AstroSystems

16"-18" TeleKit Instruction Manual

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Introduction

The TeleKit is the most advanced Newtonian truss tube telescope on the market. It's the first telescope kit to incorporate computer routed wood components. Since it's a kit, we don't have to pay a carpenter to assemble and finish your scope so you can save up to 30% while learning about telescope building at the same time! The TeleKit can easily be assembled without any prior knowledge of telescope building. Our informative instruction manual is easy to follow and includes tips on observing, finishing and materials needed to complete the telescope. Some basic tools and supplies are needed to complete the telescope. With the wood already finger-jointed, you just need to glue, sand and finish.

The TeleKit incorporates many innovations that improve performance and user friendliness. The mirror cell is a big improvement over the outdated steel frame cell. The use of Baltic Birch aircraft plywood in the frame has increased rigidity and reduced weight. Exclusive to the mirror cell is our **Mirror Transport System**. Back the collimation adjustment down and the mirror comes to rest on specially designed transport pads. Once in transport mode, add the specially designed mirror cover and be assured your mirror will be protected no matter how far your observing site. All TeleKit mirror cells come with nylon cushioned, stainless steel support sling. The cell has cooling fans and gel cell batteries with home float charger and car charger. The 16"-18" TeleKits have 18 point flotation and a clean look with the collimation bolts set in flush with the surface.

The azimuth movement on the TeleKit uses precision roller bearings at two positions and a Teflon bearing at the third for unequaled motion, less maintenance and is compatible with drives and digital setting circles. The altitude bearing is large in diameter and rides on Teflon bearings. We have also redesigned the truss attachments for improved accuracy and easier set-up. By attaching the trusses together in pairs of two at the top, we have reduced the amount of attachment points from 8 to 4. This effectively reduces the number of poles you have to deal with from 8 individual poles to 4 sets of two. The bottom truss fasteners use a positive bracket attachment system, which is rock solid and easy to use, even in the dark. Another major innovation is the QuickSwitch 2" filter slide, which is built into the upper cage. No more fumbling in the dark for dropped filters. As you observe you can quickly and safely switch back and forth between your favorite filters without removing the eyepiece!

The TeleKit is a complete observing system, including our time-tested spider and secondary mirror holder, which has an easy four-screw adjustment. The Phase 4 focuser can easily handle loads up to 5 pounds, moves on precision ball bearings, and carries a *lifetime* warranty. Pneumatic transportation wheels are standard on all TeleKit models. The upper cage stores in the mirror box for compact and efficient storage. A light shroud to cover the trusses is standard equipment. Rounding out the package is full technical support and advice. Throughout the TeleKit development phases, performance and user friendliness were always top considerations, but we also kept aesthetics in mind. Because you can take extra time and care in the finishing, the TeleKit will draw compliments from day one. With the clean appearance and the intricacy of the finger-jointing, you not only will have the best performing, but also one of the best looking telescopes available.

TeleKit advanced features

1. The QuickSwitch filter slide is an integral part of the focuser mount. It enables you to have four filters at your fingertips. You may load with nebula filters such as OIII, UHC, H-beta, Deep Sky or color filters and go back and forth between positions quickly, easily and safely. The fifth position is open and will allow a Barlow, 2" collimator or binocular viewer to project through the slide.

2. Upper truss clamps are operated with fast and positive cam clamps (no tools). The truss tubes are held together in pairs which makes transportation and set-up a breeze.

3. Lower truss fasteners are positioned in the mirror box corners for fast and accurate set up, and are secured with eight knobs - no fumbling in the dark.

4. Finger jointed boxes. This method of joinery makes the rocker box and mirror box durable and is the hallmark of the finest craftsmanship. The Baltic Birch plywood is both strong and attractive.

5. The large diameter altitude bearings feature textured laminate riding on Teflon pads. This results in smooth motion and low maintenance and are drive and digital setting circle compatible.

6. The TeleKit primary mirror cell features a drop down tailgate for easy mirror access and removal.

7. The azimuth bearings feature innovative sealed precision roller bearings mounted on stainless steel axles at two positions and a Teflon pad at the third. This allows the TeleKit to move with zero backlash and require minimum maintenance.

8. All the trusses are made of 6061-T6 aluminum, the finest quality tubing available. Supplied too, are the truss covers for professional appearance and protection. The light shroud (a $100.00 value) is included as part of the TeleKit.

9. The upper cage is light, strong and can store in the mirror box for safe transportation.

10. ***AstroSystems*** spider and secondary mirror holder are an unbeatable combination for strength and precise collimation. The secondary holder utilizes our unique four collimation screw system, simplifying adjustment.

11. Stainless steel hardware is used extensively. This gives excellent corrosion protection and lifetime good looks.

12. The Phase 4 focuser has a 3:1 reduction, the optional Moonlite CR2 has a 8:1 reduction and the Feathertouch has a 10:1 reduction to give precise focus movement. The gear-down also increases the torque when adjusting focus. This allows fingertip adjustments without moving the image. The drawtube rides on four precision ball bearings for stability with the heaviest eyepieces.

13. Ten-inch pneumatic wheels allow the TeleKit to roll easily over grass, loose dirt or gravel.

14. The Ground Board is round for drive compatibility.

Why Build?

The following are some obvious and maybe some not so obvious advantages of building your own TeleKit.

Flexibility

By building from "the ground up," you have complete control over the appearance of your TeleKit. Color, type of coatings, number of coats, degree of sanding before finishing are all under the control of the builder. By putting in the time and effort to achieve a superior finish, a TeleKit can easily surpass the finish and appearance of any commercially available telescope.

Personal satisfaction

Successfully completing a project of this magnitude can only result in the well-earned pride and satisfaction deserving of the effort. Some owners have expressed that they use their telescopes more and get more satisfaction since they feel closer to their "own" telescope.

Confidence

The thorough understanding you gain in completing the TeleKit is an excellent springboard to move on to other projects and telescopes.

Education

Once the TeleKit is completed, the builder understands Newtonian optics, collimation, truss tube telescopes and wood finishing. This kind of understanding only comes from hands-on construction.

Accessorize and modify

What's to keep you from modifying or adding any accessories to a telescope that you know inside and out? Nothing! Digital setting circles, drive systems, dew removal systems and finders are easy to install and adjust.

Repair and maintain

The owner is completely familiar with the TeleKit and knows what components may need periodic maintenance and adjustment, understanding exactly how to do it and what tools are needed, without instructions! Should any mishaps mar or damage the TeleKit, a thorough understanding of the construction and finish make repairs a snap.

Being an ATM (Amateur telescope maker)

You'll be able to discuss topics with other ATM's from a position of experience. You are now in the company of other ATM's such as: Galileo, Alvan Clark, Isaac Newton, William Herschel, Russell W. Porter, Robert E. Cox, Bernhard Schmidt, Earl of Rosse, John Dobson, Clyde Tombaugh and Leon Foucault.

Bragging rights

Let others know that you are proud of what you can accomplish.

Overview

Glossary

Throughout this manual, terms that may not be familiar to the first time telescope builder will be used. This section will introduce you to some of these terms and explain the location and function of the truss telescope parts.

Aperture The size (diameter) of the light collecting component, in the case of the Newtonian reflector, the primary mirror.

Altitude This term characterizes one direction of movement made by the two axis mount described in this guide. Altitude is the up-down movement, measured in degrees, with the horizontal being 0° and straight up (zenith) being 90°.

Alt-Az Mount Short for altitude/azimuth mount. Azimuth is the right-left movement, also measured in degrees, made by the mounting described in this guide. Celestial north is 360° and counting clockwise, east is 90°, south is 180° and west is 270°.

Balance Point The point along the centerline of a telescope at which the weight to the front just balances the weight to the rear. Since the primary mirror and other components toward the rear are the bulk of a telescope's weight, the balance point is much nearer the rear. This is the point around which the telescope moves in altitude. The altitude bearings are placed with their center corresponding to the balance point. The telescope is balanced here and will have no tendency to move once positioned.

Center of Gravity Point at which any solid is balanced along all three axes.

Collimation The process of aligning the telescope's optics to form their optimum image.

Dobson's hole Any portion of the sky near the zenith. The movement of the truss tube telescope alt-az mount used in this guide is the most difficult to move in azimuth in this area of the sky. This is due to the observer having less leverage in azimuth as the telescope is raised in altitude.

Focal Length The distance from the surface of an optic at which it forms an image (the focal plane). The focal length of the Newtonian primary mirror is one half its radius of curvature.

F/Ratio The ratio of the focal length to aperture (primary mirror diameter).

Illumination This refers to the size of an image at the focal plane illuminated by the primary mirror. The size of the secondary mirror usually determines the maximum size of the 100% illuminated image, but the size of the upper cage opening and focuser drawtube can also have an effect.

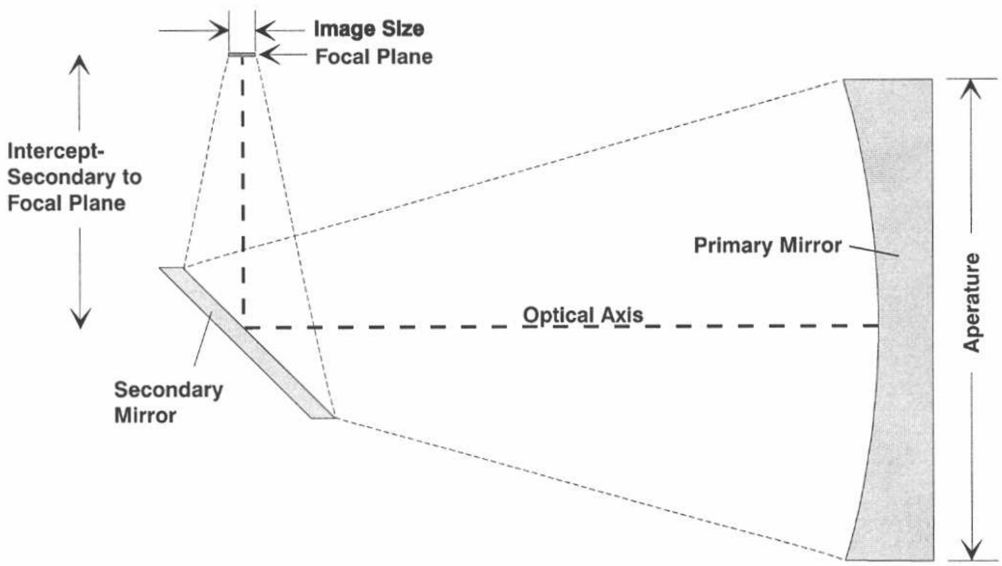
Intercept Distance The distance from the center of the secondary mirror to the focal plane, as measured along the optical axis.

Light Baffle Any opaque material used to line the upper cage assembly to exclude stray light.

Newtonian Refers to the optical design used in this manual, first proposed by Sir Isaac Newton in 1678.

Obstruction The ratio of the diameter of the secondary mirror to the diameter of the primary mirror. This is used as a guide in comparing various Newtonian telescopes. Less than 15% is considered very good, less that 20% being acceptable and over 20% having excessive diffraction and lowered resolution. A short f/ratio (<4) telescope will require a large secondary as a result of the optical geometry.

Optical Axis An imaginary line that coincides with the center of the parabolic curve in the primary mirror. It extends back to the secondary mirror, turns 90° and aligns with the center of the focuser drawtube.



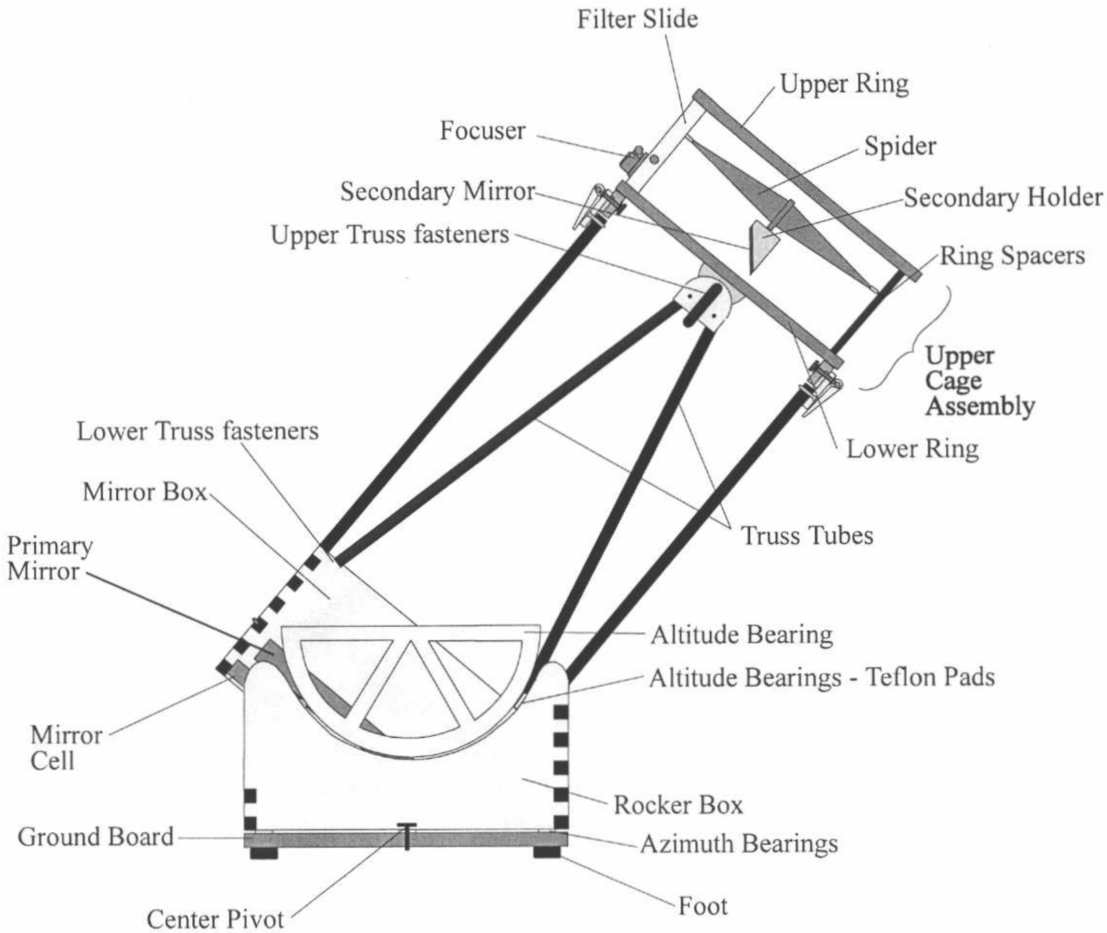
Primary Mirror The concave parabolic mirror that reflects the light in a Newtonian telescope back to the focal plane to form an image.

Secondary Mirror The smaller elliptical flat mirror that redirects the light out the side of the telescope, through the focuser to the eyepiece.

Torque A force that produces twisting in a stationary object and rotation in a moveable object.

Zenith The point in the sky directly overhead. This is at an altitude of 90° relative to the observer.

Part Terminology



Altitude Bearings These plywood semi-circles support the telescope on its base and by virtue of their circular shape allow the telescope to rotate, moving it in altitude.

Altitude Bearing Pads Teflon bearings mounted to the rocker box on which the altitude bearings rest. They are positioned against the laminate on the altitude bearings and give the telescope smooth and effortless movement in altitude.

Azimuth Bearings Two roller bearing positions and one Teflon position on which the telescope rests. They have very low friction, giving the telescope smooth and easy movement in azimuth.

Center Pivot The bolt that holds the rocker box to the ground board. The center pivot is fastened to the ground board, providing a pivot for the rocker box to rotate.

Focuser The device that accurately holds the eyepiece centered on the optical axis and allows movement of the eyepiece along the optical axis to achieve focus for any given eyepiece/observer combination.

Foot These support the telescope on three evenly spaced points for optimum stability. Feet suppress any possible flexure while the telescope is being moved and are thick enough to allow the telescope mount to clear most rough ground.

Ground Board The ground board acts as the interface between the telescope and the ground. It holds the feet and the azimuth bearing pads, remaining stationary as the telescope turns in azimuth.

Light Shroud Any opaque material that covers the open framework of the truss tube to exclude stray light and the heat of the observer's body, improving images.

Lower Ring The lower ring of plywood along with the upper ring and ring spacers form the structural framework of the upper cage assembly.

Lower Truss Fasteners These fasten the lower end of the truss tubes to the mirror box.

Mirror Cell This supports the primary mirror evenly to keep the mirror's figure from being distorted. It also allows the mirror to be accurately tilted for alignment.

Mirror Box The plywood box that holds the primary mirror and its cell. The altitude bearings and lower clamp blocks are also mounted on the mirror box.

QuickSwitch Filter Slide This holds the focuser to the upper cage assembly as well as holding up to 4 filters that can be quickly positioned under the focuser.

Ring Spacers These hold the rings of the upper tube assembly together and provide the attachment points for the secondary mirror/spider assembly.

Rocker Box The rocker box is the movable portion of the telescope mount. It rotates on the ground board to move the telescope in azimuth. Its side walls have a semi-circular cutout, where the altitude bearing pads are mounted. The telescope's altitude bearings rest in these cutouts and allow the telescope to rock, or move, up and down in azimuth, hence the name.

Secondary Holder This holds the secondary mirror in place and allows precise adjustments to align this mirror.

Spider The four-vane support that holds the secondary holder and mirror in the center of the telescope tube. It is designed to cast the smallest possible shadow on the primary mirror.

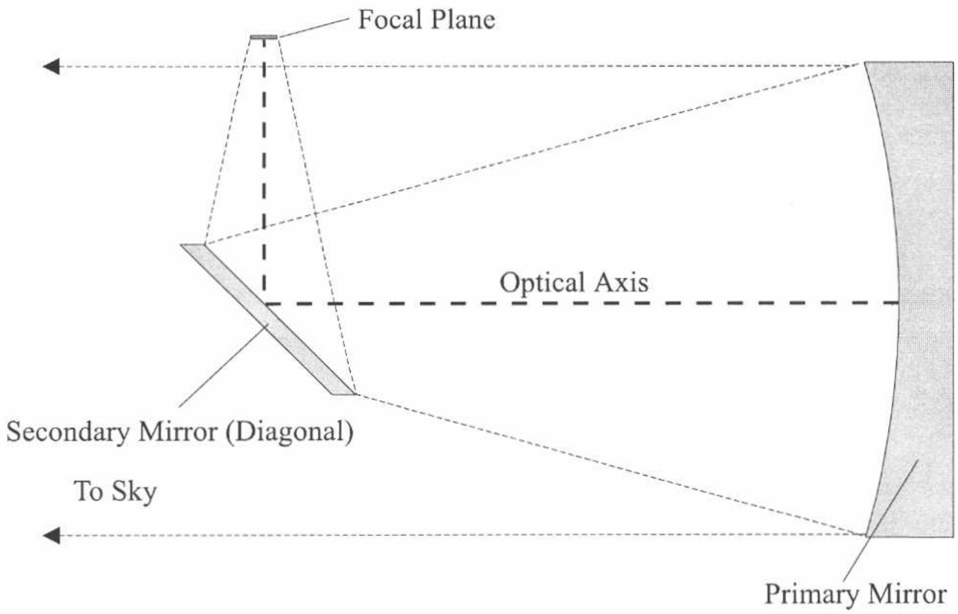
Truss Tubes These form a rigid framework that connect the upper cage assembly and mirror box.

Upper Ring The uppermost plywood ring that along with the lower ring and ring spacers form the structural framework of the upper cage assembly.

Upper Truss Fasteners These hold the upper end of the truss tubes to the upper cage assembly.

Optics

The TeleKit is based on the Newtonian optical configuration developed by Sir Isaac Newton in 1678. This optical design utilizes a concave parabolic primary mirror and an elliptical flat secondary mirror, see below. An eyepiece is then placed at the focal plane to magnify the image. The Newtonian's simplicity, image quality, low cost, ease of construction and use has made it the logical optical design for large aperture amateur telescopes.



Basic Newtonian Optical Configuration

The Primary Mirror

The primary mirror is the heart of the telescope. Its diameter, optical figure and reflective coatings will determine the quality of the final image. Although the imaging capability of the primary mirror is highly dependent on cost, there are exceptions. As a rule, get the best you can afford and have it tested and certified. This is money well spent to ensure that your time and energy will be invested in building a telescope that will provide quality images. Effects of "seeing" (the combination of atmospheric transparency and turbulence) greatly affect the imaging capability of the primary mirror, and cannot be overstated.

The choice of focal length of the primary mirror affects cost, availability, telescope length, balance point, ladder height, collimation and secondary mirror size. Short focal length primary mirrors are typically more expensive, less consistent in quality and are more difficult to collimate. They also require larger secondary mirrors and necessitate highly corrected, expensive eyepieces. The advantages of shorter focal lengths are shorter telescope tube lengths that allow small, stable ladders. Wider, brighter fields of view (given the same eyepieces) are also possible with shorter focus primary mirrors.

The pros and cons are just the opposite when comparing long focus primary mirrors to short focus primary mirrors. For these reasons, most truss tube telescopes are made with a f/ratio (the ratio of focal length to primary mirror diameter) between 4 and 6. A f/ratio less than 4 is rarely used due to demanding optical characteristics, along with greater cost and fabrication difficulties. A f/ratio over 6 creates balance difficulties with the truss telescope, requiring either large amounts of counterweight or a higher (less stable) balance point. Tall, awkward ladders are also a problem with longer focus telescopes.

The Secondary Mirror

Since it is a part of a complete system, the same guidelines for quality also apply to the secondary mirror. Suggested sizes listed in the Tables in Appendix 1 are an acceptable compromise between minimizing secondary mirror weight, cost and size while maximizing the illumination of the field of view. A 100% illuminated image size (**I**) of 0.2-0.4 inches was chosen for the Tables in appendix 1. Commonly available secondary mirror sizes could require moving up to the next larger secondary size to avoid an unreasonably small illuminated image (**I**).

The choice of secondary mirror size is a source of great debate among amateurs. A rough guide is to use a secondary mirror that is less than 20% of the primary mirror's diameter. At about 20% secondary mirror obstruction and greater, a perceptible fall-off in image contrast occurs. The geometry of the Newtonian optical system results in smaller (relative) secondary mirror obstructions as the f/ratio or aperture increases.

Secondary Offset

While it is technically correct to offset the secondary of a Newtonian telescope, it does not make a perceptible difference in the visual image. Offset may also complicate collimation since the visual appearance of the properly collimated system won't look concentric. Having enough adjustability in the optical supports can also make it difficult to offset the secondary. For these reasons it is not recommended that secondary offset be introduced. The exceptions are telescopes used to image, (either photographically or electronically), or very low f-ratios, (under f/4).

Offset is accomplished by moving the secondary mirror away from the focuser and toward the primary a specified amount. This will even the illumination at the edges of the field and maximize the use of the secondary mirror. The secondary mirror intercepts the cone of focusing light at varying distances from the primary mirror. The part of the secondary closest to the primary intercepts a wider portion of the light cone than the part of the secondary further away; so offsetting the secondary will produce even field illumination (see figure Page 8).

Optical Coatings

The most frequently used optical coating on the primary and secondary mirrors are vacuum deposited thin metal films with a protective overcoat(s). Aluminum is the metal of choice since it readily evaporates in a vacuum to form smooth continuous coatings. Aluminum also has good adhesion to glass and is sufficiently stable to be used in most environments. The aluminum is deposited in a layer just thick enough to be opaque, usually 500-600 *atoms* deep. This insures that the optical coating will not change the shape of the all important mirror surface.

The reflectivity of aluminum in the visible portion of the spectrum is only exceeded by silver, which is not used in amateur telescopes due to its environmental instability. The reflectivity of an aluminum coating can be boosted by adding pairs of metal oxide films over its surface. Properly applied films can increase the reflectivity of aluminum by approximately 1% for each pair. These "enhanced coatings," as supplied to the amateur market, are usually formulated to provide 94-96% reflectivity. They are more environmentally stable due to the thicker overcoat layers, but this comes with a premium price tag. Enhanced aluminum films are difficult to apply on mirrors over 16 inches in size due to inconsistencies in film thickness.

For this reason and cost considerations, enhanced aluminum is a good choice for the secondary mirror and primary mirrors 16" and under. A standard aluminum coating on the primary of 90% reflectivity and enhanced coatings on the secondary will give an overall system reflectivity of about 85%. Both surfaces enhanced coated will give 92% overall reflectivity, a real advantage on smaller aperture telescopes.

The Eyepiece

Eyepieces provide a focused image for the eye that the brain then interprets. As such, eyepieces are the most important telescope accessory, providing the critical link between the telescope and the eye. The choice of an eyepiece is a very personal one, depending on such things as desired field of view, object under observation, the telescope, location, sky conditions and observer experience. With so many variables it is not possible to choose eyepieces based on the telescope alone, but there are some considerations worth noting. Most eyepiece designs will perform satisfactorily within a certain range of f/ratios. The highly corrected, wide-field type give outstanding performance with f/ratios over 6. They are preferred for f/ratios between 5 and 6, and are necessary for quality views with f/ratios under 5. This includes such eyepiece designs as the Nagler and similar designs. Medium corrected eyepieces such as the Panoptic, Erfle and similar designs give excellent views with f/ratios over 5. Below f/5 the have noticeable loss of sharpness at the edge. The least corrected eyepieces such as the Plossl, Kellner, Ramsden and similar designs have narrower fields of view and noticeably less sharpness over a large part of the field when used with telescopes under f/6. Two-inch eyepieces are preferred for wide, low-power fields of view, minimizing vignetting, or edge of field light loss. Two-inch eyepieces usually have a larger eye lens and long eye relief, a great advantage to viewer comfort.

Eyepieces come in all shapes and sizes

Magnification

This is found by dividing the telescope's focal length by the eyepiece's focal length (using the same units). For example, a telescope with a focal length of 1829mm (72 inches), when used with a 26mm eyepiece would yield a magnification of 70. The highest magnification possible is most often limited by atmospheric turbulence or tube currents from a primary mirror that is still attaining equilibrium with the air temperature. When experiencing a lack of atmospheric transparency, it is helpful to use higher magnification. This darkens the sky background at a faster rate than the brighter foreground object dims, resulting in increased contrast.

Field of View

The eyepiece design and the focal length of the primary mirror determine the field of view or the portion of the sky that the telescope is actually viewing. It is easy to calculate the actual field of view using Formula 5 on Page 12. Simply divide the eyepieces apparent field of view by the magnification. Most observers agree that eyepieces with wider fields offer more pleasing views, our eyes and brain being accustomed to wide-field views.

Eye Relief

This is the distance from the eye lens you need to place your eye to see the entire field of view. Short eye relief will require the observer to place their eye very close to the eyepiece. This is less comfortable and will contaminate the eye lens with skin oils. Short eye relief also makes removal of eyeglasses necessary. There is a general trend of shorter focal length eyepieces having less eye relief.

Exit Pupil

This is the size of the image (of the objective) exiting the eyepiece. It can be seen by pointing the telescope at the sky or a white wall and moving back a foot or so from the eyepiece. The image will appear as a small circle of light, sometimes seeming to float just above the eye lens of the eyepiece. Formula 6 on Page 12 makes it easy to calculate. Low-power eyepieces will have a larger exit pupil. This should fit into the pupil size of one's dark-adapted eye to make the best use of the telescope's light gathering power and sets a practical minimum on magnification, (see Page 84).

Eyepiece Quality

Superior manufacturing techniques such as blackening the edges of the lenses to eliminate "ghosts" (internal reflections) and anti-reflection coatings that minimize light loss and increase contrast are desirable. Glass that has low absorption and better imaging capabilities will also contribute to a quality eyepiece.

Evaluation

When purchasing an eyepiece, closely inspect for blemishes, scratches or bubbles in the lens surface. Also, check for dirt, grease or foreign material on the internal lens surfaces. This is made easier by using a strong light or direct sunlight. Check the barrel fit in the focuser as well as the condition of the filter threads. Check for "ghosting" by viewing a bright planet like Jupiter or Venus. An eyepiece's transmission can be evaluated by viewing a faint galaxy or nebulae, but use a known eyepiece for comparison since this test is greatly influenced by sky conditions. Last, determine where in the field the image begins to degrade and to what degree. When these points are deemed acceptable and the eyepiece is comfortable to use and within your budget, buy it. Good eyepieces are an investment that will greatly enhance your observing pleasure.

Calculating the Dimensions of the Optical Components

With the help of the formulae table on Page 12, we can now calculate the necessary sizes and proportions of the optical components of a Newtonian telescope. You only need to know the diameter and focal length of the primary mirror to proceed. Formulae 1 through 3 are used to calculate the important physical dimensions of the system while Formulae 4 through 6 calculate parameters of the image viewed at the eyepiece.

Abbreviations used in the following formulae:

Af	Apparent field of eyepiece	**M**	Magnification
D	Diameter of primary mirror	**N**	Secondary minor axis
F	Focal length of primary	**Rf**	Real field of view (degrees)
Fe	Focal length of eyepiece	**S**	Secondary to primary separation
I	Image size (100% illuminated)	**s'**	Secondary mirror offset
L	Secondary to focal plane (intercept)	**Xp**	Exit pupil

Telescope Component Calculations

Formula 1.	**Secondary Size**	$N = \frac{L(D - I)}{F} + I$
Formula 2.	**100% Illuminated Image Size**	$I = \frac{NF - LD}{F - L}$
Formula 3.	**Secondary Offset**	$s' = \frac{N(D - N)}{4(F - L)}$

Telescope Performance Calculations

Formula 4.	**Magnification**	$M = F / Fe$
Formula 5.	**Real Field**	$Rf = Af / M$
Formula 6.	**Exit Pupil**	$Xp = D / M$

The Tables in Appendix 1 are based on the intercept distance (or secondary mirror to focal plane distance) is equal to the radius of the primary mirror plus 3.6 inches. This is the height of the QuickSwitch filter slide plus the Phase 4 focuser plus in-travel. This "in-travel" allows focusing for different observers eyesight, variations in eyepiece design, and the use of a Barlow Lens. A value of 0.25" was chosen to satisfy most eyepiece/vision combinations. This makes a total of 3.6", which added to the radius of the primary mirror results in "**L**," the intercept distance.

Example: A 16" primary mirror with a 72" focal length and a 25mm Konig eyepiece (70 degree apparent field of view). A 0.56" **I** (100% illuminated image size) was used. This value can be smaller (0.1-0.2") for a telescope optimized for planetary observing and larger (0.3-0.6") for a telescope optimized for deep-sky observing.

Secondary size:	$\mathbf{N} = \frac{11.6\,(16-0.56)}{72} + 0.56$	**N** = 3.05" (this is the clear aperture of the commonly available 3.1" secondary)
Magnification:	$\mathbf{M} = \frac{1829}{25}$ (72 inch FL)	**M** = 73X
Real Field:	$\mathbf{RF} = \frac{70}{73}$	**RF** = 0.96 degrees
Exit Pupil:	$\mathbf{Xp} = \frac{16}{73}$	**Xp** = 0.21" or 5.5mm

Design

In most ways, the TeleKit is like any other telescope. The design choices that have been given priority force compromises in other areas. The two primary design goals of the TeleKit are **performance** and **appearance.** The following are some of the reasons *why* the TeleKit looks the way it does and is built the way it is. Some of the compromises forced by these design goals are also discussed.

The Four Performance Goals of the TeleKit

Motion

A crisp, easy movement with no backlash, even at high power is necessary in a high performance telescope. It is also desirable to have equal resistance in both altitude and azimuth to achieve the most precise movement. To achieve this the telescope must have:

Stiffness: Large diameter trusses tubes, double-thick rocker box sides and secure truss fasteners.

Low center of gravity: A lightweight upper cage and truss poles.

Low "stiction": Large altitude bearings with a textured laminate bearing surface riding on Teflon pads in addition to roller bearing/Teflon azimuth movement.

Optical Performance

Precision optics are of no use unless supported and adjusted properly. Stability of the support system under varying thermal and directional movement is necessary. Ease of adjustment is the surest way to maintain collimation.

Ease of adjustment: There are no tools required for the primary mirror cell. The intuitive two axis secondary adjustment is fast and accurate. The Phase 4 focuser has a built-in 3 to 1 reduction.

Adjustment stability: Stiff, large diameter trusses keep the upper cage sag below 1/8 wave. A stainless steel sling eliminates sag and loss of primary mirror collimation.

Optical support: A 9 point primary cell flotation is used for optimum mirror support.

Contrast: The focuser is mounted low in the upper cage, giving optimal contrast and dew protection. A light shroud is included to eliminate stray light and body heat from the optical path.

Vibration: The truss tube covers and solid wood construction combine to dampen vibrations in 1-3 seconds even at high power.

Observer Convenience

Filter Slide: Fingertip selection of up to four filters plus protected filter storage.

Eyepiece position: The eyepiece is tilted up from the horizontal 14 degrees on 10 "-15". This makes low altitude observing much more convenient, especially noticeable on smaller telescopes.

Focuser: The incorporated 3 to 1 focus reduction or 8:1 with the optional Moonlite or 10:1 with the optional Feathertouch gives a torque advantage that allows fingertip movement without jiggling the image. This reduction also allows precise movement of the eyepiece.

No-tool set-up: With the possible exception of a hex key (supplied) to adjust the secondary holder on 2.6" or smaller secondary holders, no other tools are required.

Transportability: Safely load, unload and move your telescope with ease.

Compact storage

Storing the upper cage in the mirror box is a space saving feature and protects the upper cage. The trusses are also held in pairs, simplifying set-up.
Tailgate mirror cell: Easily access your primary mirror for cleaning or removal.

Superior construction

Stainless steel hardware: Eliminate corrosion, loss of strength and maintenance.
Finger jointed boxes: Strong and accurate.
Baltic Birch plywood: Superior strength, stiffness and stability.

Appearance goals

The TeleKit was designed with the goal of achieving a uniform exterior appearance. It was realized that a truss telescope could be made that was not only functional but also aesthetically pleasing. It was apparent from field evaluation for the first few years of truss telescope design that aesthetics was very important among amateur astronomers.

Eliminate exterior hardware

A finger jointed mirror box and rocker box and internal doweling of the upper cage removes almost all the usual external hardware, giving uninterrupted views of the wood veneer. The TeleKit is not an advertisement for a hardware store. A clean exterior also makes the telescope safer and easier to move.

Improve eye appeal

Finger Joints are strong and accurate and are the choice of professional woodworkers.
Baltic Birch plywood has a pleasing uniform grain and the light veneer can be stained virtually any color.

Compromises

Weight and size

To achieve compact storage by placing the cage in the mirror box, the mirror box needed to be larger. This increases the weight, although pocketing the inside of the rocker box minimizes this increase. The use of Baltic Birch plywood also increases the weight since it is about 15% higher density than the closest comparable material. The use of 1/2" (actually 12mm or 0.48") Baltic Birch on the 16" TeleKit, which helps minimize weight, giving a total telescope weight of 102 pounds (46.4 kg.).

Construction Notes

!! Very Important !!

Understand each step and have the necessary tools and components ready, as well as enough time to do a thorough job. Dry fit the parts so you are familiar with each step and if you encounter any difficulties or do not understand the construction procedure, contact Astrosystems before proceeding.

Tools

Following is a list of tools that are necessary as well as some that are convenient. The TeleKit can be assembled with hand tools, but power tools will speed the construction and usually give results that are more consistent. This list is also in Appendix 5, Page 98.

