PLAN FOR RESTORATION OF

THE SEARS TOWER

AND

CONTENTS

Draft.
Not quite complete.

Comments Please.

Fred

Contents

RENOVATION OF THE SEARS TOWER, THE 15″ TELESCOPE, AND THE ROTUNDA

1 Introduction

One-hundred and forty years ago, the Harvard the "Great Refractor" was the largest telescope in the United States. For the past decade it has stood unused and immobile under the dome atop the two-story Sears Tower in Cambridge. The room below the telescope room, the Rotunda, presently contains four 1957-era exhibits and pictures of astronomical subjects which surround the granite supporting pier. This room serves as a rather dark passageway connecting two buildings. Over the years, there have been several plans to refurbish the telescope or the exhibits but very little has actually changed.

This report describes a plan to renovate the building, the telescope, and the exhibits to make a small, integrated, astronomy museum. The material will emphasize both historical accomplishments, and current projects at Harvard College Observatory and the Smithsonian Astrophysical Observatory. (These jointly form the Center for Astrophysics).

The overall design concept for the public areas encompasses three distinct spaces, each with a distinct function, and each representing a distinct era in American science. The old building and the magic of the old telescope will give visitors a sense of history and an appreciation for the problems and techniques of astronomy in the 19th century. An office, located midway on the stairs between the first floor and the dome will be furnished as the director's office at the turn of the century. This will bridge the gap between old and new and will contain furniture and equipment used by local astronomers at that time. Exhibits illustrating modern astronomy will occupy four alcoves surrounding the pier in the Rotunda. A second small office at the foot of the stairs leading to the dome will contain

an interactive computer display.

This report details the necessary renovations, the exhibits, the interior design, and the associated costs.

2 The Sears Tower

The oldest part of the complex, now occupied by the CfA on Observatory Hill in Cambridge, is the two-story-high "Sears Tower" housing Harvard's historic 15-inch (Great Refractor) telescope. The building was erected in 1846–the same year as the founding of the Smithsonian Institution–and the telescope was installed one year later. For the next twenty years, this beautiful, 20-foot-long, mahogany-veneered telescope was the largest in the United States.

Inside the tower, a granite pier supporting the telescope rises 43 feet to the observing floor under the dome. That pier is topped by an 11-ton solid granite block that carries the telescope and its mount. The 30-foot-diameter dome, weighing approximately 14 tons, was reputedly built by a whaling shipwright and is sheathed in copper. A velvet-upholstered observer's chair once moved around the telescope on circular tracks and could be raised or lowered by a pulley system, so the observer could be put into position at the eyepiece. The entire system–telescope, dome, and observing chair–was a prime example of the 19th Century craftsmanship.

Among its many early scientific accomplishments, the refractor was used to discover the eighth satellite of Saturn and to make the first observation of Saturn's inner ring. The first photograph of a star (a daguerreotype of Vega) was made in 1850, and plates of ~~many more~~ others followed thereafter. Ironically, photography contributed to the demise of the Great Refractor as a useful research tool, since its color correction and clock drive were

ill-suited to the new photographic methods. Gradually, the instrument and its magnificent observing chair fell into decay, as did the building around it.

Exterior repair (cornice), dome repair, dome floor, Rotunda floor.

3 Telescope and Observing Room (to be restored to 1847-1866)

Beneath the huge dome of the Sears Tower, the top-floor Observing Room houses the telescope and its observing chair. To capture the spirit and style of the 19th Century builders, both the instrument and its surrounding environment will be returned to their original states.

After the external work has been accomplished on the dome and the shutters, the first priority would be the telescope itself. A replica of the original clock drive has been completed, but there is not much sense in installing it now, since the telescope itself has to be dismounted for general repairs. The metal replacement section at the upper end of the tube will be replaced with a laminated mahogany veneer section. The motor drive from the declination axis will be removed. These changes will lighten the instrument and make it possible to remove most of the ugly set of lead counterweights near the eyepiece end.

The observing chair is in bad disrepair and needs to have fractured member replaced, new upholstery, and paint. It needs a fresh set of pulley ropes so that the chair can revolve around the dome. In conjunction with the restoration of the chair, the floor needs to be refitted, and the iron rails on which the chair moves have to be re-anchored.

