THE CLEANING OF A CLASSIC *(Part One of Two)*

Article by F. Jack Eastman
Photos courtesy of Chris Ray

A decision was made early in 2010, after the visit from Chris Ray and Fred Orthleib of the Antique Telescope Society (ATS) that we should remove, disassemble and thoroughly clean the 20-inch Clark objective of Chamberlin Observatory's historic telescope. The task was to begin September 28 and continue for at least four days.

To my knowledge, I don't believe the lens had been properly cleaned since it was installed in 1894. It most likely had its front surface cleaned in situ (perhaps during Dr. Everhart's directorship) and the front element may have been removed, but there are no records indicating what was actually done or when. We intended to provide complete documentation of the disassembly and cleaning process, as well as measure the curvatures, thicknesses and spacings of this lens assembly.

It is fortunate that this telescope is of the Boyden design, one of two (that I'm aware of) where the front element is in its own cell and is designed to be reversed, changing the airspace, thereby changing the color correction to the photographic blue and shortening the focal length by an order of a meter or so. This proved to be a distinct advantage, as the separate cells for the two lenses would be easier to handle and the removal of the glass from the cells would be considerably easier.

On Wednesday, September 29th, the team assembled at Chamberlin Observatory. It consisted of Chris Ray, from ATS, who would preside over the operation, Dr. Robert Stencel, Observatory Director, Aaron Reid, Observatory Administrator and me. Chris has had extensive experience in the restoration and maintenance of old and large telescopes, and his knowledge and experience was an invaluable asset to the success of this job. Also helping was DU student Brian Kloppenborg, whose assistance was greatly appreciated. Incidentally, Brian is featured in the April issue of Sky & Telescope in a wonderfully informative article on digital photometry.

The first operation was to aim the telescope down at the floor and securely tie the tube to the pier, as the instrument would be many foot-pounds out of balance after removal of the objective. Aaron produced plywood cutouts that fit against the telescope tube and the pier, secured these in place with two-by-fours, and tied the telescope to the pier with several turns of climbing rope. Earlier in the year, the loose screw that was rattling around in the tube had been removed (it proved to be a pin from a broken internal u-joint that was subsequently repaired last spring when the RA clamp and slow-motion system was serviced), so there was no danger of anything landing on the rear of the lens.

The three screws holding the front (crown element) cell to the rear cell were carefully removed and the cell carried by the four of us over to the table provided for the operation (cell and glass weight: 118.5 pounds.) The six screws holding the rear (flint element) cell were removed (again, carefully) and the cell containing the flint element was carried to the operating table (cell and glass, 80 pounds). The retaining ring was removed and the cell picked up and very carefully lowered over a table-mounted tripod, which would hold the glass as the cell was lowered over it, thereby removing the glass from the cell. This tripod was essentially an upside-down three-legged stool with soft lint-free pads on the "feet" that would support the glass.

Once this was accomplished, the bare lens could be carried over to the cleaning stand and washed with mild detergent and distilled water, rinsed with distilled water and dried with lint-free cotton pads. While the glass was out, the cell was thoroughly cleaned and all signs of rust and corrosion were removed. It was interesting to see a polished silvery ring ~6 mm wide inside the cast iron cell which defined the lateral position of the glass. The material of this ring may have been German Silver, a composite of copper, zinc and nickel that has great resistance to corrosion and is also used for the finely-engraved setting circles on the telescope and for transit instruments, sextants and the like.

Chris Ray, from the Antique Telescope Society, examines the lens cell from the 20-inch Clark refractor at Chamberlin. Undertaking the cleaning of the elements proved less daunting than first thought, and Chris's knowledge and experience were invaluable in understanding the various components of the assembly and how best to restore them.

