Figure 1: The Dearborn telescope, after consevation, December 1998, on display in* From the Night Sky to the Big Bang *exhibition at the Adler Planetarium.

The Conservation of the Historic Dearborn Telescope

Craig Deller, The Deller Conservation Group, Ltd., Geneva, Illinois

ABSTRACT: The Dearborn Telescope has been in the collection of the Adler Planetarium and Astronomy Museum since 1930 (*fig. 1*). Considered the largest in the world when it was built, the telescope has significant historical importance to both Chicago and astronomy. This paper will examine the telescope's history, condition examination, and original surface recovery treatment.

Introduction

THE ADLER PLANETARIUM AND Astronomy Museum on Chicago's lakefront, the first planetarium in the Western Hemisphere, was scheduled to begin a major expansion and renovation of its magnificent 1930s Art Deco building. Deller Conservation was asked to conduct a condition report on the Dearborn telescope in anticipation of its being disassembled and placed into storage as the new addition was being built. What was the structural condition of the telescope, which had not been disassembled since its arrival at the Adler in 1930? And was it stable enough to withstand the stresses of a complete disassembly? There were a few cracks in the wooden tube and losses to the metal components, but we felt confident it could indeed be disassembled, stored and reassembled in the new exhibit space without significant risk.

However, as we conducted our examination, we found areas that displayed what could be the tube's original surface. The then-current surface of the tube was very dark and opaque and, being in a somewhat darkened display area, it was nearly impossible to ascertain that the tube was, in fact, a beautiful walnut burl veneer. The decision was made to see what had made it turn so dark, to see if the original coating was intact and retrievable, and to preserve what had been the largest telescope in the world.

History

Alvan Clark and Sons

Three instrument makers—Alvan Clark and his sons, George Bassett Clark and Alvan Graham Clark of Cambridge, MA—figured importantly in the great expansion of astronomical facilities that occurred during the second half of the 19th century (*fig. 2*). Almost every American observatory built during this period, and some observatories abroad, housed an equatorial refracting telescope and often the auxiliary apparatus as well[1] made by the Clarks. Five times the Clarks made the objectives for the largest refracting telescopes in the world; and the fifth of their efforts, their 40-inch lens at the modern University of Chicago's Yerkes Observatory, has never been surpassed. Their optical work, which was recognized as unsurpassed anywhere in the world, was the first significant American contribution to astronomical instrument making.

Figure 2: Alvan Clark (center) with his sons.

Alvan Clark was born in Ashfield, MA in 1804, the fifth of ten children. Little is known about his father other than he was descended from a Mayflower passenger, Thomas Clark. Alvan began his professional career in a wagon maker's shop. It was during this time that Alvan visited Hartford and had his first exposure to art. So inspired, he quit the shop to study drawing and engraving. Soon, he traveled the Connecticut Valley painting small portraits of people who, by chance, were later involved in astronomy and Clark instruments. It was during this time he met his future bride, Maria Pease. They married in 1826 and lived to celebrate their sixtieth wedding anniversary, an event noted by *Science Magazine*.[2]

He worked as both an engraver and artist until 1836 when he renounced engraving to earn his living by painting portraits. He kept his studio open until 1860, however, when the Alvan Clark & Sons telescope business appeared lucrative enough to support his family.

Alvan Clark became a telescope maker almost by accident. As interest in astronomy increased in 1844, spurred by the appearance of the great comet the previous year, Alvan's son, George Bassett Clark, then a student at Phillips Academy, followed Newton's example and took a broken dinner bell and melted it down to make a reflecting telescope. Alvan watched his son's experiment with growing enthusiasm and, like any father, could not refrain from giving him the "benefit" of his "maturer judgement;" he then promptly became involved with the construction of telescopes.