Necessary

Bar clamps (8)
Drill plus Drill bit set 1/16"-1/4", 1/2"
Countersink or combo #8/countersink bit
Wrenches - 9/16", 3/4", 15/16"
Ruler - 12"+ / Tape measure - 10'+
Hammer or mallet
Drafting triangle or square
Utility knife / Scissors
Spatula / Pliers
Coarse wood file
Sanding block, sanding sponges
Screwdrivers - Phillips and flat

Optional

Router
Router Bits - flush trim - 1", radius 1/8"-3/16", 1/4"
Random orbital sander
Spray gun and compressor

Supplies

Paper towels
Contact cement (laminate type)
Drop cloth - polyethylene or non-porous material
Sandpaper (60-80, 120-150 and 220-320 grit)
Lighter or matches
Epoxy kit (supplied with the TeleKit)
Old clothes / apron
Masking tape / Black vinyl tape
Dust mask / Earplugs
Pencil, permanent marker
Locktite or Super glue (cyanoacrylate)
Polyethylene plastic / Sacrificial wood

Finishing Supplies

Polyurethane topcoat
Stain (if used)
Flat black paint
Brushes - finish (1) and disposable (2)
Cleaning solvent for finish and Acetone
Wood putty (birch color)

Work Area

The work area should be roomy enough to move parts around. Lighting is the most important single factor since this directly affects the construction and finishing results. Low tables with a cushioned surface, such as old carpet or carpet runner is an excellent work surface. This cushions the wood parts so any stray particles that get under your work will not scratch or dent the veneer. Be sure the ventilation is compatible with dust from sanding or routing and solvents from finishing. If parts are moved outdoors or into a garage to finish, be wary of wind, bugs and debris.

Adhesives
Many types of adhesives have been evaluated and it is found that a slow-cure epoxy works best. There are alternatives but they all have disadvantages.
Fast Cure Epoxies are expensive, can be brittle, have short working time and do not penetrate the wood for optimal adhesion.
Urethane Glue is very expensive, has a short working time and can be temperamental when used at low humidity and foam at high humidity, giving a low density, weak joint.
Yellow and White Wood Glues have short working time, poor penetration and poor adhesion on aircraft plywood and require surface to surface contact for optimal strength.

After extensive tests and trials with prototypes, it was determined that a slow-cure epoxy adhesive works best for the TeleKit. Sandability and joint strength were our number one requirement. It was found that the ***AstroSystems*** epoxy leaves no surface stains or hold-out that would affect the finish. This was found to be true for clear-coating only; stain may not cover the epoxy in the surface grain of the wood. After 1-2 days of curing, the epoxy can be sanded easily. In a torture test, the joints of a 22" rocker box were destroyed by driving over it with a RV. No joints failed at the epoxy line. This test also put it under severe tension, forces the telescope will only experience in small amounts in normal use. The epoxy may be messy if not handled carefully. Acetone will work to clean-up epoxy off of wood and anything else when it is still tacky, but be aware of its adverse affects on plastics and painted surfaces as well as flammability and odor. The supplied Nitrile or vinyl gloves will protect your skin, and make clean up a lot easier (acetone will dissolve the gloves, use them accordingly).

The cure time of epoxy is very temperature dependent. At room temperature (70 degrees), the full cure time is 7-10 days and cure to sand is 1-2 days. The epoxy gives about 1 - 1.5 hours of working time before it thickens beyond usability. It is recommend the telescope components be kept clamped for 24-48 hours, or longer if it is cold. Try to leave fillets in the corners (fillets are small radii that join the two opposing sides). Fillets are easiest to accomplish by slowly running your finger down the corners, spreading the excess epoxy into the inside corners. It is also suggest wearing old clothes and using a 2-3 mil or heavier polyethylene drop cloth on which to work. The epoxy cures especially slow when thin and on the worktable or plastic will stay tacky for many hours.

Preparing the Wood
The wood is prepared by first filling any small surface defects. If needed, remove veneer from the supplied scrap for repairs. Any voids in the edge can be filled with wood putty. It may take the addition of a small amount of red and black stain or colorant to the usual yellow wood putty to get a match that will finish the same as the wood. This is available as red and black acrylic artists paint. Experiment with some of the scrap wood supplied and topcoat to insure that the putty is a good match. Extra sanding is necessary on edges where wood putty is applied. Thorough sanding will expose fresh veneer that will finish more consistently. Always sand with the grain of the wood and start with the finest grade sandpaper that is necessary, usually 120-180 for veneer and 60-80 for the edges. Hand sanding requires finer grades of sandpaper on the veneer than power sanding. Pre-sanding parts before assembly can save time and improve sanding consistency, especially in tight corners. The upper cage is an excellent place to pre-sand. A note of caution, do not oversand the face veneer, it is thin and may show darker layers underneath.

Start with the edges of the components. They take the most sanding. Use caution while sanding the edge, if the sandpaper wraps around the edge it will cause sand marks against the grain on the surface veneer. These are very hard to remove and just add unnecessary work. Sandpaper may vary widely in the size range of the grit as well as the durability of the adhesive. Spend a little extra to buy premium sandpaper and change to a new piece when the cutting action of the paper slows. The following table is a guide in selecting sandpaper; numbers refer to grit size. Grit size is the number of wires per inch of a screen used to filter the abrasive.

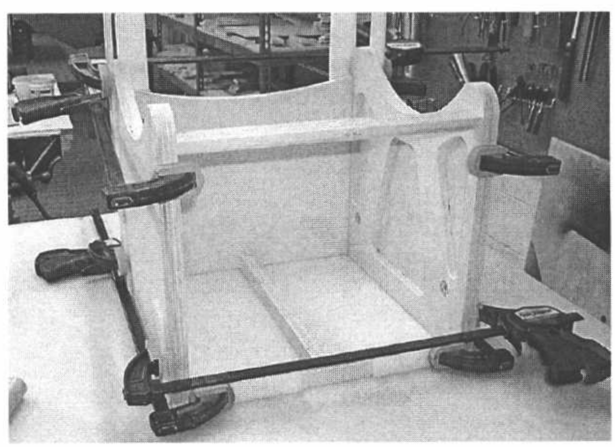
	Hand sanding	**Power sanding**
Coarse	100-120	60 - 80
Medium	150-180	100-120
Fine	220-250	150-180
Extra Fine	300-320	220-250

Most of the TeleKit parts are pre-sanded to at least a medium finish. Aluminum Oxide paper is recommended because it lasts longer, and gives results that are more consistent. Be careful not to round over the edges of the upper cage rings, spacers and fasteners. All flat edges need to remain flat in order to provide tight, clean joints when epoxied. Clean sanded parts with a dry rag, vacuum or air duster. DO NOT USE WATER.

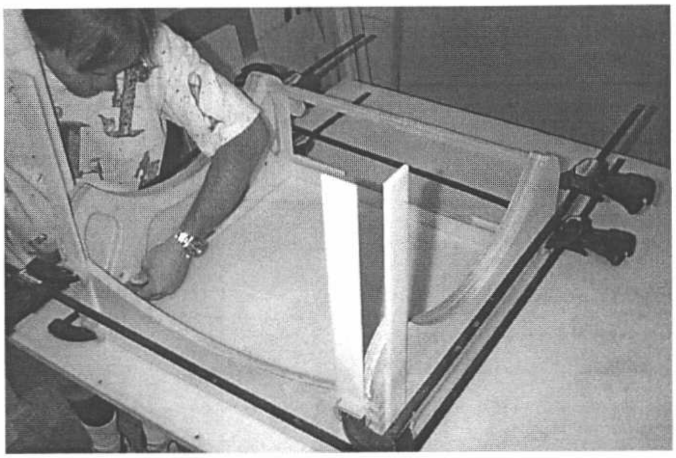
If you are sanding and you chip or mar the wood veneer, use a piece of veneer that you remove from some of the supplied scrap Baltic Birch plywood and proceed with these steps:

1. Cut a piece of veneer that is close to the shape of the damaged part.
2. Glue it in place with wood glue or fast cure epoxy. Wipe excess glue away.
3. Let it dry thoroughly.
4. Sand until the new veneer is shaped properly.

A Note on Achieving Square



This can be a challenging part of the kit's assembly, but typically the mirror box and rocker box will self-align during assembly due to the large surface area of the finger joints. You may only really need assistance for the Mirror Box, but it sure is nice to have a friend there when the clamping starts. It takes 8 clamps to fully clamp the mirror box, 7 clamps for the Rocker box. Even with machined tolerances, every kit has its own characteristics. Achieving square may require cutting wood spacers for inside the box to keep the sides from bowing in when clamped. Wood warps and has variations from piece to piece, so it may take more clamps or a different clamping configuration to get the box square. It is suggested you get clamps from a local rental service or possibly borrow them from a friend or neighbor. It is necessary to use clamps that have cushioned surfaces or use wood or plastic between the clamps and telescope. This avoids marring the wood surface.



Check the mirror box for square at the bottom, middle and top of the box. It is most important to have a perfect square at the bottom of the box, where the mirror cell is installed. An inexpensive 90-degree plastic drafting triangle works well. The top will have clamp blocks inserted, which act as a reinforcing gusset and help square the top. Give yourself extra time when gluing. Then you can check and recheck square during the critical hardening time.

The rocker box will require a spacer at the front. This is due to the narrow (front) board allowing the sides to flex inward due to clamp pressure. The supplied spacer quickly remedies this. Assemble the rocker box first so you can cut down your glue spacer and re-use it for the mirror box later, although this is rarely necessary.

When checking for square, keep these things in mind: if you have wood that bows inward toward the inside of the box, use spacers to push the sides out (when clamped) to square. You may need to tap them in with a hammer. Be sure to push the sides out evenly. If you have sides that bow outward, use a clamp to pull them in straight. When using this method, it is usually not necessary to put corner-to-corner clamps on to achieve square. Should some out-of-square appear, try releasing the clamps and re-tightening. The tightening sequence and amount when the box is first assembled is usually the problem. You can readjust clamps and move the side for 1-2 hours after mixing the glue. Recheck after 2-3 hours, as this will be the last opportunity before the epoxy sets. While rare, clamps can loosen or slip.

Finishing Notes

Astrosystems recommends that the TeleKit be finished with at least 2-3 coats of a clear semi-gloss polyurethane floor finish or spar urethane. Outdoor or boat finishes, often called spar varnish, are made for continuous exterior exposure to weather and is NOT suitable for a telescope finish. They typically dry much slower, dry softer and have a very unappealing green tint when aged for a few weeks. This is very apparent on a light wood, such as Baltic Birch. The spar polyurethane performs perfectly for a telescope, giving great moisture resistance while drying fast, hard and having an appealing honey gold color when aged. Our favorite is Minwax's spar urethane called Helmsman in the semi-gloss. While it flows and levels nicely, this can be a challenge in cold weather (<70 F) with runs and sags, especially on the cage and altitude bearings. This necessitates multiple thin coats.

Clear finish will simplify the finishing since no pretreatment is necessary as with staining. Gloss finishes tend to accentuate any blemishes or scratches and will dry more slowly. Satin (nearly flat) finishes tend to minimize the veneer color and grain pattern. Birch veneer already has a subtle grain pattern. A clear semi-gloss will minimize fingerprints, sanding and finishing inconsistencies. Probably the greatest advantage of only using a clear finish is that it can be easily repaired and refinished. It will give the wood an appealing "honey" color that looks great with the black accents of the shroud and components. The lighter color is also easier to see in the dark.

Our recommendation is to apply a first coat of polyurethane that has been reduced 50/50 with a compatible solvent (mineral spirits if solvent based). This gives excellent penetration and the best protection. Two or more coats of full body finish follow this. After thoroughly drying, a light sanding will remove any runs, sags or bumps. The last coating can then be applied. If the finish you are using is available in aerosol form, use two light coats sanding with fine (220-320) between coats. This allows you to achieve a very smooth and uniform final coat.

It is difficult to recommend specific finishing materials and techniques. The cost, availability and consistency of finishes vary greatly. An individuals experience and skills also play a role. The safest approach is to talk to knowledgeable vendors and then practice on scrap wood. Hardware stores and building centers carry a variety of clear wood coatings. Our suggestion is to look for "interior" grade solvent based polyurethane floor coatings or spar urethane. Our tests with the water borne materials have not been very successful, although some areas of the country only carry these. The water borne coatings dry water white, leaving the Baltic Birch "pasty" looking. They also tend to stay water sensitive for years.

Staining

For TeleKits that will be stained, it is easier and results that are more consistent can be obtained when staining the parts individually before assembly. Be sure to minimize stain on surfaces that will be epoxied later and allow 3-4 days to fully dry. Light wood, such as Birch, is notorious for inconsistent staining. TeleKit owners have reported that a stain pretreatment is necessary for such a light colored wood. Try locating books at you local woodworking store or library on the various staining techniques commonly available. Scrap pieces of plywood are supplied to practice technique and evaluate color.

Blackening

Some parts are painted flat black to eliminate scattered light and increase contrast. Included is the inside of the mirror box, the bottom of the rocker box, the top of the lower truss clamps, upper cage baffle. To make sure all necessary parts are blackened, simply take the eyepiece out of the focuser and look into the telescope. Anything seen from this perspective should be painted flat black for the best image contrast. Coat the wood surfaces first with clear to seal and protect them, then use a thin coat of flat black. This also makes finishing the exterior of all parts easier.

When the clear finish has dried, tape off the areas to blacken and coat with a very thin layer of black paint. Two methods can be used to achieve adequate adhesion when re-coating. The surface can be lightly scuff sanded with sandpaper or the blackening can be applied before the first coats are fully dry (less than one week). If the second method is used, be aware of the phenomenon of critical recoat which causes wrinkling. When a different coating is applied over the top of any air-dried coating, the solvents may wrinkle previous coats. First test a small inconspicuous area and use very thin "dust" coats. Our favorite anti-reflection coating is Rust-Oleum painters touch 2X flat black aerosol

Upper Cage - Part 1

Parts

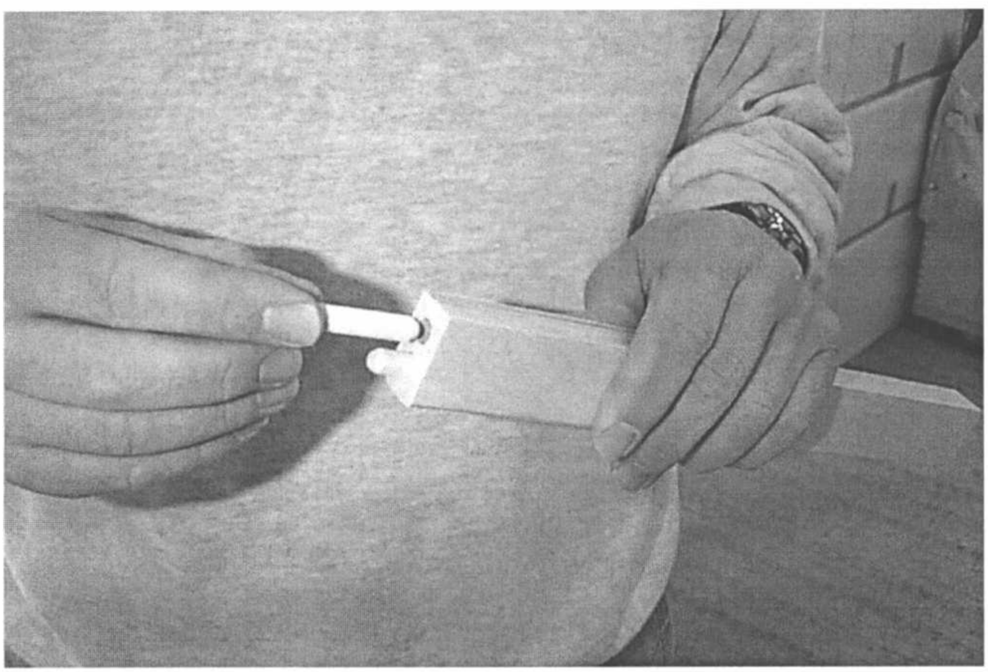
2	Upper cage rings
4	Ring Spacers
4	Upper truss mount blocks
24	Glue dowels - 5/16" x 1.3"

Tools / Supplies

4	Clamps
	Epoxy kit (for the whole TeleKit)
	Paper towels
	Acetone

Assembling the Cage Rings and Ring Spacers

After all parts have been prepared, dry fit the components to check fit to familiarize you with the assembly. Use caution when dry-fitting parts; once a dowel has been inserted, it may be difficult to get back out. You may want to use only one on most parts to check fit. Make any adjustments at this time. Check that the part of the dowel protruding is 0.3" or less so it will not bottom out in the hole of the cage ring. Shorten the dowel if necessary with a knife or saw. To start assembly, take a 5/16" glue dowel and cover the lower 3/4" with epoxy and apply epoxy into the ring spacer holes and end surface. Finding the right amount of epoxy takes a little experience. You want the parts to be fully wetted and the epoxy to form a fillet between parts, but you want to avoid the mess of having to remove too much. Whenever possible, avoid getting epoxy on surfaces that will be finished. It helps to have a roll of paper towels and a little acetone nearby.



Next, insert the dowel into the end of the ring spacer until it bottoms out. Do this for all the holes on all the spacers, a total of 16 holes and 4 spacers. Wipe excess epoxy away with cotton swabs (Q-tips) or paper towels.

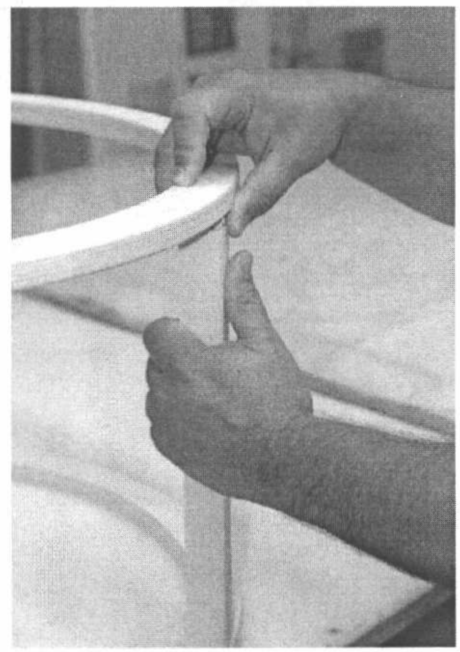
Do not apply excessive amounts of epoxy in the hole. When too much epoxy is put in the hole, it can create hydraulic pressure when the dowel is inserted that can split the plies or squirt out along the plies. It can also force the epoxy out through the veneer layers. If the dowels don't seem to seat all the way in, that's okay, but do not use force to insert them. Just shorten the dowels if more than 0.3" protrudes.

Inserting the Ring Spacers into the Bottom Ring

Once all the spacers have the dowels inserted, install them in the rings. Lay the bottom ring in front of you (the bottom ring has holes on both sides). Apply epoxy with a brush to the 0.3" of dowel that sticks out on the end of the spacers as well as the end of the spacers, which are marked with a red dot. Insert the spacer into the two spacer holes on the lower ring, also marked with a red dot.

IMPORTANT: The spacers must go into the lower rings with the red dot matching the dot on the bottom ring. This is to orient the spider mount holes correctly. The rounded edges of the spacers face outward or away from the middle of the rings. Wipe away excess epoxy immediately with a paper towel and a little acetone, if necessary. Repeat for the remaining three spacers. The following table shows the distance from the bottom ring up to the spider mount hole.

TK Size	Secondary Size	Spider mount hole from from lower ring (in.)
16 - 18	2.6	6.7
16 - 18	3.1	7.6
16 - 18	3.5	7.9
16 - 18	4.0	8.1

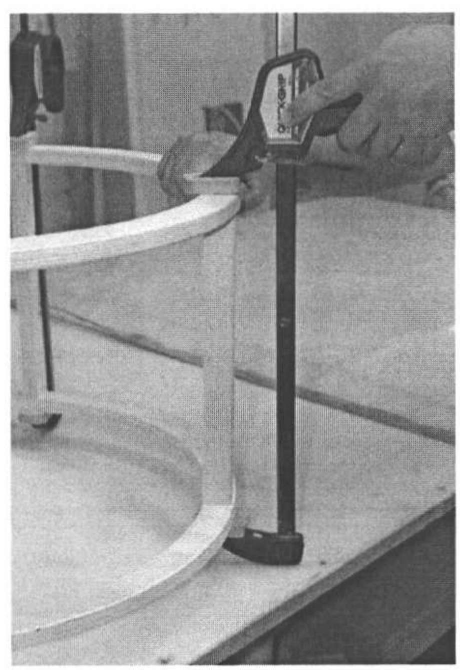


Inserting the Spacers into the Upper Ring

Add epoxy with the brush to the ends of the spacers that are now facing up. Apply epoxy to all 8 dowels and the ends of the wood spacers. Then, carefully place the upper ring on the dowels with the corresponding holes aligned. A gentle tap with the palm of your hand will be enough to get it started.

When all dowels are lined up and partially inserted, use the bar clamps force to pull the rings and spacers together.

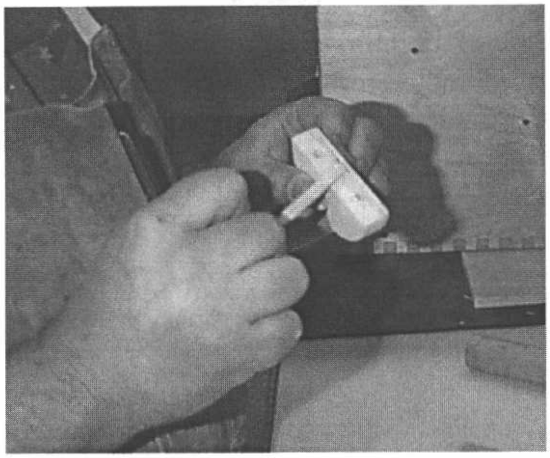
DO NOT USE A HAMMER. Clamp all four joints with bar clamps and allow them to cure for 24 hours. Use pieces of the sacrificial plastic, which are supplied in the kit, to protect the wood veneer if you are using pipe clamps with metal faces.



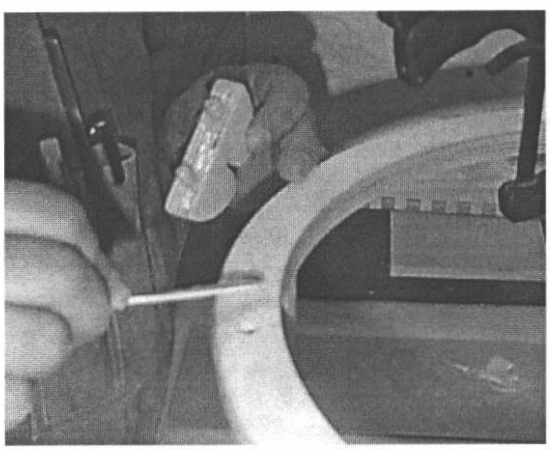
Check the spacers with a drafting triangle to make sure it is square with the ring. Sometimes bar clamps can skew to the right or left. If it is not square, remove the clamps and try again. The weight of the clamps or their orientation will sometimes torque the part enough to push it out of square. You may have to experiment with the orientation of the clamped part or the clamps themselves to square the cage.

Installing the Upper Truss Blocks

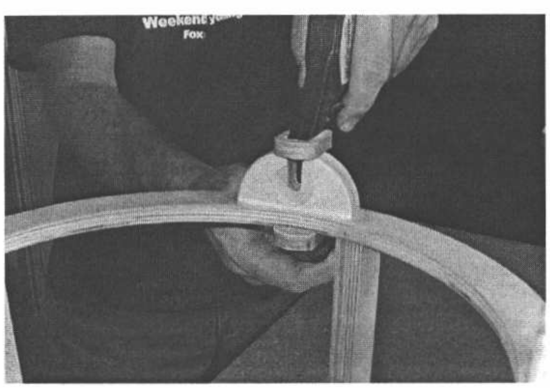
After letting the upper cage epoxy cure for 24 hours or more, you are now ready to install the upper truss blocks. Dry fit the parts to check for proper glue dowel length and shorten if necessary. The round 1" cut-out on the block face is oriented toward the inside of the cage (see bottom photo). Apply epoxy to the lower 3/4" of a dowel. Insert into the bottom of the block. Do this for both holes on all 4 Blocks.



Next, place the upper cage with the top ring down, exposing the holes for the blocks, which will now be facing up. Take one of the blocks and apply epoxy to the 0.3" of dowel that is protruding as well as the bottom surface of the block. Gently insert the dowels into the holes on the bottom ring. DO NOT FORCE OR HAMMER. Use bar clamps or Quick-Grip clamps and squeeze the blocks until they seat against the lower ring. Repeat for the remaining 3 blocks. Place a clamp on all 4 of the blocks, making sure to wipe away any excess epoxy. Let them cure at least 24 hours before removing clamps.



Finish sand the edges smooth and fill any voids or defects with wood putty. Try to find wood putty that matches the birch color for repairs. Give the surface a hand sanding with 220 or finer grit paper, always sanding the face veneer with the grain. Smooth the inside edges of the rings, leaving the rabbit (ridge on inside) intact, this allows the light baffle to flush up against the inside, giving a smooth edge when grasping the front edge to move the scope, see lower photo at left. Blend the radius on the outside of the rings for a continuous transition from one surface to another. Run your hand over all the surfaces, any rough spots will be noticed for further sanding.



It is recommended that a first coat of finish be thinned 50/50 with the appropriate solvent to fully penetrate the surface. Once this is fully dry, fine sand to remove any roughness and follow with 2-3 more coats of finish, because of the number of inside corners on the upper cage, it is suggested that aerosol be used for all the finish coats. A final fine hand sanding, with special attention to any sags or runs that may have developed, is followed by a light continuous coat of the same finish from an aerosol can. This will give a finish rivaling any professional finish.

Upper Cage - Part 2

Parts

1	Laminate light baffle
1	Spider and mounting hardware
1	Secondary holder
1	QuickSwitch filter slide
1	QuickSwitch mounting hardware
2	Light baffle mounts for QuickSwitch
1	Phase 4 focuser or optional Moonlite,Feathertouch

Tools / Supplies

Sandpaper
Drill and 9/64" bit
Flat black paint
Ruler / square
Scissors / utility knife
Marker / pencil
Phillips head screwdriver

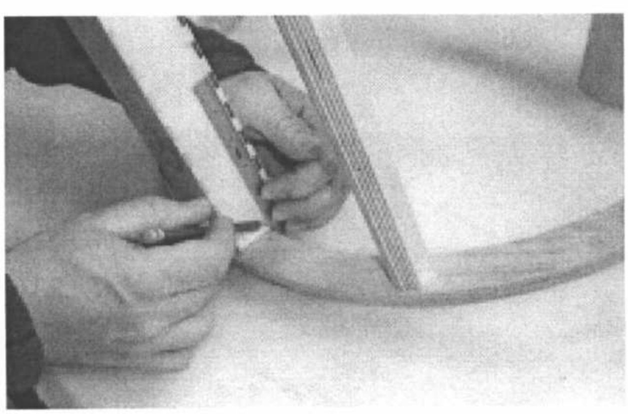
Hardware

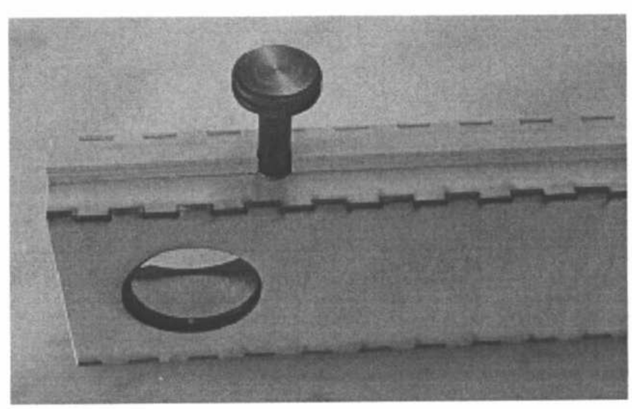
4	Spider screws #10-32 x 1.5" – 1.75"
4	QuickSwitch screws #10 x 1" FH ss
2	Rolls of double sided tape
4	Light baffle screws #4 x 3/8" PH ss
4	Spider washers #10 ss
4	QuickSwitch screw eyes #6 x 1"
2	Focuser screws #10 x 1.25" FH ss

Sanding and Finishing the QuickSwitch Filter Slide

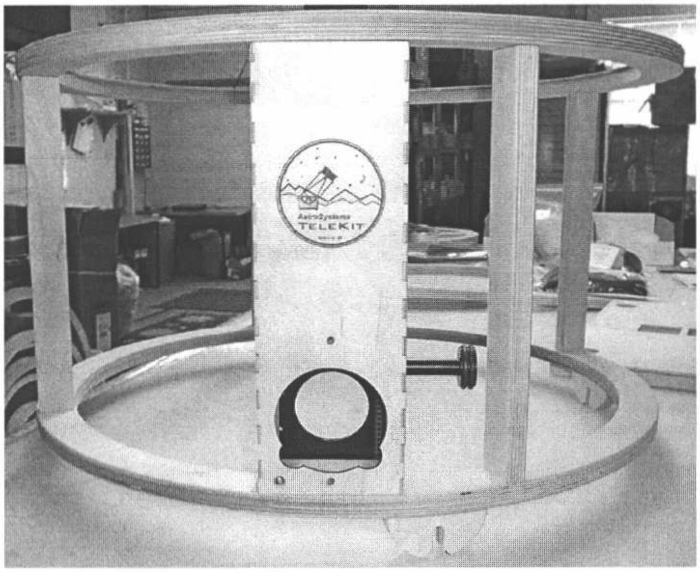
Finish sand the exterior of the filter slide and dry fit the slide into the upper cage to insure proper fit. You can now epoxy the light baffle stops along the sides of the QuickSwitch. Because of small variations, it is best to determine the position for the baffle stops with the slide in place. The rounded side of the baffle stop faces the front (logo side). Temporarily put the 4 mounting screw eyes in the ends of the slide, set it in the cage, and mark the actual position where the cage ring meets the side of the filter slide, left photo below. Mark the top and bottom of both sides and connect with a line. The back of the baffle stop will be flush with this line, the rounded front will be forward of the line toward the front of the filter slide.

The baffle stop on the knob side will need to be cut in two to clear the knob, right photo below. You can make the cut angled to more closely fit the knob. The light baffle stops hold the laminate squarely next to the filter slide and serve as a dividing line between the finished top and flat-black bottom. After the sanding is completed, it's time to coat the filter slide. Apply the same finish to the QuickSwitch, front and back as your telescope. Everything below the flat side of the baffle stop plus the backside is painted flat black. Mask off the front and filter hole, plus any other areas where paint may make its way in. Coat the bottom with flat-black paint.



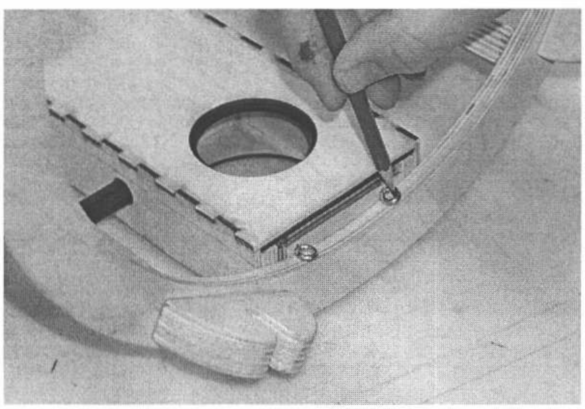


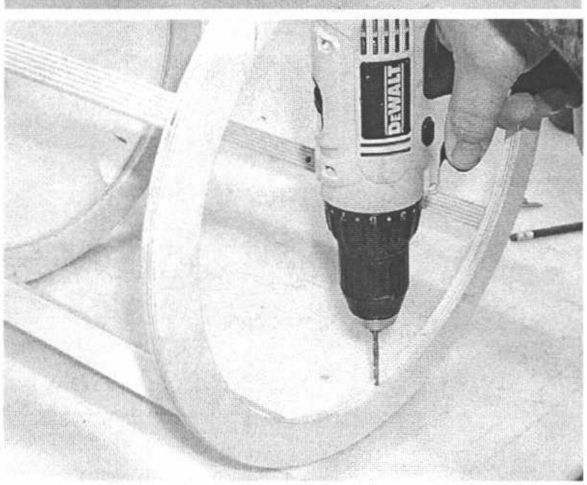
Installing the QuickSwitch Filter Slide



While it can be mounted on the right or left as seen from the front of the telescope, the TeleKit was designed to mount on the left side as seen from the front. There is more room to position finders with this orientation, but go with your preference. The QuickSwitch can be mounted between any of the four spacers. You may have a preference depending on cage veneer appearance. The QuickSwitch can be as close as 3" from the spacer, preferable on the 16"-18", and still allow clearance for the control knob and filter slide so it clears the truss clamp and trusses when it's fully extended. This orientation is shown at left. Install the mounting screw eyes in the pre-drilled holes in the end of the filter slide. The center of the eyelet hole should be 3/16" from the surface, screwed in all the way until the ring of the eye screw is flush with the surface.

Mark and Drill the Mounting Holes



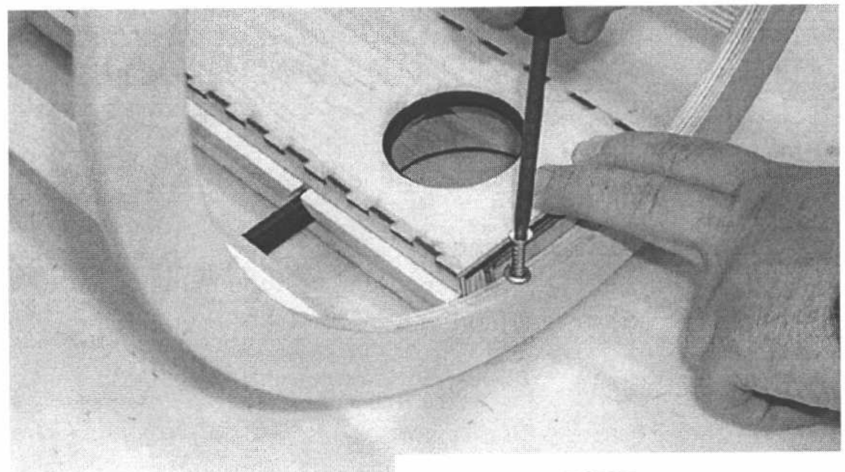


Mark your drill holes by marking the center of the screw eye. Do this for all four mounting holes. Make sure when you are marking that the QuickSwitch is lined up on both cage rings to insure that it is installed squarely. Check the filter slide fit after marking the holes. It is usually necessary to notch the ring lip for the eye screw to seat properly.

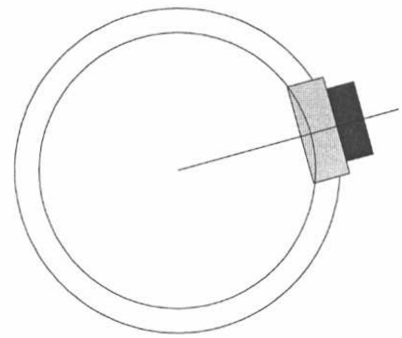
Wrap masking tape around the 7/64" drill bit 1" from the end. Remove the QuickSwitch and drill all four mounting holes into the inside edge of the ring. It helps to punch the wood so the drill bit leads into the marked hole position. Drill bits tend to "walk" when drilling into end grain.

Use masking tape to set your drill depth. This is an easy way to set up your drill for precise pilot holes and insures that you won't drill too deep. Drill down until the masking tape touches the surface.

Installing the QuickSwitch Filter Slide



Install the QuickSwitch filter slide using the four #10 x 1" mounting screws supplied with the kit. The focuser end of the slide is oriented towards the end of the cage that has the truss mounts. Check with a drafting triangle to make sure it is square.

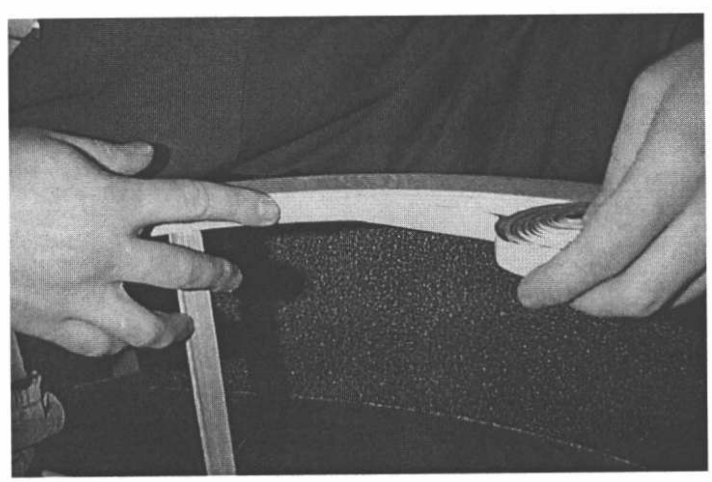


Position the filter slide as close as possible to a spacer on the 16" kit, making the angle close to 20 degrees. This makes viewing at lower altitudes more comfortable and allows the filter slide to clear the trusses. The diagram at right shows the filterslide/focuser. It is necessary to carve or sand a small notch in the bottom ring lip to allow the filter slide screw to clear. It is also necessary to notch both ring lips for the screw eyes to seat properly against the ring.

