RENOVATION OF THE 15" TELESCOPE AND SEARS TOWER

Nathan L. Hazen May 15, 1990

INTRODUCTION

This document is to report the studies and cost estimates done in support of Fred Seward and Owen Gingerich relating to restoration of the 15" telescope and Sears Tower at HCO. This work was within the larger context of also furnishing the area with exhibits and interpretive material for public consumption. What I will describe here mostly addresses the telescope itself, its mount and the building. Display issues are addressed by others.

The telescope and mount strategy derive largely from my own views as an instrument engineer with a historical bent. Some specific items - the tube restoration and the Observer's Chair - have benefited from inputs from the SPNEA.

With regard to the building, a variety of cost inquiries have been made over the last two years to support grant application activities. The result has been a wide variation in the views of what work is required, what the costs might be and how they might be categorized. Here I've tried to arrive at an assimilation of these data and describe what I think to be the most considered approach based on that consultation and advice and my own engineering judgement.

TELESCOPE

General

Elements of the telescope and mount require substantial work to bring them to a reasonable display condition, to ameliorate the effects of the misguided 1955 modernization or to stabilize ongoing deterioration. The most cost-effective approach is to totally disassemble the instrument and mount, distribute the parts to where the detailed work on each is done (with great care to security, of course), and then to put the whole thing together when all that is finished. Although this may seem drastic at first blush, I believe that the work will proceed much more efficiently and with more care than could be achieved in place. The mechanical and rigging skills are available in people known to me within the University, although the team would necessarily be chosen with care. It should be noted that the instrument originally arrived from Germany in parts and was assembled by the Director and his staff; we can do as well. Another benefit of full disassembly is that it allows a more careful evaluation of condition and examination for historical markings and artifacts.

The time interval for all the telescope work would be about four months and would precede the work on the observing level floor. The Observer's Chair restoration would proceed in parallel, while the telescope was out, as would the work on the dome and dome door drives. The scaffolding used during the telescope disassembly would be reconfigured for the dome work and again for the telescope reassembly.

Tube

The main issue here is the damage sustained on the objective end in 1955, resulting in placement of a metal tube extension. The work has been discussed at length with SPNEA carpentry staff and is well understood. The tube will be stripped of all external hardware, leaving a net weight of less than 500 lbs. It will then be moved to another site for the wood and veneer work, and its finish renovated. This task will probably be the rate limiting step in the instrument renovation.

The tube is constructed of three layers of longitudinal "staves" laid up in staggered fashion and totalling one inch in wall thickness. These staves are of a light fir or pine type material and they are covered on the outside with a thin mahogany veneer. The renovation strategy is to restore the damaged end to its former appearance and function. This will be done as follows:

A) Remove the existing metal tube extension and survey the condition of the tube and the nature of the original materials.

B) Build a plug to serve as an internal mold during the renovation.

C) Laminate up the required tube end using similar materials and dimensions to the original and scarfing into the existing tube wall as necessary.

D) Apply new veneer over the repair and back to the upper brass clamp ring which will serve to camouflage the disparity.

Objective & Mount

The objective will be removed early-on and stored in a secure location. I have already done this once, including disassembly of the air-spaced lens, in 1970. Although the cell need not be disassembled this time, some work may be required to adapt it to the renewed telescope tube. It was apparent earlier that the internal fittings were not original, with some modifications adapted to the metal tube repair; these may have to be revised. An appropriate approach will be established during the tube assessment described above.

Tailpiece End

Some parts of the tailpiece does not seem to be of a quality consistent with the original telescope. After documentation and disassembly, the parts will be inspected, compared to historical records and a strategy defined for renovation. Some new parts will probably be required to emulate those lost. The focus will be on visual representation of its probable configuration in 1847.

Finder Telescope

The finder currently in place has no relationship to the original or any early variant except in its general size. Lacking any remaining contemporary material, the strategy here is to simply spruce-up the present finder, which is brass and doesn't look too badly from a distance.

MOUNT

General

The "German" mount for the 15" telescope is in reasonable condition except for normal dirt and grime AND the effects of the disastrous "modernization" initiative of 1955. The thrust of an historically sensitive refurbishment at this time should be to reverse both of these circumstances. The only reasonable way, and the most economical approach as stated previously, is to simply take the whole mount apart, clean and restore the individual parts, make a limited number of display quality parts to emulate those lost earlier, and to reassemble it. Obviously all the work would be documented photographically, and no approaches would be used that were not reversible.