It was son George who was directly responsible for the first telescope and was the nucleus of the company. We know little of him, perhaps due to the fact of his constant devotion to the business. His brother, Alvan Graham, was as deeply involved in the business as George. While George did mechanical work, Alvan Graham, with an eye as keen as his father's, figured and tested the object glasses.[3] "Clark really had a knack for working glass. He would test a lens in his workshop, sight a star with it and throw it out of focus so he could see where the defects were. Then he would put some optical rouge on his thumb and actually feel where the error was, the tiny bump on the surface, and polish it away."[4]

On the night of January 31, 1862, while testing the lens of the Dearborn Telescope, Alvan Graham discovered the faint companion to Sirius. The German astronomer Bessel, years before had predicted this companion from the wobbling motion of that brightest star in the sky.[5]

Arrival in Chicago

Because the records of the Chicago Astronomical Society were destroyed in the Great Fire of 1871, the history of the telescope's coming to Chicago is based upon a report given by the Secretary of the Society, Mr. Thomas Hoyne, on March 16th, 1874 which in turn is based upon his memory. The following is from that 1874 report:

"The first movement towards the creation of an Observatory in Chicago took place in December of 1862. A gentleman named Mr. Forey came to Chicago with the authority to sell a large telescope manufactured in New York by Mr. Fitz for $8,000.00."

In order to create an interest in the creation of an Observatory in connection with the then University of Chicago, it was determined that Mr. Forey give a lecture about astronomy at the University. It was quite successful, and a call for subscriptions was made. From that, a committee was created to expand the subscription drive with a view to the founding of an Astronomical Observatory Society in Chicago. The drive was highly successful and a sub-committee was formed to visit New York as soon as possible to purchase the "Fitz Glass."

In the meantime, a member of the Committee, Mr. Mixer, learned of a "…great telescope left upon the hands of Mr. Clark by the University of Mississippi, in consequence of the breaking out of the war of rebellion."

Mr. Hoyne left Chicago January 20, 1863 for New York with the intention of seeing Mr. Fitz, but instead left New York immediately for Boston to see Alvan Clark.

While the Chicagoans were making their plans, the Director of the Cambridge Observatory had plans of his own to make Clark's "Great Glass" the possession of his Observatory. But with the outbreak of the Civil War, finding subscribers in

Boston proved very difficult, and his plans were put on hold. Upon being tipped off that Chicago had learned of Mr. Clark's work, Cambridge moved to secure the instrument first. Mr. Clark had a prejudice that his greatest work stay near his home in Cambridge. But when Mr. Hoyne came willing to pay the first installment that day, Mr. Clark Sr. was convinced by his son that,

"His interest…was secured at once in favor of a city that did not higgle about price or terms…" The then-record 18 1/2-inch clear aperture lens was purchased for Chicago, along with a contract to mount it, for $18,100.00. With the purchase secured, the next important step was to provide a site to receive the telescope and establish an Observatory.

In the early part of May, 1864, with the site secured and the tower and its revolving dome of 90 feet in height erected, both Mr. Clark Jr. and senior, arrived in Chicago with the glass and mountings. Alvan Clark Sr. stayed nearly one month to see his work completed, and then left the instrument in the hands of the new Observatory."[6] The University gave Alvan Clark Sr. an honorary degree in 1866.[7]

From 1862 to 1868, the 18 1/2-inch lens was the largest in the world. Housed at the original University of Chicago in Douglas Park, it was used from 1864 to 1886. When the University was hard hit financially after the Great Fire of 1871, and the resources of those supporting the Observatory were hit equally as hard, the endowed observatory found itself in severe financial difficulties for a period of several years. In 1881, the University became involved in legal action over its property. This ultimately lead to the Chicago Astronomical Society gaining possession of the telescope, and on July 14, 1887, the Society was served notice to vacate University of Chicago property by October 1. The result was the choice of Northwestern University in Evanston to become the home of the Dearborn Telescope. It was transferred in 1889. In 1911, a modern type of mounting and metal tube was constructed. The original lens was removed from the wooden tube and reinstalled in the modern mounting where it continues in use for instruction and research today.

Nearly 18 years later, in 1929, the Chicago Astronomical Society transferred ownership to Northwestern University and then donated this original historic mounting and wooden tube to the Adler Planetarium, then being built[8] (*fig*. 3).

Examination

Over the years, the wooden surface of the veneered tube had apparently been routinely revarnished,

Figure 3: The Dearborn telescope at the Adler Planetarium, circa 1933.

perhaps as part of a maintenance plan. This varnish had deteriorated over the years, darkening and obscuring the wood. It is conceivable that the resins used darkened naturally and the surface was resaturated with the same varnish from time to time to clarify the surface, which may account for the numerous layers found.