Thus, the telescope and observing chair will be restored to operating condition. We are advised, however, that the chair will probably not stand up if used by every visitor. The dome shutter will also not remain watertight under continuous use. The restoration,

therefore, is to "limited operation." The instrument could be available for observing on special occasions but not for open nights or on a regular basis.

The two alcoves on the northeast and northwest sides of the dome will be cleaned out and fitted with special high-security plexiglas doors. The alcoves also need attractive indirect lighting for the exhibits to be chosen by Will Andrewes, curator of the Harvard Historical Scientific Instruments Collection. We expect to place an early brass telescopes in the northwest alcove and a variety of nineteenth-century instruments in the northeast alcove. Robert Noyes has promised some original drawings of Donati's Comet, made with the 15-inch telescope, and it would be appropriate to place them in the northeast alcove. The Smithsonian is also purchasing a set of Trouvelot astronomical drawings. Since Trouvelot worked with the 15-inch telescope, it would be appropriate to frame a few of them to place on the walls of the dome, if the temperature extremes do not propose a problem with the plates.

After renovation is finished, we will install a sound-and-light program in the dome so that an automatic program will spotlight various parts of the telescope and exhibits in synchronism with a short soundtrack.

4 The Director's Office: (to be restored to 1905-1910)

Immediately below the Observing Room and just off a landing on the spiral staircase to the ground floor, there is a small room called the "Director's Office." This will be refurbished as a typical astronomer's office of the early 1900s. The room's centerpiece will be the famous "rotating desk" of E.C. Pickering. As fourth director of HCO, Pickering had a special lazy-susan-style desk constructed so he could work concurrently on several different projects moving the separate piles of paper in front of him each time he switched subjects. The desk was later used by Harlow Shapley, and is now in the hands of his son,

Alan Shapley, in Boulder, Colorado, but has been promised to us. There will be shipping fees for this and also for the two chairs from the residence, once owned by Bart J. Bok and now in the hands of Ray White in Tucson. We have recently received the candelabrum from Annie J. Cannon's family home, whose prisms inspired her to think about spectra. We expect to place the candelabrum and other artifacts in this room. A glass or plexiglas arrangement will be constructed to allow unobstructed viewing, but providing protection for the items displayed.

5 The Rotunda (Astronomy of the late 20th and 21st Centuries)

The Rotunda is a circular room 28 feet in diameter set within the square walls of the Tower at ground level. The granite pier supporting the telescope is at the center of this chamber. The Rotunda serves as a passageway between two buildings of the CfA which join the Tower on the east and west sides. It also serves as the entry to the historic telescope for public visitors during the monthly Observatory Nights and the twice-annual Children's Nights.

Four alcoves fill the space between the walls at the corners of the building. These presently hold outdated exhibits on Halley's Comet, x-ray astronomy, optical tracking of meteors, and radio astronomy. Two of the alcoves have hoods that protrude into the walk space. Light boxes with (faded) transparencies line portions of the wall. Although some of the exhibits are moderately interesting, the overall impression is of a dark, cluttered place with dust-filled corners; rather an embarrassment to the Center.

This most public of spaces will be remodeled to create a large, cheerful, well-lit area. The stone pier, a feature of interest and beauty, will fill the center, and will not be obstructed by attachments. The light boxes and alcove hoods will be removed, leaving the structure closer to its original configuration. Four exhibits, one in each alcove, will illustrate the work of the Center and pique the curiosity of visitors.

The Rotunda exhibits will be designed to impart to visitors some of the magic of astronomy and to illustrate the distribution of matter and radiation in the universe. The exhibits will show current research at CfA, and will include historical contributions of HCO. The four alcoves will follow a common style so the Rotunda-as-a-whole is consistent and pleasing. The three-dimensional displays in each alcove will be semi-permanent (5-10 years) and maintenance free, but accompanying pictures and text will be arranged so that they can be changed with minimal effort.

Modern multiwavelength astronomy, will play a prominent role. The Rotunda will be lighted by a strip of lights mounted seven feet above the floor along the circumference of the outer wall. The fascia concealing these lights will form a continuous band passing above the alcove windows and just above the doors. The four foot sections of this fascia will be used to illustrate twenty-one decades of the electromagnetic spectrum - stretching from a radio wavelength of 1 km to gamma rays of energy over one TeV. The fascia will be slightly translucent acrylic with opaque letters specifying wavelength and wave band.