Right Ascension Axis

The plan is to restore the R.A. axis to its form at the time of the delivery. This is because a) it is simpler, and b) a replica of the original drive exists (see below). The argument that the Clark drive of 1855 is more representative of the early productive period is valid, but no detailed documentation exists regarding that drive, and to construct a replica would be very time-consuming. In other aspects the R.A. axis is in reasonable shape, except that the graduated circle was butchered in 1955.

It is the plan to cosmetically restore the R.A. circle and fit it with dummy verniers and eyepieces during the general refurbishment described above. The main worm drive gear will be cleaned, and the worm re-shafted (it was cut off in 1955) to match the replica drive and the original drawings.

Drive System

The 1955 electrical drive has already been removed from the telescope (revealing to our amazement the original right ascension graduated circle). An excellent operational replica of the original Merz & Mahler governor drive has been built in Florida, complete except for the last shaft adapters. The task here is to complete this work and mount the finished system on the telescope and pier.

Declination Axis

Restoration here requires the removal of the 1955 electrified drive and associated mounts, construction of a replica declination clamp, cosmetic restoration of the graduated circle, and the fitting of dummy verniers and eyepieces. This will be planned in detail during disassembly based on examination of the parts. It would appear that the hub of the original declination circle is still in place and was used to form the ring gear for the electrical drive. How it will be adapted to this restoration remains to be seen.

Pier

The granite pier shows some of the ravages of time and the zeal of eager experimenters. The remains of the electrical cabling will be removed and the holes filled with simulated granite. The pier as a whole will be cleaned with non-invasive techniques. Any adaptions for the governor drive will be restored.

OBSERVER'S CHAIR

The Observer's Chair is in deteriorated condition, but can be easily stabilized and refurbished to a functional display condition. It is not appropriate to plan substantial use of the chair given its historical value, nor to renovate it to support such use. It was designed and built to be used by a limited few skilled observers, not the general public.

SPNEA staff examined the chair in detail to come up with the restoration estimate. The strategy is to remove the chair proper to their furniture shop for refurbishment. However the main structure will be done in the dome because it is too big to remove. It will be refurbished before the floor and rails, and then jacked up on shoring for this activity.

DOME & SHUTTER DOORS

Door Rehabilitation

The shutters are of two types. The upper doors are relatively recent and are built with fiberglass skins over wooden frames. The lower three doors, quite a bit smaller, are original copper-sheathed counter-weighted sash mounted in a curved triple frame. The latter sash are currently caulked closed.

There is quite a spread of opinion on the degree of functionality that should be retained by these doors and how to handle their rehabilitation. This is reflected in the spotty coverage by the building consultants whose input is summarized in the cost comparisons following. My own belief is that we cannot support a fully operational door system whereby anyone can open the slit at will. Such a situation would allow the possibility of disastrous damage to the instrument and the interior of the dome if difficulty were encountered, incur substantially larger ongoing maintenance costs, and present the risk of damage due to inept operators.

I'd like to suggest a compromise which would allow the retention of a fully operating door system, while obtaining full weather-tightness. This is to make a one-piece fiberglassed cover, like the lid of a tin box, that fits over the aperture from the outside, doors and all. Using a scaffolding, it could be largely assembled in place from pre-cut parts, fiberglassed, coated green and have a lifting hook to permit a boomed crane to lift it off at will (with a little notice and money). The cost estimate included in the summary sheet, while representing only one consultant's view of what shutter rehabilitation might cost, I believe might be sufficient to construct such a cover, with less being spent on the underlying doors.

Door Drives

The chain drive system for the doors is largely intact, but some rehabilitation is required. The attachments from the chains to the upper shutter doors should be strengthened, and the winch gear/clutch assembly should be taken apart and overhauled. The *fastenings holding the drive frame to the dome must also be* tightened or renewed.

Dome Drive

The dome drive occupies the southeast alcove on the observing level. Much of the drive train is original, but it was fitted with an electric gear-motor in more recent times. The strategy is to remove the electric drive and associated

steelwork, build a replica hand-wheel and pinion and refurbish the remaining parts to a functional display condition. Some pictorial documentation exists and the frame is original.