Installing the Laminate Light Baffle

To mount the laminate into the cage, cut two pieces of the 1/4" wide double-sided tape to the dimensions shown on the next page. Cut two 12" pieces of 1/4" for the laminate stops on the sides of the QuickSwitch. Cut the 5/8" into four 12" strips for the spacers.

Try to minimize touching the tacky portion of the tape as its being applied, as oil and dirt affect its adhesion. Be sure the inside cage surfaces are free from dust.



Roll the tape along the inside of the rings starting at the QuickSwitch. Position the tape in the middle of the rings. Press down as you go, pressing and sliding along will sometime cause the tape to bunch. After applying the tape to the rings, cover the four spacers with the 12" pieces of tape and the laminate mounts on the QuickSwitch with the 1/4" x 12" strips. **DO NOT REMOVE THE PROTECTIVE WHITE LAYER AT THIS TIME.**

The following list shows the length of the tape cut from the rolls supplied.

TeleKit Size	Upper & Lower Ring	Cage Spacers	Filter Slide rails
16"	(2) 1/4" x 52.0"	(4) 5/8" x 12"	(2) 1/4" x 12"
17.5-18"	(2) 1/2" x 58.0"	(4) 5/8" x 12"	(2) 1/4" x 12"

Installing the Light Baffle

This takes some extra care on smaller kits, since the baffle must be rolled into a smaller diameter. A great help is to warm the laminate in a hot car, by a radiator or sunny window, making it pliable and less brittle.

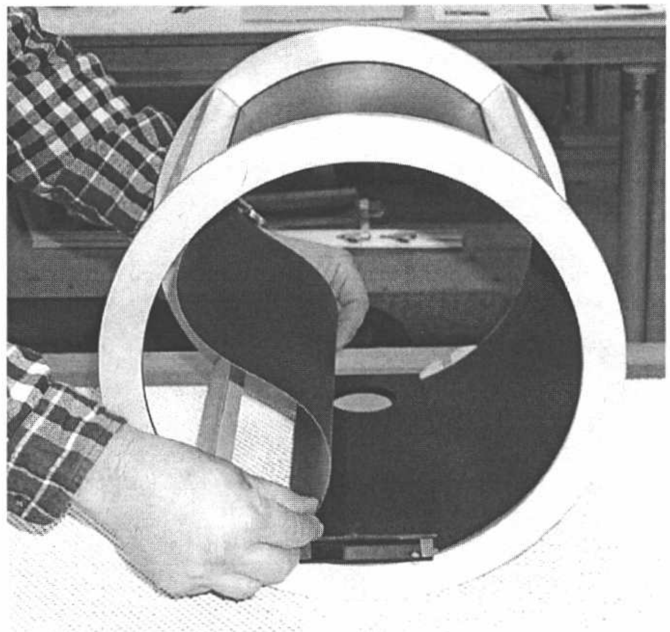
Trim off the excess tape with a knife or scissors. This is a good time to double check that the tape is well pressed onto the rings. Allow the tape to adhere to the cage for a few hours or overnight. This makes removal of the white backer easier. The edges and corners of the light baffle can be sanded or filed to remove sharpness or roughness. Paint the backside of the light baffle flat black and allow to dry before installation. It can be painted after installation but this requires a great deal of masking. Clean the exterior of the light baffle before installation, using window cleaner, wipe away any fingerprints, dust or dirt, especially along the edges. Clean only the black outer or exterior surface.

The laminate was cut accurately, but in rare instances it may need to be shortened in length. Take small amounts off and then retry the fit. The small adjustments in length are made by scoring the backside with a utility knife and carefully bending the edge toward the color side with pliers. Always bend the edge in the direction of the front and it will break cleanly along the score. Sand the sharp edge to avoid injury and round the corners.

CAUTION: The laminate is only .028" thick and somewhat brittle, especially when it's cold. Use care in handling and installing the laminate.
DO NOT FORCE IT.

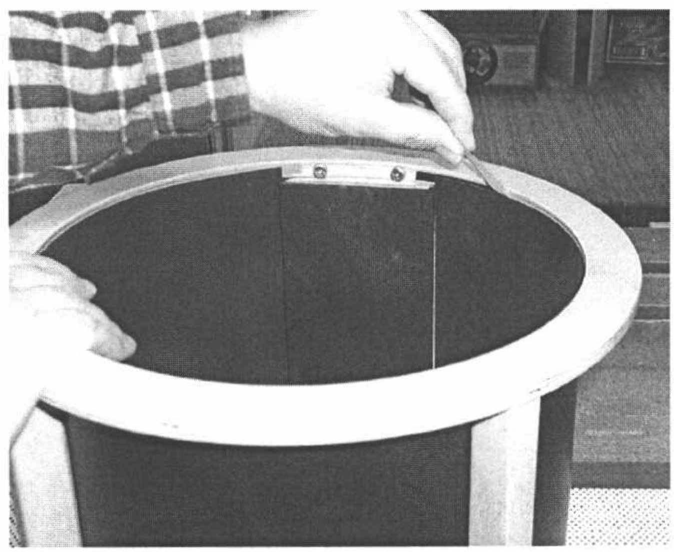
To install the light baffle, roll the baffle, flat black side in, and insert in the cage. Flush one end up against the filter slide with the extra length passing over the back of the filter slide.

Carefully push an S bend in the laminate and place the end against the filter slide side. Carefully bend the laminate, placing too much force in one place will cause it to crack or break.

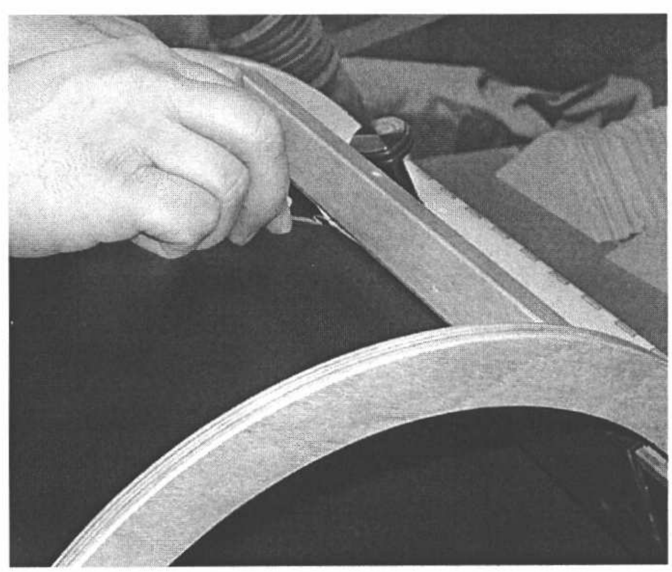


When the laminate is let go, it will give a loud pop as it snaps into place up against the cage rings.

Mount the laminate permanently by starting the removal of the backing tape on one of the rings. Tweezers or needle nose pliers may be needed to pull the end of the tape backer. Line-up the laminate evenly all around before removing the backer, or it will be off at the other end. Working slowly, pressing the laminate down 3-4" behind as the strip is pulled away. Another tool to help pull the backer from the spacers is a dental pick, easily found at hobby stores (see photo below). If the laminate is not seated against the ring, start pulling the backer opposite the filter slide by pulling up the backer and cutting it. Work each side, pressing as you go. This will even the gap next to the filter slide instead of all the gap being on one side.



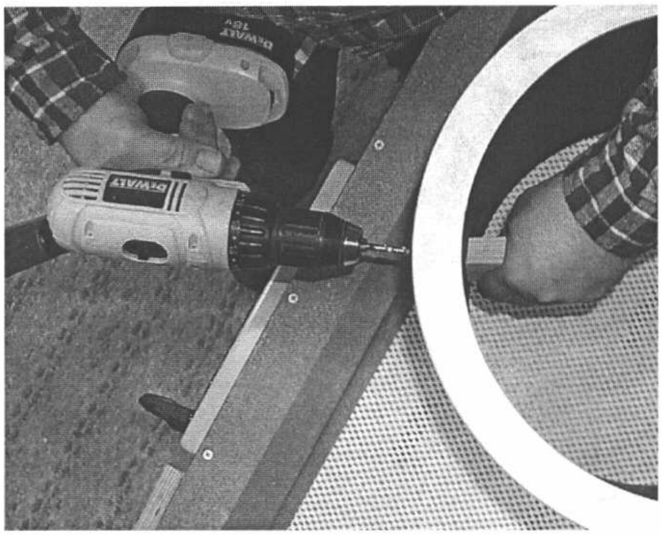
After the top ring is done continue with the spacers, the lower ring, and last the laminate mounts on the QuickSwitch. Should the laminate corners bow inwards next to the filter slide, use the four #4 x 3/8" screws to securely fasten the laminate to the rings at the laminate corners. Pre-drill a 7/64" hole in the laminate corners and avoid over-tightening the screw.

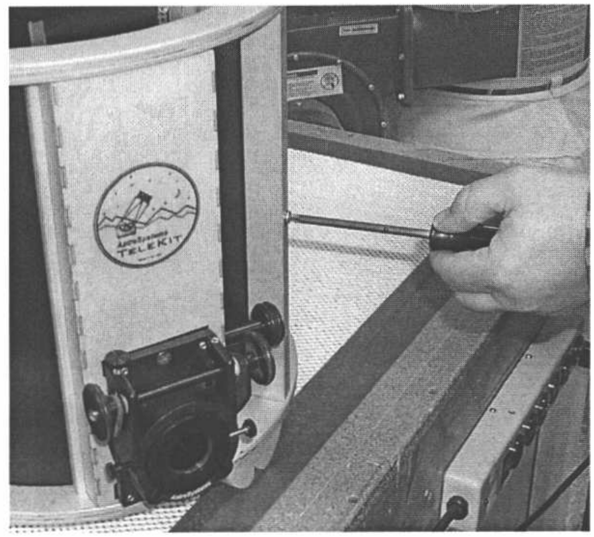


Installing the Spider

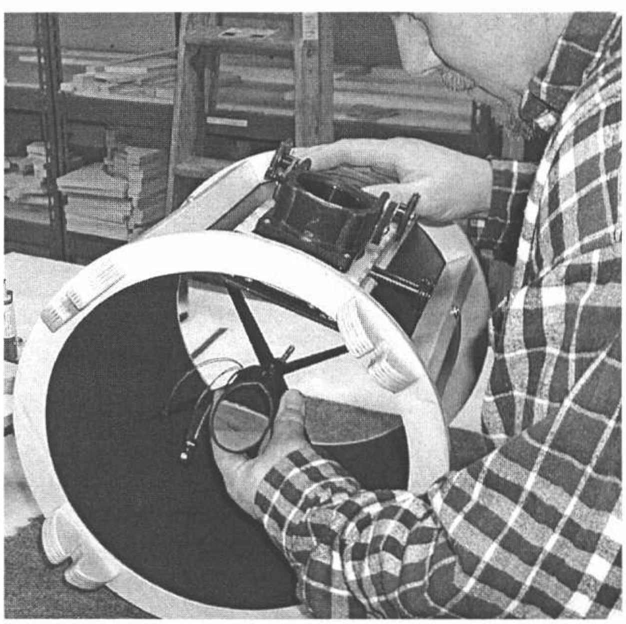
You will need to drill a hole through the laminate to mount the Spider. Use a 13/64" drill bit and a sacrificial block of wood to drill the holes. The spider mounting holes are already in the ring spacers. Use this hole as a guide to drill through the laminate. Hold the wood up against the inside to prevent the Laminate from splitting or cracking.

Use caution when drilling towards yourself.





Next, using the hardware supplied, mount the Spider. Put one washer on each mounting bolt and insert through the spacers into the Spider, tensioning it so that moderate pressure at the center of the spider body will not deflect any of the vanes. If the screws don't start easily because of slight alignment, the holes can be opened-up or slightly angled with a drill. Each vane will give a "twang" when plucked if tensioned equally.

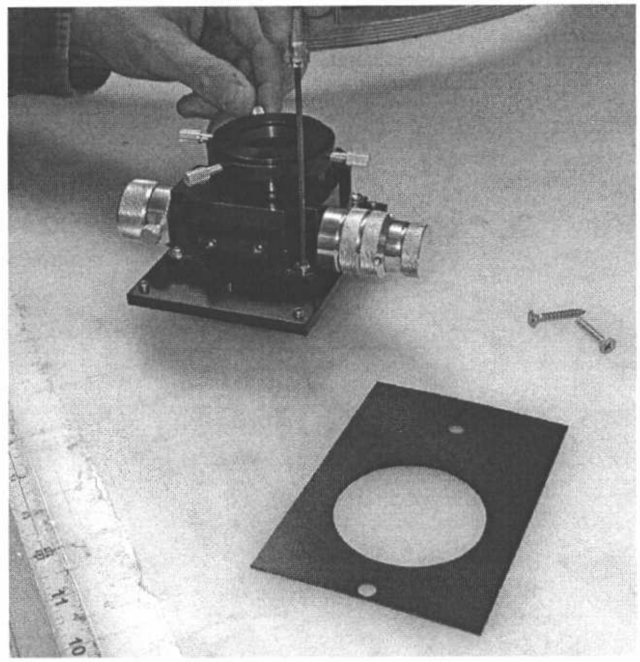


Installing the Secondary Holder

The secondary holder will not need to be accurately positioned at this point. Refer to the directions on collimation of the spider and secondary holder for that. Position the holder by removing the nut and washer on the end of the shaft, insert the stud into the spider and replace the nut and washer. Roughly center the secondary holder under the focuser, loosening the nuts on the shaft to laterally shift the holder. Remove the holder and install the secondary mirror when the upper cage is complete.

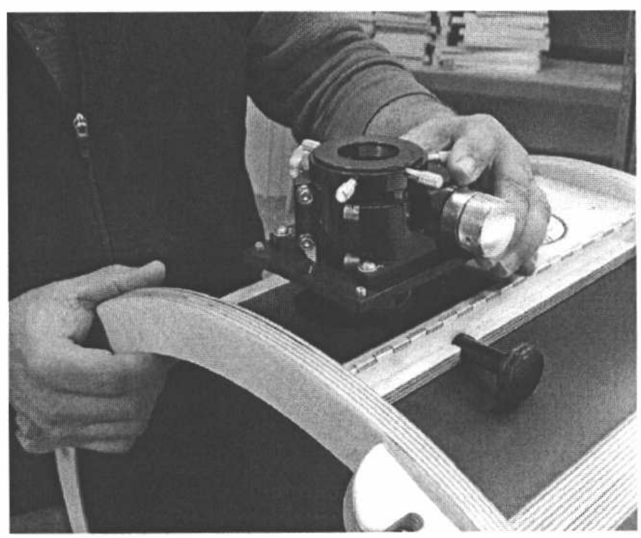
Installing the Focuser

Note that these instructions are for mounting the focuser and not for aligning it. For specific instructions on focuser alignment, see Page 68.

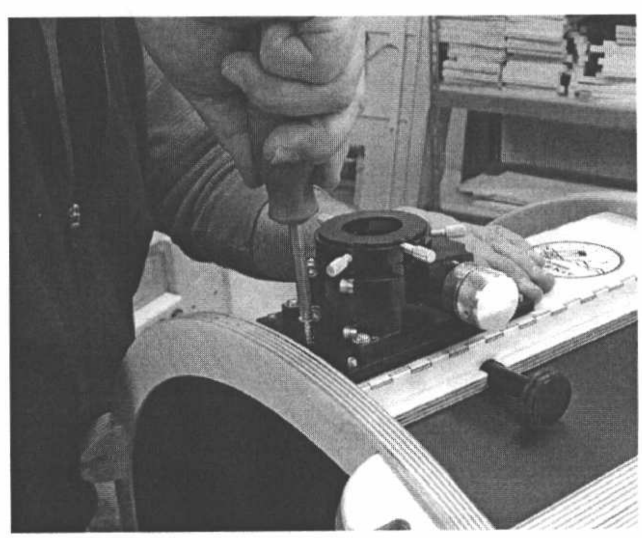


First, attach the Moonlite focuser to the base using the #8 x 5/8" screws with a washer. Make sure the leveling screws in the Moonlite base are not protruding and the focuser is flush against the base. It is attached to the side of the base on the side with the two countersunk center holes.

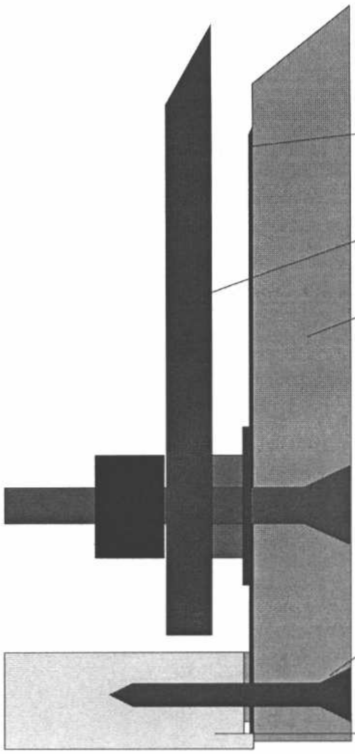
NOTE: The focuser shown in the photos has the fine focus knob on the left when pointed up, this is preferred for the focuser being mounted on the right (when looking at the telescope from the front). The focuser is more commonly mounted on the left as seen from the front and will be supplied with the fine focus knob on the right.



Next, place the laminate mount down and set the focuser into the hole on the QuickSwitch.



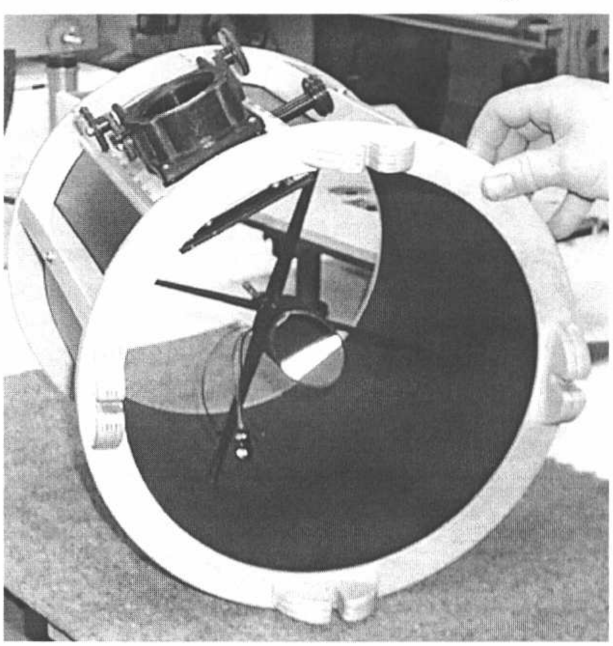
Last, secure the focuser to the QuickSwitch filter slide with the two #10 x 1.25" wood screws included with the mounting kit, taking care not to over-tighten them.



Installing the Counterweight System or Optional Accessory Mount

Note It is not necessary to install this counterweight system until it is determined it is counter weighting of 1 pound or more is needed. The counterweight system and accessory mount both use the same attachment method. A plywood bar is attached to the inside of the cage with screws going through the light baffle into the cage ring. This is very secure and shows no external hardware. Finish the internal mount board with a penetrating coat of clear and when dry, a coat of flat black. Position the mount board opposite the focuser and mark the position of the holes to be drilled into the rings. Use a 5/32"" bit and drill through the light baffle. Switch to a 1/8" bit and drill 1" deep into the rings. Mount the board with the #8 x 1.25" screws and using a 1/4" bit and a piece of scrap on the outside, drill through the light baffle. Slide the 1/4" flathead bolts through the board and fasten on the exterior with a nut and washer. One to two counterweight bars are positioned on the bolts and held with the knurled nuts (see Page 64).

The optional accessory mount is used to securely mount heavier accessories, like optical finders, to the upper cage. First finish the longer board with clear polyurethane as a sealer and when dry, spray with flat black. The shorter, thicker accessory mount is finished like the telescope. Determine the best location for your accessory (finder, etc.). Note: A Telrad or small reflex finder can use double-sided tape and mount directly to the light baffle, the accessory mount is not needed. Mount the longer flat black board on the inside of the cage as described above. Position the 3/4" thick accessory mount board on the outside of the cage, flush against the light baffle and drill a 9/64" pilot hole 3/8" deep into the board. Use a tape marker on the drill bit to avoid drilling through the mount. Attach the accessory board to the internal board with the two #10 x 7/8" flathead screws.



You are now finished with your TeleKit upper cage assembly. Details on aligning the focuser and the secondary mirror and general collimation of the telescope are in the collimation section of the instructions, Pages 67-75.

Ground Board

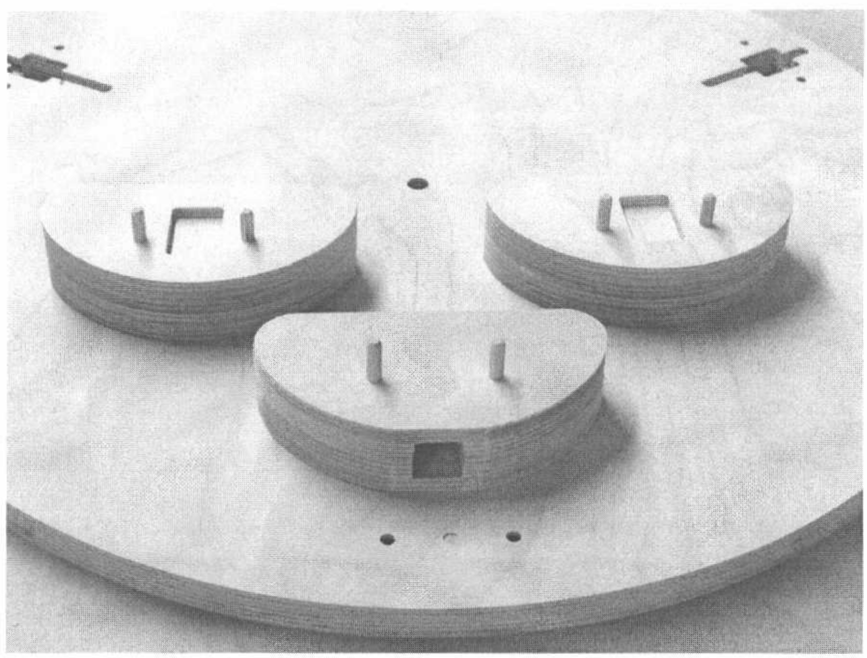
Parts		**Tools/Supplies**
1	Ground board	Drill - 9/64" drill bit
9	Foot mount plates (2 with bearing clearance)	Wrench or Socket 5/8"
2	Axles 5/16" x 2.3" stainless	Pencil
8	Bearings	Phillips head screwdriver
3	Laminate foot wear pad	Locktite or superglue

Hardware

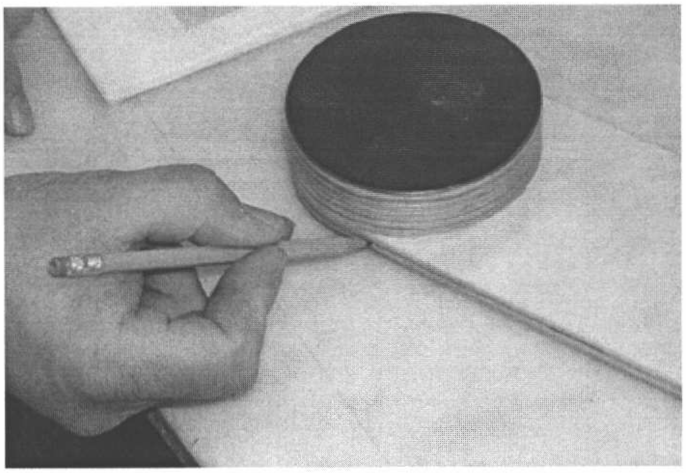
1	Hex key 5/64"	1	Pivot bolt locknut 3/8"
6	1/4" x 2" Positioning dowels	1	Pivot bolt 3/8" x 1.5" brass w/set
1	T-nut 3/8"	1	Teflon Bearing 1.5" x 1.5"
2	Washer 5/16" ss	1	Teflon Screw #8 x 1/2"
1	Washer 3/8" ss		

Assembling the Ground Board

To easily sand the edges of the feet they are assembled first, sanded and then attached to the ground board.

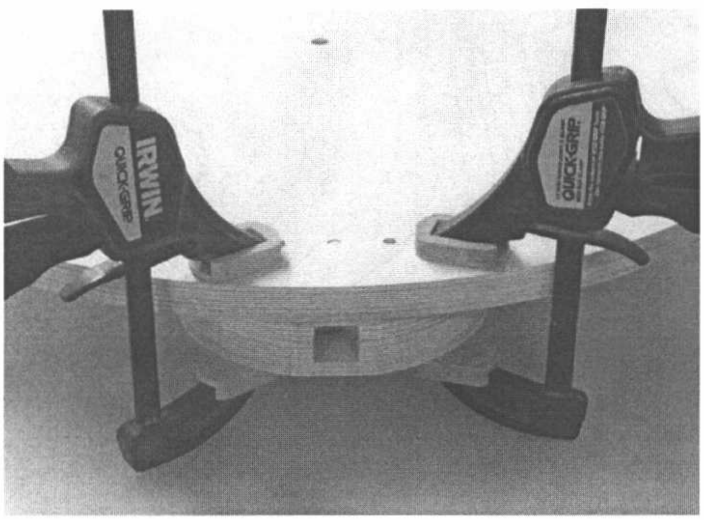


Apply epoxy to one face of a foot and using the glue dowels, assemble the feet with clamps. Each is a stack of three feet, two with the bearing clearance. Allow the extra dowel length to protrude from the topside. When thoroughly cured, fill any edge voids with wood putty. Sand the edges, starting with coarse sandpaper and working through a fine grade of sandpaper.

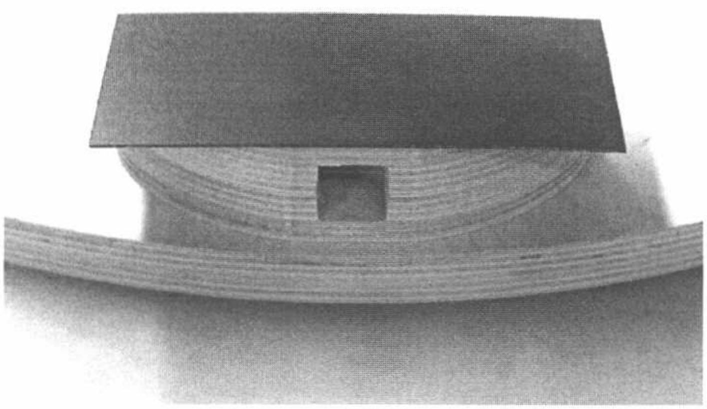


For the optional 3 lobe groundboard, the edges of the top of ground board are rounded over using a router or sander. A 1/8" radius router bit is suggested. The bottom edges are rounded over as well, but it is necessary to avoid rounding over the front edge so that there is no gap between the ground board and the foot. Place the foot on the ground board and mark with a pencil where to stop the round over.

For the standard round groundboard it is suggested to use a sander to break the top and bottom edge. This protects the veneer and allows the maximum contact on the edge for a drive.



Attach the feet by applying epoxy to the topside with the protruding glue dowels. Align the glue dowels with the holes in the ground board and attach to the bottom side (opposite side of where the axle slots are). Use 2 clamps on each foot mount plate and allow to cure overnight.

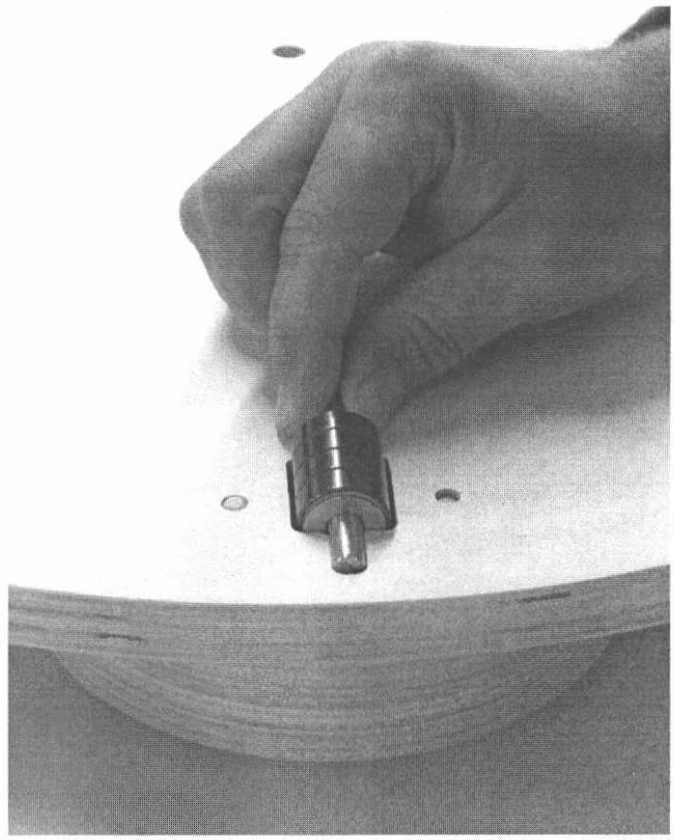


Sand the bottom of the 3 feet and apply the laminate protective surface using contact cement. When the contact cement is dry, the laminate can be rounded over using a router with a 1/8" round-over bit or sander. If you are using a sander, trim the laminate to be a close fit before attaching. This will minimize sanding and avoid any chips, cracks or de-lamination when sanding. Sand so any forces from the sanding push the laminate down.

Using the same finishing techniques previously described on Pages 16-19, sand and finish the ground board. When dry, the 3/8" T-nut can be installed in the bottom of the ground board, see the drawing on Page 62. A small amount of epoxy is applied under the flange of the T-nut and it is placed in the hole. Use a hammer and a sacrificial piece of wood to set the teeth into the Ground board.

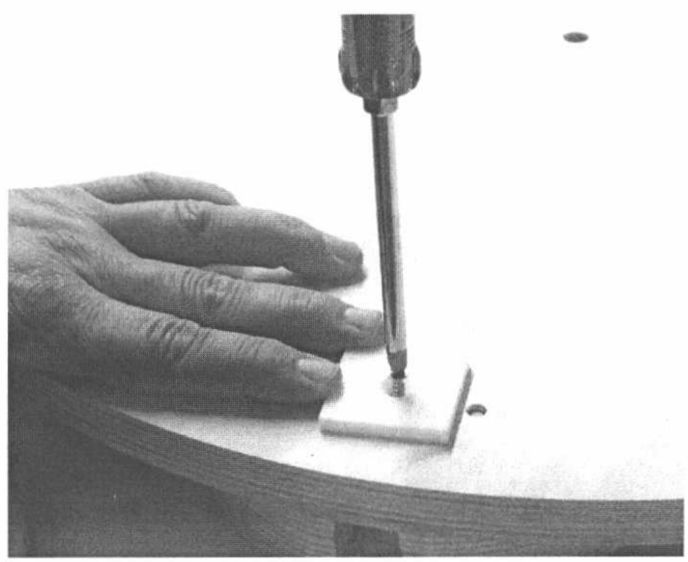
Axle and Bearing Installation

Slide four of the supplied bearings on one of the axles. Place a 5/16" washer on last and drop into the slot/pocket in the ground board. The axle slot is machined with a metric bit so it is 0.005" oversize but coating build up can make this a tight fit. You can use a piece of wood and a hammer to set the axle, just be sure to hit the axle only, not the bearings. The washer is on the end away from the center of the ground board.



Azimuth Teflon Bearing

The position for the Teflon azimuth bearing is marked on the ground board with a shallow 1/4" diameter mark. Pre-drill a 7/64" hole 0.4" deep at this position. Attach the teflon bearing with the supplied #8 x 1/2" flathead screw.



Mirror Box

Parts

2	Mirror box sides
1	Mirror box front
1	Mirror box back
4	Corner Gussets
2	Mirror cell mount blocks

Tools/Supplies

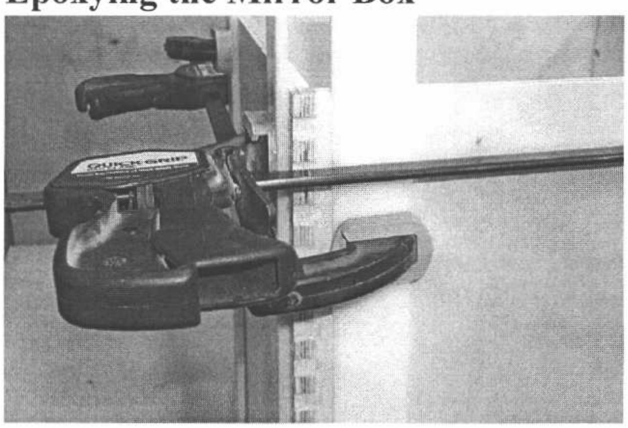
8	Clamps
6'x 6'	Plastic drop cloth
	Paper towels
	Sander / Sandpaper
	Acetone
	Epoxy Kit

Preparing the Parts for Assembly

Sand the insides of the mirror box. Remember that the inside of the mirror box will be sealed with clear finish and then painted flat black. Only a rough 80 - 120 grit sanding is necessary. Be careful when handling the finger joints, as the veneer and corners are fragile until assembled. If the veneer is damaged, peel the veneer off a scrap piece of plywood for repairs. Use some fast setting epoxy (5 min.) for this type of repair. Do not sand the outside of the mirror box at this time.

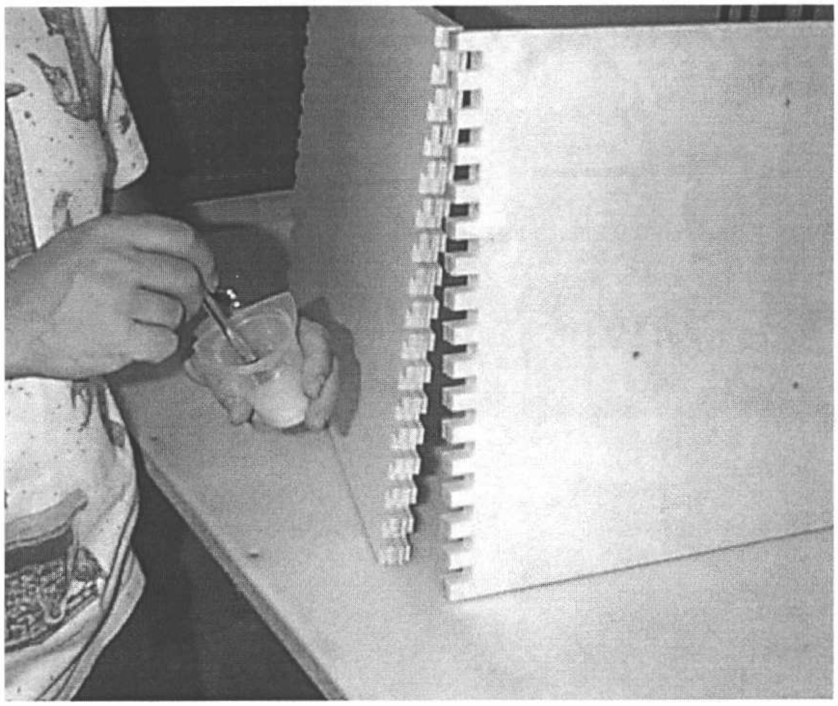
Next, dry fit the parts. This is very important, allowing you to familiarize yourself with the mirror box assembly before you apply the epoxy. The parts should slide easily into place and have equal gaps above and below each finger. DO NOT FORCE THEM. If they do not slide easily together, file or sand the tight fingers. Using clamps, snug up the parts and check for square. At this time, the mirror box should be close, with simple flexing being all it takes to bring it into square. Another way to check this is to measure the sides across the diagonal (corner to corner), making sure both diagonal measurements are equal.