Fortunately, the metal elements attached to the wooden tube had not been removed when the surface was recoated. This allowed access to what was thought to be the original surface. By removing one of the brass elements, we were able to conduct distinct analysis on the lower layers of coatings.

In order to determine the nature of the materials, we began with a series of solvent tests. These were designed to get a feel for what the coating in question might be. The first test was with ethanol. The surface did in fact react quickly affirming we had a spirit varnish, as opposed to an oil-based varnish. A spirit varnish could be made up of any number of natural resins that readily dissolve in ethanol. The list is long and includes shellac, rosin (colophony), sandarac, Manila copal, and many others. An oil-based varnish is quite different. The process in the 19th century for oil varnishes used fossil resins like Congo Copal or amber, which were cooked in an oil, usually linseed, until the resin broke down allowing the oil to serve as a vehicle for the resin. Once dry, the film would undergo a drastic change. Through both polymerization and oxidation, the oil film crosslinks and becomes impervious to simple solvent testing. With spirit varnishes, on the other hand, the solvent simply dissolves the resin being used to allow it to be spread. As the solvent (usually ethanol) evaporates, the resin remains behind as the protective film which can be redissolved in that solvent. These simple tests rule out a much more complicated series of oil based coatings and allowed us to proceed to the next step. We then proceeded to try to determine which resin makes up the film. As mentioned, the ethanol suggested a wide variety of resins. Moving to a different class of solvent would narrow down the possibilities.

The next solvent used in our test was acetone. The number of natural plant resins that are fully soluablized in acetone is more limited, eliminating more in the list of potential materials. The heavily degraded top layers were quickly soluablized with the acetone, where as the undercoating (possibly original) was more resistant to the acetone. This

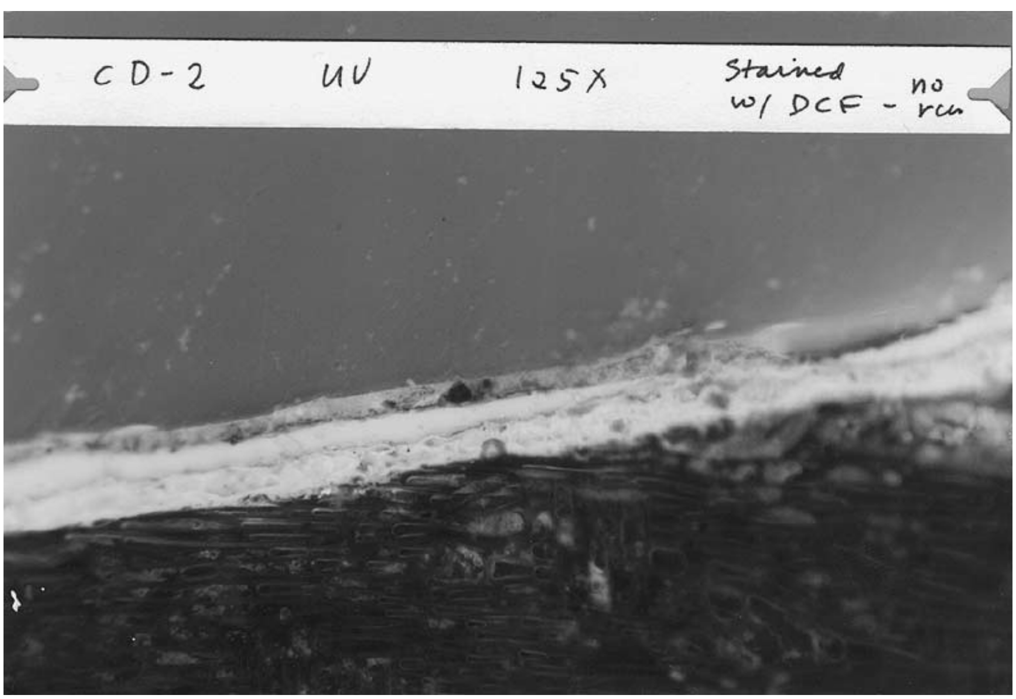

Figure 4: Cross section verifying solvent tests.

