SHOPS AT CALTECH

WITH the decision made in 1928 to attempt a 200-inch telescope, past experience indicated the necessity of constructing special shops for finishing work on the mirror and development and fabrication of auxiliary apparatus for the project. Following the plan so successful at Yerkes and Mt. Wilson, Dr. Hale planned his third observatory with shops as an integral part of the project. The instrument shop, completed in 1931, and the optical shop, in 1933, were financed with funds from the Rockefeller grants.

INSTRUMENT SHOP

First to be built was the instrument shop, a one-story structure 70 feet by 197 feet, with a mezzanine floor for engineering offices and drafting rooms. The building is lighted by windows on the north and south sides, and through inclined "sawtooth" skylights.

A crane, normally equipped for five-ton capacity, but which can be rigged to carry considerably heavier loads, runs the entire length of the shop. All of the heaviest machinery is located in the central bay, where it is directly accessible by the crane. This location serves a two-fold purpose, permitting the crane to carry work to and from the machines, and also facilitating the dismantling of the machines themselves for overhauling.

Nearly all apparatus for the Palomar project, from the 10-ton gears cut for the telescope's right ascension and declination movements down to the smallest instrument part, has been manufactured here on the Institute campus. In a large woodshop for pattern-making, located in the southwest corner of the instrument shop, patterns for castings ranging in size from the great 14-foot gears just mentioned have been turned out. In most cases, actual casting was the only operation carried on outside the shop.

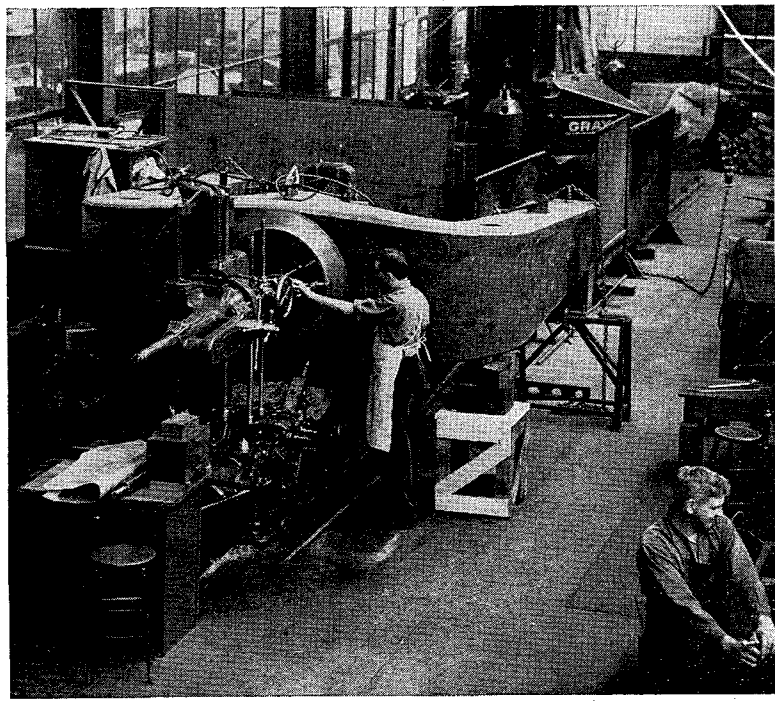
Opposite the pattern shop is the welding department, which also contains several heat-treating furnaces for hardening and annealing. One of the largest jobs done recently in this department was the fabrication of the 5½-ton fork mounting for the 48-inch Schmidt telescope from steel plates.

Since the shop's inception in 1930, its facilities have been used for a wide variety of work. Construction of all control cabinets, desks, and electrical test facilities, adaption of stock electrical parts and instruments to specialized telescope control, and installation and servicing of the short-wave radio formerly used for communication with the Observatory have been part of the shop crew's activities. In addition, all of the machinery for the optical laboratory, varying from the mechanism for grinding a 36-inch mirror to a machine for finishing the 200-inch, has been built in the instrument shop.

During the war when construction on the 200-inch project was suspended, the shop turned to Navy-sponsored work for the Institute. The usual complement of 24 workers was expanded to 70 to carry on rocket and torpedo research and development.

One of the most interesting jobs to be done in the shop was the machining of the three 14-foot gears for the 200-inch telescope right ascension and declination drives. These gears, each weighing ten tons and containing 720 teeth, were cut to an overall tolerance of one ten-thousandth of an inch. To cut the three gears required two and one-half years. And to achieve the degree of precision required, work was carried on inside a specially constructed, air-conditioned room maintained at constant temperature between 74° and 76° F.

