Big Telescopes on a Roll

The world now has a number of projects for telescopes in a size range thought to be impossible not many years ago

By DIETRICK E. THOMSEN

The first astronomical telescope was two lenses in a tube; Galileo could hold it in his hand. Today's telescopes are so big that mountaintops sometimes have to be sheared off to make room for them, and they are getting even bigger.

Until about a decade ago, astronomers thought they had reached the practical limit of size with telescope mirrors of 5 or 6 meters diameter. Now, thanks to technological developments in the construction and management of large mirrors, these limits are being surpassed, even doubled. The world now has approximately 10 projects in different stages of construction, planning or discussion that intend to use mirrors larger than 6 meters.

Glass was the greatest hindrance to building large mirrors. To image the sky properly, a telescope mirror must keep the shape of its curved surface precise. The necessary stiffness seemed to require a thick backing of glass behind the reflecting surface. As diameters got up to 6 meters or more, a catch-22 came in: In large telescope mirrors the amount of glass seemingly required for stiffness would slump under its own weight and distort the reflecting surface it was supposed to maintain.

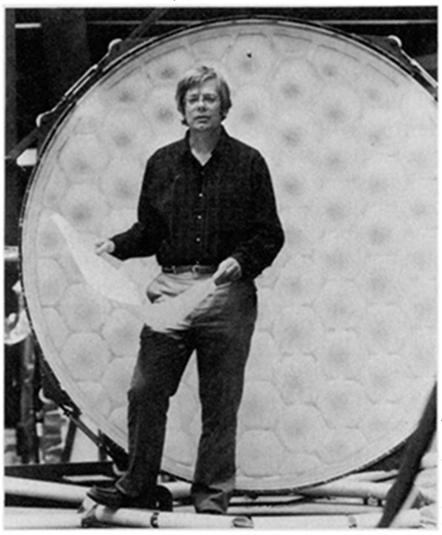
Two solutions are actively being tried. One stops relying on the glass for stiffness. Such plans envision a segmented mirror with what telescope designers call "active support," an arrangement of levers and thrusters that holds the overall shape of the mirror, compensating for gravity, wind stress and other distorting factors.

The second solution is still "passive." It relies on the stiffness of the glass but aims to prevent slumping by leaving out most of the glass. It turns out that this is possible if the back of the mirror is in the form of a proper kind of honeycomb shape rather than a solid slab.

Such honeycombing seems first to have been tried with the 5-meter mirror on Palomar Mountain. J. Roger Angel and his associates at the University of Arizona in Tucson have developed it into a production-line technique, in which plugs of water-soluble material set in the bottom of the mold make the voids in the honeycomb and are then washed out of the finished mirror with a high-pressure stream of water.

A major innovation of Angel's group is to use a rotating mold. Rotation gives the upper surface of the telescope blank a paraboloidal surface instead of the flat surface of ordinary casting. A paraboloid is the surface shape most telescope designers want, and so starting with it greatly simplifies the grinding and polishing of the surface. For a large conventional mirror, shaping and grinding take years, and the time and expense of this step posed another hindrance to planning mirrors bigger than 5 meters.

The recent developments have meant, among other things, that two people are having significant influences on an entire generation of new telescopes. Nearly all the current large projects have had Harland Epps of the University of California at Los Angeles involved in the design of their optics, and most of them will want mirrors of the type Angel casts.



Univ. of Arizona

J. Roger Angel with a 2-meter mirror.

Angel's group started out with a 2-meter rotating furnace. Having successfully cast 2-meter mirrors, they began about three years ago to build a new casting shop under the stands of the football stadium on the Tucson campus with the intention of ultimately casting 8-meter mirrors (SN: 2/16/85, p.106; 1/17/87, p.40). A session on the status of the large-telescope projects at the recent Workshop on Instrumentation for Ground-based Optical Astronomy, held at the University of California at Santa Cruz, heard from John Hill of the University of Arizona that the 8-meter turntable has just been completed. It now carries a furnace of 3.5 meters diameter for its first project, a mirror of that size for the projected ARC telescope, expected to be cast in November.

Later Angel and his colleagues expect to cast another 3.5-meter mirror for the National Optical Astronomy Observatories (NOAO). It will be about three years before they complete the expansion of the furnace to 8 meters and cast the first 8-meter mirror. The furnace is all electric, and one not-so-trivial piece of information for statistics buffs and game players is that it will take 2.2 megawatts of electricity to make one 8-meter mirror. "That ought to dim the lights in Tucson," one meeting participant commented.

The business of making 8-meter mirrors promises to be a good one. The Columbus project, which intends to build what its planners call a "big binocular" telescope on Mt. Graham in Arizona, will require two 8-meter mirrors. It plans an instrument in which both telescopes may work together to form a single image or work separately as desired. The Magellan project, planned to be the largest telescope ever built in the Southern Hemisphere, will want one 8-meter mirror. The European Very Large Telescope project, which plans an array of large and small mirrors at an as yet undecided location, will eventually want four 8-meter mirrors (SN: 1/3/87, p.10).

According to Sidney Wolff, newly appointed director of NOAO, that group will also want an 8-meter mirror. In her talk at the meeting she indicated that the long-discussed National New Technology Telescope (NNTT), which would be the most ambitious of the new projects, has been put on the back burner. According to the most recent plans, the NNTT would be a square array of 8-meter mirrors that could work together to simulate the light-gathering power and resolution of a single 16-meter mirror or could work separately (SN: 1/3/87, p.10).