A one and a half foot section will show the colors of the visible spectrum.

A few unobtrusive pictures, probably line drawings, will be placed on or close to this band to illustrate astronomical instruments used at the various frequencies and perhaps some common associations, such as a TV set and a dental x-ray.

The four alcoves will show four aspects of astronomy. The exact content is not yet determined. Possible themes are: the Solar System, stars in the Solar Neighborhood, structure of the Milky Way, the Local Group, and large-scale structure of the Universe. As an illustration, one of these is described in detail in Appendix E.

A Building Repairs

A.1 General

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. This is an assimilation of these data. We describe a considered approach based on these consultations and advice and our own engineering judgement.

A.2 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 k statements and bid estimates in advance of the start of work will illuminate the best approach.

A.3 Rotunda 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. Our 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.

A.4 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).

B Restoration Details - The 15″ Telescope and pier

The telescope and mount strategy derive largely from the views of N. Hazen, 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.

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 and 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, 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 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.

B.1 Tube

The main issue 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 will be 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.

B.2 Objective

The objective will be removed early-on and stored in a secure location. We 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 will be established during the tube assessment described above.

B.3 Tailpiece End

Some parts of the tailpiece do 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.

B.4 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.

B.5 Mount

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.

B.5.1 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.

B.5.2 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 and 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.

B.5.3 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.

B.6 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.

C Restoration Details - The Observing Room

C.1 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.

C.2 Dome and Shutter Doors

C.2.1 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 rather spotty coverage by building consultants and their cost estimates. Our 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.

We propose 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, we believe sufficient to construct such a cover, with less being spent on the underlying doors.

C.3 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.

C.4 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 associatesteelwork, 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.

C.5 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. 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.

C.6 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 pre-supposes construction in place to high quality residential standards, and with pre-existing drawings.

D Details - The Director's Office

E Details - Rotunda Repairs and Exhibits

The following description of an exhibit concerning The Local Group will illustrate what might be done. The subjects of the four exhibits have not yet been defined.

E.1 Example of an Alcove Exhibit

The Local Group consists of two massive galaxies, the Milky Way and M31 (the Great Galaxy in Andromeda), plus a few smaller systems. The alcove would contain a scale model of this region of space. The backdrop will be dark, but not black, with a few painted, distant galaxies. The larger galaxies of the Local Group be suspended in the space within the alcove. M31 and the Milky Way in this scale are three inches in diameter. Each will be an acrylic disk, illuminated from within by a small light. Color transparencies will be attached to the faces of the disks so the viewer sees faintly luminous spiral arms and nuclear regions. M31 and the Milky Way are separated by seven feet. The visitor must stand at the window and look up or down to see the galaxies. In the lower part of the alcove are the Milky Way with attendant Large and Small Magellanic Clouds nearby. Above the visitors head are M31, M32 and M33.

Below the alcove window and to the sides, words and pictures will present related

modern and historical observations. We have digital images of M31 in radio, infrared, visible, and x-ray wavebands. Our image processing laboratory will produce a set of color pictures, each scaled to the same orientation and size, illustrating the different appearance of M31 in several wavebands.

Supernovae in the Local Group provide an opportunity for an interactive feature illustrating both historical astronomy and an event prominent in the news three years ago. In 1885 a supernova was observed in M31. In 1987, one occurred in the Large Magellanic Cloud. Bright supernovae were also observed in the Milky Way in 1006, 1054, 1572, and 1604. The model galaxies could contain very small bulbs which would light when visitors press a button. A simple circuit would regulate the light intensity to illustrate a Supernova light curve, a rapid rise to maximum and a slow decay. One panel would present measurements made here in 1885-1886 on the supernova in M31, demonstrating a link between past and present astronomy.

E.2 Walls and Ceiling

The lights and wiring presently attached to the stone pier, will be removed. The two east alcoves (formerly with hoods) will be modified to the same form as the others, with the addition of floor, wooden wall, and window (so the alcove is sealed and dust free). The ceiling and walls will be painted a light color. New lighting and signage will be installed for the exhibits. Heavy duty carpeting will cover the floor.

The black ceiling with stars and the murals over the east, west and south doors, would be painted over. The sun mural over and on the east door could be preserved, if desired. The milky-way mural over the north door is on plywood and will be removed and stored.