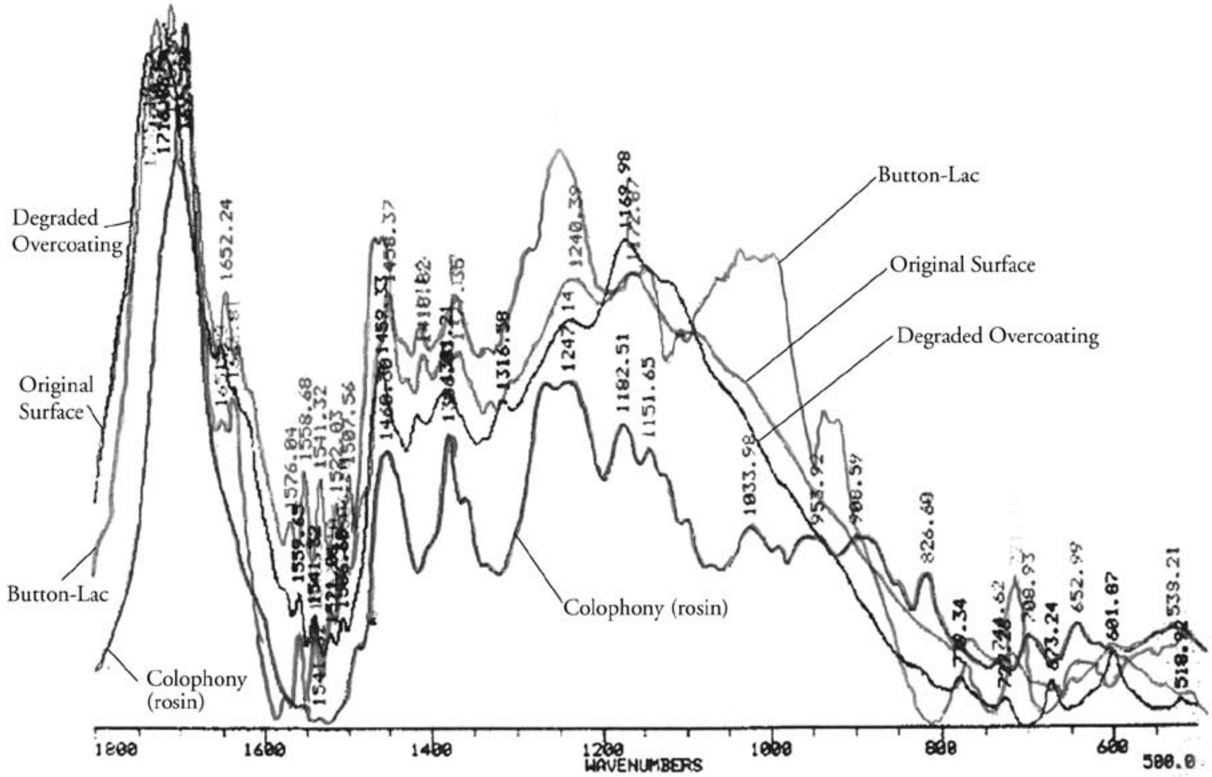

Figure 5: Results from Fourier Transform Infared Spectroscopy.

gave reason that there were two distinct materials making up the coating history.
The solvent test results, and an educated guess in coating materials of the period, led us to believe that we were dealing with the easily degradable turpenoid resin, colophony, as the darkened top layers. These tests also suggested that the undercoating might be shellac. A chemical test with di-phenylamine dissolved in sulfuric acid, was used to tests for cellulose. The test was negative, ruling out an entire class of coating materials that would include nitro-cellulose lacquers.

To verify the solvent tests, we moved to the microscope with a cross section (*fig. 4*). Under normal light (125X) we could see the distinct layering of many years of recoating. Switching to the ultraviolet, those distinct layer became more pronounced. The top layers fluoresced the common whitish-green often associated with most plant resins. However, the plugged pores of the wood fluoresced orange, strongly suggesting the original layer was shellac, as shellac has the unique ability to fluoresce orange under the UV.

Biological stains were also applied to the cross section.[9] Rhodamine-B showed a positive for oils suggesting that the top layers had an oil component. Research into 19th-century practices and the results of the solvent tests suggested we may have had a colophony (pine rosin) based varnish leanly bound with oil, which allowed the acetone test to put the colophony into solution. The original mixture would not have been the traditional oil varnish recipe described above, but rosin dissolved in turpentine (turpentine was commonly used, but another solvent is possible) and an oil added perhaps as a plasticizer.[10]

In an effort to confirm the use of a colophony-based varnish as the top degraded varnish layer, and shellac as the original, we moved to Fourier Transform Infrared Spectroscopy (FTIR) (*fig. 5*).