The shop building also houses a complete electrical department. Chief electrician is Jerry Dowd, who joined the Mt. Wilson project as a truck driver in 1907, switching to the 200-inch job in 1930 when the shop went into operation. All electric equipment was built under his direction and was wired and tested under the same roof before being installed.



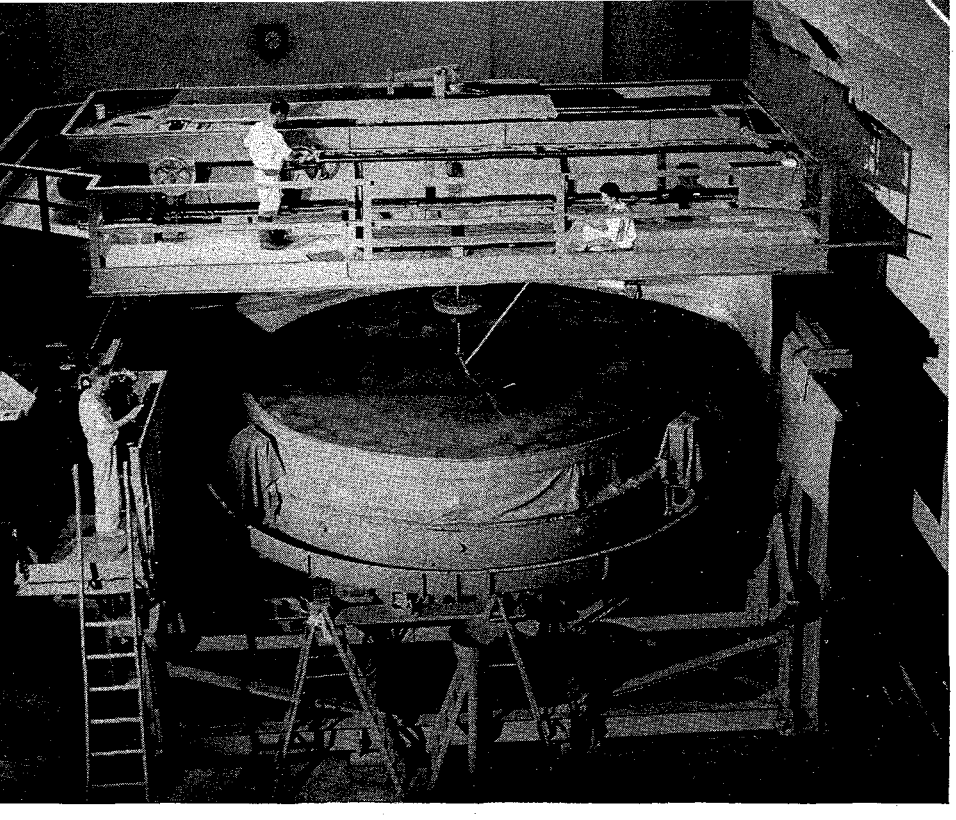
The 48-inch Schmidt telescope fork on the Lucas boring mill in the instrument shop. In this photograph, looking west, the pattern shop is to the left.

OPTICAL SHOP

One of the most important factors that had to be considered in designing the optical shop was its 17-foot scale. Facilities for the grinding and testing of the big mirror were all-important, although the shop would be used only for small auxiliary mirrors and testing after the 200-inch was moved to Palomar.

Completed plans provided for one large room, 52½ feet wide, 165 feet long, and 48 feet from floor to ceiling. The floor is of reinforced concrete divided into sections, each section completely isolated from the walls and adjacent sections to absorb earth disturbances. In turn, each section is floated on three inches of cork for insulation. The walls and roof are similarly of reinforced concrete and lined inside with cork.

For air conditioning a large blower is installed in the attic. This blower has a capacity of 12,000 cubic



Looking north in the optical shop. The 200-inch mirror is being given its final polishing. This scene was the usual one during polishing operations from the observation gallery at the south end of the shop.

feet per minute, and is equipped with facilities for washing the dust from the air as it enters the building and for maintaining a constant relative humidity.

Unlike the instrument shop, the optical shop has no windows connecting with the outside. Instead, constant illumination is provided by lights in the ceiling which are insulated from the room by heat-absorbent glass.