F Details - Interactive Exhibits

A small office is available at the base of the stairs leading to the 15" telescope. There is room for two exhibits which might allow the visitor to see a short movie or to manipulate computer keys. Possibilities for these are:

1. A small computer with digital image display. This would be set up so the visitor could call up a few astronomical images (such as regions of the sky recorded at different wavelengths) and to zoom in on any area he/she desires.

2. A VCR/TV showing short movies produced by the WIPL group here. Suitable subjects might be Einstein and gravitational lensing, the formation of the moon by a collision between Earth and another small planet, M. Geller and a Slice of the Universe, etc.

3. A slide projector which cycles through 35 mm slides illustrating a current CfA research project.

G Costs

There have been four inputs to the building cost estimate process. None have been 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. 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 came 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. We considered the pluses and minuses of the above and came up with the figures below 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 specific estimates by N. Hazen or certain work tasks bid on by SPNEA people or N.E. Scaffolding. The last item - the exhibit cases in the dome - are based on numbers worked out by E. Hauck.

G.1 Building Repairs

Carpentry: cornices, gutters, dome, doors	45
Sheet metal roofing	20
Caulking	1
Doors, windows, shutters	5
Strengthen and fireproof rotunda floor	25
Preservation consultant, architect	10
Masonry	10
Metal railing	1
Exterior paint	5
Sub Total	122 k$

G.2 15″ Telescope and Pier

Scaffolding	4.5
disassembly	3.5
rebuild telescope tube woodwork	9.5
Polish and protect brass	15.0
Refurbish RA and dec axes	7.0
Adapt replica Mertz drive	2.0
Refit objective cell	1.0
Reassembly	3.5
Miscellaneous general refurbishment	4.5
Sub Total	50.5 k$

G.3 The Observing Room

New flooring	10.0
Reset track for observing chair	2.0
Refurbish Observer's chair	
Carpentry	8.0
Paint	1.0
Upholstery	3.0
hand rail	1.0
Telescope shutter rehabilitation	8.0
Aperture door drive, mechanical	3.5
Dome drive, mechanical	5.5
Exhibit Cases	10.0
Interior paint	5.0
Lighting fixtures	1.0
Display fixtures	0.5
"Sound and light show" fixtures and controls	5
Alarm	5
Sub Total	68.5 k$

G.4 The Director's Office

Paint	1
Graphic material	2
Protective barrier	2
Furnishings	donated
Sub Total	5 k$

G.5 The Rotunda

Steam clean central pier	0.5
Plaster repair	1.0
Paint	5.0
Floor underlayment	2.0
Rebuild alcoves	4.0
Electrical, Remove existing wiring, New wiring	7.5
Carpet	2.5
Lighting fixtures	2.5
Fascia to conceal lights	1.0
Sub Total	26.0 k$

G.6 Rotunda Exhibits

Silkscreens	2.5
Photos	2.5
Typesetting and Signs	0.5
Graphics production artist	3.0
Light boxes or light panels	2.5
Model maker and four alcove models	12.0
Sub Total	23.0 k$

G.7 Interactive Exhibits

Computer and disk	?
Paint	?
Graphic material	?

G.8 Management of Project

Sub Total	?

