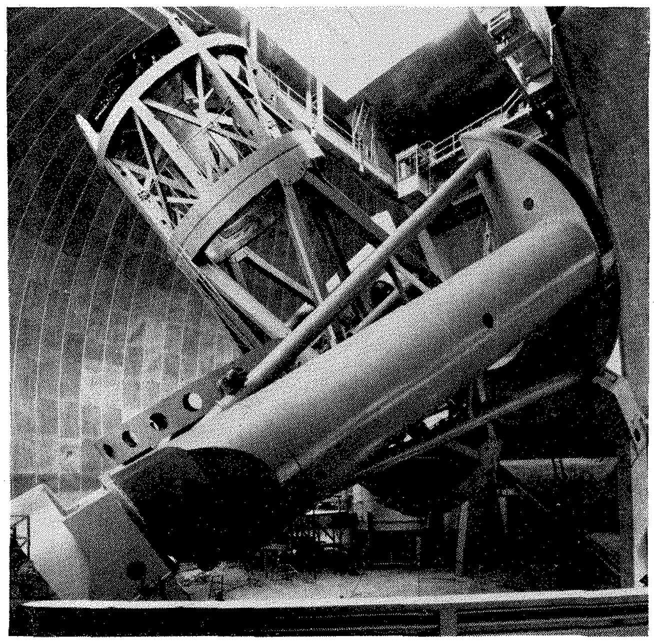
The Palomar Story

A Progress Report



The Hartman screen — in place at the end of the 200-inch, above — makes it possible to measure the shape of all parts of the mirror with an accuracy of a millionth of an inch.

BECAUSE THE 200-INCH telescope is now in the public domain, the Observatory Committee this month made a public announcement of the private problems it has to solve before the 200-inch can get to work as advertised. Complete down to the last twist of a screwdriver and thoroughly frank, the announcement ought to go a long way toward explaining to an impatient public why nescient newsmen can't yet get the answers to their favorite questions ("How about those canals on Mars? . . . What's new with that expanding universe? . . . When's that big eye gonna *see* something?")

According to the committee, the 200-inch may not be in operation until next fall.

Since December, 1947, when the first test photographs were made with the 200-inch—barely a month after the big mirror went into the telescope—Dr. Ira S. Bowen, Observatory Director, and his staff have been locating "bugs" in the instrument, finding out why they appeared and what could be done about them.

"Mostly," Dr. Bowen said, "our major difficulties have concerned the mirror and its supporting mechanism, although at one time a chatter developed in the right ascension mechanism which gave us a lot of grief." This had to be overcome before accurate tests of the mirror could be made.

Tests taken with a Hartman screen over the end of the telescope—this screen makes it possible to measure the shape of all parts of the mirror with an accuracy of one or two millionths of an inch—revealed that the mirror was not holding its form as it should. A long series of adjustments and tests of the 36 support mechanisms which were designed to maintain the mirror's correct figure in all positions, showed that they were not all working properly. There was too much friction in these mechanisms to allow the free balance that was necessary. Last summer, following dedication of the observatory, each of the 36 support levers was modified. Subsequent tests revealed that the friction had been reduced sufficiently to remove this trouble.

When the final tests of the mirror were made in the Optical Shop at the Institute, it was found that the outer edge was too high by about 20 millionths of an inch. However, there was reason to believe that when the mirror was placed in the telescope in a horizontal position the edge would probably sag by about this amount. Consequently the decision was made to accept the mirror without further correction, since if the edge were over-corrected it would be much more serious than the present under-correction.

Although every test known to science was used in figuring the mirror in the Optical Shop, a true picture of how it would behave under actual operating conditions could not be determined until it was in the telescope. When the Optical Shop was built, this problem was given very careful study. To do in the Shop what could be done in a telescope would have required adding a 125-foot tower to the building, at a pre-war cost of more than $100,000. The tower would have had to be solid and completely insulated. It was decided that this would not be necessary. "I think we would still make the same decision today," Dr. Bowen says.

Under actual operating conditions, the astronomers discovered that the mirror was not sagging at the edge as much as had been expected. When it was found that the support system had to be modified, there was reason to believe that this might also serve to control what had now become a "turned-up" instead of a "turned-down" edge. Subsequent tests revealed that this condition was corrected to some extent but not enough to assure the accuracy sought.