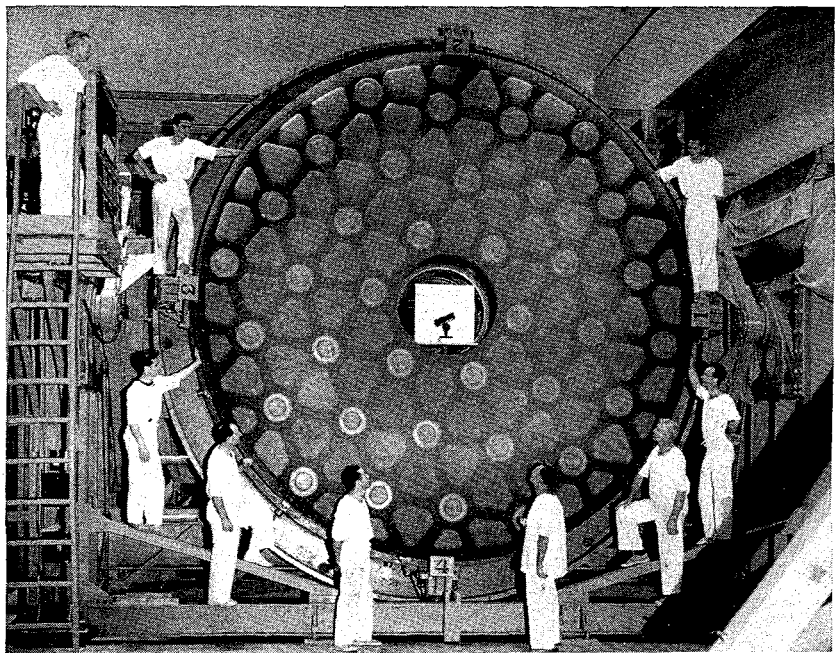
For handling the mirror and moving necessary equipment, there is a 50-ton overhead crane capable of traveling the entire length of the room. At the south end of the room a glass-enclosed, insulated observation gallery has been constructed which is open to the public on work days.

Entrance to the large room is provided by two huge doors having a clearance of 23 by 23 feet. On the west side of the building are two floors of smaller rooms where the auxiliary mirrors were made. The entire building is equipped with hot and cold water, gas, and alternating and direct current electricity.

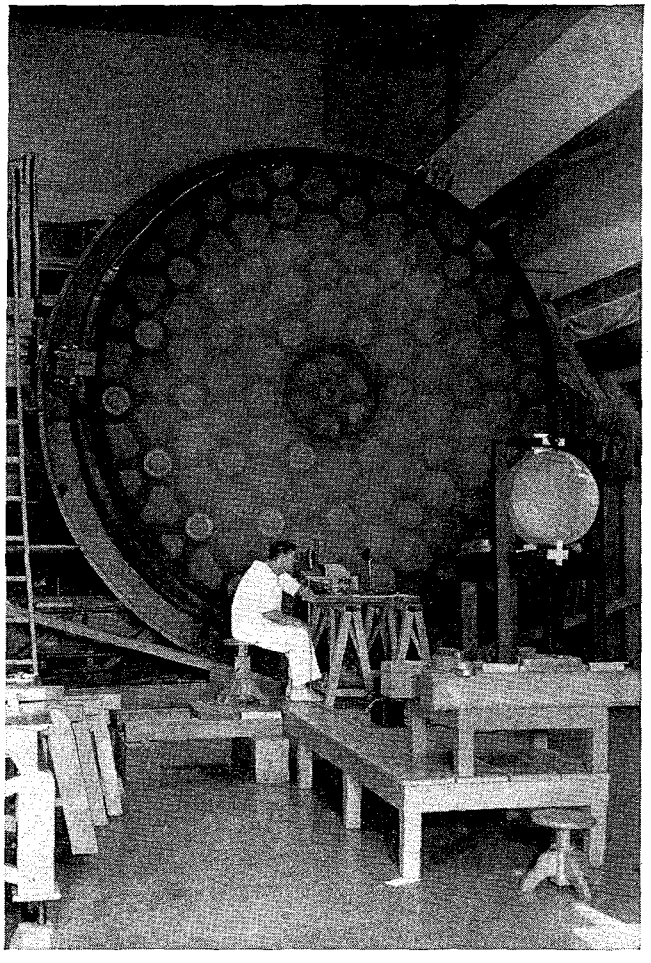
The most important piece of equipment in the shop has been the 200-inch grinding and polishing machine. This machine weighs 160 tons, and has a width of 30 feet, length of 36 feet, and height of 26 feet. At its front end is a turntable 17¼ feet in diameter for carrying the mirror, while the grinding and polishing tools are driven over the Pyrex surface by a bridge-and-trolley unit which comprises the machine's upper structure. Second of the mechanisms is a 120-inch machine of the same general construction on a smaller scale. There are also 60-inch, 48-inch, and 36-inch machines, of "beam" type construction. Other equipment includes stands for mounting the smaller mirrors and Foucault knife-edge sets for testing.