G.9 Total Cost of Project

Total	$295.0 k$

H SCHEDULE

H.1 Building Repairs

H.2 Telescope

H.3 The Observers' Room

H.4 The Rotunda Area

H.5 Rotunda Exhibits

H.6 Observer's Room Exhibits

H.7 Interactive Exhibits

H.8 Director's Office

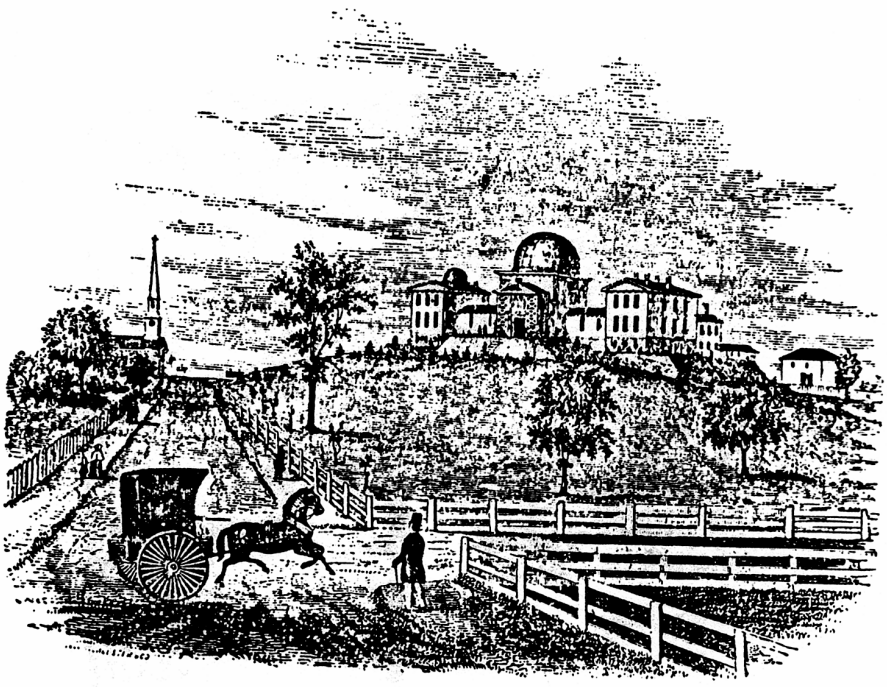

Figure 1: Harvard College Observatory in 1851, as viewed from the corner of Concord Avenue and Bond Street. The Sears Tower is the central building with large dome.

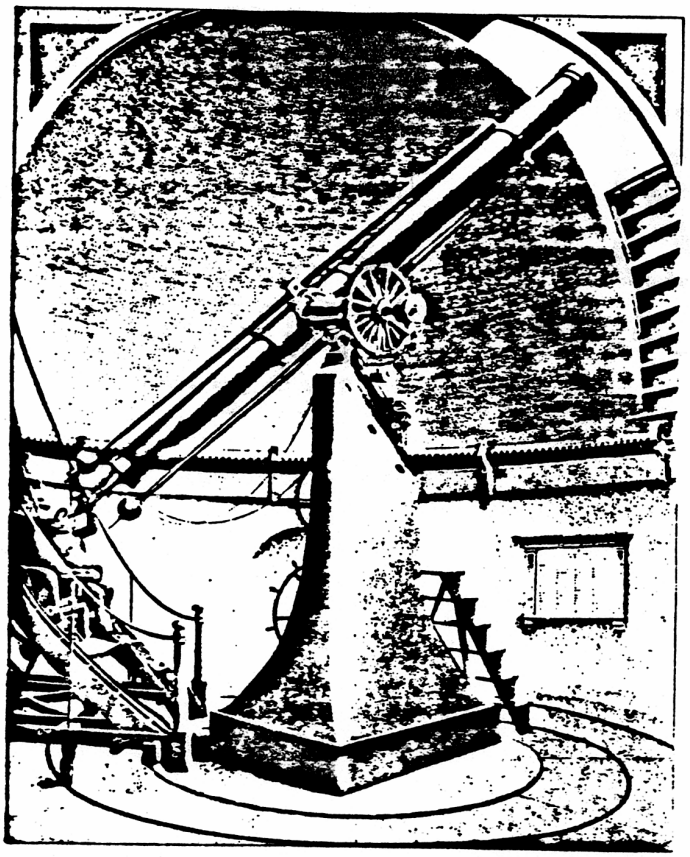

Figure 2: The 15″ telescope. The lower part of the observer's chair can be seen on the left.