The cleaning and rinsing procedure was repeated for the front cell. This time, however, we met with difficulty. There was much rust and corrosion which prevented the retaining ring from being removed. The retaining screws were reinstalled from the inside of the cell, giving us "handles" on which we could exert more force; the ring finally came out with much difficulty. This rust and corrosion also prevented the glass from coming out. One heart-stopping moment was when the glass came partially up on one side, then dropped back into place with a resounding "clack"—it probably fell only a couple of millimeters, but it was a scary moment. No harm, no foul, but we gave up at this point and Aaron spent considerable time scraping rust and corrosion out of the cell, especially around the edge of the glass. The cell was flooded with soapy water and we tried again to remove the glass, this time with success.

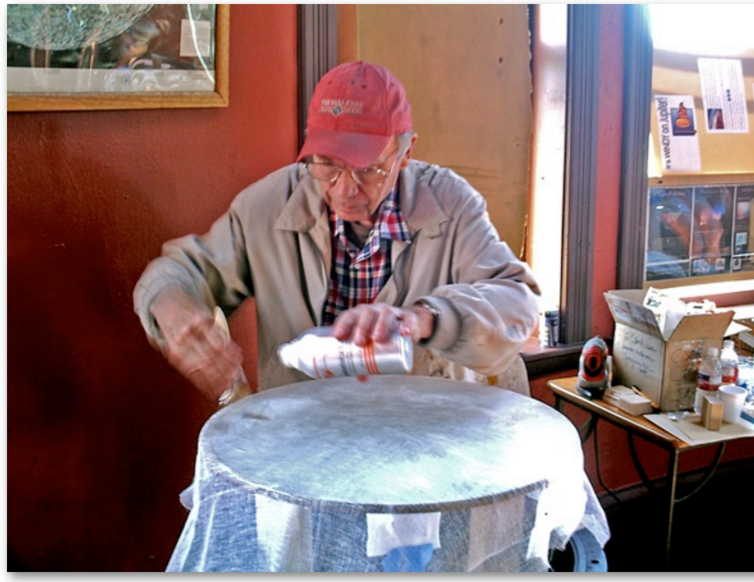
As the glass was removed, the positions of the lenses (clock angle) relative to the cell were marked with a waterproof marker, also indicating the direction the lens element was found so we wouldn't replace the lens backwards. The outer surface of the front element (the crown) was very dirty, so Chris decided to give it a collodion treatment. Collodion is gelatin dissolved in ether (note: gotta be used in a well-ventilated area)! Chris painted a layer of the stuff on the lens, placed a sheet of cheesecloth on it and applied a second coat. After several minutes this coating was peeled off, and all the crud on the glass came with it, a very effective trick for removing all the particulate matter otherwise stuck to the glass without any rubbing or other action which could damage the lens surface. The lens was then washed as before with the flint element. The cell was thoroughly cleaned and treated with "rust reverser," a chemical that turns rust into a harmless polymer and prevents any further damage and corrosion. Aaron determined the point on the cell that is at the bottom when the telescope is stowed and drilled a small "weep hole" just behind the silver edge support which would allow condensed moisture to drain out and help prevent any further corrosion. It was noted that there were stains on the lens from the bronze blocks that supported the glass, indicating that the crown element had rotated or was incorrectly assembled after a previous cleaning, with the position having shifted about twice the width of the blocks. After a best-effort at removing these stains, which involved a bit of polishing with optical rouge (well outside the clear aperture of the lens)! it was reassembled in what we thought was the proper orientation.

LENS CHARACTERIZATION:

With the objective completely disassembled we had the perfect opportunity to measure everything we could. Chris measured, and documented, every possible dimension of the cells and I measured the curvatures on the 4 lens surfaces using a spherometer with feet on a 202.6 mm circle. The probe was a Starrett dial indicator, 0.2"-travel reading to .0001-inch (2.5 um). I have a 7-inch optical flat which can be used to zero the smaller instruments. I also have a larger (8.5-inch diameter) piece of glass, which looks much like a plate glass mirror blank and appeared to be flat on both sides. Using the small spherometer, I compared it to the known optical flat; it seemed to be flat to the accuracy of the small spherometer. I also placed it in front of my 32 cm Newtonian. It did defocus the image very slightly and caused a minimum of image degradation—it may have been a window of some sort in another life. Zeroing-out the large (y=101.3 mm) spherometer on this glass, then measuring the radius (R) of my 32- cm mirror, I came within less than ~1% of the accepted value of 4866 mm—I declared it flat enough for our purposes.