OBSERVING LEVEL

Floor

The floor at the observing level is structurally sound, but needs refurbishment. The old linoleum covering needs to be removed, the tracks re-fastened, the underlayment consolidated and a new surface installed. It is significant that this floor does not qualify structurally as a public space (uncontrolled numbers of people) and to do so would require historically damaging work. I think these are circumstances we must accept - that visitor group sizes be controlled and that unguided visitation around the telescope not be permitted. There are other good reasons for these practices, as well, considering the security of the instrument and displays. The above course of action for the floor is only viable under these circumstances.

Alcove Displays

The northwest and northeast alcoves, currently used for active storage, are to be enclosed with secure glass fronts and fitted with display lighting. The estimate for this is just a guess, but pre-supposes construction in place to high quality residential standards, and with pre-existing drawings.

ROTUNDA LEVEL

Floor

The rotunda (first level) floor represents perhaps the stickiest problem in the Sears Tower renovation. This is because of its original cantilevered design, the substantial piping and machinery load added in recent times, its current compromised structural condition, the present building code requirements relating to public space and passages, and the desire to limit the destructive impact of the renovation on the historical content.

Each of the recent consultants has had a different view on what the problem is and how it might be solved. Some have not considered it at all. My view is that for something like the highest price that was proposed we can probably do what has to be done, but that we will have to go through a careful review and definition process to firm up a consensus work statement, requiring some hard choices and compromises. Perhaps a whole new modern floor structure is the only choice.

Walls & Ceiling

Although one consultant considered repair work on the plaster walls and ceiling, that is best treated in the alternate budget on displays; it consequently won't be considered further here.

BUILDING & DOME EXTERIOR

Roofing

The cornices, gutters, etc. on the Sears Tower are clearly in need of immediate attention - they are currently shored in place to keep them from falling off. The case for the condition of the copper sheathing on the stationary roof and the dome is less clear, as is the best approach to these problems.

A conservative cost approach is to budget for a complete replacement of the copper sheathing on both parts after restoring the structure of fixed "watertable". There might be some latitude on whether all that must be done which could be decided based on either findings during the early course of the work or in advance by the available funding level. The amount allocated on the budget sheet is the best current estimate of the whole job. The low limit is 1/3 of that. Some careful work statements and bid estimates in advance of the start of work will illuminate the best approach.

Other Aspects

There are a variety of details which have been addressed by various consultants and need to be attended to in this restoration. The upper level (outer) doors are deteriorated wood and need outright replacement. In addition, the iron security doors inside these need refitting of their hinges and bolts.

The south entry is an attached peak-roof structure which is in need of some masonry and carpentry repairs. Some additional minor masonry work may be required around the balcony on the north face. The balcony itself is the only remaining one of the original three and as such needs careful cleaning and protection.

The entry into the dome from the Building B roof is a recessed stairwell which collects debris. This leads to deterioration of the door frame and should be remedied (it was included in at least one of the consultant's schedules).

BUDGET STATEMENT

The budget is divided into two sections: first, that portion having to do generally with the building and secondly, that concerned with the instrument and its immediate surroundings.

There have been four inputs to the building cost estimate process. None have predicated on firm work statements, so there is quite a variation in the focus and detail of the responses. The first data derive from a Planning Office study dating from 1986 (?) which has been updated periodically for inflation. I understand these were used in the Mass. Preservation Project "Pre-Application" of 12/5/88. The second data were contained in the full application for the above project dated 4/14/89 and were given by the preservation architect Roger Panek. The third come from a structural engineer Conor Power and his associates who reported to us through the SPNEA on 12/26/89, and the last are from Bob Bonica of the firm of Briggs, Associates, in a study sponsored by the HCO business office in April, 1990. In recent discussion with Owen Gingerich, we considered the plusses and minuses of the above and came up with the figures in the "assimilated budget" column as being a reasonable compromise among such differing definitions and numbers.

The other costs - those having to do with the instrument - are more direct and derive either from my specific estimates or certain work tasks bid on by SPNEA people or N.E. Scaffolding. The last item - the exhibit cases in the dome - are just a guess.