Various grinding and polishing tools were used on the mirror, ranging from the full size 200-inch tool to ones just a few inches in diameter. Some tools were fabricated from thin sheet metal, others of cast iron or aluminum, the material used depending on the requirement for the particular operation.

The principal procedure followed in facing the grinding tools was to cement on ceramic or glass blocks which could be replaced when worn out. For the polishing operation, blocks of pitch replaced the grinding blocks. Abrasives used for grinding were composed of silicon carbide or aluminum oxide mixed



The finished mirror shortly before it was taken out of the optical shop and trucked up Palomar Mountain. The 40-inch center plug has been removed, and in its place is a replica of Newton's telescope, with which he discovered the moons of Jupiter. Marcus Brown, optician in charge, is at center right. Photograph by E. R Hoge.



Marcus Brown checking for parabolic accuracy near the end of the polishing. The 200-inch disk has been turned to a vertical position on the grinding and polishing machine for testing.

with water. Iron oxide (rouge) mixed with water also was used for polishing. To prevent scratching the surface of the mirror, a constant program of sweeping and mopping was carried on, and when changing from one grade of abrasive to the next, even the walls of the room were thoroughly washed. For protection against foreign particles, particularly metal chips, which would mar the mirror's surface, workmen were required to leave their street shoes outside the large room. Rubber soled shoes and uniforms were provided to replace their street clothes, and as an added precaution, a magnetic sweeper was kept in constant operation on the floor.

Marcus H. Brown

Marcus H. Brown, in charge of the Institute's optical shop, has been the man directly supervising the grinding operation of the 200-inch mirror. From 1936 to 1947, except for the interruption of the war years when endeavors were turned to government research, Brown and his crew of 21 men executed the precision task of smoothing the Pyrex surface to Dr. Anderson's requirements.

First taken in to Mt. Wilson's optical shop in 1928, Brown had no training as an optician until that time. Doing odd jobs in the laboratory shops, he showed such interest in optics that he eventually was given a chance to work with the men who had ground the 100-inch Hooker telescope mirror. His training and experience under them, combined with intensive study on his own, led to his appointment in 1931 by Dr. Anderson as optician in charge of the grinding of the 200-inch.

From 1932 to 1936, Brown completed the organization of the optical shop, selected his crew, and made preparations for the arrival of the mirror. Many of the tools and procedures used in the grinding and polishing were developed by him during this preparatory period.

When he supervised the packing of the finished mirror for its trip to the Observatory on Palomar Mountain in November 1947, Brown was the only man who had stayed with the 200-inch disk since it was brought into the shop in 1936.

Dedication of the Observatory

(Continued from page 8)

without a long section devoted to the part played by Dr. Robert A. Millikan, who so wisely led the California Institute through all the years until 1945. He has been a member of the Observatory Council from the beginning. He and Dr. Hale and others discussed the plan exhaustively from the start. It was Dr. Millikan who boldly pledged the Institute to assume responsibility for the enterprise including financial responsibility for its operation.

To these four men I have named and to the multitude of others who made outstanding contributions we all join in tribute. This Observatory stands as a monument to their collective efforts. And it is a living monument. For from this Observatory will flow down through the ages the one indestructable thing that mankind achieves—new knowledge, new understanding.

As is known, the Board of Trustees of the California Institute of Technology and the Carnegie Institution of Washington some time ago agreed mutually that the Palomar Observatory and the Mount Wilson Observatory should operate cooperatively as one, under single management, with mutual sharing of facilities and staff. I wish only to emphasize that the California Institute has entered into this cooperative arrangement with greatest enthusiasm. In dedicating this Observatory, we dedicate it as one part of the Combined Observatories. We pledge ourselves to work in fullest collaboration with the Carnegie Institution as we devote our combined facilities to the service of science. We deeply appreciate the collaboration of Dr. Bush and the other officers and trustees of the Carnegie Institution. We and they are fully aware that in combining talents and facilities in this way we are creating in Southern California the mightiest astronomical center the world has ever seen or is likely ever to see. The California Institute assumes its share in this joint enterprise with pride, but also with humility and a deep sense of our responsibility.

The word "dedicate" in the English language means to set apart by a promise. It is essentially synonymous with consecrate, which means to make holy by a special act. The word has more than a formal or material significance. It carries also a spiritual implication. It is in this sense actually that we do today set aside this temple of learning and promise that it shall be devoted henceforth to deepening man's intellectual and spiritual understanding.