four steel pads against which the bearing rests. The only frictional forces then to be overcome are the shearing forces created in the oil film itself—one six-hundredth of the friction caused by roller bearings. The seven-foot bearing at the south end was similarly floated on an oil film.

The many phases of construction, both of the telescope framework itself and of structures and improvements at Palomar Mountain, were directed by Captain Clyde S. McDowell, borrowed from the Navy by Max Mason. "Captain Sandy" had been working at the New York Shipbuilding Company's plant in New Jersey when he was brought west to superintend construction work for the Observatory Council. Plans and specifications passed through his hands to be distributed to manufacturing concerns all over the country whose facilities could accomodate the big orders. For the telescope itself there was the 55-foot tube, designed by Mark Serrurier, the steel supporting cell for the mirror, and the yoke-and-horseshoe combination which supported the telescope. On the moun-

Byron Hill

Byron Hill, superintendent of construction for the 200-inch telescope, is the only man in these pages whose permanent address is Palomar Mountain. After graduating from C.I.T. as a Tau Bete civil engineer in 1925, Hill turned to concrete construction work. The City of Pasadena was one of his employers soon after graduation, and he continued to work in various engineering capacities when he joined the Buildings and Grounds Department at Caltech. In these years Hill also did consulting work on concrete construction in Pasadena. From 1933 to 1936 he was superintendent of inspections for the Metropolitan Water District, which was building the acqueduct to carry water from the Colorado River to Los Angeles. In 1936 he was appointed to his present position, and soon moved to Palomar Mountain where he is to day.

Engineers check the measurements of a finished "point", one of two such pieces forming part of the massive yoke of the 200-inch telescope mounting. Westinghouse photograph.

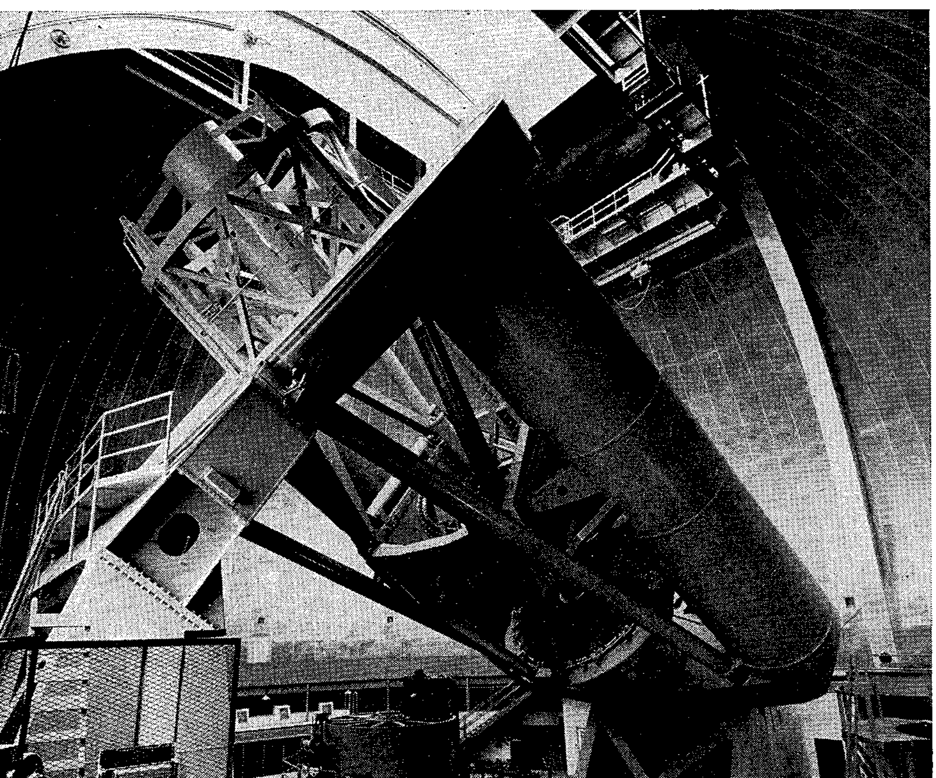


tain there had to be built the domes, the electric plant, housing for personnel, communication lines, and a road up the mountain sufficiently wide to permit trucking in of all the prefabricated parts.

In 1935, work began at Palomar Mountain. The next year Byron Hill became superintendent of construction there, and in the succeeding years the Palomar community gradually took shape. Besides the 137-foot dome for the 200-inch telescope, there are the 48-foot and 20-foot domes for the two smaller Schmidt telescopes. On Utility Hill are the power house, shops, and water tanks. For housing there is the two-story, 16-room Monastery for observers, and a number of cottages for staff and families. A dial phone system provides intercommunication between buildings on the mountain and outside lines afford regular telephone service. The paved road was built by State and San Diego County funds.

The Palomar location, considered almost 50 years ago before the Mt. Wilson site was chosen, affords astronomers perhaps the best seeing conditions in the Southwest. Numerous considerations influenced the choice of Palomar Mountain. First of all it was agreed that the telescope should be in a moderate latitude, where at least three-fourths of the sky is visible at some time of the year. Considerations of a southern hemisphere location were rejected since very little investigation of that sky has been done and the 200-inch was to be used primarily to further investigations already begun. It would have been more convenient to locate the new instrument on Table Mountain next to Mt. Wilson, but civilization was encroaching even on that remote spot and lights from the San Gabriel Valley were becoming more numerous each year, already clouding long exposures with the 100-inch. Besides, Table Mountain was on the edge of the unstable San Andreas Fault, and liable to be badly shaken in case of earthquake.

Dr. John Anderson and a number of Caltech students did a comprehensive survey of possible locations between Mono Lake in the Sierras and the Mexican border and Arizona, testing the seeing conditions from mountain peaks to desert flatlands. Their findings indicate that next to artificial light or earthquakes, the most serious interference for observers came from rising currents of hot air, encountered at mountain edges or on overheated desert sands. Their final choice is accessible over modern roads, is isolated from urban glare. The mountain is known to be a solid granite block, 25 miles deep, 30 miles long, and 10 miles wide—well protected from earth stresses. There are no near ledges or hot sands to provide heat wave interference. Still, the mountain is near enough to Mt. Wilson and Caltech so that staff members can alternate between the observatories, and Palomar equipment can be tested in Pasadena when necessary.



The Hale Telescope completed, showing tube at nearly full declination resting within the prongs of the horseshoe bearing. Weight of the entire structure is 530 tons. Photograph by E. R. Hoge.