The Association of Universities for Research in Astronomy, which manages NOAO for the U.S. government, has approved long-range plans to build the NNTT on Mauna Kea on the island of Hawaii. However, in the near term, says Wolff, it would be better to concentrate on a single 8-meter telescope, probably for a Southern Hemisphere location.

"There is a good deal of scientific justification for such a project," she says. Furthermore, experience with it would help in the final design of the NNTT. Also, it seems right to her that the federal government, which supports NOAO, should bear some of the cost for developing telescopes of the 8-meter class. For such a project, NOAO would need the help

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of universities, however. Wolff says three are interested, two of which prefer a northern site, one a southern site.

Another new prospective customer for an 8-meter mirror is the Large German Telescope (DGT), which will be something of a hybrid between the single large mirrors and the segmented mirrors. Its primary mirror will be 12 meters in diameter, with an 8-meter single mirror in the middle and segments around it. Gerhard Schnur of Ruhr University in Bochum, West Germany, told the workshop that the project is sponsored by AVU, an association of all German universities with programs in astronomy.

So far AVU has no government funds, but it intends to ask the West German government for money in 1988. Meanwhile, the group has interested some industrial firms in looking at various aspects of the planning, particularly Zeiss and Heraeus for the optics and Krupp for the mechanical structure. Krupp engineers tried various computer simulations for mountings, but none seemed to fit the bill, until someone hit on the idea of supporting the telescope on three hydraulic rams like the flight simulators on which airplane pilots are trained. Having decided that, the planners now also propose using an inertial guidance system such as flight simulators use for pointing the telescope.

The DGT, which may in the long run become an international project, is intended for a Southern Hemisphere location — perhaps the southernmost of them all. One site under consideration is the Victoria Range in Antarctica. The DGT will be optimized for infrared observations, and Antarctica would be an excellent place for such observations because of the dryness of the air there. Water vapor in the air absorbs infrared.

Antarctica has been a kind of international laboratory for earth sciences for decades, and a certain amount of astronomy has been done there, too. However, this seems to be the first time anybody has seriously proposed putting a major multipurpose telescope on the frozen continent. One reason such ultra-remote locations are now thinkable is the development of automation and remote control.

The development of on-line data processing and ways of transmitting large amounts of data long distances have made it possible for astronomers to supervise a telescope from home. The ARC telescope is a pilot project in this respect, as it aims to be fully automated and remote controlled. To be located at Sacramento Peak, N.M., the ARC is sponsored by a consortium of universities including the University of Chicago, the University of Washington at Seattle, Washington State University in Pullman, New Mexico State University in Las Cruces and Princeton (N.J.) University.

As Bruce Balick of the University of Washington puts it, this list "includes members in every time zone of the United States," and of course, users will come from other institutions as well. The telescope is designed for quick change of data-taking equipment and quick change of astronomers. One of the things it will be able to do, which the more rigid scheduling of traditional telescopes usually cannot, is react to changes in the weather, changing observing programs according to what the weather will permit, reserving the most sensitive observations for the best weather periods and so forth.

According to Balick, the system is designed so that, in response to the prearranged schedule or weather changes or some serendipitous event in the sky, a simple phone call will alert a certain astronomer, sending that person to a home computer, a MAC for example, or to his or her office at the university if more sophisticated computing capabilities are required.

While all these projects either are waiting or may wait for the University of Arizona shop to cast mirrors for them, two projects for segmented mirrors also go forward. The SpectroScopic Survey Telescope (SSST) is a project of the University of Texas and Pennsylvania State University. It will assemble an 8-meter light-gathering area out of 73 segments, making a spherical surface with a 26-meter radius of curvature. It will be only partially movable, but will nevertheless fulfill its purpose of surveying the sky to get spectra of faint objects (down to 19th magnitude).

Lawrence W. Ramsey of Pennsylvania State University in University Park reported that the site for the SSST has been chosen on Mount Locke near Marfa, Tex., where the University of Texas McDonald Observatory is located. The truss that will hold the mirror has been designed, and a mirror test facility and polishing lab are in place.

The largest of all the projects actually under way is the 10-meter Keck telescope of the California Institute of Technology and the University of California. The building for the Keck telescope has been completed on the summit of Mauna Kea, and Jerry E. Nelson of the University of California at Berkeley proudly displayed at the Santa Cruz meeting a picture of the ship that had brought the dome to Hilo from Vancouver, British Columbia, where it was fabricated. The dome is now being assembled beside the building on top of the mountain.

The primary mirror of the Keck telescope will be a hyperboloid made of a large number of segments. The segments are thus off-axis pieces of a hyperboloid, and the usual method of grinding, which depends on axial symmetry, wouldn't work. Instead, the group is using a method called stress polishing, in which the segment is stressed so that it is bent slightly out of shape. In this condition the grinding machine can cut what to it is a spherical surface, and then, when the stress is removed and the segment relaxes, the proper piece of the hyperboloid is there. According to Nelson, the first segment has succesfully undergone this process, and it went faster than the contractor, ITEK, expected.

The sensors that will monitor the shape of the mirror are mostly built, Nelson says, and a contract has been let for mass production of the actuators that will hold and correct the shape. Everything is on time and on budget, he says, and they expect the telescope to see its first light in 1990. □

Keck Telescope

The dome for the Keck telescope was fabricated in Vancouver, British Columbia, and shipped to Hilo, Hawaii, in disassembled form. It is now being assembled on the summit of Mauna Kea.