Epoxying the Mirror Box



You will need 8 clamping strips. These are pieces of scrap wood that will be placed next to the epoxied finger joints. The fingers extend 20-30 thousandths above the surface so it is not possible to clamp at the edges. Use clamping strips that are about an inch wide and as long as the mirror box height. The slight offset necessitated by the clamps being away from the edge may cause the sides to bow in slightly. This is normal and will not remain after the clamps are removed.

You may want to put a drop cloth on your worktable in order to keep excess epoxy from becoming a permanent part of your workbench. It will take between 60-80 ml total of mixed epoxy to glue the mirror box fingers. You can always mix more but unused epoxy will be wasted. The proper mixture is equal portions (mix ratio 1 to 1 by volume) of the epoxy (milky white) and hardener (tan).

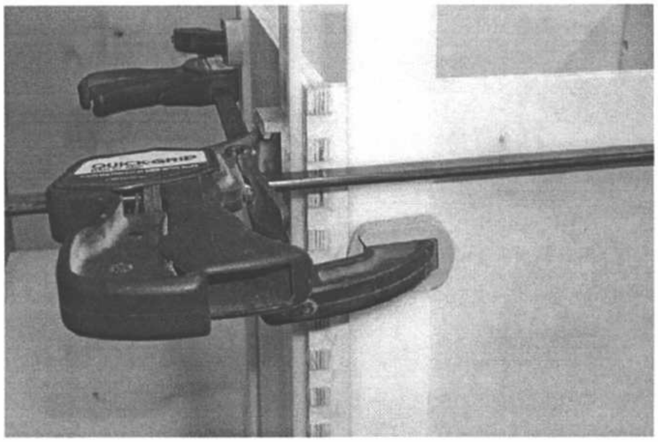


There are two methods for applying the epoxy. The first way is to dry fit all four sides, then to separate one corner and apply epoxy to all contacting surfaces of the fingers. After you are done with the first corner slowly slide the parts back together and move onto another corner. This way is a little more time consuming, but easier for one person. Use a liberal amount of epoxy. You want enough on the fingers to ooze out when you fit the parts together, see photo on Page 36. Try to minimize getting the epoxy on the exterior veneer, this just makes sanding and finishing more time consuming. Your main concern at this time is to apply enough epoxy so it will form a good, solid joint with no gaps. Do not wipe off the excess yet.

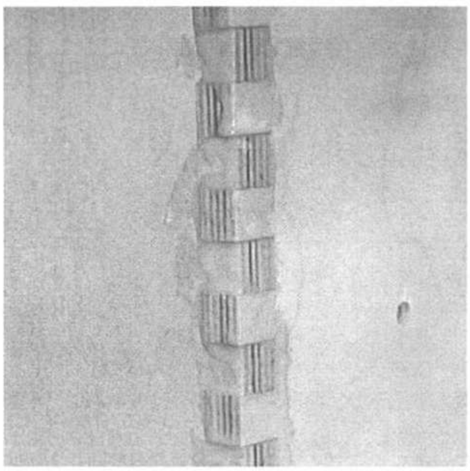
The second method of applying the epoxy is easier if you have help or would like to apply the adhesive in less time. One person takes the sides, and the other takes the front and back pieces. Each person applies adhesive to his or her two parts. When finished applying the adhesive, fit the parts together. Do not wipe the excess epoxy off yet. It will be easier to clamp if you have a friend around to help with the clamping. Keep in mind that you can not clamp directly on the corners, or finger joints. As mentioned earlier the fingers project above the surface to insure a flush sanded joint. This makes it necessary to clamp to the side and to apply proper clamp force on the appropriate panels. Do not get epoxy on your sacrificial wood pieces or you will epoxy them to your telescope permanently (covering them with plastic wrap will avoid their sticking).

Apply the clamps four at the top and four at the bottom, making sure the joints are consistent. Apply even pressure around the box, tightening each clamp by small amounts in a sequential manner. Epoxy is very strong, even when it bridges a gap. It is not necessary to tighten to the point where the wood contacts itself; epoxy is a great gap filler.

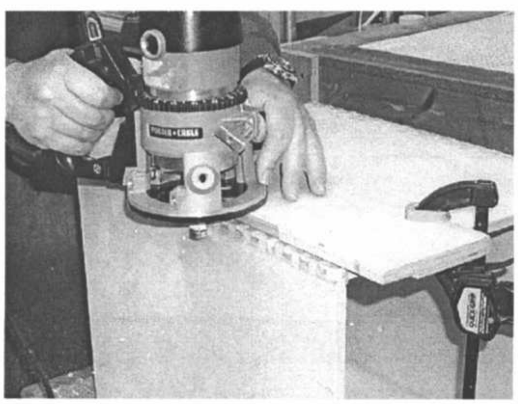
Check to insure the front and back panels have been assembled with the top edge toward the top. This is the end with the countersunk holes for the T nuts for the truss fasteners. The countersink for the T nuts faces toward the inside of the mirror box as well as the countersunk holes for the altitude bearings and the two ¾" holes for the mirror cell pivot mount.



This picture shows proper clamping positions. At this time you can use a spatula or mix stick to spread the excess epoxy to fill any small gaps at the finger joints. Apply an epoxy fillet to the inside corners. There is usually enough excess at the inside corner to just run your finger along to form the fillet. Add epoxy if needed. Polyethylene clamp strips have been used in the photo to allow clamping next to the finger joints. Use the acetone, if necessary, to clean up and wipe away unwanted epoxy on the wood. Keep checking the box periodically to make sure a clamp hasn't slipped off or shifted. Keep the box clamped for a minimum of 24-48 hours, or longer, if done in a cool workplace.



After removing the clamps the four internal gussets can be epoxied in. They are positioned 3.5" down from the top. If your clamps are not deep enough to hold all four at once you can lay the mirror box on its side and glue two in at a time. With plenty of epoxy it is not necessary to clamp them. Once cured you can apply more epoxy and create a wide fillet where the gusset contacts the mirror box, both top and bottom.



The photo at left shows a typical mirror box edge after removal of the clamps. This amount of glue is normal and will be removed by routing and sanding or just sanding. You can now complete the exterior of the mirror box. A router with a flush trim bit does an excellent job of trimming the small portion of the finger that protrudes as well as quickly removing the epoxy on the surface. It is necessary to use a flat board on which the router base can rest. The protruding fingers and excess glue are far too rough to guide the router smoothly when flush trimming. The photo below shows a wood guide that has an undercut about 1.25" wide and 0.12" deep to lay flat on the side of the mirror box over the rough glue. This gives the router base a smooth surface to move on and clear the protruding finger joints and glue. Note this notch on the underside of the board in the photo at left.

The fingers and epoxy can also be sanded smooth with medium grit (120) sandpaper, but be careful of cutting too deep into the veneer on the surface. Change the paper out often to avoid glue clogging and to keep the paper cutting well. Next, a 1/8"-3/16" radius round-over along the fingerjoints and on the other exposed edges is recommended, see page 97. This not only looks good but also protects the veneer from damage. The mirror box still requires the mirror cell mounts (Page 45) and lower truss clamps (Page 47) to be epoxied in before final finishing of the mirror box.

Mirror Cover

Parts

1	Mirror cover

Tools/Supplies

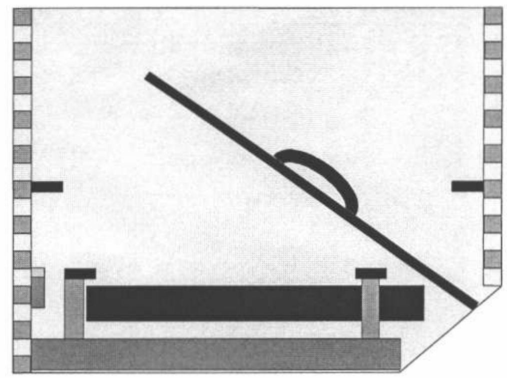
Drill 7/64", 7/32" drill bit
Phillips screwdriver
Scissors

Hardware

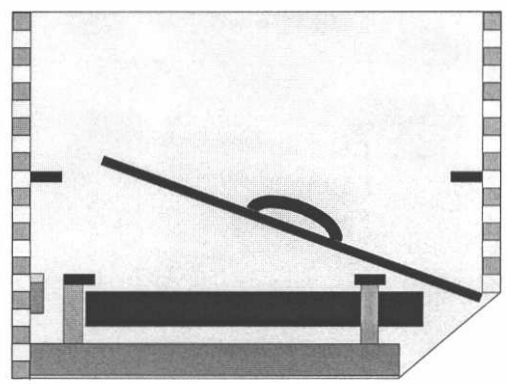
1	Mirror cover handle	Black steel	4	Handle screws	#8 x 1/2" flathead
3	Felt pads	3/4" self adhesive	1	8" Velcro "loop"	edge protection

Mirror Cover

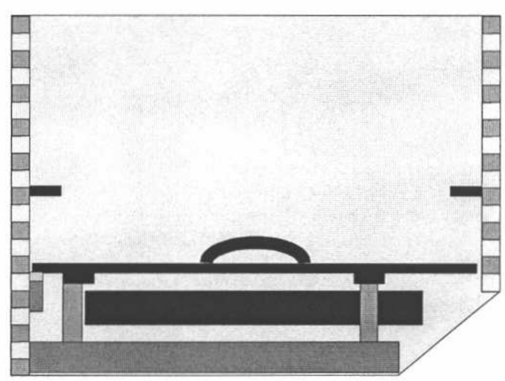
First, check the fit of the mirror cover into the mirror box. The cover should fit in the mirror box with 1/10" clearance all around. Sand the edges if the cover is tight. Sand and seal the mirror cover with clear polyurethane. Finish sand the cover and then coat with clear or semi-gloss black on both sides.



The handle is installed in the center of the mirror cover with the (4) #8 x 1/2" screws provided. Drill 7/64" pilot holes using the handle as a template. Place felt dots on the top of the three mirror cell retaining discs for the mirror cover to rest on. This also prevents wear between the two, which could generate debris that would end up on the primary mirror surface. Use small strips of the protective black Velcro "loop" around the edge so the cover slides in smoothly. Eight pieces about 2" in from each corner works well.



The mirror cover is installed as the sequence at right shows. A slight tug will release the catch when removing the cover.



Primary Mirror Cell

Parts

1	Mirror cell frame	6	Flotation triangles
3	Connecting bars	3	Transport dowels
3	Location dowels	2	Sling mount dowels
3	Mirror retainers	1	Orientation ring
1	Cable Sling Assembly		

Tools/Supplies

Drill
13/64" Drill bit
Locktite/super glue
Clear finish
Flat black finish
Epoxy glue kit

Hardware

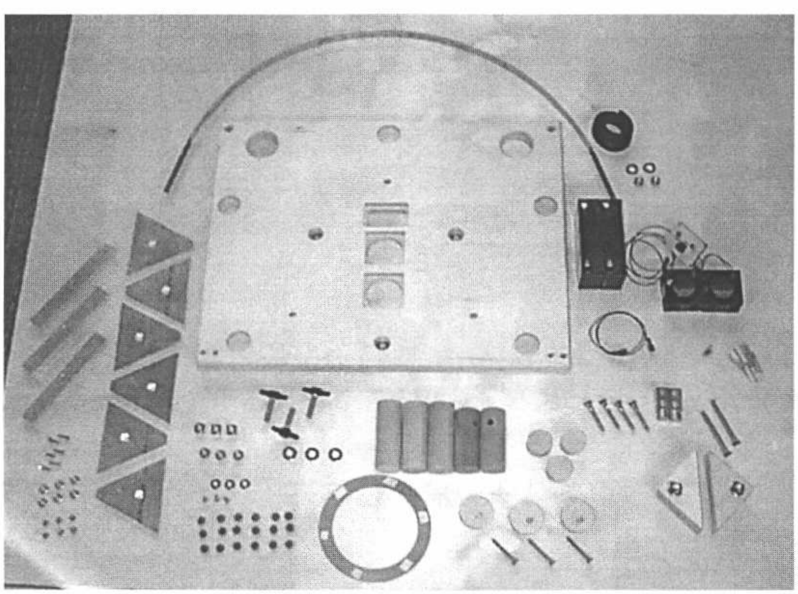
3	Collimation bolts	3/8" x 1.5"	3	Collimation washers	3/8" ID x 1" OD
3	Square nuts	3/8"	3	Nuts	3/8" jam
3	Pad Retaining screws	#10-32 x 1/2"	3	Retaining washers	1/4"
18	Flotation points	1/2" dia. carpet	3	Mirror retainer screws	#14 x 2"
6	Pad screws	#10-32 x 3/4"	6	Pad pivots	#10 finish washer
6	Nuts	#10-32	2	Sling nuts	1/4"-20 nylock
2	Sling washers	1/4"	2	Cable Sling Retainer	Velcro

Hardware (pivot and mount assembly)

2	Hinge pin	3/4" dia. x 2" long	4	Mount screws	5/16" x 2" lag
2	Mount bolts	1/4"-20 x 2.25"	2	Mirror cell mounts	wood w/1/4" Tnuts

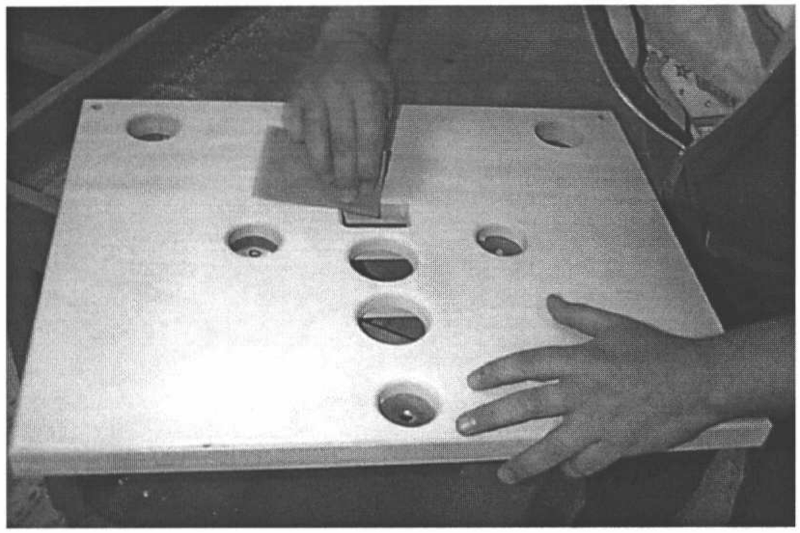
Hardware (cooling fans and controls)

2	Batteries	6 V, 3Ah gel cell	1	Battery interconnect	Jumper wire
2	Fans	12V 60mm	2	Fan Grill	60 mm
8	Fan mount screws	#6 x 5/8"	4	Control plate screws	#4 x 3/8"
1	Control plate	Fan, charge control, connecting wire			

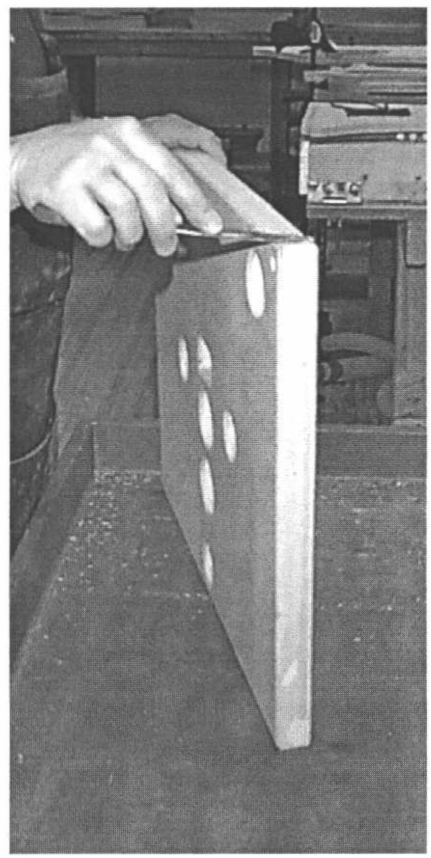


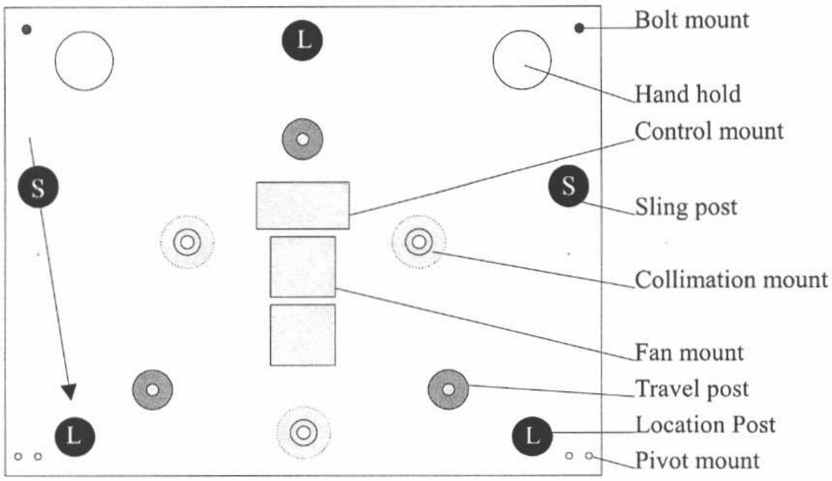
Assembling the Mirror Cell

Prepare the wood frame by first using wood putty to fill any voids or chips. When the filler is dry, thoroughly sand the flat portion of the edges. Use hand sanding to smooth the rounded portion of the edge and maintain the uniform curve. Sand the inside of all holes, giving special attention to the fan, control and hand hold holes. The inside corners can be rounded and smoothed if desired.



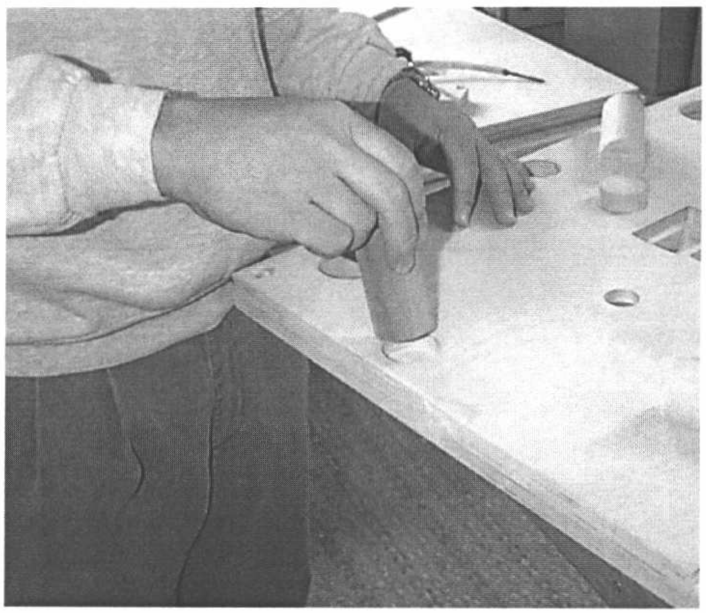
Sand the inside of all holes, giving special attention to the fan, control and hand hold holes. The corners can be rounded and smoothed if desired.



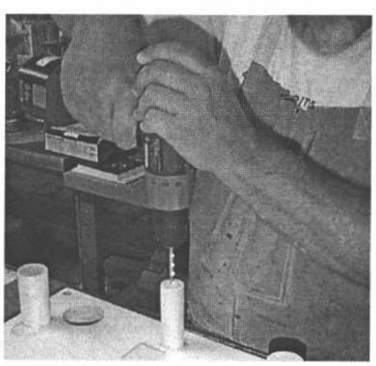


Mounting the Sling, Locator and Travel Dowels

Scrape away any glue in the mount holes and dry fit the location and sling dowels. The three longer location dowels go in the top center and bottom left and right holes. The sling mount dowels go in the right and left holes about 1/3 of the way down, as pictured at left.



Mix some epoxy on the supplied gray plastic sheet and apply to the dowels and in the holes. The sling mount dowels have a cross-hole toward the upper end. The dowels are pressed and rotated in the hole to uniformly coat both the hole and dowel. A small bead of epoxy being forced up next to the dowel indicates just the right amount of epoxy. If no epoxy is forced up, remove the dowel and apply some more, especially if the hole is a loose fit. The dowels must be oriented so that the center of the location dowel directly below it can be seen when sighting through the cross-hole. You can also place a pencil in the sling dowel to check its orientation. (See the arrow in the drawing above for cross-hole orientation).



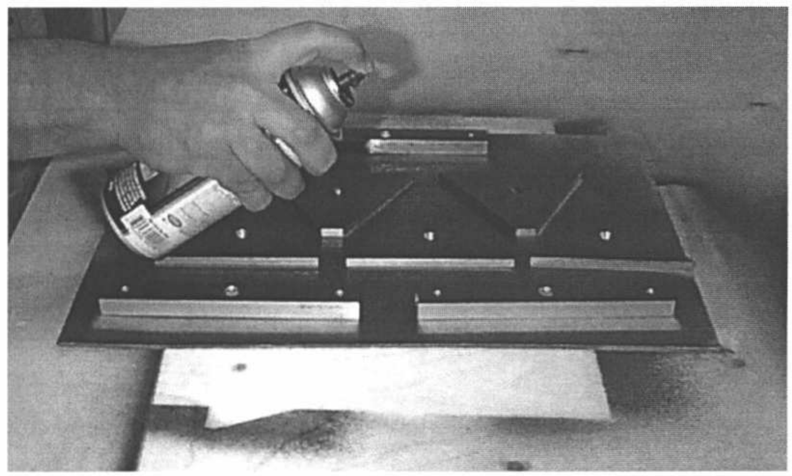
The transport dowels are epoxied on the surface, one at the shallow 1/4" mark just above the square fan control hole. The other two are epoxied to the two positions where dowels were used to locate the two boards when they were assembled. Spread epoxy on one end of the post and a little in the pre-drilled hole. This surface mount is sufficiently strong since the travel dowel supports a vertical load when used. Allow to cure overnight.

The location posts are then finished by drilling a 3/16" hole 2" deep centered in the end (see Photo at left).

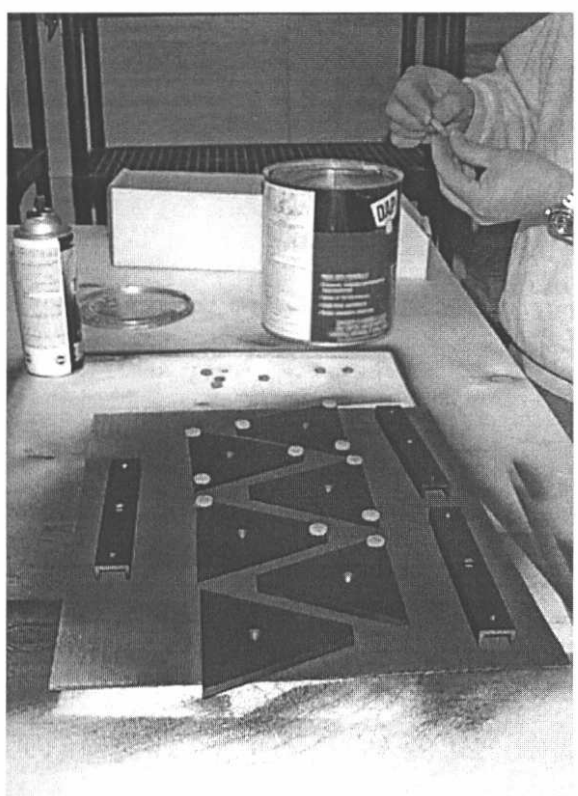
Finishing the Frame

Finish the frame the way the rest of the telescope is being finished. We recommend sealing the inside of the frame with clear and then masking the edge and through holes (hand hold, collimation, fan and control) before spraying with a light coating of flat black. It is easiest to place the frame on some old newspapers outdoors and apply a thin uniform coat, paying special attention to the sides of the dowels. It is recommended that the edge is masked and only the top 1/4" of the side is black. After the cell is dry, attach the 1.5" round carpet pads to the three transport supports with contact cement.

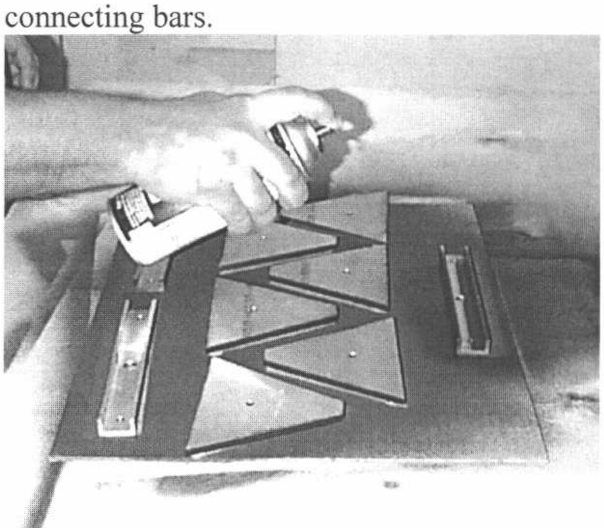
Flotation Pads



Following are the instructions to paint the flotation triangles and hardware. It is not necessary, but does give the parts a finished look. Clean the flotation pads and cross bars in hot soapy water and dry. Lay the pads and bars out on a scrap piece of cardboard or newspapers outdoors. Using black aerosol paint (glossy-flat, your choice), coat the front side of the pads (countersunk hole) with several light, uniform coats.



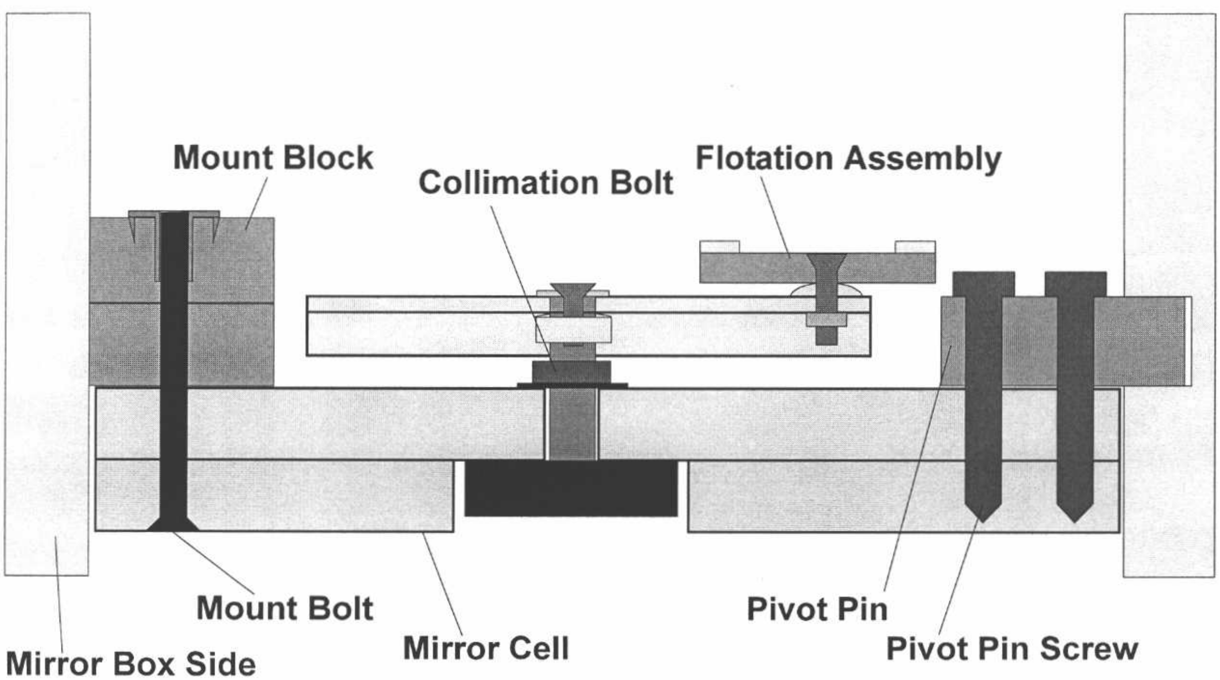
Allow to dry for 30-60 minutes, then use contact cement to fasten the flotation pad cushions to the corners of the triangles. Turn the parts over and paint the backside of the flotation triangles and the connecting bars.



Allow to dry for 1-2 hours, then use contact cement to fasten the flotation pad cushions to the corners of the triangles. Turn the parts over and paint the backside of the flotation triangles.

Flotation Pad Assembly

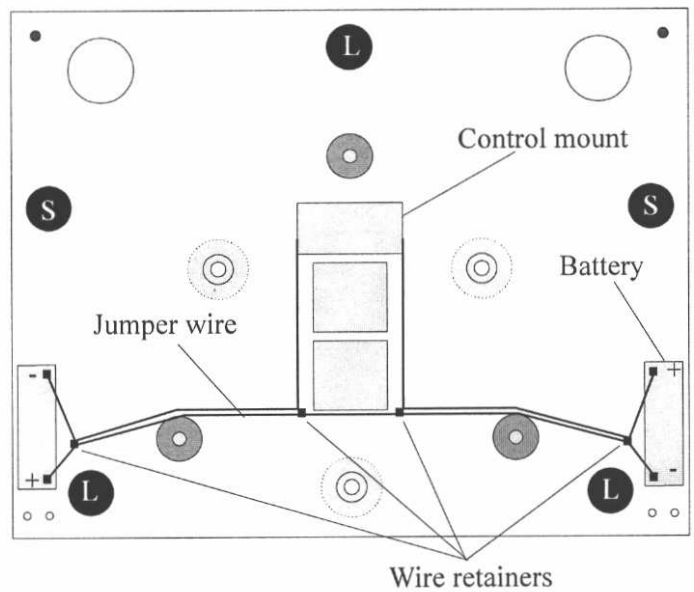
Assemble the pads and bars by inserting a #10-32 x 3/4" flathead screw through the pad. Place one of the rounded finish washers over the screw and then through the hole in the crossbar. Last a nut goes on the screw to hold the assembly together. The proper adjustment of the nut allows the pad to pivot, or float and make uniform contact with the back of the primary mirror. To adjust, snug the nut on to the screw and then loosen 2/3 turn. The nut is held in place by applying super-glue, Locktite or a small dab of paint. The paint and Locktite are serviceable, the super-glue is permanent.



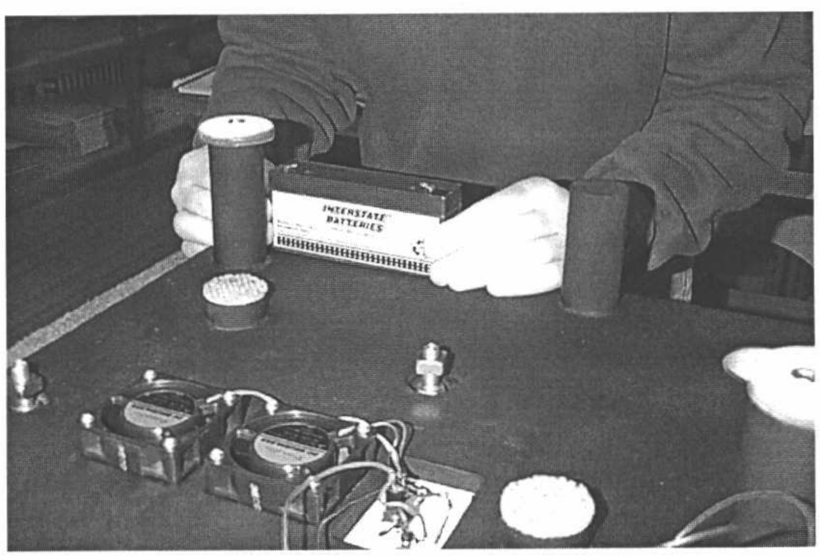
Fans / Controls / Batteries

Install the fan control from the mirror side of the frame in its mounting hole. Check to insure it is oriented so the printing is correct. The fan hole will be below, or down from the control panel. It is not necessary to pre-drill a pilot hole for such small screws, just press firmly when starting. Secure with the four #4 x 3/8" screws. They require a #1 Phillips screwdriver. The fan(s) are mounted with 4 screws per fan.

The kit is supplied with two 60mm fans and eight #6 x 3/4" mounting screws. Check the fit of the fan(s) and fan grille(s) in their mount holes and remove any glue or uneven spots so they seat evenly. Mark one of the corner holes with a nail set or nail and drill a pilot hole for the screw with a 3/32" drill. Use tape on the bit to mark depth. Install this one screw and then mark the other three on each fan. This method gives accurate hole position, unless the fan is a tight fit, it may move around if you try to mark all 4 at once. Do not over-tighten the fan screws, it can deform the fan body.



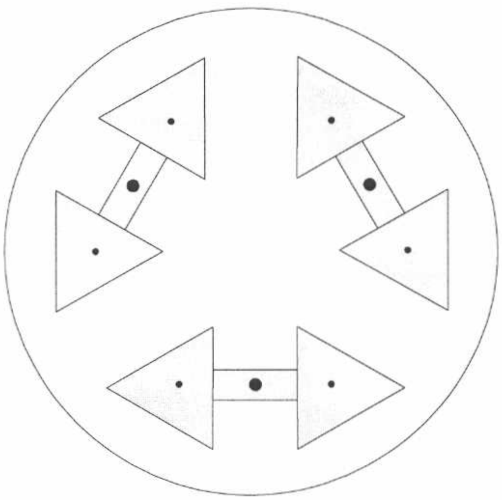
Mount the batteries by removing the protective cover from the tape on the bottom of the battery. They are positioned 1/4" from the frame edge and 1" from the centerline of the pivot mount holes. Orient the terminals toward the center of the cell and press the battery firmly to seat it on the tape. It will take 24 hours or more for the tape to achieve its maximum strength.



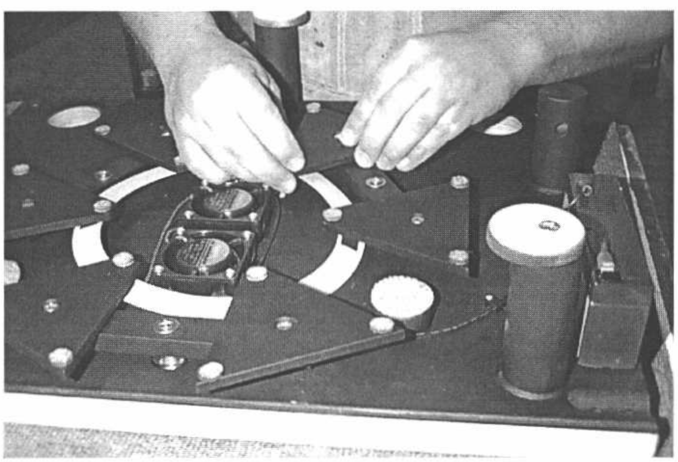
The positive (red) wire from the control panel is routed past the fan, next to the transport post to the battery and attached to the positive (red) terminal. The negative (black) wire is routed to the other battery and attached to the negative (black) terminal. The jumper wire is attached to the negative (black) terminal of the first battery over to the positive (red) terminal of the second battery. This wires the two 6V batteries in series giving a total voltage of 12V. The wires are held in place by the plastic clips with nails, 2 at the bottom edge of the fan and one at each battery. This wire routing keeps the wires from being crushed when the flotation assembly is sitting on the frame in transport mode.

Collimation Bolts and Flotation Pads

Install the collimation bolts from the front of the frame and retain with a 3/8" washer and then a 3/8" hex nut (see drawing Page 42). Tighten the nut and then loosen 1/8 turn. This allows the collimation bolt to turn freely. Use Locktite or superglue to fasten the nut on the bolt. When dry, thread the square nut on the collimation bolt with its rounded side facing the primary mirror. Place the crossbar on the bolt so it rests on the square nut. Use a 1/4" washer and a #10-32 x 3/8" flathead screw in the end of the collimation bolt to retain the crossbar.