SEARS TOWER RENOVATIONS: - COST COMPARISONS AND PROPOSED ASSIMILATED BUDGET - - N.L.HAZEN - 5/11/90

Item: (line items taken from subject documents)	-Preservation Project- Pre-Appl. 12/5/88	Full Appl. 4/14/89	Conor Power 12/26/89	Briggs/ Bonica 5/1/90	Assimil. Budget 5/11/90
Photos	469				
Sign	391	500			
Preservation Consultant; Architect	23437				10000
Masonry		19000		3500	10000
Metal Railing		1000			1000
Carpentry: Cornices, gutters	109375	9000	20000	45000	
Chair, Dome, Doors	12500			or	
Sheet Metal; Roofing	3125	18000		65000	65000
Caulking		1000			1000
Doors, Windows, Shutters	4688	8000		(5000)	5000
Telescope Shutter Rehabilitation		8000			8000
Plaster Repair		1400			(in display)
Floors: "Resiliant" Flooring		7300			
Second (observing) Floor					
First Floor/ Basement			20000	35000	35000
"Wiring/ Fireproof Basement Ceiling/ Plaster"	25000				
Paint: Exterior	12500	15200		(5000)	(Harvard
Interior	4687	11600			maintenance)

OTHER ASPECTS - Estimates by NLH unless indicated	Estimate Basis	
Observer's Chair Refurb. incl. Paint & Cushions	SPNEA; 4/12/90	15000
Telescope, Mount, etc.		
Scaffolding	bid; N.E. Scaffold; 4 mos.	4500
Disassembly of Whole Telescope & Mount	3 m-w	3600
Tube: Objective end rebuild (woodwork)	SPNEA; 4/12/90	9500
Brasswork: Clean, polish and protect	SPNEA; 4/12/90	15000
Refurbish RA & Dec. axes; associated parts	4 m-w; 2K mat'ls	6800
Adapt Replica Merz drive	1 m-w; 1K mat'ls	2200
Refit Objective cell	1 m-w	1200
Reassembly of Whole Telescope & Mount	3 m-w	3600
Misc. General Refurbishment, Teles. & Pier	2 m-w; 2K mat'ls	4400
Dome Drive; Restore Machinery as Necessary	3 m-w; 2K mat'ls	5600
Aperture Door Drives; Restore Mechanical Aspects	2 m-w; 1K mat'ls	3400
Exhibit Cases, Observing Level Alcoves		10000

RENOVATION CARPENTRY TASKS - HARVARD 15 INCH TELESCOPE

draft Task Statement by Nathan Hazen, January 18, 1990

TELESCOPE TUBE

This is a hollow wooden tube of 1 inch wall thickness, about 22 feet long, with an outer diameter tapering from about 12 inches at one end to about 16.5 inches at the other. The roundness is stabilized by a series of internal metal annular rings. The tube is constructed of a light fir-type wood, with the wall composed of strips, each approximately 1/3 inch thick and 1 inch wide, laid down in three layers with staggered joints. The outer surface is veneered with mahogany and the inside is covered with a cardboard-cloth laminate. The larger end of the tube was damaged some years ago, resulting in outright loss of about three feet. Since that time a metal tube has been bolted in its place.

The task is to restore the end of the tube in wood by scarfing in and laminating new staves out to the original length, covering the repair with new mahogany veneer, and doing some interior finish comparable to the original. There may be some small repairs elsewhere on the tube to be done at the same time. The work should aim to use material and adhesives comparable to the original or contemporary with them, but this is negotiable depending on cost.

I would expect that the tube would be removed from its mounting and stripped of all extraneous hardware by Observatory personnel. The restoration work could be sited on the floor of the observing room, elsewhere in the Observatory, or the tube could be crated and delivered to the carpenter's shop, whichever is most economical. In the last case, issues of security would have to be addressed.

OBSERVER'S CHAIR

This is an assembly about 10 feet high and 9 feet wide, with two narrow sets of stairs bounding a central two-person settee which can be cranked up and down on curved rails between them. The assembly is mounted on wheels which run on tracks imbedded around the observing floor. The structure of the Observer's Chair is heavy wood; the fittings and machinery (chains, pulleys, wheels, rails, etc.) are iron and brass. Red velvet cushions are used on the settee.

The task is to restore the Chair assembly and the mechanical devices to sound condition. There is some minor wood breakage, some of the fittings need re-seating, and many of the joints are somewhat loose. A judicious mix of

traditional and modern materials might be used, subject to negotiation, with the emphasis on restoring appearance and function. New cushions must be made.

Because of its size the Observer's Chair cannot be removed from the dome so most of the work must be done there, but some subassemblies could be detached.