An existing black anodized aluminum track on the inside of the dome provided the mounting surface for the mylar strips. (See Figure 1.) This track was cleaned and ruled as part of the installation preparations. A metal scribe was temporarily attached to the mounting for the encoder read head and pressed tightly against the track. The dome was then rotated one revolution so that the metal scribe marked a guideline on the track, tracing the path that the encoder read head would follow.

Each mylar strip was then glued onto the track using 3M Spray Adhesive type 77, which forms a permanent bond. The strips were aligned to the track using the guideline produced by the metal scribe, and aligned to each other using the dovetail patterns printed at the edges of each strip. The printed sequence numbers were used to insure that the strips were installed in the proper order. Since the strips must be glued with the printed side facing the dome, the printing viewed through the mylar appears reversed. To compensate for this effect, the sequence numbers were printed backwards so that they will be read correctly when viewed this way. Note that these numbers are for the benefit of the people who assemble and maintain the mylar strips, and are not part of the code scanned by the optical sensors on the read head. In addition, each encoder tick mark on the timing track is individually numbered to provide immediate visual confirmation of the dome position.

Assembling and installing the mylar strips was the most tedious part of implementing this system. It took about 45 minutes to print one set of the mylar transparencies on the laser printer, and about 6 hours to cut and tape them into the 3- by 30-inch strips. Gluing the strips to the dome required about 45 minutes. The parts cost of the mylar sheets, aluminized tape, laser printer toner, and spray adhesive was about $45. These costs (parts and labor) are for the 1-meter telescope dome, which is 23 feet in diameter, and would need to be scaled up accordingly for larger domes. Using 100 feet as a rough estimate of the diameter of the domes for the 3-meter and 10-meter telescopes, these costs would scale up by a factor of 4.4 to about $200 in material and about a man-week of labor.

Maintainability

We were concerned with how to repair the installed mylar strips if any of them were damaged. To test the feasibility of repairing a damaged piece, we glued a second piece on top of an existing one. There was no impact on the functioning of the system, nor any glitch at the splice. This is an advantage of printing the encoder tracks as individual sheets rather than as one continuous roll; small areas can be repaired without having to manufacture and install a complete replacement band. Since each piece has its own sequence number, a damaged piece can easily be identified and its replacement quickly located. To repair the damage, one would clean the surface of the damaged area, trim the replacement piece to size, apply the aluminized tape, and glue the new piece over the damaged area. To expedite this type of repair, a complete spare set of printed mylar sheets is now stored at the 1-meter telescope, along with a roll of the aluminized tape and a can of the spray adhesive. The cost of materials for the spare set of mylars, roll of tape, and can of glue was about $30.

Accuracy and Reliability

There are several advantages to using this system rather than the more traditional solution of mechanically coupling a rotary encoder to the dome. To start with, mechanical complexity is reduced by eliminating most moving parts. If the dome is not out-of-round and does not wobble about as it rotates, then the encoder track surface will remain within the depth of focus of the optical sensors, and the encoder read head can be completely stationary. In this case, the dome itself will be the only moving part in the system.

Unfortunately, the domes at both the 1-meter and 3-meter telescopes are out-of-round by more than one inch, and this exceeds the depth of focus of the optical sensors. As a result, the read head must move radially to keep the optical sensors focused on the encoder timing and data tracks. This is accomplished by a spring loaded parallelogram linkage, which is simple to machine. Unfortunately, this linkage introduces a small (less than 1/8 incremental tick), but tolerable, uncertainty in the azimuthal position of the read head. A piston (keyed to prevent rotation of the concentric cylinders) could be used instead, but would require more complicated machining.

Besides being out-of-round, the encoder track surface at the dome of the 1-meter exhibits considerable vertical warping. To correct for this problem, the optical sensors are mounted on a vertically pivoting block attached to the end of the parallelogram linkage. The proper spacing and alignment of this assembly is provided by two wheels which connect to this block and which roll along the encoder track surface. Neoprene O-rings are used as the tires on these wheels because of their exceptional resistance to ozone. (At altitudes above 4,000 feet, the ozone concentration is sufficient to degrade normal buna-N O-rings.) The traction provided by these tires is unimportant. If they slip, the functioning of the encoder is not affected.