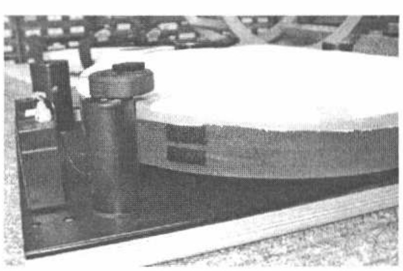


Peel the cover from the double-sided tape on the gray plastic orientation ring and slide it under the flotation triangles. Orient the triangles as pictured at left and gently lift the ring to adhere to the tips of the flotation pads. If a triangle moves pull the ring off it immediately, straighten and reattach. Once the ring is attached firmly, press the tape to the flotation triangle tips. This flexible ring allows the triangles to adjust to the back of the primary mirror and evenly support its weight.



Final Assembly

Install the wood keepers with #14 x 2" screws in the top of the location post. The keepers are drilled off-center to overhang the primary mirror and act as a safety catch should the telescope be pointed below the horizon or accidentally get turned over. Touch-up the retainer screws, battery clips and wire retainers with flat black paint. You can install the pivot pins and paint them flat black. Mask around the edge of the cell to prevent over-spray. When dry they can be removed prior to installing the cell in the mirror box.



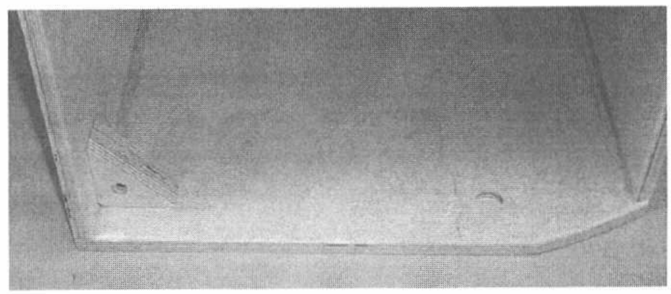
Sling

The new cable sling allows more freedom of collimation movement, especially for lighter mirrors and requires no adjustment once installed. The threaded eye bolts are positioned in the drilled post and the nut threaded on 1/4". This gives the plenty of slack to place the mirror in the cell. Attach the two sets of cable guide Velcro to the primary mirror edge. It is positioned with a 1/8" gap between the two pieces of hook Velcro. The gap is centered on the edge of the mirror. They are attached about 1" away from the location posts (see photo). The single piece of loop Velcro is fastened over the two pieces of hook, securing the cable so it stays centered on the mirror. When the mirror in place, tighten both sling nuts until the space between the three location posts and the edge of the mirror is even (about 1/16").

Primary Mirror Cell Mount

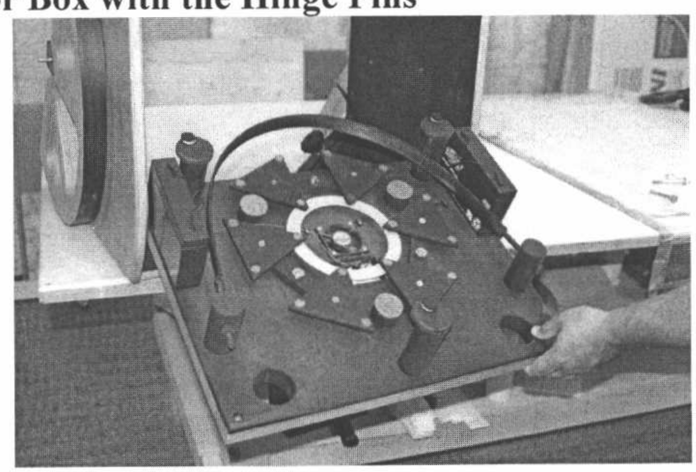
Fastening the Mount Blocks into the Mirror Box

The face of the primary mirror cell is mounted with a 0.2" inset into the bottom of the mirror box. This places the cell into the mirror box enough that it is somewhat protected if the telescope is set down on the mirror box. The top side of the mirror cell will be level with the bottom edge of the 3/4" pivot holes in the side of the mirror box.



The two mirror cell mount blocks mount into the bottom corners of the mirror box between the side and the front and are positioned 1.15" inset from the edge (16") and 1.6" (17.5/18"), see the drawing on Page 46. The front of the mirror box is the same length as the sides, the back being the short board. Mark the two corners using the distance from the edge of the mirror box to the bottom edge of the pivot hole, approximately 1.15" (16") or 1.6" (17.5"/18"), but measure to confirm. Rotate the mirror box so the corners marked for the mounts are down (closest to the work surface).

Mounting the Mirror Cell in the Mirror Box with the Hinge Pins

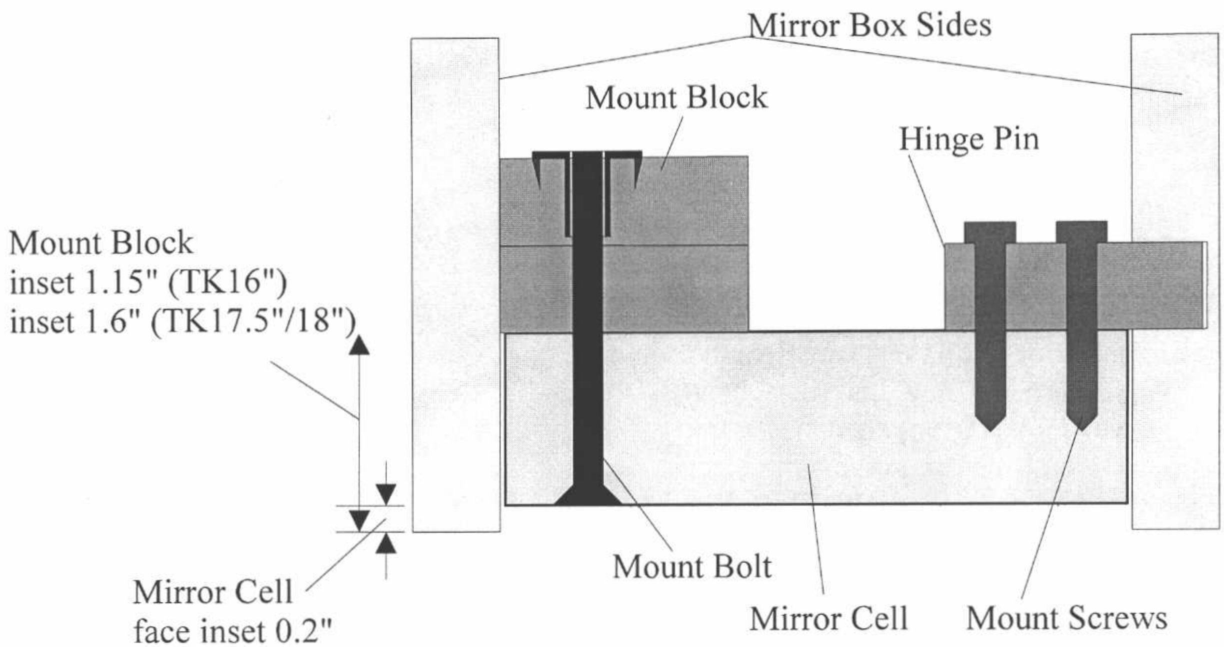


This is a check for mirror cell fit in the mirror box. Place the mirror box on a flat surface with the two pivot mount holes near the surface of the worktable. It is suggested that you cushion the worktable so it will not mar the mirror box or mirror cell. Plug the ends of the hinge pins into the holes in the mirror box.

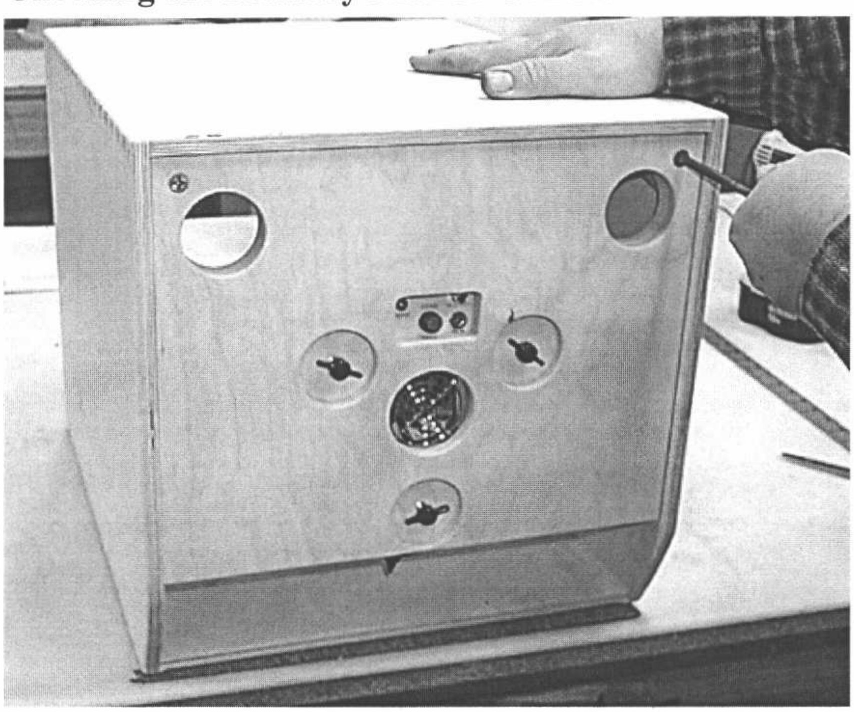
The four hexhead lag screws are used to fasten the primary mirror cell onto the hinge pins. Lift the mirror cell up to the hinge pin, and then fasten with the hardware.

The primary mirror cell should swing up and into the mirror box. If it is tight or rubs sand the edge before finishing the primary mirror cell, so it swings into the mirror box freely. Remove the primary mirror cell for the next step.

With the corners marked and the proper orientation determined, apply epoxy to the two sides that will contact the mirror box. Line the mount block up with the mark and clamp in place being sure that the part of the T-nut showing is toward the top of the mirror box. Use a mixing stick to finish the installation by applying a uniform fillet of epoxy on all edges of the mount block. Allow the epoxy to cure for at least 24 hours.



Checking the Primary Mirror Cell Fit



Reinstall the primary mirror cell hinge pins and primary mirror cell into the mirror box using the four 5/16" x 1.5" (2" on 18" Telekit) Lag bolts. Swing the cell up and slide the 1/4" x 2" screw through the cell into the mount block. Use a Phillips screwdriver to finish tightening. Sand the edges of the mirror cell if there is any interference between the cell and mirror box. After the truss clamps are installed, see Page 48 to finish the mirror box.

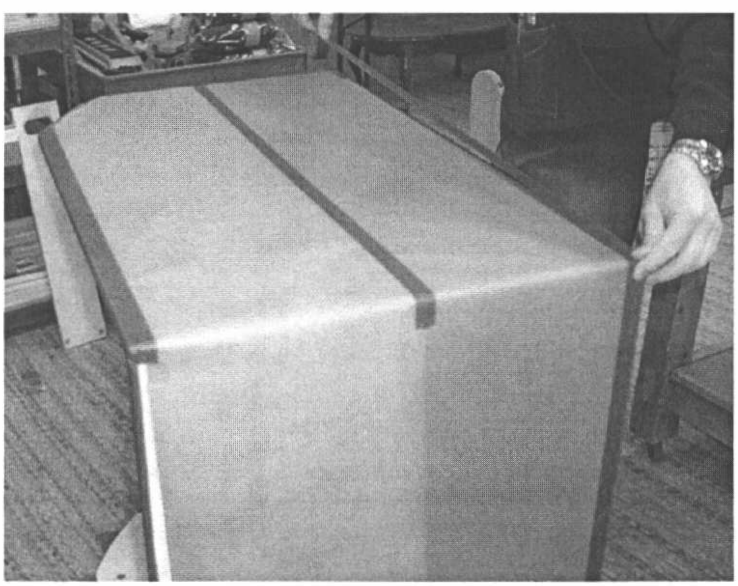
Mirror Box

Finishing the Mirror Box

The mirror box is now ready for finishing. After completing the radius on the edges and fingers as outlined on Page 36, a final fine sanding on the edges and veneer is required. Using sandpaper or a sanding sponge of 220 grit or finer, sand with the grain until "silky" to the touch. Inspect all edges and surfaces for imperfections that would need to be filled with wood putty. Check the veneer surfaces with a strong light or window in front of you. Make sure you have eliminated the "Zebra" pattern of compression variation from the manufacture of the plywood. They appear as subtle lines running perpendicular to the grain with about a 3/8" (9mm) spacing. Thorough fine sanding will remove them, since they are more noticeable after the finish is applied, but avoid sanding too deep. Apply stain at this point if it is being used. It is recommended that you practice on the inside or on the scrap sent along to perfect the application.

Reduce your finish with the appropriate solvent about 1:1 and apply the first finish coat, inside and out. This allows the coating to penetrate fully for better protection and seals the interior, making it possible to coat the interior with a thin coat of flat black. Fine sand the exterior after the seal coat and follow up with 2-3 brush coats or 3-4 spray coats of finish, allowing the finish to dry between coats. Carefully use extra fine sandpaper, 320-400 grit, and then finish with a very thin final coating, using an aerosol if available. This last thin spray coat will give a uniform, professional looking surface, free of brush strokes, sags or runs.

Allow the mirror box a few days to fully cure before coating the inside surface with flat black paint. This prevents the handling or the masking tape from marking the surface. Protect the exterior with paper and masking tape (use the blue easy release). Use an aerosol flat black paint like Rust-Oleum painters touch 2X flat black aerosol or equivalent mineral spirits based paint to coat the inside surfaces. Avoid build-up of paint in the mirror cell hinge mount hole so the hinge pin is not a tight fit.



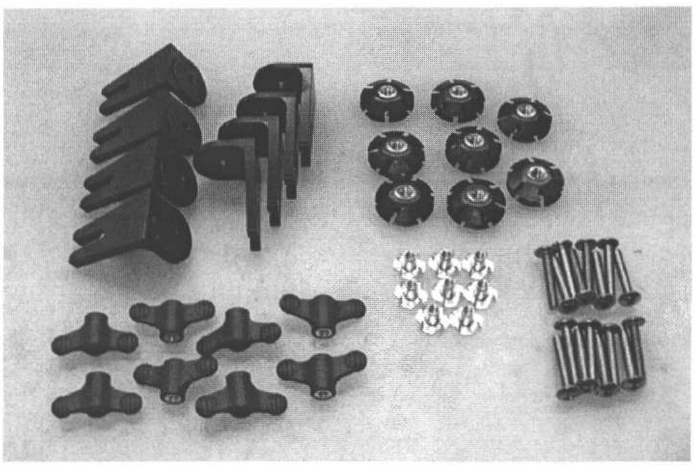
Installing the Lower Truss Fasteners

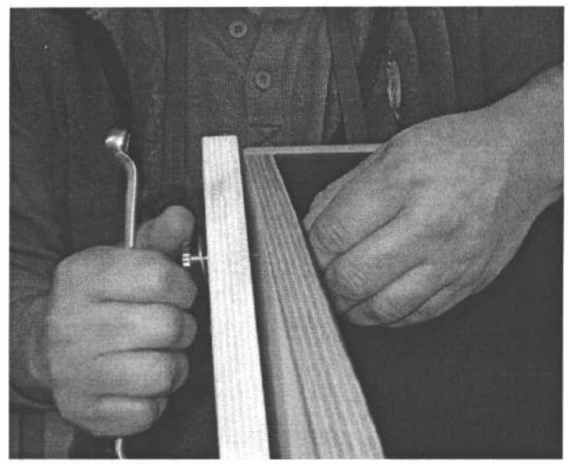
Parts

8	Truss Bracket
8	Knob
8	Mirror Box ¼-20 x 1.5" Truss Head
8	Tube Connector (shown in photo but preinstalled in the trusses)
8	Bracket Bolt ¼-20 x 1.25" Button Head
8	T nut ¼-20
1	Installation Bolt with fender washer ¼-20 x 1.5"

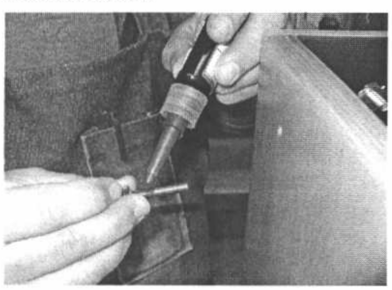
Tools/Supplies

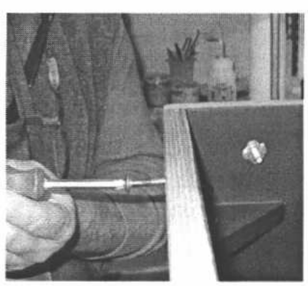
#2 Phillips Screwdriver
Scrap Wood
7/16" wrench





Once the mirror box has been finished and coated with flat black on the interior the Lower Truss Fasteners can be installed. First the T nuts are installed on the inside of the mirror box. Drill a ¼" hole in a piece of scrap wood. Apply a small amount of epoxy on the underside of the Tnut flange and place in the pocket inside the mirror box. Using the scrap wood, place the fender washer over the head of the hex head installation bolt and run through the scrap wood. Place against the outside of the mirror box and thread into the Tnut. Pull the Tnut into the mirror box and insure the flange of the Tnut is below the inside surface of the mirror box. Repeat for all 8 Tnuts. The scrap wood protects the outside of the mirror box, keeping the head of the screw from crushing the outer veneer during installation.





Complete the installation by placing a small amount of Loc-tite near the head of a truss head screw and thread into the Tnut from the outside of the mirror box. Tighten the screw but not to the point of crushing the veneer. The Loc-tite will hold the screw securely in the Tnut. For faster, consistent collimation, place spots (red paint or fingernail polish) at each corner. Number them 1-4 for each corner and mark the top plug of each truss to match.

Altitude Bearings

Parts

2	Altitude bearings
2	Laminate Strips

Hardware

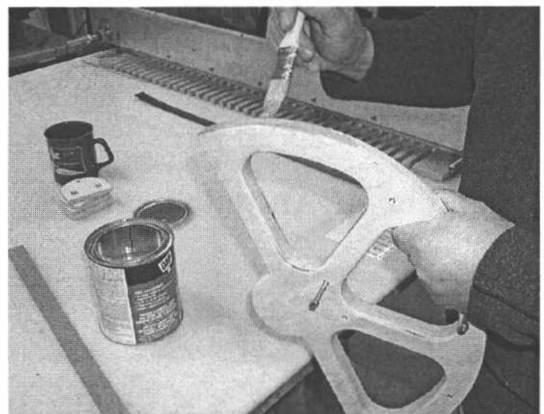
12	#10-32 x 1" flathead bolts
2	#10 x 1.25" screws
2	#10 Nylon stop washers

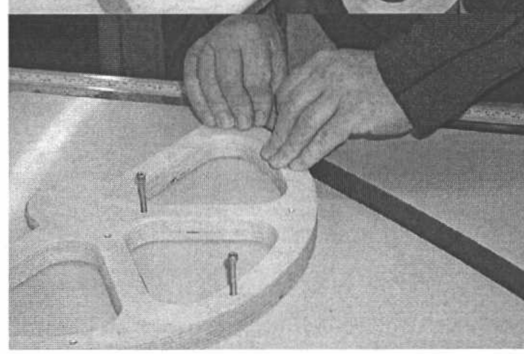
Tools / Supplies

	Contact cement
2	Clamps
	Disposable brush

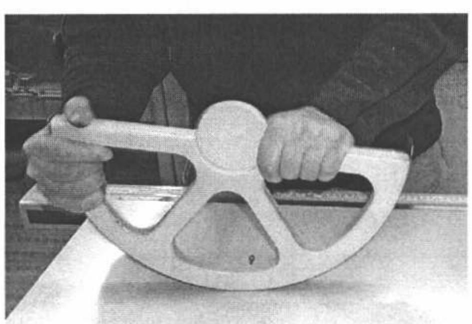
Installing the Altitude Bearing Laminate

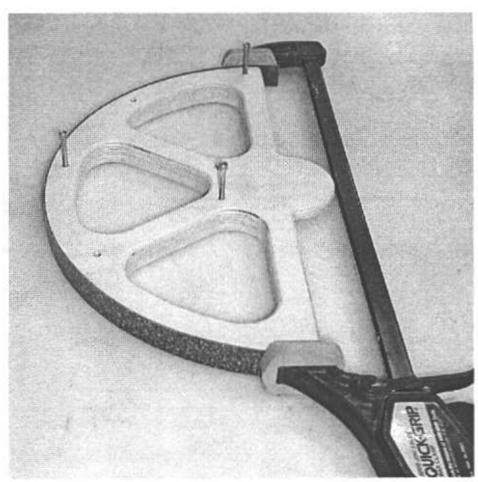
The textured laminate is applied to the round edge of both bearings. It is helpful to roll the laminate strips with the "granite" textured color surface out for a few hours to several days. This will pre-curve the strips and allow them to conform to the curve of the altitude bearing better. Coat the edge of the altitude bearing and the backside of the laminate with contact cement. The edge grain of the altitude bearing is very porous and may require two coats. Using a disposable brush apply the contact adhesive using brushstrokes from the center to the edge. This helps keep glue off the veneer surfaces.

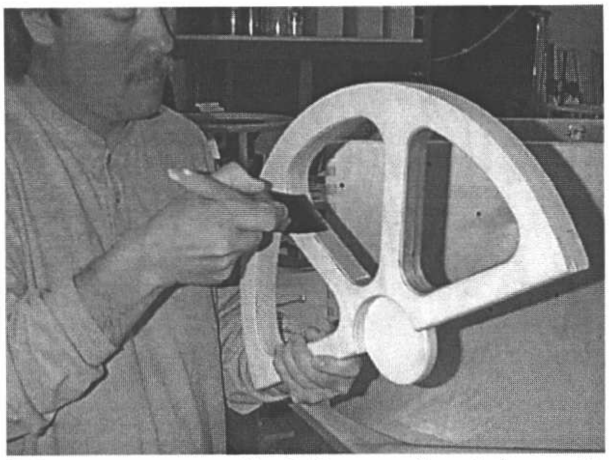




After both of the glue surfaces have dried for 15-20 minutes and lost their gloss, apply the laminate. Lay the bearing flat on a table with the outside face of the bearing down. Start from one end of the bearing, applying even pressure down and against the bearing as you wrap the laminate onto the bearing. Roll the bearing from the center out with pressure, a table or carpet work well. It is impossible to remove the laminate and start over, so be very careful to start the laminate straight. Use a bar clamp across the top to hold the ends of the laminate tight. Let the adhesive set for 24 hours. You can trim the excess length off the ends with a utility knife. Score the back and bend the end toward the top of the bearing, snapping the extra length off.

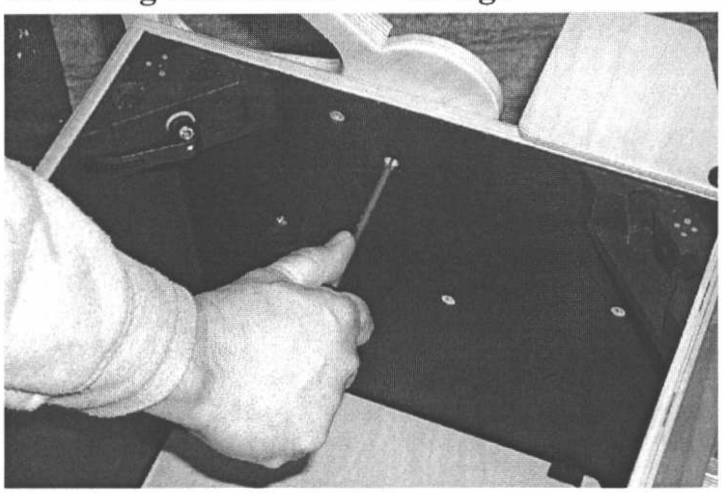




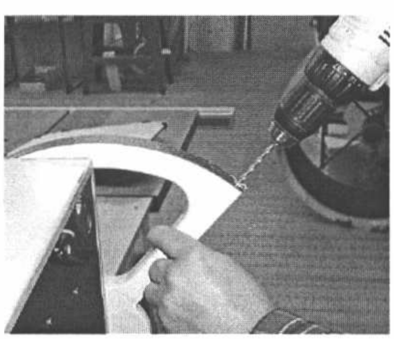


The laminate is cut slightly wider than the bearing to allow one side to be sanded so both sides are flush. By placing the outside face of the bearing down there will be minimal sanding on that side while most of the flush sanding will be on the backside. Sand the edges flush with the sander. Sand or file the ends flush and round the ends over with a sander. Sand the bearings starting with medium and ending with fine. Apply a diluted coat of finish for maximum penetration and then fine sand to remove any roughness. You may want to mask the laminate surface to keep off finish. Complete the finish with 2-3 more coats, a final fine sand and then a light aerosol coat of the same finish. Allow the bearings at least 2-3 days to dry since the pressure of mounting them will cause the slightest tackiness to glue the bearings to the mirror box.

Installing the Altitude Bearings



There is a right and a left altitude bearing having mirror image bolt holes. By placing the altitude bearing up to the mirror box you can determine which bearing goes on which side by aligning the bolt holes. There are six #10 x 1" flathead bolts for each altitude bearing. The one screw hole under the truss clamp is tight, use a screwdriver set into the screw to tap it in. With the six screws protruding, position the altitude bearing on the screws and start all by hand, then tighten. Make sure the coatings on the mirror box and altitude bearing are fully cured so the bearing will not stick and make future removal difficult. You can touch-up the bolt heads with flat black if desired.



The altitude stops are installed in the end of the altitude bearing. Center the stop on the end of the bearing flush against the top edge. Mark and drill a hole and using light pressure, 3/16" diameter just through the laminate only. Finish the hole with a 5/32" bit 1.25" deep. By enlarging the hole through the laminate the #10 screw will not split the laminate. Install both stops in the bearings. These keep the telescope from pointing below horizon and the mirror falling forward against the retainers.

Rocker Box

Parts

2	Rocker box sides
2	Rocker box ends
1	Rocker box bottom
1	Laminate square
20	Bottom screws #6 x 1.25"
1	Pivot Bushing
1	Wood Spacer

Epoxy glue kit:
Epoxy A
Epoxy B
Beaker
Nitrile gloves
Mixing sticks

Tools/Supplies

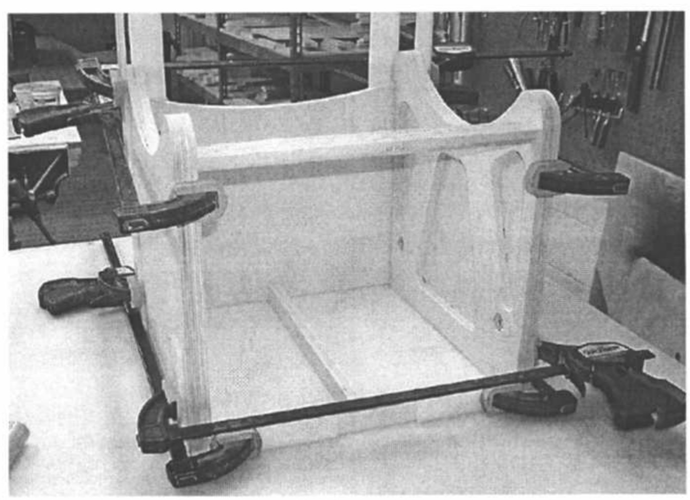
	Acetone
	Paper towels
6'x 6'	Plastic drop cloth
7	Bar clamps
	Drill bit 7/64", 9/64" and 1/2"
	Countersink

Sandpaper: 120, 220, 320 or equivalent
Strip of sacrificial wood
Laminate contact cement
Pen/pencil
2" Disposable brush

Preparing the Parts for Assembly

The first step is to sand the inside of the rocker box and the rocker box bottom. The inside of the box is pocketed. Remember the inside of the box will be painted flat black so only a rough 80 - 120 grit sanding is necessary. Use caution when handling the parts before assembly, the finger joints are fragile and sharp until epoxied. Should a veneer chip occur on the fingers, you can take scrap wood and peel the veneer for repairs. Use fast setting epoxy for this type of repair, being careful to not get glue on the surface. The outer surfaces are sanded after assembly.

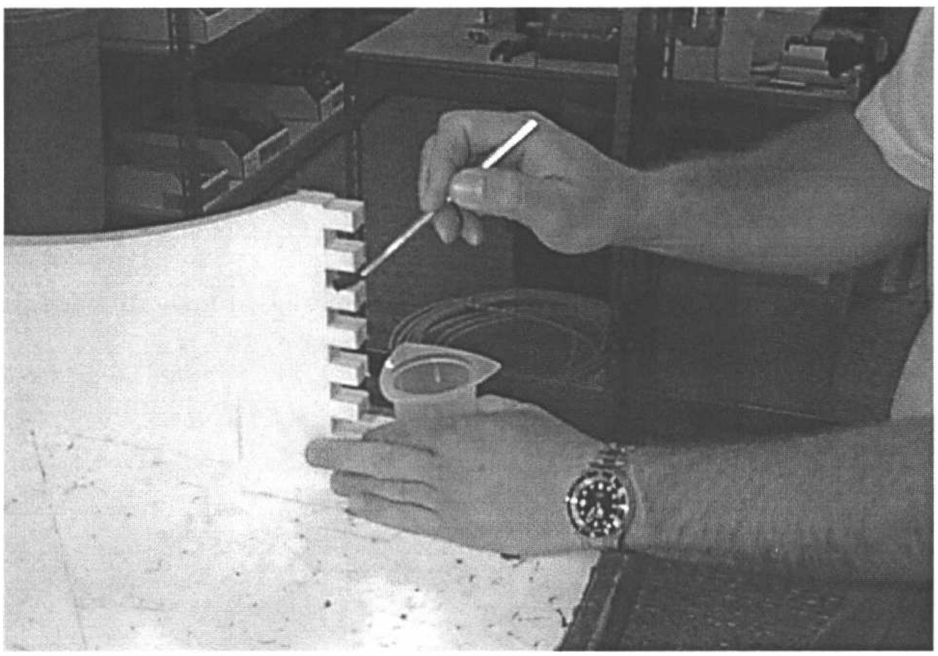
Second, dry fit the rocker box sides. This allows you to familiarize yourself with the parts before you apply any epoxy and insures they fit tight. The parts should slide easily into place. DO NOT FORCE THEM. If they do not slide easily together, file or sand the tight fingers and remove any glue from manufacture.



Using clamps, snug up the sides, front and back and check for square. Flexing is all it should take to bring the sides into square. Another way to check this is to measure the sides across the diagonal, making sure both diagonal measurements are equal.

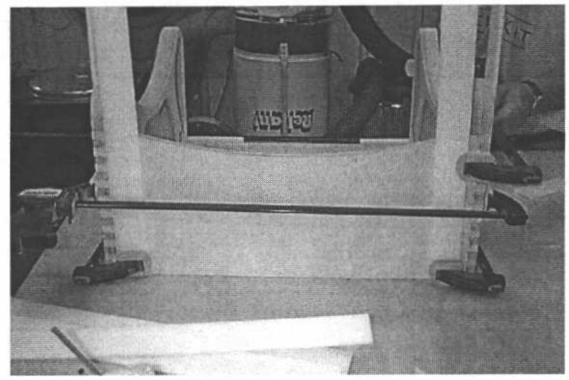
Assembling the Rocker Box

You will need to cut eight clamping strips. These are pieces of scrap wood or plastic that will be placed next to the epoxied fingerjoints. The fingers extend 20-30 thousandths above the surface so it is not possible to clamp on top of them at the edges. It is suggested wood strips about 0.25" thick and about an inch wide and a foot long. Try to minimize any epoxy on the wood strips as it will make removal difficult and possibly tear the veneer. Wood can be covered with plastic wrap (Saran or equivalent) using masking tape to hold the plastic in place. Thick polyethylene strips are ideal since the epoxy won't adhere to them. The four sides of the Rocker Box are epoxied first. Place a plastic sheet on your worktable in order to keep excess epoxy from becoming a permanent part of your workbench. It will take 50-60 ml total of mixed epoxy to glue a 10-15" Rocker Box. For a proper mixture, you need to use equal portions (a mix ratio of 1 to 1) of the epoxy (white) and hardener (tan).



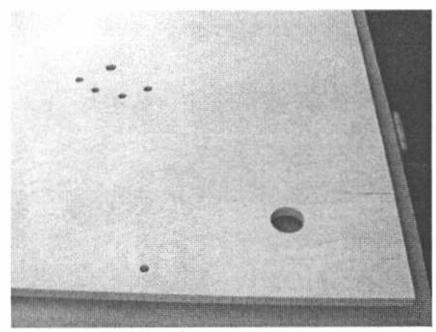
There are two methods for applying the epoxy. The first method is to dry fit all four sides, then separate one corner and apply epoxy to all contacting surfaces of the fingers. After you are done with the first corner, slowly slide the parts back together and move onto another corner. This method is more time consuming, but is easier for one person to do. Use a liberal amount of epoxy. You want enough on the fingers to ooze out when you fit the parts together. Don't worry about getting epoxy on the veneer of the wood, even the large, dry clumps will sand off, but try to minimize this to speed sanding later. Apply enough epoxy so it will form a good, solid joint with no gaps. Do not wipe off the excess yet.

The second method of applying the epoxy is easier if you have help or would like to apply the adhesive in less time. Each person applies adhesive to the finger joints of a separate side. When finished applying the adhesive to all eight ends, fit the parts together. Do not wipe off the excess epoxy.

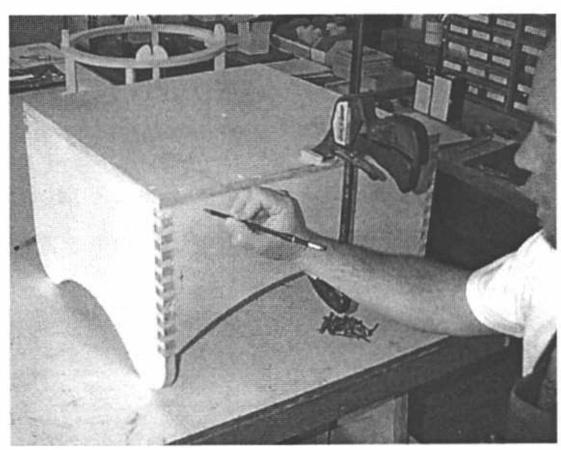


It will be easier to clamp if you have a friend around to help. Keep in mind that you can not clamp directly on the corners, or fingerjoints. As mentioned earlier, the fingers project above the surface to insure a flush sanded joint. This makes it necessary to clamp to the side to apply proper clamp force on the appropriate panels. The backside of the Rocker Box is shorter so you will need to use an internal spacer during the epoxying step to keep the sides from leaning in with the clamp pressure. Apply even pressure around the box, tightening each clamp by small amounts. At this time, use the excess epoxy on the exterior to fill any gaps next to the finger joints. Apply an epoxy fillet to the inside corners, using a mix stick or your finger to form the fillet. Acetone or denatured alcohol will clean away any unwanted epoxy on the wood, or you. Check the box periodically to make sure a clamp hasn't slipped or shifted. Keep the box clamped for a minimum of 24 hours or longer if done in a cool workplace.