The FTIR spectrographs were very useful in ruling out a large number of natural plant resins and narrowed the focus to colophony and shellac enough for us to make the determination of resin type and to design the treatment. The spectrographs

Figure 6: Ultraviolet fluorescent lighting shows results of cleaning.

suggested that both the degraded overlayers and the suspected original underlayer may have had been the same materials, or at least possible resin mixtures. The degraded condition of the resins may have also contributed to the similarities in the spectrographs.

Treatment

With enough verification from the FTIR to confirm rosin as the principal resin in the degraded upper layers, we proceeded to devise a treatment.

The scope of the treatment would be one of original surface recovery, in which we would design a means to remove the added layers of colophony and expose the original coating of shellac. A wide variety of materials were tested including aqueous-based cleaning solutions such as resin soap.[11] While these water-based solutions cleaned the colophony surface well, they were not aggressive enough to remove the degraded layers. Our initial solvent tests led us to begin with acetone as a possible tool.

After numerous areas of delaminated veneer were stabilized with hide glue (251-gram strength) and losses were filled with both small patches of new walnut veneer and colored wax, the removal of the rosin layers was undertaken.

Pure acetone proved to be far too aggressive and uncontrollable. Adding a small amount of mineral spirits (less than 10%) made the solvent more controllable. However, working with a round tube, and the high volatility of the acetone/mineral spirits mixture, we found the need to gel the mixture for control.[12]

Initially we worked under normal light, checking the cleaning results by ultraviolet fluorescence (*fig*. 6). We could easily see the amount of degraded material being removed (green auto-fluorescence) exposing the original shellac layer (orange auto-fluorescence). It should be noted that shellac is known to change its auto-fluorescence from orange to green when it is exposed to extended periods of high ultraviolet light.[13] Switching from normal light to UV fluorescence to check progress proved to be awkward and did not allow maximum control of the acetone/mineral spirits gel. By working under UV fluorescence exclusively, we were able to see the progress of the solvent gel easily. Once the orange fluorescence of the shellac appeared we would quickly clear the gel with mineral spirits and proceed to the next section. For a project with such a large surface area (22 feet), this approach speeded up the treatment dramatically. Areas approximately 12 inches by 10 inches proved to be the maximum that could be effectively and efficiently controlled.

Once the degraded layers were removed and the original shellac coating was exposed, we could see areas in which the surface was quite thin, along with several losses. The shellac film itself was intact and not terribly degraded. In an effort to prolong the life of the shellac film (by reintroducing a solvent phase) and to help clarify it, the surface was lightly saturated with ethanol.

The existing shellac surface needed to be protected, and, to compensate the losses in the coating, an additional resin would be needed. The addition of another shellac layer would have negated a main purpose of the treatment, which was to preserve this 19th-century layer of shellac. A new shellac layer would have become intractable from the original making the future separation of one from the other impossible. It was decided that Acryloid B-72 would be the resin of choice due to its clarity and stability. It also allows the original layer of shellac to fluoresce orange in UV light. The choice of solvent for the B-72 was also important. In order to create a sufficient bond to the original shellac layer and still allow the B-72 to be easily removed, xylene was chosen. Tests showed that a sufficient bond existed and its reversibility with xylene was very good.

However, due to the curved nature of the tube, the B-72 (15% solution in xylene) created disfiguring sags. Once set, the B-72 film was leveled with 220 sandpaper, but in order to create the desired burnished surface, the B-72 surface was rubbed with ethanol in a traditional French polish technique utilizing a cotton pad wrapped in cotton sheeting. While not adding any additional resin material, we were able to reduce the sagging and brush marks and create a burnished surface by manipulating the surface with the ethanol.

As part of the documentation, a small (3x 3 inch) area of the degraded top layers was left intact near the lens end of the tube.

We next turned our attention to the brass mounts. Initial examination showed no coating on the brass except for a small area on the base that tested (with di-phenylamine) for cellulose. Our conclusions were that the brass, while it may have had a coating applied in the 1860s, had been routinely polished removing all traces of any possible coating. Through years of handling by the public, the brass elements had a heavy layer of grime as well as a heavy layer of oxidation.[14] With input from the curatorial staff, the decision was made to polish the brass elements enough to remove the oxidation layer, but not to create an overly polished surface. Precipitated chalk was tested and proved ineffective for such a large project due to the degree of oxidation and accumulated grime. Autosol[15] proved very effective. Once the metal surfaces were cleaned on both the tube elements and the base, the surface was sealed with Agateen #27 1:1 to thinner.