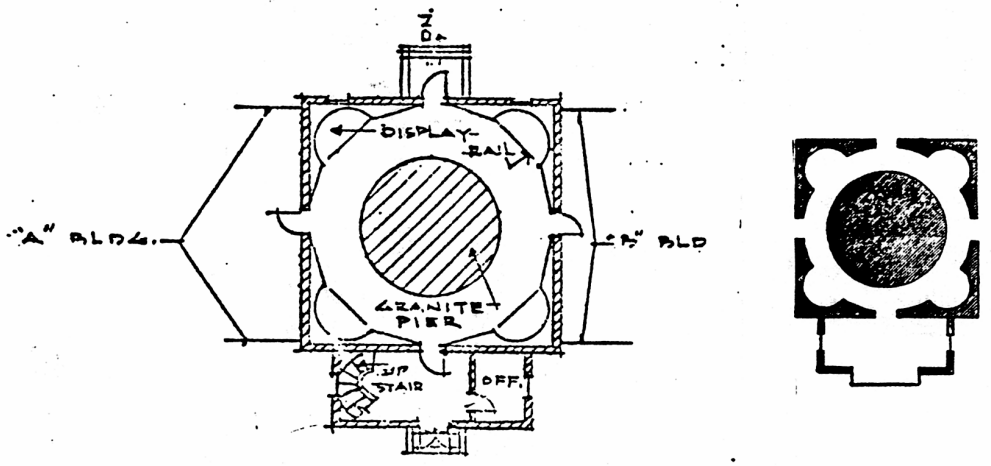

Figure 3: Map of the Rotunda.