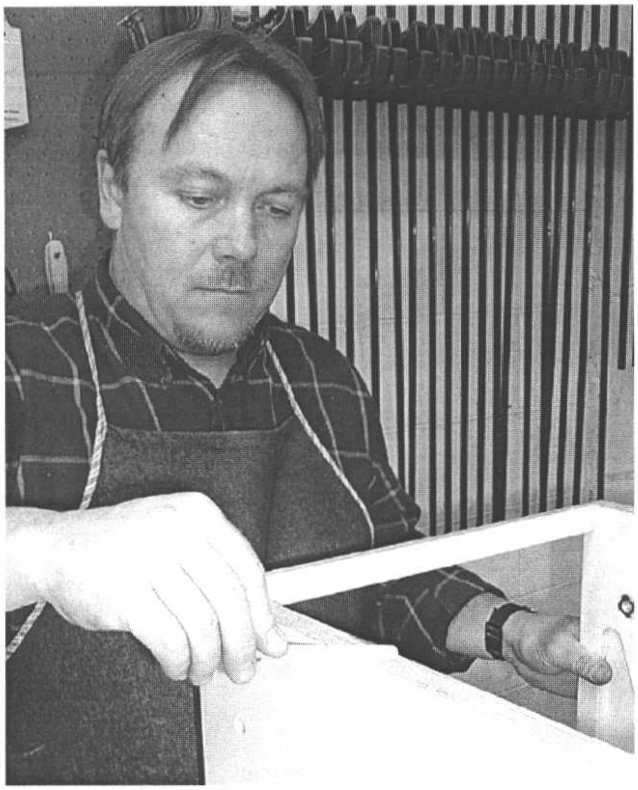
Preparing the Rocker Box for Bottom Installation



The bottom edges of the assembled rocker box are now sanded flat. Place the rocker box with the top down, and sand away any excess epoxy on the bottom edges. Place the bottom panel against the rocker box to check for fit. **NOTE,** if you have a rocker box bottom with predrilled holes for a drive, the larger hole is oriented toward the taller front board. Don't worry about small gaps, the pressure of the screws will pull the bottom down onto the sides. Mark the rocker box bottom (the center stepped hole is the top of the bottom board) for the edge holes. They are drilled 0.3" in from the edge on the front and back where the wood is single thick and 0.5" in on the sides where the wood is double thick. The first hole is 1.25" from the corner and the other two are in from the corner screws 4" and halfway between the center and edge screw. This makes a total of 4 per side. A 9/64" drill is used for the through hole in the single layer bottom panel, then countersink for the flathead of the #6 particle board screw.



After drilling the Rocker Box bottom, clamp it on the Rocker Box in order to mark the pilot holes that go into the rocker box sides. The bottom is positioned flush or with a slight overhang at all edges. Later any extra length of the bottom can be sanded or routed flush with the sides. Once the bottom is in place, use a couple clamps to hold it and mark one side with a X spanning the bottom and side. This gives you a registration mark to replace the bottom. Use the 7/64" bit to drill the screw pilot into the sides and install a screw hand tight. With the clamps and a screw to maintain the bottom position, drill all the screw pilot holes down into the sides. You can use the internal spacer to push the sides into place, if they are bowed, as you drill the holes and clamp.



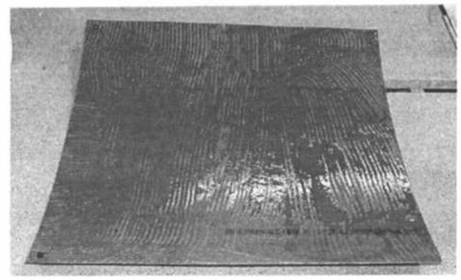
Remove the bottom and clean off any sawdust or splinters and sand the bottom panel to remove any roughness when the drill broke through so the bottom sits flush. Apply epoxy to the bottom edges of the rocker box and using the registration "X", replace the bottom. You may find it convenient to place the rocker box on the floor to drive the screws. Install all the screws, then flip the rocker box over. Apply a fillet of epoxy inside the rocker box around all four sides. Let the bottom cure for 24 - 48 hours.

Speed and uniformity are improved when a router with a piloted bearing is used to flush trim the fingers and bottom edge. If a sander is used, install fresh sandpaper and make sure the epoxy has cured fully so it doesn't "fill" the sandpaper. This allows the sandpaper to cut the edges of the fingers and bottom edge faster than the surface veneer. Fine or worn paper will not cut the edges as fast and leaves a noticeable high and low surface across the fingers.

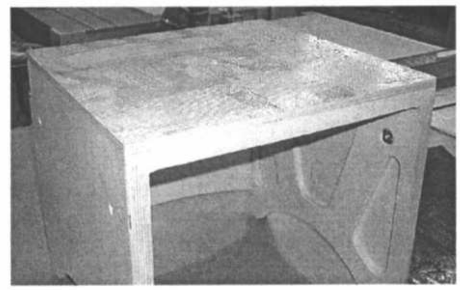
A mechanical sander improves speed and consistency. Use a 120 grit paper then progress to 150-180 grit, then 220 (or equivalent grits). You can tell when the epoxy has been removed; the wood will no longer look translucent. Use caution to avoid sanding all the way through the first layer of veneer and keep the sander as close to the edge as possible. Deep sanding marks are difficult to remove from the face veneer. It is recommended that you round the corners on any exposed edges, this protects the veneer from chipping.

There are a number of different methods for rounding them over. By hand, you can cut the round over in a template and sand until the edges match the template. The fastest and most precise method is to use a router, (see Page 97). If you have never used a router, a book on router use can be obtained in order to familiarize yourself with basic router principles. Use a 1/8" - 3/16" radius round-over bit on the finger joints and a 1/8" - 3/16" radius round over on the other edges of the Rocker Box.

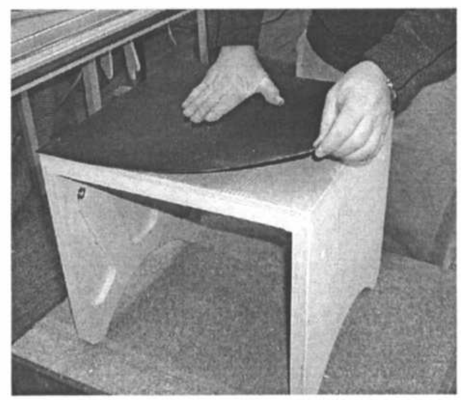
Installing the Laminate onto the Bottom of the Rocker Box



Sand the bottom clear of any bumps and clean away any dust. The screws can be filled in with wood putty to give a smooth consistent surface. Use an inexpensive disposable brush and apply laminate contact cement evenly to the entire bottom of the laminate (rough side, not the black side). Be aware of any pieces of dust or dirt that may cause bumps in the laminate. Do not "rebrush" the glue after application, as it will cause the contact cement to "ball" and have high spots.

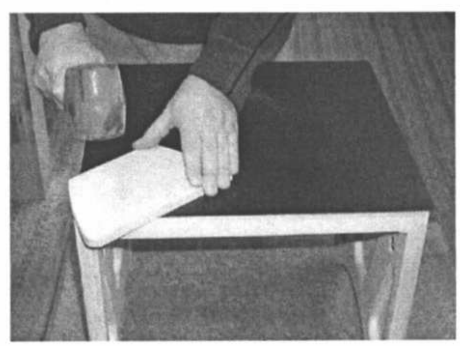


Next, apply the contact cement to the entire bottom of the rocker box, following the instructions on the container. Work quickly and ventilate the work area. When the contact cement has lost its gloss (15-20 minutes), it is time to apply the bottom. Place the laminate on the rocker box, making sure it extends over all sides a small amount.

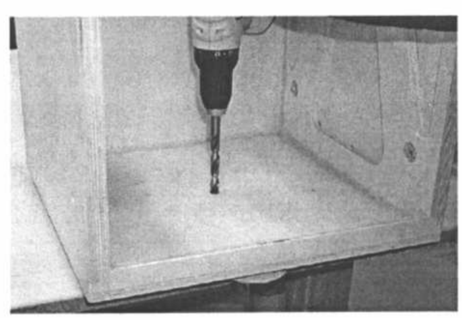


Caution: Make sure you place the laminate on as straight as possible as it is impossible to reposition it once the two contact cement surfaces have touched.

After you have pressed the laminate on by hand, use a piece of wood to press down the edges. Use a block of wood and a hammer to tap down the middle. Next, sand, file, or route the edges of the laminate flush with the bottom.



After it is flush, you need to put a bevel or small radius round over on the edge to protect the laminate. A bevel is a small angled edge like those on laminate counter tops. Sand, file or route this as well. The bottom edges are a 0.12" radius or a 0.12" bevel. Now you can finish sand your rocker box sides. Once fine-sanded you can then finish the rocker box as outlined on Page 19. You may want to mask the bottom edges of the laminate with masking tape, in case you accidentally have over-spray or drips.



Set the rocker box on a piece of sacrifice wood and drill the pivot bushing hole through with a 1/2" bit. You can also use a small bit, drill many holes at the edge, and then file the hole in the laminate smooth if you don't have a 1/2" bit.

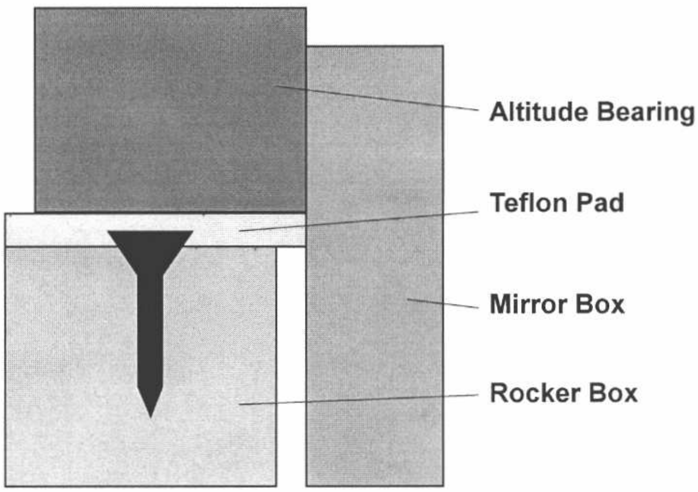
Altitude Bearing Pads

Parts

4 Altitude Teflon pads
8 #8 x 1/2" screws

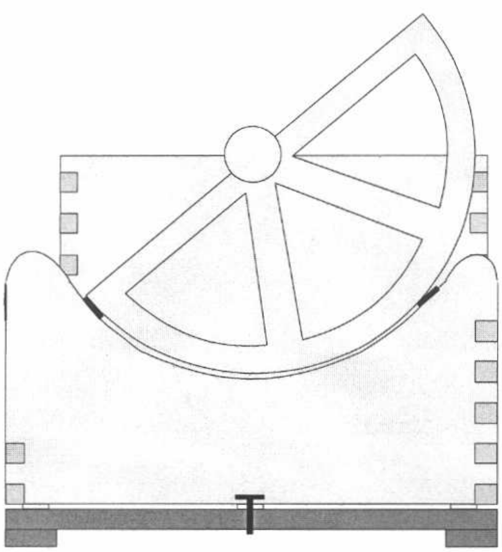
Tools/Supplies

Phillips screwdriver
Drill
Drill bit 7/64"



Mounting the Altitude Teflon Pads on the Rocker Box

The 4 Teflon altitude bearing pads are 1.1" wide and the rocker box is 1" wide. This allows 0.10" of overhang of the Teflon pad towards the inside of the rocker box. This overhang centers the mirror box in the rocker box and allows the Teflon to do double duty as an altitude bearing pad and preventing any contact between the mirror box and rocker box.



Place the mirror box with attached altitude bearings (less primary mirror) in the rocker box. With the mirror box pointed up mark the edge of the altitude bearing. Carefully rotate the mirror box 90 degrees and mark the edge of the altitude bearing for the other side. These marks on the rocker box represent where the top edge of the Teflon is positioned. Position the pads on these marks and inset them 0.10" toward the center of the mirror box as per the drawing above. Note the pads are drilled off-center so when the Teflon is offset toward the center, the holes are centered on the rocker box side. The two holes in each Teflon pad are then marked and a 7/64" pilot hole is drilled in the rocker box. Secure the Teflon with the #8 x 1/2" screws provided.

Rotate the mirror box to insure that the two boxes are held apart an equal amount between both Teflon pads. Check to see if the Teflon bearing inset is not putting undue force on the mirror box and causing it to drag or bind. Shave a small amount off the Teflon bearing with a utility knife if this is the case and recheck.

Truss Fasteners

Parts

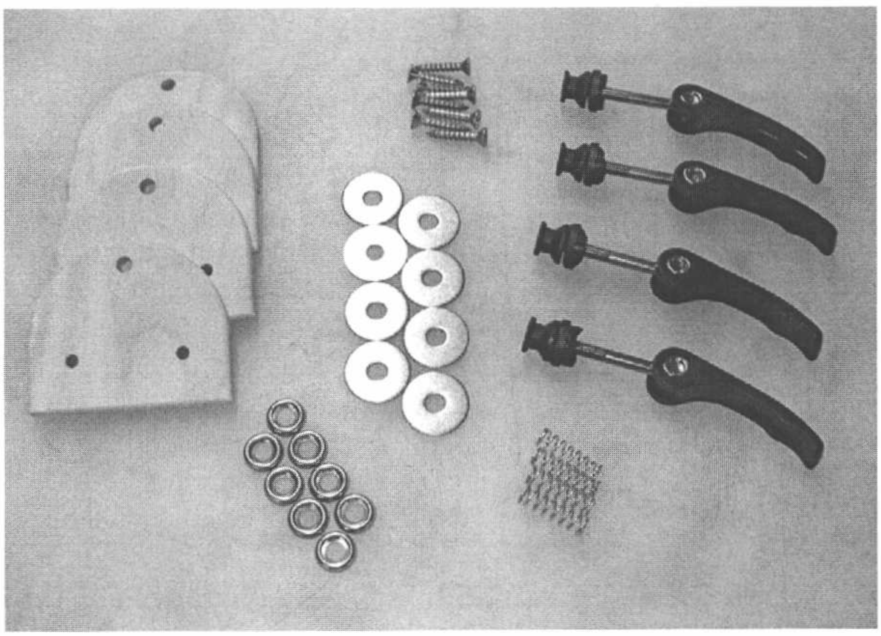
4 Fastening plates

Hardware

4 Springs - 1/4" ID
4 Cam levers w/nut
8 Washers - 1/4" fender
8 Truss screws #10 x 1" FH
8 Finish Washers
8 Wood truss plugs

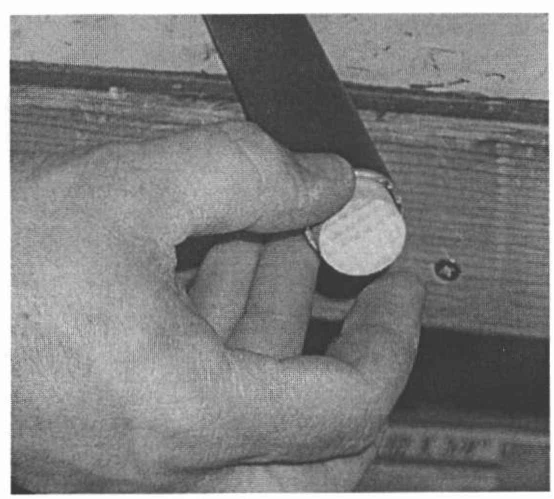
Tools / Supplies

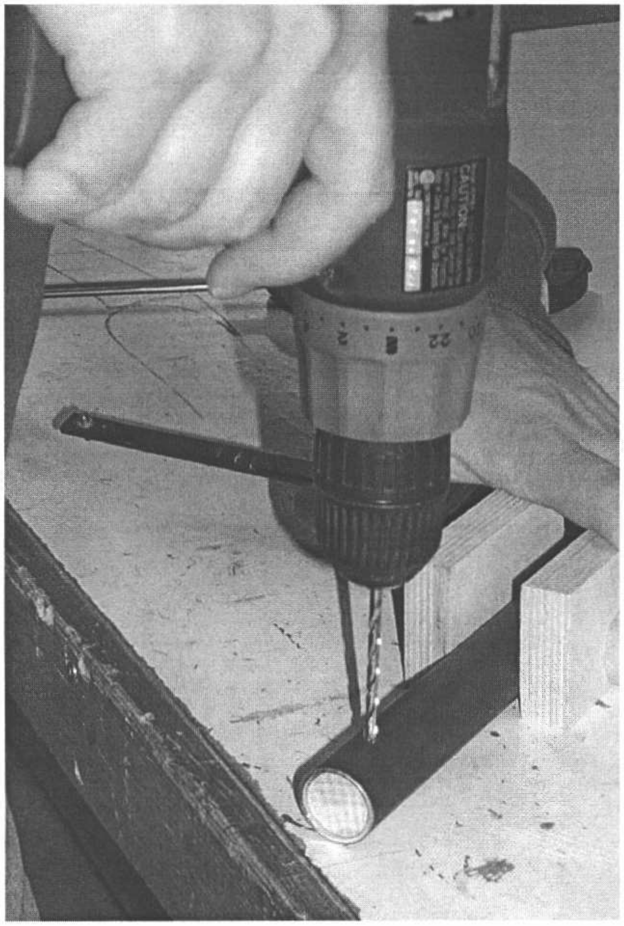
Drill
Brushes for glue
Drill bits 1/8", 11/64", 3/16
Epoxy glue kit



Installing the Dowel Plugs into the Trusses

Check the fit of the dowel plugs into the top end (the covering extends to the end at the top) of the truss tubes. The dowels are usually loose so just fill the gap with epoxy. For the best adhesion, lightly sand and then clean the first 2" of the inside of the truss tube with solvent. Mix a small amount of epoxy (20-25 ml) and apply some into the truss tube and some around a wood plug. Insert the plug in a continuous twisting motion to spread the epoxy uniformly as the plug goes in. Slide the plug in until it is flush with the end. Wipe any excess epoxy away. Place masking tape over the end of the truss tube, press to seal tightly and then set the truss tube upright to cure with the plug at the bottom.



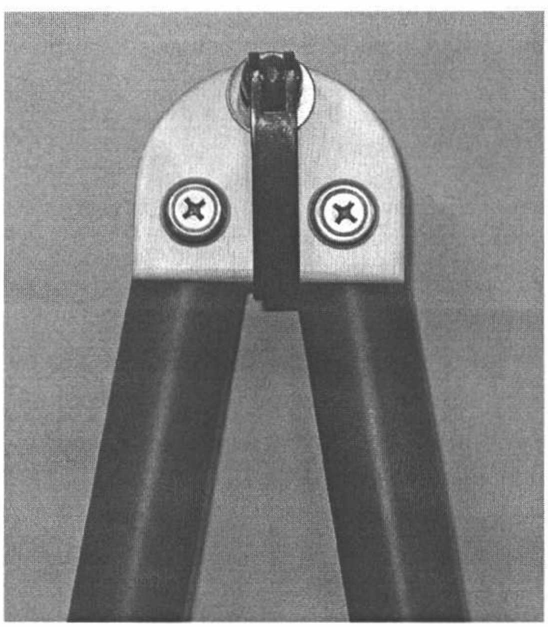


Installing the Dowel Plugs into the Trusses (cont.)

This allows the epoxy and plug to be flush with the top and gives a uniform flat end. Be sure to work on a covered table and place something nonporous under the tubes in case of minor leakage. Check after a short time to insure that the tape has formed a tight seal and epoxy is not running out. When cured, remove the tape from the end of the truss tube and sand smooth and flush if necessary.

Drilling the Truss Tubes for the Fastening Plate

Measure 1/2" from the plugged end of the truss tube and mark. Drill a 11/64" hole through the truss tube and the dowel plug, stopping before going through the opposite side of the truss. Repeat for all 8 truss tubes. Next drill a 3/16" through just the aluminum tube, but not into the wood plug so the screw will start easier. Be careful not to drill the larger hole into the wood plug, the drill will try to pull into the wood as soon as it breaks through the aluminum truss. A slow drill speed helps and you can stop the hole just before it completely goes through the truss. The screw will thread through a small amount of aluminum.

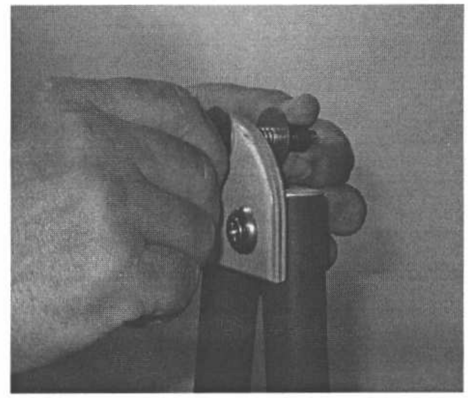


Installing the Fastening Plates onto the Trusses

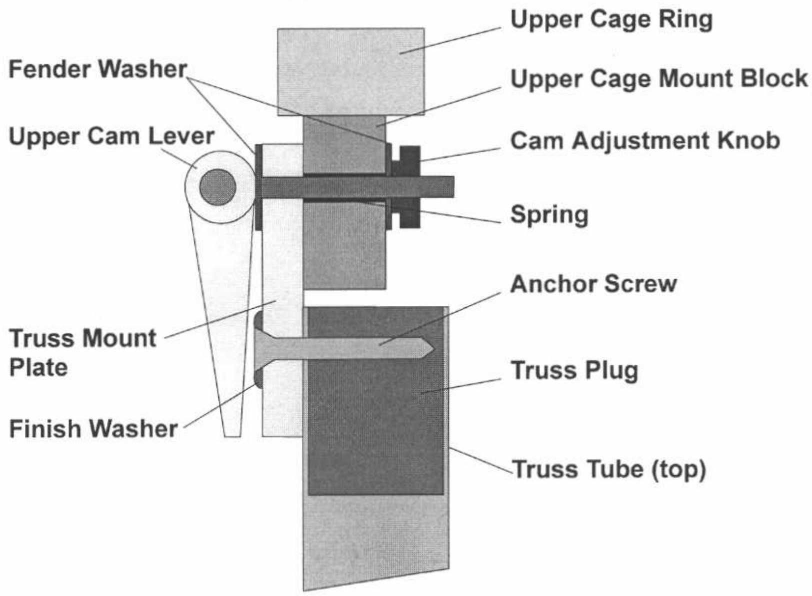
Place two trusses next to each other with the pre-drilled holes up. A drop of white or yellow wood glue on the screw tip will keep the screws from loosening. Position the finished fastening plate over the holes, slide a finish washer over the screw and drive the #10 x 1" screw into the plug in the truss. Tighten until the plate is snug but allows the truss to rotate on the plate with a little resistance. Repeat for all the trusses. You will now have four pairs of truss tubes.

Installing the Cam Handles and Hardware on the Fastening Plates

A 1/4" stainless steel fender washer is placed on the bolt and cam assembly. This is then inserted through the hole in the backside of the fastening plate followed by a spring, a fender washer and then the thumbnut. Adjust the pressure by loosening the cam and turning the back thumb knob. The cam should have moderate resistance at the halfway point and greater pressure when fully down. Avoid adjusting the bolt so tight that the front stainless washer compresses the wood. Repeat for all four fastening plates. This completes the upper truss fastener installation.

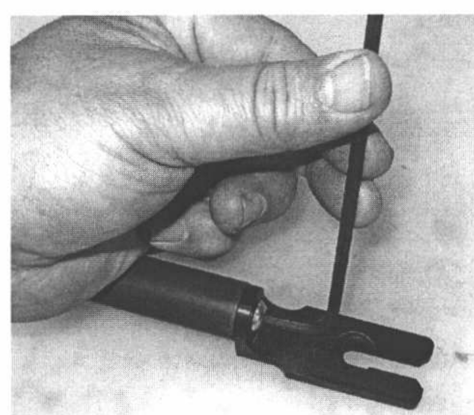


Upper Truss Fastener



Installation of the Lower Truss Fasteners

Thread each knob part way on the bolts in the mirror box. Place a small amount of Lock-tite on a screw and insert through the countersunk hole in a bracket and thread into the bottom of a truss into the pre-installed tube connector. Lay a pair of trusses on a table and orient the truss plate down against the table. Orient the truss bracket with the slot down and tighten.



Final Assembly of the Trusses

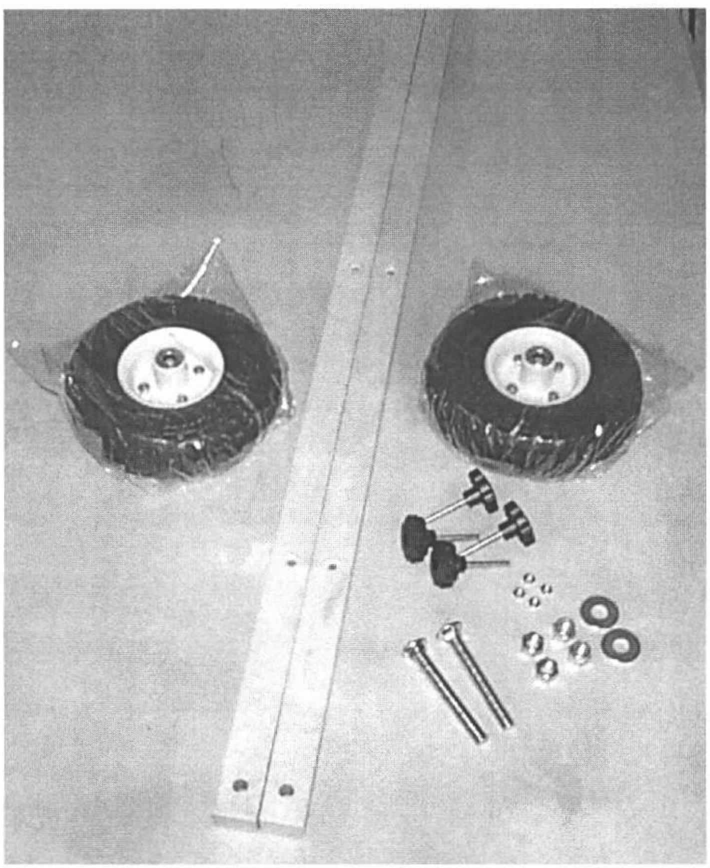
A 1/2" x 1" piece of Velcro "hook" is placed on the bottom of the truss cover where it is flush with the mirror box. Orient the Velcro toward the outer side. This is used to hold the bottom of the light shroud from pulling up over the trusses. Check the shroud fit first, often the shroud will stay down without the Velcro.

Transport Wheels

Parts				Tools/Supplies	
2	Handles	Wood 60"		Wrench - 15/16" (24mm)	
2	Wheels	10" x 3.5" semi-pneumatic		Locktite or epoxy	
Hardware					
2	Wheel bolt	5/8" x 5" carriage	8	Felt pads	black PVC
2	Washers	5/8" flat zinc	4	Washer	5/16" SS
2	Nuts	5/8" zinc	4	Washer	Nylon 5/16"
2	Locknuts	5/8" nylock	4	"T" Nut	5/16" x 3/8" Zinc
4	Knob	Wood 2.25"	4	Knob Bolt	5/16-18 x 3" Fe/Zn
4	Nuts	5/16" jam nut			

Finishing the handles

Sand and finish the handles. Extra coats of finish on the handles are a good idea since they get a lot of wear and tear.

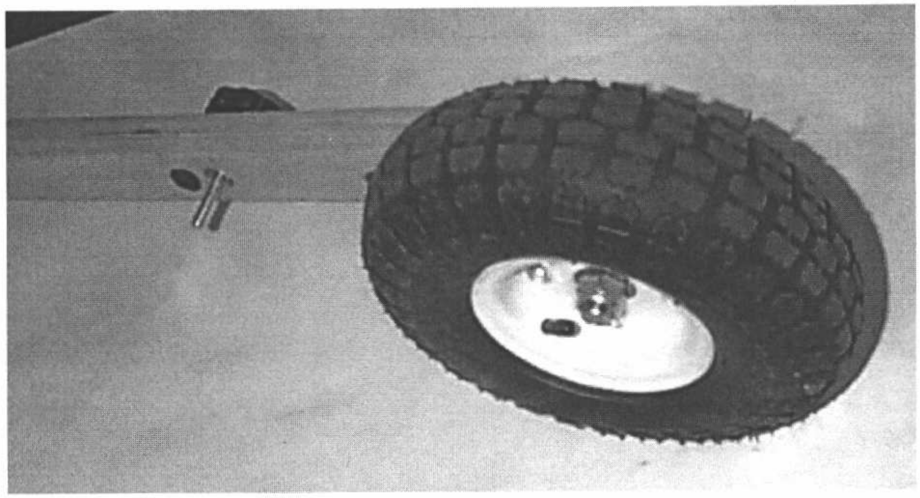


Mounting the Wheel Axle on the Handles

Mount the 5/8" x 5" wheel axle bolt through the end of each handle so the square below the head seats into the countersunk hole. Position the flat washer and regular nut onto the bolt and tighten, pulling the square portion under the bolt head into the handle. This swage fit locks the bolt in the handle. Put the wheel on, long center protrusion first. Fasten the wheel onto the bolt with the locknut (the one with the nylon insert). Tighten the nut then back it off a quarter turn so the wheel turns freely.

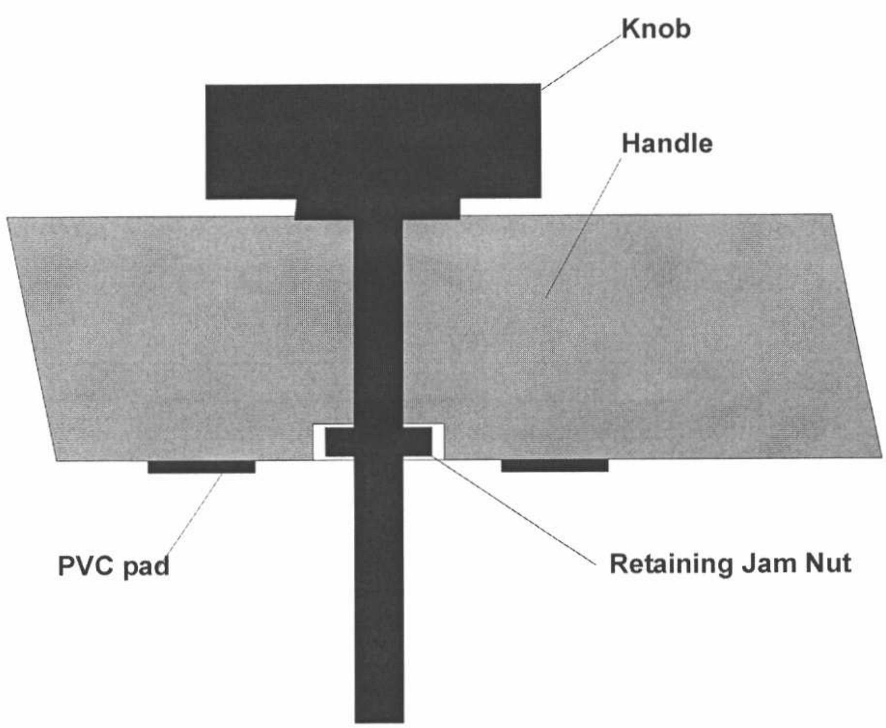
Finish and Install Knobs

Sand the wooden knob and finish with 2-3 coats of clear polyurethane. When dry, slide a nylon washer on the bolt and install in the handle with the bolt protruding on the side of the handle with the wheel (see photo P. 61). Thread a 5/16" stainless jam nut onto the bolt and thread on until the nut is below the surface in the handle countersink. Adjust the nut so the knob rotates freely and then locktight or superglue the nut in place. To complete the transport handles apply the 8 PVC cushions about 1" away from the bolt on each side of the bolt. This will cushion the handle against the rocker box.



Finish the wood knobs with polyurethane and when dry, slide a nylon washer up against the flange of the "T" nut. Position the knob with attached stud into the hole. Thread the 5/16" jam nut on the bolt so it is in the countersink in the handle. Snug this nut onto the stud and then back off about 1/4 turn, this insures the knob and threaded stud turn freely in the handle. Locktite or superglue the nut in place. This will allow the bolt to be retained in the handle and thread into the rocker box. Insure that the jam nut is below the surface of the handle so it will not contact the side of the rocker box when the handle is installed.

Position a PVC pad on the handle at each side of the bolt so it cushions the handle when bolted on the rocker box. This completes the transport handle assembly.



Final Assembly

Parts

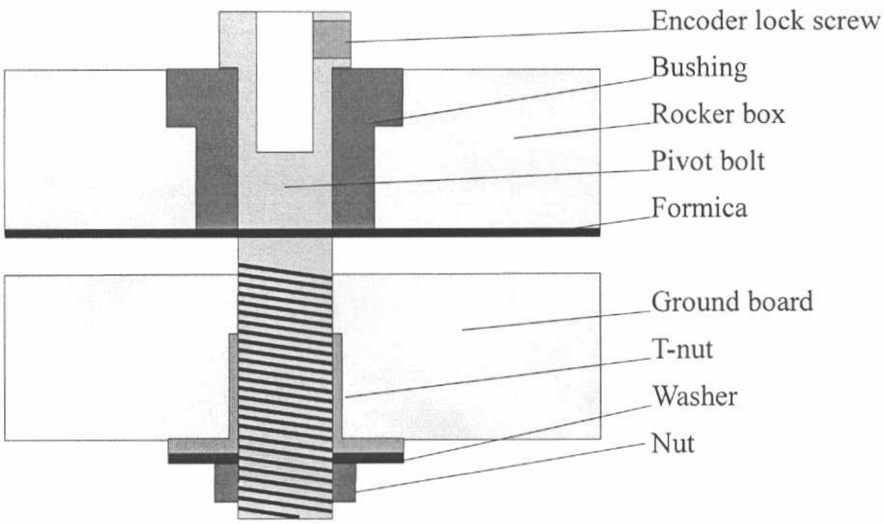
Completed ground board
Completed rocker box
Primary and secondary mirrors
Completed mirror box with altitude bearings and primary mirror cell
Completed upper cage
Completed trusses

Tools/Supplies

Scissors
Wrench – 9/16" (2)

Hardware

Pivot bolt 3/8" x 1.5"
3/8" nut
3/8" washer

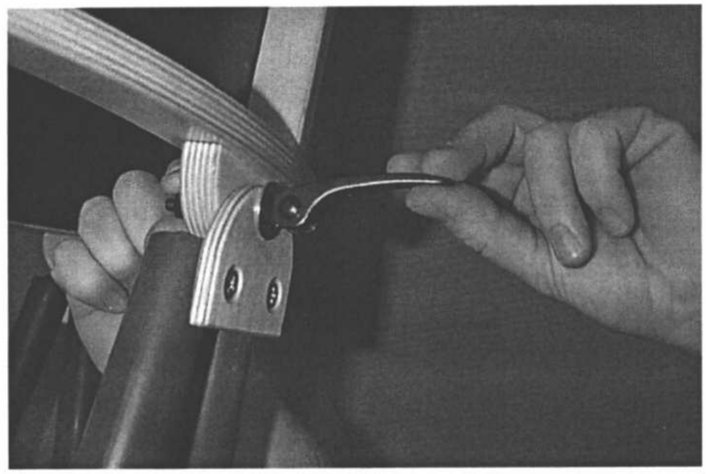


Connecting the Rocker Box to the Ground Board

The rocker box is centered on the ground board and the pivot bolt is inserted through the bronze bushing in the bottom of the rocker box and into the T-nut in the ground board. It is tightened until there is a fraction of play between the two, as felt when raising one corner of the rocker box. The rocker box will turn freely with this adjustment. Install the 3/8" washer and jam nut on the bottom of the pivot bolt and tighten. It is necessary to hold the head of the pivot bolt with a wrench while tightening the nut on the bottom of the ground board. While this locks the pivot bolt to the groundboard, you may want to use some removable locktite to hold it securely. Any "coarseness" felt in the motion is due to the bearings not being loaded with the total telescope weight. They will smooth out as the rest of the weight is added. Adjust the bearings for proper contact against the rocker box. Check by sighting into the gap between ground board and rocker box bottom. This insures that both bearing sets are riding with their full length against the rocker box bottom. If only an outer or inner bearing is contacting the rocker box bottom, use aluminum foil to shim under the axle to bring all bearings flush. This is necessary to prevent unnecessary wear of the laminate.

Assembling the Mirror Box, Trusses, and Cage

Place the mirror box into the rocker box. The two Teflon altitude pads will keep the mirror box centered since they overhang towards the center of the rocker box, as set-up on Page 56. Push the mirror box through its travel to check clearance. You can place 2-3 felt pads on the inside of the back of the rocker box to cushion the mirror box when it is swung up to just past zenith and contacts the rocker box. The pairs of trusses are inserted into the bottom truss fasteners with the cam handle on the upper fasteners facing out, and then the lower fasteners are tightened.



The light shroud is placed over the trusses next. Loosen the upper cam fastener and place the cage on the fastener bolt. Make sure the cage is seated fully on the fastener bolt and then tighten the cam levers. Each upper fastener can be adjusted by the thumbnut on the inside end of the fastener bolt and then closing the cam. The cam will have some resistance at half position and close tightly when rotated down. Avoid over-tightening, the cam has enough force to compress the wood. Pull the light shroud over the bottom ring on the upper cage and down over the bottom of the trusses.