The cast iron base had been repainted in the past and the decision was made simply to clean the paint surface and apply a microcrystalline wax.

Another aspect to the project was the four chamfered steel support arms. These arms were attached to the wooden tube to prevent distortion. The steel was covered with a pressed paper material that was delaminating. B-72 (1:1 acetone/ethanol) was used to resecure the layers to the steel. The pressed material was not analyzed beyond a cross section for microscopy. The cross section exhibited the same layering of varnishes as found on the tube, but as the cleaning proceeded, it became clear that the original surface was paint on the paper layer. A green layer was found which was thought to be the original. With the multiple layers of added varnish removed, the painted paper surface was found to be terribly abraded and the decision was made to repaint these arms. An isolating barrier coat of B-72 (20% in xylene) was applied, and then the arms were painted with latex in a similar green tone.[16]

Conclusion

With recent advances in cleaning techniques and selected coatings removal, we are able to remove degraded and inappropriate coatings while minimizing the risks to original layers. We are also able to produce the appearance of traditional finishes with modern materials by manipulating those materials with traditional techniques.

Acknowledgments

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End Notes

1. This would include the brass and iron mounts.

2. *Science*, vol. 7. 1886; 303-304.

3. Warner, Deborah Jean. 1968. *Alvan Clark and Sons; Artists in Optics*. Smithsonian Press.

4. Chester, Geoff. Naval Observatory, *Smithsonian Magazine,* September, 1998 p. 28.

5. Undated exhibit text.

6. Excerpted from the report given by Thomas Hoyne to the Society and the Board of Directors of the Dearborn Observatory, March 16th, 1874.

7. Warner, Deborah Jean. 1968. *Alvan Clark and Sons; Artists in Optics*. Smithsonian Press. p. 23.

8. Excerpted from a booklet published by Northwestern University, "The Dearborn Observatory Past and Present" 1964; plus an undated exhibit text.

9. Results from TTC (triphenyl tetrazolium chloride) for the presence of carbohydrates, and FTIC (fluorescein isothocyanate) for proteins, both proved negative.

10. Mussey, Robert editor. 1825. *The Cabinetmakers Guide*. London.

11. Resin Soap: Abietic acid, triethanolamine (TEA), Triton X-100, distilled water. Aqueous cleaning solutions included: Brij 35, distilled water, TEA; Pluranic L-61, TEA, distilled water with the pH adjusted to 8.5.

12. Acetone was gelled with Ethomeen C25 and Carbopol 954, and 10% (volume) of mineral spirits was added.

13. While the mechanics of this phenomenon are still unclear, we are confident this did not happen in this case, as the telescope would always be in a darkened environment preventing the ultraviolet damage to the shellac film. (Research is being done that has reproduced the effect.)

14. Note: since the telescope had been accessible to the public for many years, numerous parts were missing.

15. Autosol is a brand name for an abrasive paste used to remove rust from metal. Solvol Autosol is thought to contain a fine abrasive powder dispersed in spirit soap.

16. Note: it was originally decided by museum staff that the arms should be black for aesthetic reasons. A black layer of latex paint was applied only to be repainted with a green layer.

About the Author

Craig Deller is a private historical furniture and objects conservator in Geneva, Illinois. He received his Bachelors of Science Degree from Southern Illinois University in 1976 and participated in the Furniture Conservation Training Program of the Smithsonian Institution, 1990-1994. He continued his training with Dr. Walter McCrone, Richard Wolbers and others. An AIC member since 1982, he received his Professional Associate status in 1993. He is an active participant in the Objects Specialty Group and the Wooden Artifacts Group. He has been President of the Chicago Area Conservation Group from 1993 to the present, and is currently the Director of Communications for the AIC. He is also currently an adjunct faculty member in the MS Program in Historic Preservation of the School of the Art Institute of Chicago. Address: The Deller Conservation Group, Ltd. 2600 Keslinger Road, Geneva, Illinois 60134