Additional tests of both the mirror and its support system were made. A new factor showed up. The mirror was not adjusting uniformly to temperature changes; the outside edge was adjusting more rapidly than the center. As a result, the edge was turned up by different amounts, depending upon the temperature to which the mirror had been exposed during the preceding 24 hours. Here the "bugs" problem now stands.

What can be done about it? Several things, the astronomers say. One solution, and the one that will be attempted first, will be to devise a means of equalizing the air temperature beneath the mirror and inside the mounting point sockets with air about the outside edge. A system of small fans may be installed inside the cell which holds the mirror so as to circulate inside air enough to get equalized change.

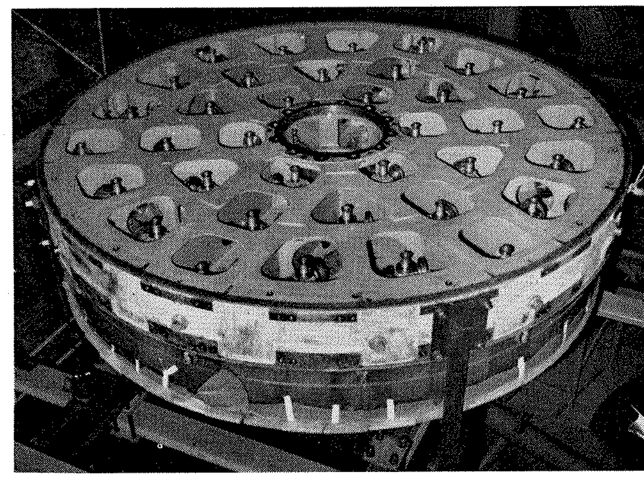
There is also a possibility of insulating the outside edge. Though previous attempts at this sort of thing with other telescope mirrors have not proved too satisfactory, it will probably be tried.

If, however, air circulation or insulation—or a combination of the two—does not provide the solution, it will probably be necessary to remove some of the glass from a portion of the mirror about 18 inches wide around the outer edge. This area represents about 30 per cent of the total mirror surface. The mirror would have to be removed from the telescope for this additional polishing.

If such polishing is required it will be done at the observatory. It would take a minimum of six months and would involve frequent tests of the mirror in the telescope to avoid any possibility of removing too much of the glass. Actually the maximum amount to be removed will not be more than a few millionths of an inch. This polishing cannot be done until spring at the earliest, since it is considered inadvisable to polish in the observatory at this time of the year.

Designing and installing a system to control the bottom and inside temperature of the mirror will require a minimum of two more months. If this proves successful and no additional polishing is necessary, things may move faster than the astronomers will venture to estimate now—providing no other problems turn up.

"We have always known there would be problems which we could not anticipate," Bowen said. "Obviously we couldn't tell ahead of time what all our troubles would be, but we knew some would show up. They always do in any new piece of equipment, and the more intricate and complicated the instrument the more "bugs" you can expect. The Hale Telescope is, by the very nature of the job it is designed to do, an intricate instrument. With the mirror we have had to deal with tolerances in millionths of inches—not just thousandths or tens of thousandths—over four times as great an area as ever before attempted. We have hesitated to say anything about our problems until we understood them. We haven't yet encountered any for which there isn't a definite remedy, but overcoming them has been, and will continue to be, a time consuming job. First you must know why the problem exists and then what to do about it. We now know this.



The 36 support mechanisms, designed to maintain the mirror's correct figure in all positions, has already been modified.

"I might point out that it was a year and a half after the 100-inch mirror went up to Mt. Wilson before the telescope was put into operation and it was nearly ten years before that mirror was thoroughly satisfactory at all times. We are trying to do an even more difficult job at Palomar.

"It is this accuracy we are going to get with the 200-inch mirror that will make the Hale Telescope 'pay off' for it is on nights of 'good seeing' that it will do its best work. It is then that we will be able to get out to the billion light-years for which it was designed. There may be no more than twenty such 'good seeing' nights in a year. When they occur we expect to be ready to take advantage of them. We are shooting at a maximum, not just a 'good enough' accuracy. We have better than that already."