The formula I used, $R=(Y^2)/2s$ (1) (where R=radius of curvature of the surface in question, Y=the radius of the circle containing the feet of the spherometer and s=saggita [depth of the curve on the surface as read from the dial probe]) is exact for a paraboloidal surface. A small error is present for a spherical surface, but even for the strongest curve, it is less than the precision of the spherometer, so I ignored it for this exercise.

We measured the lens edge thicknesses, edge separation and lens glass diameter (21.38 inches [542.9 mm]), The edge thicknesses and spacing is 12.4 mm for the crown (front element), edge spacing, 37.6 mm and 27.7 mm for the flint (rear element). Then, from our measured radii of curvature we derived the following dimensions for the lenses: Center thickness of the crown element 37.3 mm, the flint, 14.1 mm and the airspace (normal, or visual configuration) is 37.9 mm. Airspace for photographic configuration (reverse the cell for the front element) is 175.5 mm. The radii of curvatures on the four lens surfaces are, starting from the front of the lens, R_1=3151. mm, R_2=-2760. mm, R_3=-2704. mm and R_4=flat. Positive radius is convex to the front (sky side) of the lens, negative is concave forward. Following this convention, the crown element is double convex, the flint plano-concave. We then set the flint element on the cleaning stand and with a small light determined the radius of curvature of the concave surface with a Foucault-like test, and obtained 2705+/-~5 mm, close enough to the spherometer reading. We feel the thicknesses and spacing are good to the order of one millimeter and the surface radii to the order of about +/- 0.6 per cent.



Chris applies a collodion preparation to the front surface of the crown element. This highly-flammable mixture of pyroxylin, ether and alcohol adheres to solid contaminants on the lens. Draping a layer of cheesecloth over the top and allowing the mixture to dry permits the debris to be removed safely, without scrubbing, by peeling the cloth slowly from the surface.

After cleaning and rinsing with purified distilled water, the crown lens rests on a special rack to air-dry. The cleaned elements revealed almost no flaws, save for some trapped air bubbles, a testament to the care given these pieces when they were crafted.

The crown element weighed in at 31 pounds, the flint at 39 pounds—surprisingly light, but the lenses were very thin, much thinner than I expected; thinness seems to be a characteristic of Clark lenses. The cell's total weight added up to 128.5 pounds, and with 70 pounds of glass, the total weight of the lens and cells is 198.5 pounds, considerably less than my first guess at ~500 pounds.

Table 1) 20-inch Lens Prescription (visual configuration)

Surf.	Radius (mm)	Thickness (mm)	Material	Nd	Vd
1	3151.	37.	Glass	Unk	Unk
2	-2760.	38.	Air		
3	-2704.	14.	Glass	Unk	Unk
4	Inf		Air		

Table 2) 20-inch Lens Prescription (photographic configuration)

Surf.	Radius (mm)	Thickness (mm)	Material	Nd	Vd
1	2760.	37.	Glass	Unk	Unk
2	-3151.	175.	Air		
3	-2704.	14.	Glass	Unk	Unk
4	Inf		Air		

(Note: Nd is the refractive index for the yellow helium line, Vd is the Abbe number, related to the dispersion of the glass, difference in index between the red C hydrogen line and the blue F hydrogen line. Vd=(Nd-1)/(NF-NC), NF and NC being the indices at the F and C lines).

This article will be continued in the May 2011 issue of the Observer.