Installing the Primary and Secondary Mirror

The two bolts are removed from the primary mirror cell, and by holding the cell at the two holes at the top, lowered onto a solid surface, such as a box or books. The retainers are loosened and swiveled out of the way and the sling loosened. **Remove any watches, rings or loose items from your clothes or pockets.** Lower the mirror into the cell. Rotate and tighten the retainers and tension the sling so the mirror is equally spaced from all three locating posts. Grip tools firmly and make sure there are no loose tool parts. Lift the mirror cell up and replace the 2 mount screws. Tip the telescope down and see if the sling needs readjustment to center the mirror between the location posts. Replace the mirror cover before proceeding.

The secondary mirror can be installed in the holder by first removing the four side screws holding the bezel. Carefully slide the secondary into the bezel until it touches the front lip. The bezel is made from 0.025" aluminum to minimize diffraction, so be careful when handling it to avoid bending. Place enough fiber packing behind the secondary to hold it snugly in place but don't over-pack. Replace the bezel on the back plate with the four screws and install the holder in the spider. Follow the instructions on Pages 69-70 to properly position the holder. Always have the primary mirror cover in place when working on the telescope.

Adjusting the Truss Length

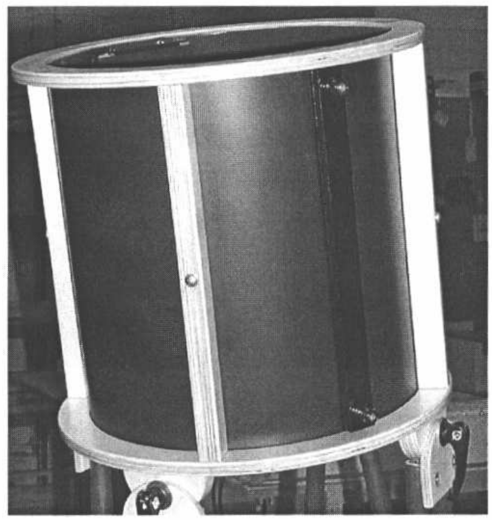
First, move the telescope outside on a clear night or at least clear enough to see a star or the moon, a distant light or mountain will not work. If an accurate focal length was provided, the truss length will allow all eyepieces to focus. Center the primary mirror between the location posts and lower onto the travel support pads. Turn the collimation bolts full forward until they stop, counting the turns. Lower the mirror half the number of turns of full travel to center the mirror. Rough collimate the telescope by eye until all the internal reflections are reasonably concentric.

It is helpful at this point to know which eyepieces focus at the lowest position and which focus at the highest position, relative to the focuser drawtube. Remove the adapter from the focuser and lower the telescope to a star near the horizon, weighting the front to keep it down. Hold a 1.25" eyepiece in the drawtube of the focuser and manually moving it in and out to find focus. A short ruler will give you the difference between the top of the fully racked down drawtube and the shoulder of the eyepiece.

If an accurate focal length was supplied, this step will not be necessary unless unusual focal position eyepieces are used. Let's say you had to hold the eyepiece 0.5" below the top edge of the fully racked down focuser. You would need to add the height of the adapter since it makes the eyepiece sit up another 0.25" higher. It is also necessary to add a little extra, say 0.2" for focus in-travel. This would allow some Barlow lenses and far-sighted people that remove their glasses to still focus. In this case 0.95" would be removed, rounded off to 1", from the trusses for proper focusing.

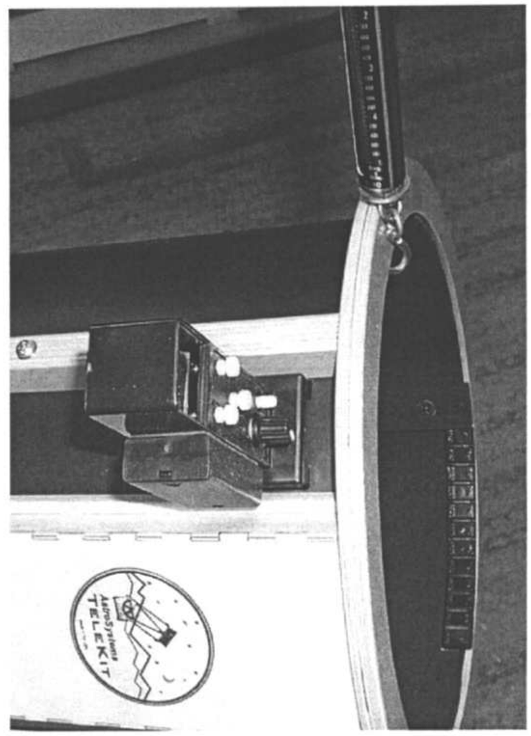
The use of some coma-correctors require another 0.3"-0.4" more removed from the truss length. Using the lowest position eyepiece means that all the other eyepieces would focus with the focuser above its minimum. For a little extra out travel, especially with 2" eyepieces, the eyepieces can be locked in place with the thumbscrew before being fully seated. You can cut the trusses with a hacksaw but a plumbers tube cutter is preferred. One word of caution, you can't add length to the trusses so it is best to remove small amounts at a time.

Balancing the TeleKit



TeleKits are proportioned to be a front light by 16-24 ounces, but variations in actual mirror diameter, thickness and focal length can cause this to vary. The advantage of making the front somewhat light is that a finder or accessories can be added to the cage later without having to add large amounts of weight to the bottom. The TeleKit can also be balanced using heavier eyepieces, if preferred. Any necessary counterweight should be added opposite the focuser/eyepiece to minimize off axis imbalance. There is already an off-axis imbalance since the focuser, finder, eyepiece and filter slide are all on one side. A large off-axis imbalance can cause the telescope to behave as if it was front light when low to the horizon, often moving down on it's own, and front light when pointed near the zenith, moving up on it's own. This phenomenon has perplexed many telescope builders, since it would seem the telescope is both front heavy and light at the same time. This is why it is preferable to have the telescope be front light and add some balance weight opposite the focuser. This improves altitude movement as well as tolerance for heavy eyepieces, especially in the 10" through 16" size, which have lower bearing loading with a relatively lighter telescope. Photo at upper right shows a steel bar system attached to the cage. Bars can be added or subtracted for balancing extra heavy eyepieces as well as fine tuning the balance. A wood bar attached to the inside of the cage rings is strong and the whole system has a very low visual impact. Available through ***AstroSystems***.

With the trusses adjusted to their proper length and the telescope assembled, you can now adjust the balance. Mount all the extra components that would affect balance. This would include a medium weight eyepiece, finders, light shroud, light baffle, dew removal gear, etc. Remove the mirror cover, since this adds weight to the mirror end. Point the telescope at about 20 degrees and give it a push up and down. It will probably be obvious which way it moves the easiest, possibly moving up or down with no help at all. It takes less weight in front to correct if light in front and more weight in back if the front is heavy.



An easy way to determine the amount of weight necessary to balance if it is front light is to attach a plastic gallon jug and add water until the motion takes equal force up and down to move. A fishing scale (see Photo at right), can be of used to determine when the force in both directions is equal. Water weights approximately one pound per pint or 8.3 pounds per gallon.

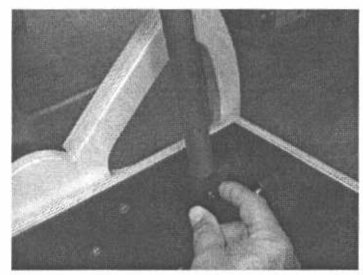
Some suggestions for adding weight if top light would be a plastic light baffle that plugs in the front. This can correct moderate imbalance and has the added advantage of extra light baffling, dew protection, and you can adjust its length for weight adjustment. A heavy or extra finder can adjust moderate to heavy weight imbalance. Place finders on low profile mounts or opposite the focuser to minimize off-axis imbalance. Strip lead, used to balance aluminum rims, is self-adhesive and can be purchased at tire stores (see photo at right). Steel bar 1/4" thick and 1.25" wide can be fastened to the inside of the cage between the rings and weighs 0.9 pounds for a 11.8" long piece. A note of caution, do not place weight on the secondary holder stud, it will cause collimation errors by spider flexure.

If extra accessories are added to the cage and the telescope is front heavy, it can take a fair amount of weight in back to balance. The amount is roughly 80% the f/ratio to one, meaning that on a f/5 telescope, if the front is heavy by one pound it will take four pounds in the rear to correct. Suggestions for adding rear weight is extra batteries, lead or steel forms or shot. Steel weights made for weight lifting can be attached to the mirror cell, but check clearance by moving the scope from horizon to zenith.

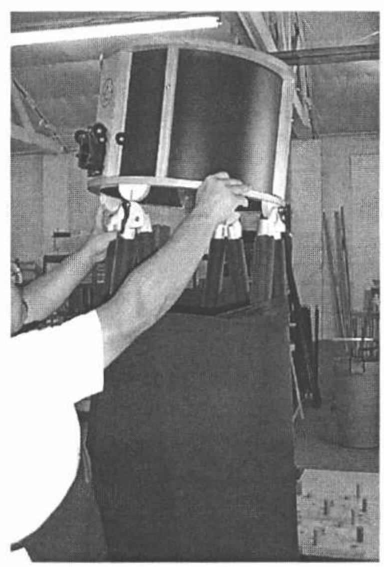
TeleKit Set-up

Location
Determine the preferred location to place your TeleKit. Check for even ground and obstacles that would make using a ladder or walking hazardous such as cactus, animal burrows, ant hills, large rocks, etc. Look for a clear unobstructed horizon, at least where it is most important for your observing.

Placement
Unload or move your TeleKit into position. When using the transport wheels and handles better stability can be realized by holding the handles closer to the telescope. This is especially true when going up or down ramps or over curbs or other obstacles. This also allows you to place your body against the telescope, which is especially helpful when moving a heavy telescope on ramps. Remove the handles and stow them where they won't present a stumble hazard in the dark.

Set-up


*Insert the truss pole bracket in the bolt using the numbers on the gusset (to minimize collimation).
*Pull the light shroud over the trusses.
*Loosen all truss fastener screws to easily clear mount blocks on the upper cage.
*Place the upper cage on the truss fasteners, sliding the mount block slot over the mount screw. Check for correct focuser orientation (14 degrees above horizontal).
*Adjust the thumbnut portion of the cam clamp for proper cam pressure on the upper cage clamps.
*The cam should firmly grip without compressing the wood mount plate. Tighten while ensuring that the mount block is fully seated on the mount screw.



*Pull the light shroud up over the upper cage edge.
*Pull the bottom of the light shroud up far enough to remove the mirror cover, always left until last to protect the primary mirror. Place the cover where it will not get soaked by dew.
*Pull the light shroud down, sliding the elastic bottom edge below the truss coverings.
*Smooth and straighten the light shroud.
*Collimate your TeleKit.
*Insert an eyepiece.
*Adjust finders and set digital setting circles.
*Turn the cooling fan on if the mirror is warm or the air temperature is expected to drop over 5-10 degrees during your observing session.
*Set-up and adjust any auxiliary equipment such as dew control, etc.
*Enjoy!

Collimation

Introduction

Preparation and mechanical alignment need only be performed the first time the telescope is assembled. Thereafter, only the optical alignment and star testing are needed to collimate your telescope. Don't underestimate the importance of mechanical alignment, most troublesome collimating jobs can be traced back to mistakes or assumptions regarding component placement.

Collimation Tools consist of the Sight Tube or laser collimator, which are used to position components. A LightPipe, Cheshire eyepiece or laser collimator, which are used to optically collimate the system and the autocollimator for fine optical collimation. All these tools are available through ***AstroSystems.***

Preparation

Position the telescope

Place the telescope on a horizontal surface or move it to the horizontal. Position the focuser so it is easily accessible. You will be moving back and forth from the rear to the front of the tube assembly to check progress and it helps to have things positioned for convenience.

Assemble the proper tools

Gather the necessary hand tools required to adjust the primary mirror cell, secondary mirror holder, spider and focuser base.

Center spot the primary mirror

It is necessary to "spot" the center of the primary and secondary mirrors. To facilitate collimation at night, a white mark on the primary is most visible. The ideal spot can be made from any type of adhesive backed white paper or label. Cut a square 1/2" on a side or a triangle 5/8" on a side and use a paper hole punch to make a smooth 1/4" hole in its center. An adhesive backed paper reinforcing ring such as the type used on notebook paper also works. The spot is placed at the center of the primary mirror.

NOTE: To avoid possible damage to your optics, remove rings, watches, bracelets, pens, pencils and any other loose articles from your person or around your work area that could fall on or scratch your mirror. It is also advisable to use a plastic or wooden ruler when measuring your optics.

The center of the primary mirror can be determined by first finding its diameter and dividing by two. Use this radius to measure in from the edge at six or eight positions around the mirror. After several measurements, you will begin to zero-in on the exact center. Use a fine tipped permanent marker to mark the center and then accurately position and attach your paper "spot." Use acetone or alcohol on a cotton swab to remove the permanent marker in the center of the spot. Another method is to use a large piece of tissue paper (thin white wrapping paper) and cut a circle the size of the primary. By folding it in half and then half again the center can easily be found where the fold creases meet. Use a scissors to cut a small amount out of the folded tips to make a hole at the center. Place this on the primary and use a marker to spot the primary center.

NOTE: Don't worry about placing a spot on the mirror, the center of the primary is shadowed by the secondary mirror. The reflection from the primary back towards the secondary mirror has a "hole" in its center from the secondary mirror shadow, leaving a small central portion of the secondary mirror shadowed.

Mark the secondary mirror

There are two ways to position the secondary mirror, on axis or offset. On axis is recommended since the advantages of offset are not visually perceptible and it makes collimation more difficult. Offset should be incorporated if the telescope is going to be used photographically, here the unequal illumination at the edge of the field will occur, or if the telescope is f/4 or less, requiring a large offset.

Mark and position the secondary mirror on-axis

Measure the center of the secondary and place a small dot with a permanent marker at that location. The spider is also positioned in the center of the tube.

Mark the tube opposite the focuser

Mark a spot on the side of the tube opposite the focuser by carefully measuring from the front of the tube down an equal distance (on the outside of the tube) as the center of the focuser drawtube. A piece of adding machine paper works well to find the dimension around the upper cage. Wrap this paper around the inside, taping 3-4". Measure its center, re-tape the paper and drill a tiny hole through to the outside. Place a mark or spot on the inside to complete preparations.

Mechanical alignment with the Crosshair SightTube

Mechanical alignment is the accurate positioning of components in the tube assembly. The importance of mechanical alignment lies in the fact that all the collimation steps that follow are either easy or difficult, depending on how well the telescope components are mechanically positioned.

NOTE: Truss tube owners are proceeding on the assumption that when the telescope is assembled the upper cage is centered over and square to the mirror box. Measuring to verify this will save time and frustration later.

Center the primary mirror in the mirror box

With open end mirror boxes, it is a simple task to measure in from the mirror box sides to the side of the mirror. With closed tubes, centering the mirror relative to the mirror mount and then centering the mirror mount relative to the tube works well. Mirror cells supplied with a sling can be adjusted in combination with cams or locating pads to center the primary mirror. It's a help to first turn the collimating screws so they all have the same amount of travel in both directions.

Square the focuser to the upper cage (or tube)

With the secondary mirror and holder removed, insert the Crosshair SightTube into the focuser. The focuser mounting screws are loosened and the adjusting feet, if the focuser is so equipped, are used to tilt the focuser until the crosshairs are centered on the mark opposite the focuser. On focusers not provided with tilt, adjustment shims made of cardboard or other suitable material can be placed under the focuser base until the crosshairs are centered on the opposite spot.

Square the spider

The spider is next squared to the optical axis. This is checked by sighting through the spider bore towards the primary. The spider bore should look directly at the mirror center spot. Adjustment can be made by drilling the mounting holes slightly oversize and shifting the spider vanes to square. Also be sure the spider screws are properly tensioned to hold the secondary securely.

Position secondary laterally under focuser

Replace the secondary mirror and holder and position it under the focuser so the crosshairs are centered on the offset spot. Washers or adjustment nuts can be used to position the secondary (see **Figure 1** below).

Position the secondary mirror rotationally under the focuser

Remove the LightPipe/SightTube and look through the focuser drawtube. Rotate the secondary holder and mirror until the reflection of the primary mirror is centered all around. Move towards or away from the focuser until the edge of the primary is just seen in the secondary. Insert the LightPipe/SightTube, adjusting its height in the focuser until only the edge of the secondary can be seen. When the primary mirror reflection is centered, lock the secondary in place. This completes the mechanical alignment.

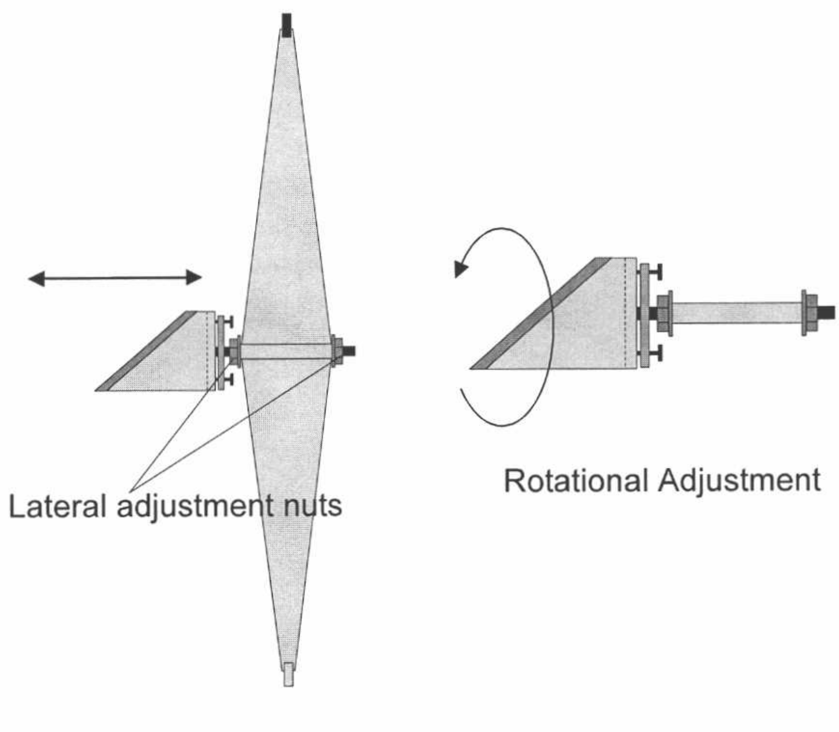


Figure 1. Lateral and rotational placement of secondary mirror

Optical Collimation with the LightPipe

Adjust tilt of secondary mirror

Insert the LightPipe/SightTube into the focuser. Adjust the secondary tilt so that the primary mirrors reflection appears centered front to back and side to side in the secondary. After this step is done, insure that the secondary spot is centered under the crosshair of the collimation tool. If not, adjust the secondary lateral or rotational position and then readjust tilt. Aligning the secondary becomes an iterative process, with each successive pass generating smaller changes to the placement of the secondary. When it is set up correctly, the reflection of the primary in the secondary should appear centered in the focuser. The spot on the secondary should be centered under the crosshair of the collimation tool. If it is difficult to focus on the crosshairs move back from the LightPipe/SighTube an inch or so.

Adjust tilt of primary mirror

Now that the secondary mirror is positioned, it's time to adjust the primary to point in the correct direction so that the optical system becomes closed. By closed, we mean that the image at the focuser (your eye) reflects off the secondary to the primary and then the primary reflects light back to the secondary, which in turn reflects the light 90 degrees back to the focuser. You will then be able to see the reflection of your own eye when you look into the focuser. The open sky or a white wall work well to evenly illuminate the view. The primary collimation screws are now used to adjust the tilt of the primary so the LightPipe reflection is centered on the primary mirror spot. At this point, it becomes obvious why the center spot was cut square or triangular. It is much easier to see the corners of the "square spot" extend equally around the illuminated LightPipe reflection when the two become superimposed, (see **Fig. 2**).

When you get through, the crosshairs on the collimation tool should aim at the dot on the secondary and be exactly centered in the circle on the primary. Simultaneously, the primary must still appear centered in the secondary, front to back and side to side. This view may vary, less of the secondary holder will show on smaller telescopes and the orientation of the spider vanes will depend on the particular telescope.

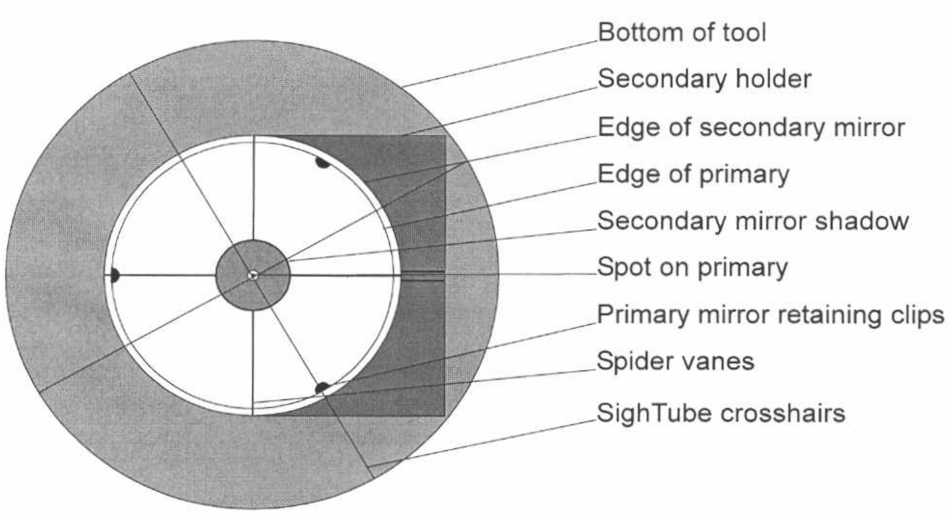


Figure 2. View through SightTube of collimated system.

After using the crosshair and LightPipe eyepieces, your Newtonian is very close to being collimated. The next step in fine tuning requires an autocollimator or you can use the star test on Page 73.

By introducing a circle of light at the focuser, the reflection of that light will appear centered on both the primary and secondary marks. This is precisely what a LightPipe eyepiece does. It has a clear diffuse upper section that introduces light into the closed system while allowing you to look through a tiny hole to see the reflection of that light in the system. If you have aligned your secondary correctly, you will only need to tweak the primary at this time. The dot on the secondary should be centered in the dark center of the light circle generated by the LightPipe. The mark on the primary should be centered in the circle of light as well. Figure 2 illustrates the collimated view.

Fine Optical Collimation with the Autocollimator

Theory

To understand how an autocollimator is used, consider the following analogy: a fun house has two mirrors facing each other in a room. One of the mirrors can be moved by using a lever in the center of the room. If you stand in the center of the room and look in one mirror, you will see your reflection. If the two mirrors are not exactly parallel, you will also see a reflection of your reflection in the other mirror. These reflections will go on for what seems forever, creating a line of ever smaller images of yourself. When the mirrors are parallel, you will only see your reflection in the mirror because your body is blocking the reflection from the other mirror. Suppose another person is looking through a small hole in the fixed mirror. This hole is centered on the position where you are standing. When the mirrors are slightly out of parallel, he sees you and a series of reflections of you in the mirror behind you from his perspective. When both mirrors are parallel, he sees only you and no reflections.

If a flat mirror is placed in the focuser of a Newtonian telescope and it has a small hole placed in it to look through, the center of the primary along with the secondary and the mirror in the autocollimator act like the two mirrors in the example. When a Newtonian is properly collimated all the multiple reflections will appear as one.

Using the Autocollimator

First, it is necessary to collimate the optics with a LightPipe or Laser sufficiently close to give a "closed" light path. Insert the autocollimator in the focuser without using a setscrew, if possible. This gives a repeatable and accurate orientation of the autocollimator in the focuser. A very loose fit or an irregular setscrew will tend to tip or shift the autocollimator.

If the initial collimation was close, you will see a dark or partially dark view on initially looking into the autocollimator. If part or all the view is bright, indicating the introduction of external light and an open optical system you will need to return to the optical alignment of the primary and secondary.

Fine Optical Collimation with the Autocollimator

Once you see a mostly dark view, you will see one or more reflections of the center spot, the brightest being the first reflection and subsequent dimmer reflections being the second or third reflection of the center spot. Reaching around and applying a light twist or tilt to the secondary will usually bring multiple reflections into view and give an indication of what rotational or tilt adjustment is necessary.

Make small adjustments to the secondary to get all the reflections to converge together. If you can see multiple images that are in a line perpendicular to the tube axis a slight rotation of the secondary will bring them together. If the images are parallel to the tube axis (left to right) then tilt adjustment to the secondary will bring them together.

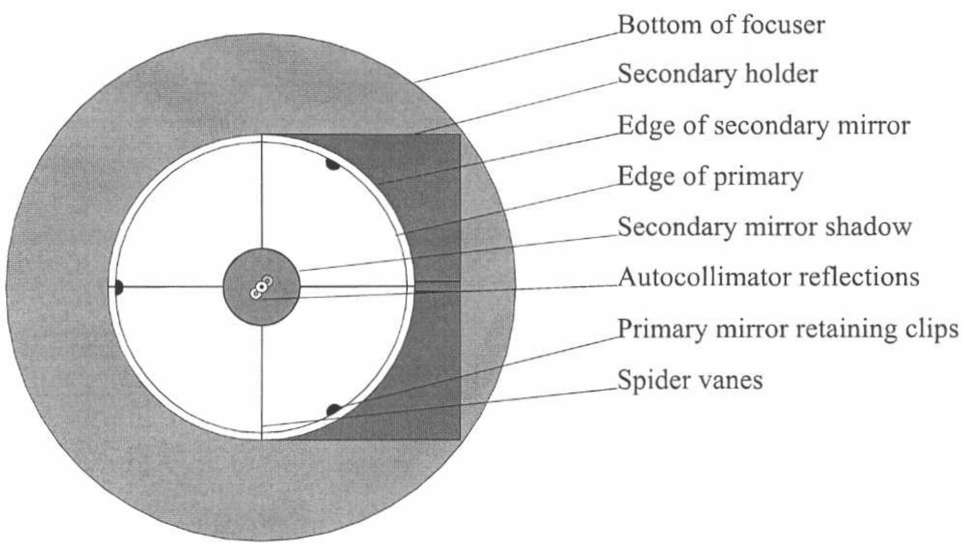


Figure 3. View through Autocollimator.

At this point, you will see very small adjustments having a great affect. Each reflection is two times the focal length, so a third or fourth reflection is 6 to 8 times the focal length! This is very sensitive and may need to be touched up as the night progresses due to thermal expansion/contraction.

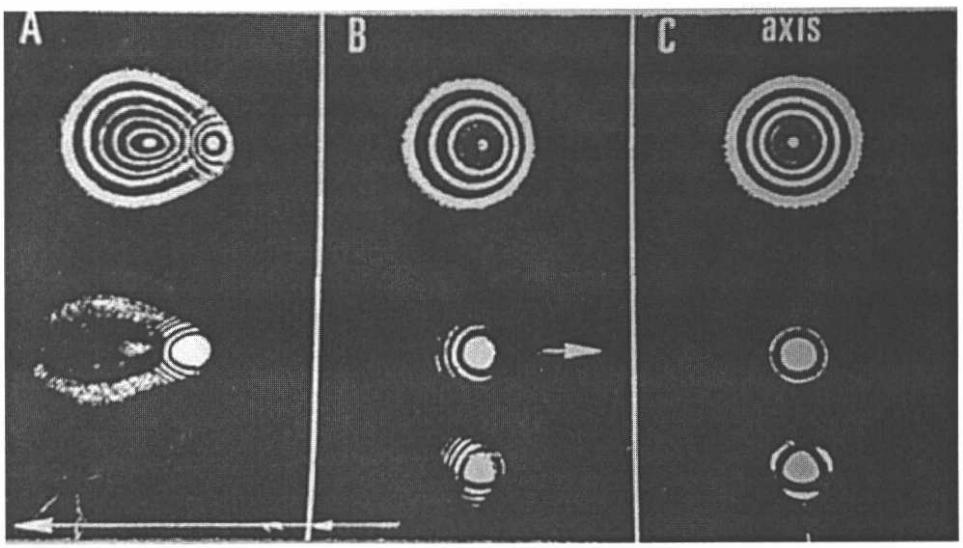
You have now reached perfect collimation.

The advantage an autocollimator has is that it can be done in daylight or under cloudy conditions. On fast systems (low f-ratio), it is the only way proper collimation can be obtained because the large amount of secondary offset (if present) will make a properly collimated system appear poorly collimated when viewed with the LightPipe.

Checking Optical Collimation - Star Test

Optical collimation can be checked and fine tuned by sighting on a star. This is a very sensitive test, if we tilt a f/6 mirror to shift the image in the focal plane by 1/100 inch, visually perceptible coma results. If the collimation screws have 16 threads per inch, this will correspond to as little as 1/8 turn. Interpreting the images seen in this test will take some experience. Locate a star of third or fourth magnitude fairly high in the sky. This improves the chances of a good image and insures the primary mirror makes positive contact on its flotation pads.

Using a medium-power eyepiece defocus the image. **Figure 4** below shows stars outside of focus in the top row and inside of focus in the bottom row. Should your image appear like **4A.**, exhibiting gross coma, astigmatism and diffraction, something is severely misaligned or has shifted and returning to mechanical alignment may be necessary. Usually the star's appearance will look much like **4B.**, showing a small amount of decentering. For more detail, shift to a high-power eyepiece. Work by trial and error, rather than trying to figure out which primary mirror collimation screw to adjust. The lower arrow shows direction in which to displace the image in the field to return the beam on axis. Once this is accomplished and checks out with high power, the telescope is accurately collimated.



A. Large centering error **B. Small centering error** **C. Perfect centering**

Figure 4. Adjusting the primary mirror with a star.

Secondary mirror offset

As mentioned at the top of Page 68, on axis secondary placement is recommended since the advantages of offset are not visually perceptible and it makes collimation more difficult. Offset should be incorporated if the telescope is going to be used photographically, here the unequal illumination at the edge of the field will occur, or if the telescope is f/4 or less, requiring a large offset.

To offset the secondary mirror, it is repositioned (offset) in the light cone coming from the primary mirror as in **Figure 5.** To make better use of the full light gathering ability of the primary mirror and more evenly illuminate the edge of the eyepiece field. The secondary mirror is positioned a small distance away from the focuser and an equal distance towards the primary. To realize why this offset is necessary we see that the light returning from the primary mirror is shaped like a *cone*. When this cone is intercepted at a 45 degree angle, the shape is larger in area on the side towards the primary and smaller on the side towards the open end of the telescope. The diagonal is shaped like a 45 degree cut through a *cylinder* and so it is uniform in area front to back and side to side. Obviously these two shapes are not the same, so shifting the secondary mirror towards the "fat" side of the light cone will help equalize the illumination at the image plane.

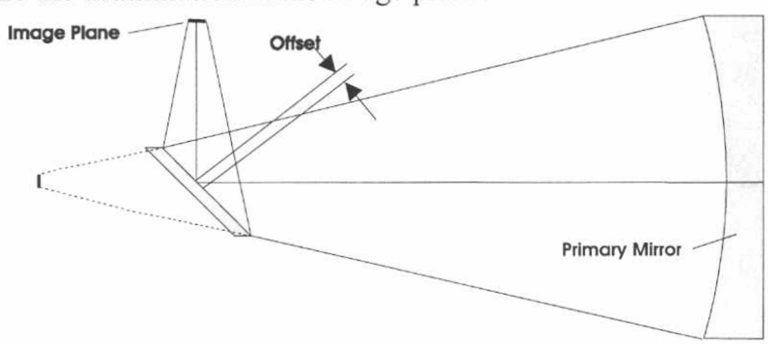


Figure 5. The secondary mirror is offset away from the focuser and towards the primary.

Note: The following example is given for incorporating offset into the position of the secondary, but is *not recommended* for a visual telescope. To calculate the amount of offset to maximize illumination of the field use the following formula that yields a very close approximation:

$$s' = \frac{N\,(D - N)}{4\,(F - L)}$$

s' = The secondary mirror offset **N** = Secondary mirror minor axis
D = Diameter of primary mirror **F** = Focal length
L = Intercept distance measured from the secondary mirror to focal plane.

An example using the above formula:

A 16" telescope has a focal length of 72 inches. The tube "outside diameter" is 19.6", the secondary minor axis is 3.1" and the focuser height is 1.5". The focal plane is 0.2" above the fully racked in focuser; this distance is known as "in-travel."

N = 3.1" **D** = 16"
F = 72" **L** = 9.8" + 1.5" + 0.2" = 11.5"

By inserting the values in the formula for offset:

$$s' = \frac{3.1\,(16 - 3.1)}{4\,(72 - 11.5)} = \frac{3.1\,(12.9)}{4\,(60.5)} = \frac{39.99}{242} = \mathbf{0.165''}$$

The offset for this telescope would be 0.07", or just under 5/64". This calculated offset is the horizontal or vertical offset, the offset along the face of the secondary is 1.414 (√2) times s'. In this case 0.07" times 1.414 gives us 0.098".

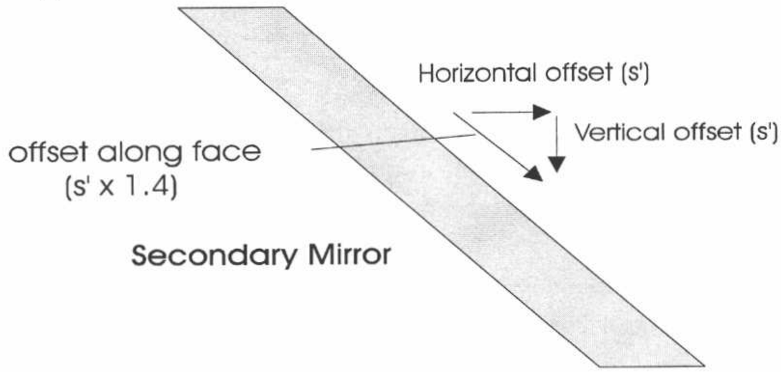


Figure 6. Offset of secondary mirror.

The easiest way to introduce offset is to position a spot, using a pointed permanent marker, on the center of the secondary mirror. Then mark a second spot, shifted by the amount of the offset, along the centerline towards the end of the secondary mirror in the direction of the tube front as seen above. This spot is centered under the focuser to move the secondary mirror the correct horizontal component of offset, while the spider is repositioned away from the focuser by the vertical component. This has the net effect of offsetting the secondary mirror along its face by the prescribed amount. The spot can be removed with alcohol and a swab when finished. Offset will cause the reflections to be non-concentric when viewed visually through the focuser or with a LightPipe.

Laser Collimation

The preceding instructions for preparation and mechanical alignment apply to using a laser collimator and are performed first. The laser is used in place of the LightPipe/SighTube throughout the instructions. Fine collimation with the Autocollimator (Page 72) or the star test (Page 73) is recommended after using the laser collimator.

Insert the Laser Collimator into the focuser. Adjust the secondary tilt so that the laser beam is centered in the primary mirror spot. After this step is done, insure that the marked spot on the secondary is centered under the beam of the collimation tool. If not, adjust the secondary lateral or rotational position and then readjust tilt. Aligning the secondary the first time becomes an iterative process, with each successive pass generating smaller changes to the placement of the secondary.

Next, the primary collimation screws are used to adjust the tilt of the primary so the laser beam reflects back on itself, reflecting off the secondary back into the hole in the bottom of the laser. TeleKits can be adjusted from the primary end by looking past the primary through the hand holes in the primary cell. The reflection of the bottom of the laser is seen in the secondary mirror. It is then a simple matter to adjust the primary mirror so the laser beam returns into the hole in the bottom of the laser body. Once the return beam is centered on the hole in the laser body, the telescope is collimated. A brightening of the laser often occurs when the return beam is positioned into the laser and is helpful to look for this to confirm centering of the return beam.

Telekit Operation

Phase 4 Focuser

The location of the focus knobs allow easy access even while wearing gloves. The o-ring grips provide a positive feel and are the same size as the drive o-ring, giving the focuser built-in replacements. The leveling feet are used to match the focuser to any size telescope tube. They introduce small amounts of tilt into the focuser to compensate for uneven mounting surfaces or if the optical axis is not coincident with the tube axis. A 3/32" hex key is used to adjust as per the collimation instructions.