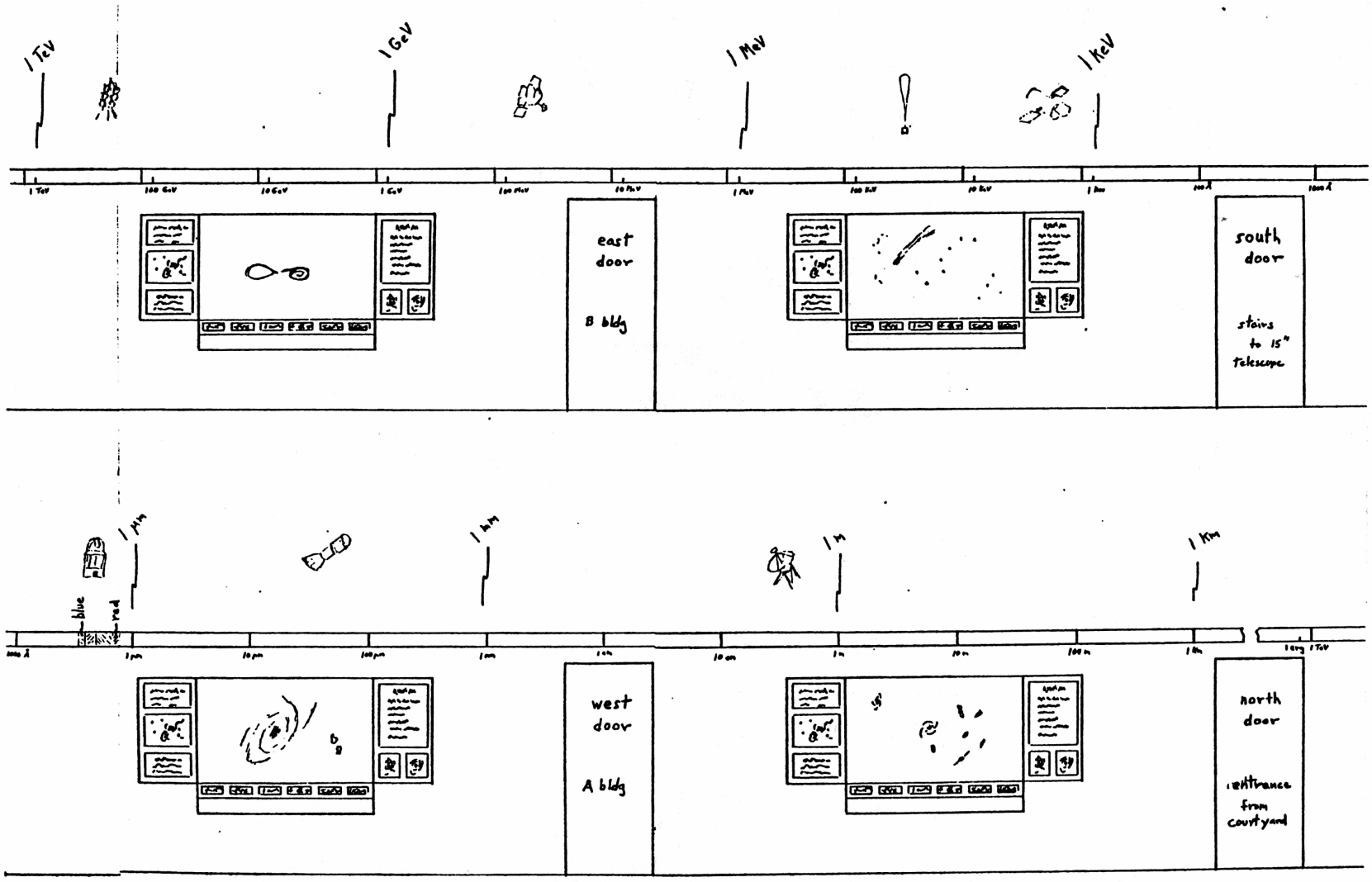

Figure 4: Astronomy throughout the electromagnetic spectrum. This panorama of the Rotunda outer wall shows the four alcoves and the fascia/illuminating light strip which has a wavelength scale inscribed. Inconspicuous pictures of astronomical instruments are located above the fascia.

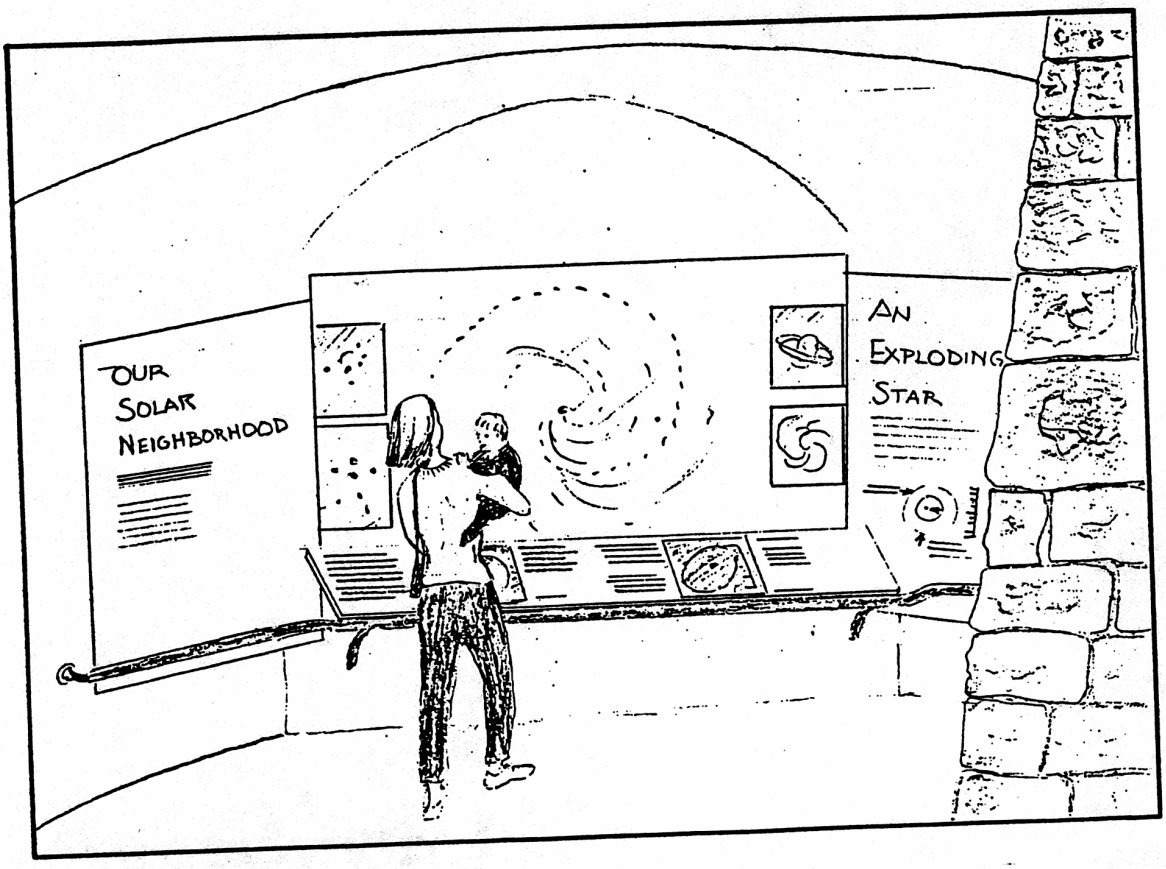

Figure 5: Layout of an exhibit in one of the Rotunda alcoves.