The tension adjustment is the right hexscrew (looking from the knob end) which applies pressure on the friction drive. It can be adjusted while observing using the supplied 3/32" hexkey. This provides a wide degree of load-carrying capacity while retaining the optimum in control, up to a maximum of about five pounds. Tightening may be necessary with heavy eyepieces or eyepiece and Barlow and corrector combinations. Use small amounts of adjustment as this control has a large affect. The left toothed-belt drive is preset at the factory and rarely needs adjustment. The toothed belt is fiberglass reinforced and over-tightening will damage the belt. The PHASE 4 focuser has a total drawtube travel of 1.2". This maintains the excellent stability and "no-slop" drawtube movement. If more "out travel" is required, the eyepieces can be secured in place with the thumbscrew before they are fully seated. The adapter for 1.25" eyepieces is anodized aluminum and threaded for 48mm filters. The PHASE 4 focuser manufactured by ***AstroSystems*** has a lifetime warranty against defects in materials and workmanship.

QuickSwitch Filter Slide

An ***AstroSystems*** first on a production telescope, the QuickSwitch filter slide gives instant access to 4 filters without the hassle of threading and unthreading in the dark. Mismatches between filter threads and eyepieces as well as unthreaded eyepieces are common. The QuickSwitch filter slide makes the use of filters fast and safe. You will find yourself using filters more often and enjoying the benefits. The filter slide is threaded for 48mm camera filters (2" astronomical) and clearance constraints require the use of filters less than 0.2" in height of the unthreaded portion. To install a filter in the last position, it is necessary to remove the focuser. It is best to choose a filter that will remain in this position. The center three positions are accessible by extending the slide down with the control knob. The first position has a larger unthreaded clearance hole for Barlows, binocular viewers and collimators . A small amount of removable Locktite or fingernail polish is sometimes used to secure the filters in the slide so they cannot loosen from rough travel. A little acetone on a swab can be used to remove the thread locker to replace or clean filters.

Filters fall into three main groups. Bandpass, color and modifying. Bandpass filters allow most of the light within a specific region of the visible spectrum to pass and the remainder of the visible spectrum to be reflected. Into this group fall the “nebular” filters such as the O-3, UHC, Deep Sky, “light pollution rejection” or LPR, Swan-Band, H-beta and others. They are very effective as long as the selected object emits most of its light in the same region the filter passes most light. These filters also function best if a specific range of exit pupil is used. The exit pupil is a measure of magnification independent of telescope aperture. It is the eyepiece focal length divided by the f/ratio or the diameter divided by magnification (see Pages 11-12). Following is a table giving the preferred ranges of exit pupil.

	Bandpass Width	Exit Pupil (near cities)	Exit Pupil (dark sky)
Deep Sky or "Light Pollution"	90nm	0.5-2mm	1-4mm
UHC	22-26nm	1-4mm	2-6mm
O-3	10-12nm	2-5mm	3-7mm
H-Beta	8-10nm	3-7mm	4-7mm

The smaller exit pupils will correspond to higher magnifications. If too small an exit pupil is used, the background sky will be dark. If too large an exit pupil is used, the background sky will be too light and have low contrast. It is recommended that you try filters before buying. If this is not possible, the UHC is a safe and effective place to start. Following are some examples of filter choice based on object.

Object	**Examples**	**Best Visual Filter (near cities)**	**Best Visual Filter (dark sky)**
Stars and star clusters	M-13, M-11	none or Deep Sky, LPR	none
Diffuse nebulae	M-8, M-17	O-3, UHC	Deep Sky, UHC
Planetary nebulae	Dumbbell, Ring	O-3, UHC	Deep Sky, UHC
Faint planetary	NGC-7293, Abell 33	O-3, UHC	O-3, UHC
Reflection nebulae	Pleiades, Trifid	none or Deep Sky, LPR	none
Faint nebulae	Veil, Rosette	O-3, UHC	UHC
Galaxies	M-101, M-33	none or Deep Sky, LPR	none
Extremely faint nebulae	Calif., Horse Head	H-Beta	H-Beta
Comets	any	Swan band	Swan band

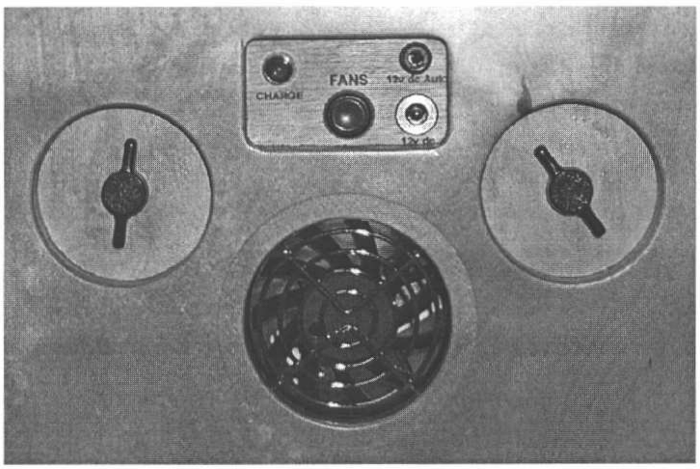
Color Filters are used to bring out the details on the planets. They are not as discreet in rejecting a specific band of the visual spectrum as bandpass. They come in light, medium and dark densities, with the dark producing the greatest contrast on objects having subtle color shadings. Color filters are dependent on the observing site, the telescope, the observer and the object being viewed. Some experimenting and borrowing is suggested. Color filters lighten colors like themselves and darken their compliments. Following is a suggested starting point for getting the most contrast gain on planetary markings. The filters having the most promise are listed first.

Mercury	Red	Orange	Yellow	Green
Venus	Red	Blue	UV/Violet	
Mars	Blue	Green	Yellow	Red (Med.)
Jupiter	Yellow	Blue	Orange	Red
Saturn	Blue	Yellow	Green	
Uranus/Neptune	Yellow (L)	Green (L)		

Modifying Filters affect light over the entire visual spectrum. Commonly used modifying filters are neutral density and polarizing. Both allow us to see more detail in brighter objects by lowering the intensity without changing the color balance. For this reason, they are used with great success on the moon.

Reducing the glare from such a bright object will allow detail to be seen and vastly improve viewer comfort. A second neutral density can be used by threading into the eyepiece. This, along with using the off-axis mask (see below), will reduce the moons brightness to render the finest detail. The polarizer can produce sharper images, increase contrast, provide brightness control, penetrate atmospheric haze and minimize the detriments of both external glare and internal reflections. Its accentuation of colors is profound and is often used in combination with color filters. For this reason an adjustable polarizing filter threaded into the eyepiece or adapter is the most useful.

Primary Mirror Cell Fans and Batteries



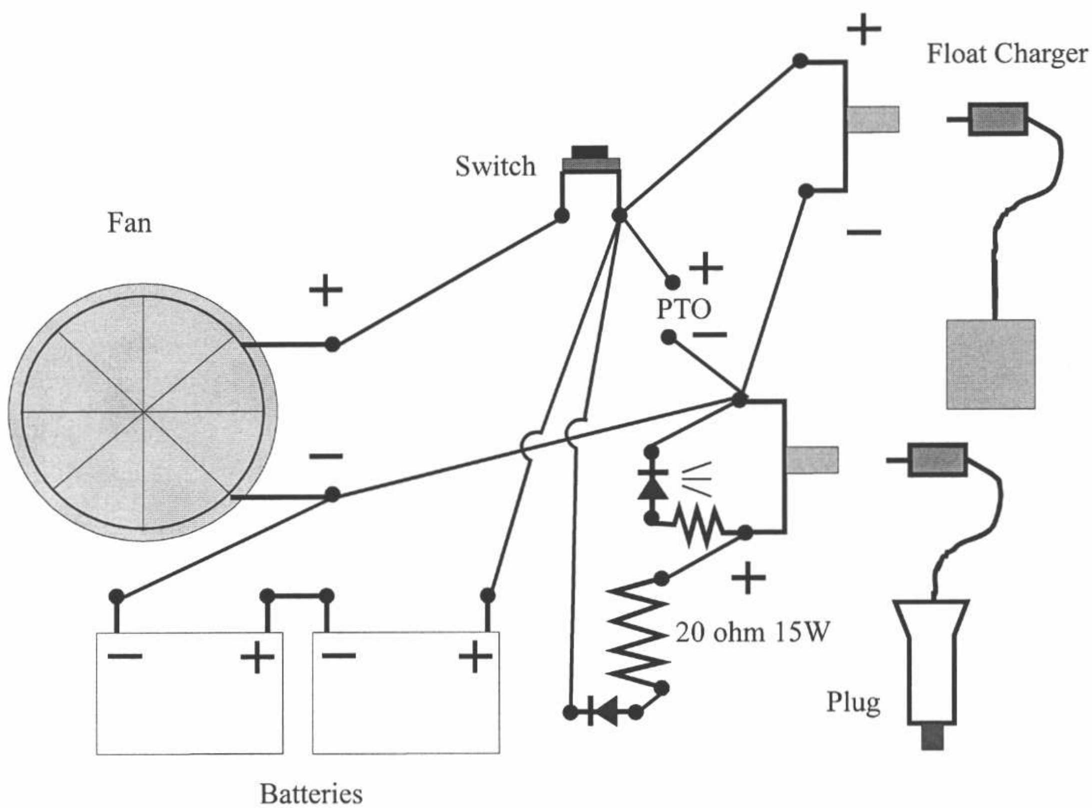
The power system supplied with the TeleKit consist of (2) six volt, 1.2 amp hour, gel cell batteries connected in series for a 12v operating voltage providing 1.2 amp hours of current. The batteries are not subject to charge memory like a NiCad and can be charged and discharged a little or a lot. They are oversized for the fans and can be used for powering other applications as long as the total load is within their capacity.

Shown at left is the power control board mounted in the mirror cell. The 12V DC auto charger uses the RCA plug (top right). It is used if charging in the field from an auto is necessary. The 110V AC float charger is a 2.1 mm x 5.5 mm power plug (lower right). The float charger has its own built-in indicator to indicate charging. The fan switch is at center and the charge indicator functions with the auto charge system only.

A twenty four-hour charge is recommended upon receiving your telescope, using the 110v AC to 12v DC adapter provided. Thereafter, two hours of charge will offset every hour of use. It is recommended that the batteries not be discharged below 11 volts and charge 4-8 hours every 3 months the telescope is not in use. Do not allow the batteries to remain discharged for long periods of time. With the AC float charger it is OK to allow the batteries to remain on charge at all times. This eliminates the possibility of a drained or dead battery.

The fan is typically operated for 20-30 minutes at dusk to help the primary mirror cool as the air temperature drops. In areas where the air temperature continues to drop at night, it may be necessary to turn the fan on periodically. To see if the primary is generating warm air currents that hinder high power resolution, point the telescope to a 2nd or 3rd magnitude star. Using a medium power eyepiece, defocus until the star is a large circle with the silhouette of the spider and holder. Slow “snaky” ribbons moving from the bottom of the mirror up are a sure indication of a warm mirror. A fast linear movement from side to side is an indication of upper air turbulence. Hold your hand in front of the telescope and you will see the slow sinuous movement of the warm air from your hand. This test allows you to evaluate the mirror's temperature differential with the air as well as the upper air turbulence that affects seeing.

Below is a schematic of the cooling fans, batteries and charging system. When either the auto charger or the AC wall charger are plugged into the system, 12v DC is supplied to the batteries. The charge indicating LED will only operate when the 12v DC auto source is plugged into the RCA charge plug. To charge from an AC source, the AC charge/float is plugged into the power plug on the panel, with the LED's on the transformer indicating charging. The float charger can be connected while the telescope is stored, keeping the batteries fully charged with no worry of the batteries being overcharged. The auto charger is used in the field if necessary, and is connected for 2 hours for every hour of battery use. Either charge system can charge the batteries and operate the fan at the same time.



To use the fan batteries for other electronic devices, such as Digital Setting Circles or secondary dew heater, add the two wires shown on the diagram as PTO (power take off). The negative is soldered to the common negative on the charge plug and the positive to the switch side with the three wires. It is advisable to use another switch and fuse for this purpose. Check to be sure the capacity of the batteries is compatible with the fan and added devices. The fans require 0.12 A/hr use per fan. Example: 3 hours of use on an 16" TeleKit is 0.72 Ahr. This would be 1/3 of the battery capacity of the 3 Ahr batteries.

Teflon Bearings

There are two sets of roller bearings in the ground board and one Teflon pad. It was found that the telescope moved too easily in azimuth with three sets of roller bearings that a breeze sometimes moved the telescope. The Teflon pad can add enough braking action for light breezes. The altitude bearings consist of two Teflon bearings on each side. Keep the Teflon and bearing surface clean for the optimum ease of movement.

Check List

Most observers need to take their telescopes to a dark sky location. This complicates the logistics of observing. Now it is necessary to be self sufficient as well as mobile. While the TeleKit lends itself to this task, it is a very good idea to have a checklist to make sure you have everything needed to make your observing comfortable and rewarding. The following checklist is only a guide; you may want to review Pages 81-84 to consider what you may be facing in the "bush." Feel free to copy, add or modify this list to customize it for your purposes. Its contents reflect the three logistical challenges of using your telescope, observing, traveling, and camping. These will change depending on the season, your destination and the length of stay.

I. Observing

Telescope / all components	Transport equipment	Telescope cover
Binoculars	Eyepieces	Batteries / chargers
Red flashlight	Table / legs	Chair
Step stool / ladder	Star charts / books	Lens cleaner / supplies
Log / paper / pencil		

II. Travel

Wallet	License / registration	Auto tool box
Cash / charge cards / checkbook	Maps and atlases	Check tires
Check fluids / gas	Duct tape / glue	Cell phone / CB
First aid kit	Insect repellent	Sunglasses
Lip balm	Sunscreen / lotion	Headache remedy

III. Camping

Tent / stakes	Mattress	Sleeping bag
Ground cover / tarp	Blankets	Pillow
Lantern / flashlight	Ax / knife	Hammer
Rope / twine	Sun shade	
Cooking		
Food / drink	Water jug / water	Camping stove / fuel
Coffee / tea and supplies	Pots / pans / utensils	Flatware
Cups / plates	Dish soap / sponge	Dish towel
Paper towels	Aluminum foil	Garbage bags
Cooler	Zip-lock bags	Lighter / matches
Dishpan		
Personal	Coat / Gloves	Insulating hat / hood
Thermal undergarments	wool socks	Insulated boots
Parka / rain gear	Pants	Shoes / hiking, casual
Shorts	Light shirts	Heavy shirts
Hat / visor	Socks / underwear	Jacket / sweater
Personal - accessories	Spare keys	Spare glasses
Lap top computer / accessories	Books	Bicycle
Radio / tape player / tapes	Cards	Camera / accessories
Personal - hygiene	Towel / washcloth	Brush / comb
Toothbrush / paste / floss	Razor / creme	Shampoo / soap
Deodorant	Toilet paper / tissues	Vitamins / medication
Contacts / accessories	Laundry bag	

Observing

Observing with a large Newtonian truss tube telescope is a unique and rewarding experience. Simplicity, fast set up and ease of use has changed the attitude of truss telescope users to "let's have fun" rather than "let's go to work." Truss tube telescope owners don't seem to miss the 30-60 minute set-up, polar alignment or awkward eyepiece position common with most other types of telescopes. The ease of finding and tracking objects is one of the first things a newcomer notices. Smooth motion with one-hand operation allows anyone to master finding and tracking objects with only a few minutes practice. The larger aperture commonly available with truss telescopes has an enormous impact on what the observer sees. The bright images now contain a wealth of detail that takes some experience to fully appreciate. Planets have crisp outlines with a tremendous amount of subtle detail. Galaxies easily show spiral structure, HII regions and dust lanes. Some of the brighter nebulae now show color, an impressive merit considering the poor color sensitivity of the eye at low light levels. A good example is the pale green of planetary nebulae or the pink, green and blue of the Great Orion Nebula.

Deep sky objects were named or were described using small aperture telescopes. A good example is the Dumbbell nebula, which looses its hourglass shape and looks more like a football in a larger telescope. All the old favorites will look like totally new objects with increased aperture. Galaxies in particular will show detail, like M 81 and M82, M 51, M 33, and NGC 4565 to mention a few. Many small galaxies will now show some obvious detail, in both shape and form. Just meander through Coma Berenices, Virgo or Ursa Major. The number of galaxies showing details is truly astounding. The extra aperture also allows using higher power since there is enough image brightness. This improves image contrast, further improving low surface brightness objects, especially when viewing towards the horizon.

With this newfound wealth of detail at the eyepiece, observers now have more to work with to hone their observing skills and thoroughly enjoy their time at the eyepiece. Observing techniques like averted vision, concentration and perception of detail can all be used to their fullest. Observational logbook entries will now contain paragraphs instead of a short note! To fully appreciate the phenomenal potential of a large aperture telescope, a transparent, "steady" sky and traveling well away from artificial lights is necessary. Good sky transparency allows faint objects to be seen with high contrast, something our eyes respond to quite well. The skies' "steadiness" (or lack of turbulence due to mixing of different temperature air masses) is imperative for the best resolution.

Lunar, solar and planetary viewing is the most productive when the sky is steady. Galaxies, nebulae and low surface brightness objects can best be seen with good sky transparency. The best views are seen when the skies are both steady and transparent, an elusive phenomenon that can change hourly. Frequent observing sessions are the only way to insure that you can take advantage of excellent seeing conditions.

Observational Considerations

There is a direct correlation between what is gained from an observing session by the observer and the factors affecting observations. When these factors are prioritized by their impact on observing, trends become apparent that observers need to consider to choose the best time, location and equipment for their needs. Evaluation of these trends shows that the order of importance is location, observer and then equipment. While some factors will always have a large impact of what is seen and to what degree it is appreciated, what are non-issues for some may be huge issues for others. The following is given so you may appreciate the complexity of the observing environment and more fully prepare for those subtleties that could make or break your observing enjoyment.

Location

The most important thing you can do to optimize the performance of your telescope is to observe from a dark, steady site. Frequently the sole requirement to observe a notoriously difficult nebula is not a large telescope or special eyepiece, but a truly dark sky. We can do little about urban lights except travel to remote locations. We cannot afford to travel to distant sites often, but sometimes moving a few blocks to a less lighted or grassy field can be a great improvement. As previously mentioned, the "seeing", which is a combination of clarity (transparency) and steadiness (non-turbulence) is the single largest factor affecting your observing.

Clarity

Sky clarity may be adversely affected by particulates, dust, (either wind borne or from plowed fields), vegetation (pollen) or volcanic. Other sources of particulates are roads, power plants or industrial and mining operations. Aerosols (suspended liquids) affect sky clarity the same way and may include water vapor (clouds, fog) volcanic (sulfuric acid) or vegetation, usually from conifers. Altitude improves clarity simply by spreading out all the above affects. Several natural sources can affect transparency such as sky glow emission, Zodiacal glow, Gigenshine glow and aurora. Extinction due to the density of the air will lower clarity and is directly proportional to the telescope's direction of sight, closer to zenith being better and under 15 degrees or so usually not usable.

Stability

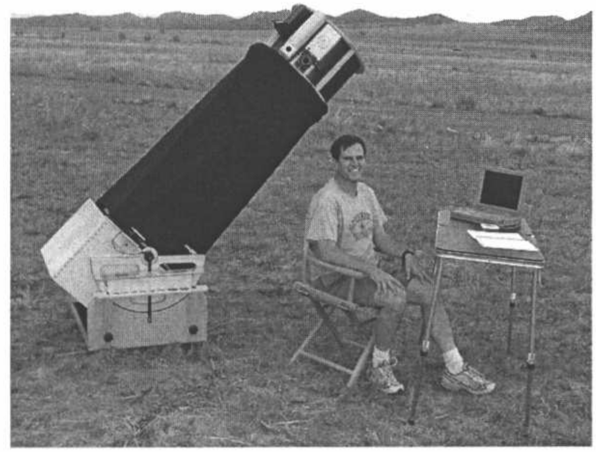
Sky stability can be affected by wind at high altitude (Jet Stream), medium altitude (0-30k feet) or at ground level such as thermal draining into low areas or valleys. Thermal turbulence can also impact stability and can come from nearby warm surfaces such as buildings, roads, or exposed rock. Large bodies of water (if no condensation), or vegetation like grass will minimize thermal turbulence.

Environment

Make safety a high priority by placing and marking ladders and step stools for high visibility. Check the ground for firmness, level and obstacles.

Latitude:	Mountains, water, temperature, humidity, condensation, dew, frost
Plants Pro:	wind break, low daytime heat, dust suppression, light blocking
Con:	cactus, poisonous, sky blocking
Animals:	Nocturnal: while observing; skunk, raccoon, dogs, etc.
	Diurnal: camp pests; birds, etc.
Insects:	biting, poisonous, pesky

The Observer



Often overlooked, but essential to enjoyable observing is to provide a comfortable environment for the observer. You will see and appreciate far more if you are comfortable. A cold, hungry, bug-bitten, fatigued or thirsty observer will remember an observing session for all the wrong reasons. Be prepared - especially for the cold. Pack extra clothes and pay special attention to the head, hands and feet. Try sitting periodically to avoid leg fatigue. Hot beverages are a great comfort, even on mild nights and some quick energy foods are helpful to stave off fatigue in the late hours. Researchers have noted that a high blood-sugar level (caused by eating food or candy) seems to counteract to some degree, the loss of retinal sensitivity due to altitude. Be aware of habits or conditions that compromise night vision, like smoking, alcohol, or poor diet. Other possible compromises, depending on the individual are caffeine and prescription medications. While it is not a recommendation, some observers feel melatonin and aspirin can be helpful the day after observing.

It has been noted that pre-exposure to bright sunlight compromises night vision. Depending on the individual, strong daytime light can affect the eye's ability to dark-adapt for up to 48 hours. Wear good sunglasses on bright days before observing, especially at the beach, on snow or at high altitudes. Many find observing with music a help in staying alert, but be considerate of the type and volume when observing in groups. Remember that a comfortable environment will help you observe longer and enjoy it more.

An observers attitude and predisposition will affect what is seen. Try to approach an observing session rested, relaxed and emotionally fresh. Being prepared and organized will keep your observing session stress-free. Thorough planning, checklists and specific boxes or totes for your astronomical gear will insure you arrive at your site with all the equipment and tools necessary. Item will be easily found when needed. Most observing sites are remote. Familiarize yourself with the area, determining what services are available. Knowing where gasoline, food, emergency services or a telephone is located is a wise precaution.

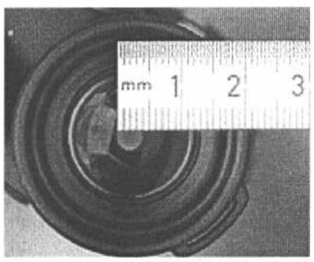
Bring clothes and shoes to match the worst-case weather. Being hot or especially cold can cause fatigue and adversely affect your concentration and safety. Knowing your own strengths and weaknesses gives you realistic expectations. Most observers are aware of their visual acuity. If in doubt, ask your optometrist if you have any conditions that would affect observing. An optometrist can also measure your pupil size for best low-power eyepiece match. If you wear eyeglasses or contacts make sure they are up-to-date. Eyeglasses that are glass with anti-reflection coatings have the highest transmission and can be dedicated for observing only. A separate set of contacts, if worn, that are clean and well lubricated will greatly enhance your viewing and comfort.

> **With a glimmer of faith he has flirted,**
> **Hates dogma that's crudely asserted.**
> **An astronomer knows**
> **That the faintest of glows**
> **Can't be seen unless vision's averted.**
> Mike Scholtes

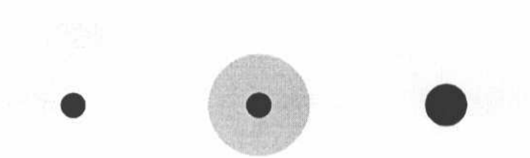
Learning visual observing techniques will enhance your ability to discern faint objects. One of the most beneficial is "averted vision", which is the technique of looking just a small amount to the side of an object. This focuses the faint image away from the center of the retina, onto a more light-sensitive area in the eye better suited for faint imaging.

Another technique is to use the unusual sensitivity of our peripheral vision to a moving stimulus. Details that are very low in contrast can sometimes be discerned if caused to move on the retina. This is easily accomplished by shifting your gauze from point to point on the object, or giving the telescope a slight nudge, bringing unsuspected detail into view.

Don't always trust your eyes. We observe while fatigued and under conditions of low illumination and low contrast, this is the opposite to that for which our eyes are most suited. Our brains are also prone to modify what we see and we are not always aware it's happening. A case in point is Schiaparelli seeing canals on Mars. Our visual processing will connect a series of markings into a line, especially when viewed under low contrast.



The exit pupil is the image of the primary mirror formed by the eyepiece. Most observers' eyes will dilate to 6-7mm and then slowly dilate less as we age. The photo at left shows a 4mm exit pupil. Using an eyepiece that gives an exit pupil larger than the observer's eye will result in the observer's eye becoming a field stop and reducing the effective aperture of the telescope. While this reduces the effective aperture of the telescope, it does allow a wider field of view. This may provide more pleasing views and ease in locating large objects. Just be aware that you are using a smaller aperture.



Some "shadowing" may occur depending on eye position since the secondary mirror shadow is a proportionately larger part of the exit pupil. For instance, if an eyepiece gives an exit pupil of 6mm and the secondary is 15% as large as the primary, the exit pupil will have a superimposed black circle of 0.9mm (drawing at left). If an eyepiece gives an exit pupil of 10mm the secondary shadow will still be 15%, or 1.5mm, but the observer's eye may only dilate to say 6mm (center drawing). The telescope is now reduced in aperture to 6/10 or 60% of its true aperture. But in the second case the secondary shadow is still 1.5mm, rather than the 0.9mm in the first case. The lighter shaded area is actually being stopped by the iris. The right drawing shows the disproportionately large secondary shadow relative to the light cone entering the eye. This will be noticed as a substantial blank spot in the center of the eyepiece that moves as you move your head. This situation is even more noticeable during the day or when observing bright objects like Jupiter or the Moon, since your eye will be less dilated and make the secondary shadow large relative to the eye's pupil. This is why there are practical limits to the minimum magnification of a telescope. (See Page 93 for a table of minimum magnification.) Stand back about one foot from the eyepiece and point the telescope towards the sky or a wall. You will be able to see the exit pupil seemingly hover in mid air.

TeleKit Break-down

Eventually the observing session comes to an end and hopefully you had a great experience. The breakdown of the TeleKit for storage or transport is much the reverse of set-up, with the exception of a few details to ready the telescope for inactivity.

Tilt the telescope to the zenith.

Raise the lower part of the light shroud and replace the primary mirror cover. Check it first for grass or debris that could drop onto the primary mirror.

Wipe any dew from the telescope.

Cover the secondary mirror.

Turn the power off to any accessories such as dew control or the fans.

Move the filter slide to its closed position.

Remove accessories such as the eyepiece, Telrad, finder or digital setting circle computer.

Pull the top of the shroud down and loosen the upper truss fasteners.

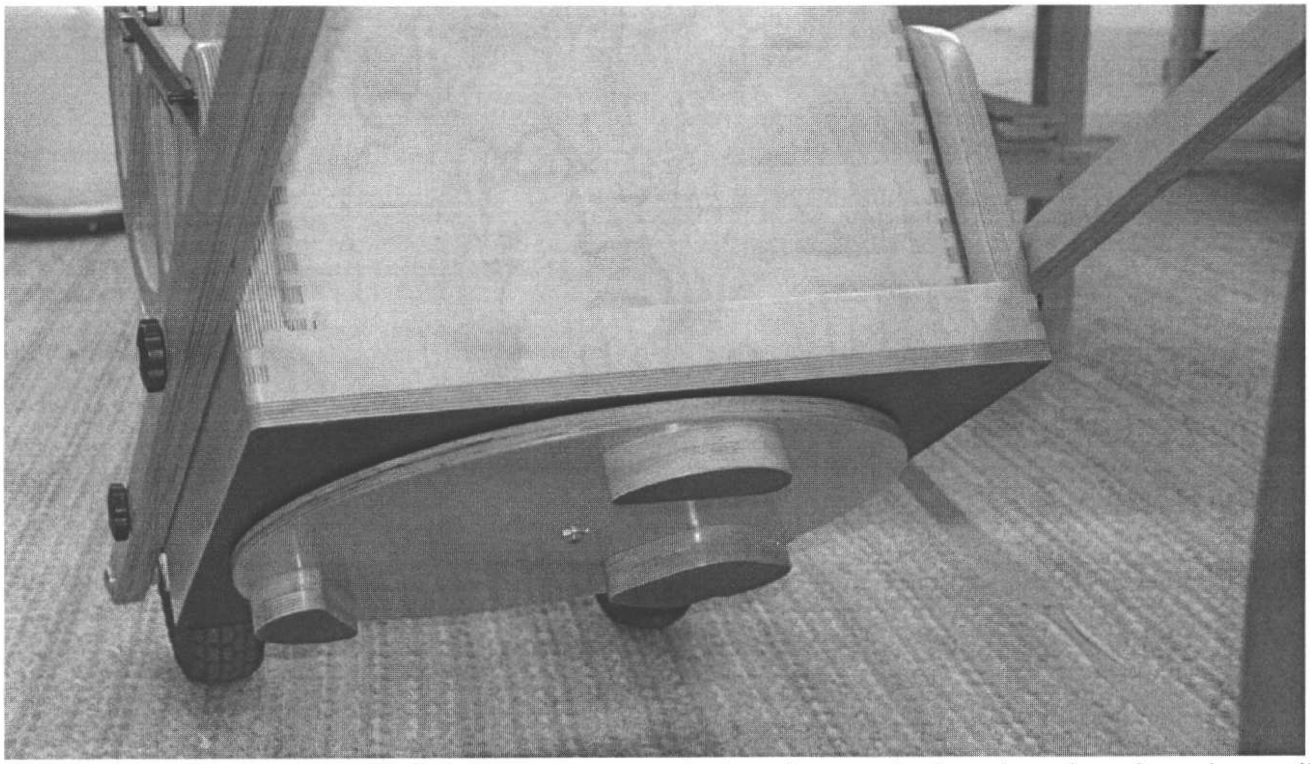
Remove the upper cage by grasping the lower ring and pushing up to slide the clamp bolts off the upper cage fastening blocks.

Remove the light shroud up and over the trusses.

Loosen the lower truss fastener, remove the trusses and stow them in a truss case or blanket. Tighten the lower truss fastening knobs so they will not vibrate loose.

Lower the primary mirror onto the transport pads with the collimation screws if you expect a rough trip.

Install the transport handles on the rocker box, making sure the wheels are on the side of the rocker box with the tall end board and the handles are on the side with the short end board. This prevents the mirror box from swinging forward when the telescope is raised with the handles.



Cover the cage with a cage case if you have one, and place the cage in the mirror box, lowering until it contacts the cage rests. It may be necessary to remove one of the lower clamp wedges and cam and angle the cage to place it in the mirror box. Just be sure to store it in a place where it will be with you the next time you set-up.

Rotate the ground board so one lobe faces back toward the handle side of the rocker box. This gives the maximum ground clearance in front between the wheels. The orientation as shown above is preferred to allow the front foot to clear any ground obstacles and prevent damage to the telescope.

Check your observing site before leaving for any lost or forgotten parts, refuse or personal effects.

Transportation

To move your telescope, make sure the handles are securely fastened and mounted so the taller side of the rocker box is toward the front, and the mirror box can't swing forward. Orient the ground board feet for maximum ground clearance (Page 86). Move slowly over rough ground and have someone balance the telescope if it is moved while assembled, (although this is not advised.)

The safety of your TeleKit and the vehicle it is traveling in is of foremost importance. A cover to protect it from scratches and dust is necessary to insure safe travel. The following recommendations will help insure that you arrive at your destination with a functional and great looking telescope.

Travel Supplies

Telescope cover
Moving pads or blankets
Loading ramps - make sure they securely fasten to the vehicle and don't exceed a 20-degree slope.

Preparation for Transport

Lower the primary mirror onto the transport pads or remove it altogether if rough roads are expected.
Cover the telescope to protect it from dust and wear.
Always transport the telescope with the primary mirror in the horizontal position.
Moving pads or heavy blankets can be used to cushion against wear.
Position other items so they cannot fall onto your telescope. Be aware of items like coolers or batteries that can leak or emit fumes, which can damage your telescope.
Position the telescope over the axle in trailers for the smoothest ride.
You can leave the transport handles on for protection if space allows.
Cushion the upper cage in the mirror box with installed felt pads, padding or cage case.

While in Transit

Stop and check your gear at least once during the trip, preferably early in your trip to correct any packing or orientation problems that may arise.

Departure

Make adjustments if you found travel to the observing site caused any problems.
Check your site to insure nothing was left behind.

Return

Recharge batteries if needed, you can leave your TeleKit plugged in with the float charger if you prefer.
Clean the telescope and optics if necessary.

Storage

Like any piece of precision equipment, the TeleKit requires some attention to detail before being stored for an extended period. Some of these recommendations may be helpful for short periods of storage between observing sessions, depending on the storage environment.

The main culprits that can cause excessive maintenance and repair are condensation of moisture or aerosols and dust. If you understand the possible sources of these materials and protect the telescope effectively, it will look and perform the same after storage as before.

The Primary and Secondary Mirror

Since it is a large mass of glass with low thermal conduction, it will lag behind the air temperature. If the mirror cools enough overnight, it can be well below air temperature in the morning as the air temperature quickly rises. If it is stored where the humidity is high enough, it will condense moisture on its surface on a daily basis. This could be catastrophic to the mirror coatings and practically "weld" contaminants on the surface. Solutions are to have a small light (15w) as a heat source near the mirror to keep the mirror warmer than the air and lower the humidity. This can be used with a timer to minimize cost. The mirror surface can be coated with an inert material such as colloidion, which is brushed or sprayed on and allowed to dry. It can be easily peeled off when the telescope is put back in service. The telescope can be stored in a dry or thermally stable area. Last, the mirrors can be removed and stored in a better environment or a well-sealed box. Just remember that there is a high liability when the primary mirror is handled; it is smooth, heavy, expensive and unforgiving.

Telescope Storage

Aerosols are liquids that will evaporate and then condense on a cool surface. They will behave much the same as water but can be much more stubborn to remove. They include oils, glycols and plasticizers. Aerosols are prevalent in plastics, (especially vinyls,) from cooking and in garages around autos. Be aware that these areas may mean an optical cleaning problem if used for storage.

Dust is the most likely problem with storage. A tight fitting breathable cover that is dust-proof and a soft cotton cloth on the mirror under the wood cover is effective for dust, aerosols and moisture. You can have a tent and awning company or a camping supplier supply the material and possibly fabricate the cover to your specifications. The best material is a heavy nylon with an internal seal coating, such as the ***AstroSystems*** telescope cover. This cover can also be used in transportation but it is recommended that the cotton contact cloth on the mirror be removed for transport. It could contain abrasive dust that with transportation movement could sleek the coatings.

Special Storage Considerations

Some dust and aerosols are especially nasty. These may include salt spray, if you are near the ocean. Pollen has a built-in adhesive and can be very difficult to remove. Some industrial areas can contaminate the telescope with caustic residues. Road or rock dust is very abrasive. Last, it would be wise to consider the possibility of small animals, rodents and insects taking up residence. An enclosed area like your telescope is a natural home for mice and many insects. The best defense here is to make sure there is no access for them. Most "by-products" of insect or animal habitation will damage optics and wood.

Maintenance / Adjustments

The TeleKit has been designed to minimize the maintenance required by using stainless steel hardware almost exclusively and bearing surfaces that are pre-lubricated or non-lubricated. Keeping your telescope clean is the primary maintenance required. The following are some maintenance or adjustment items, but you may find they are rarely, if ever, needed.

Phase 4 Focuser
Each Phase 4 focuser is made of the finest materials available and will not rust or corrode under normal use. It requires NO lubrication. Merely keep your ***AstroSystems*** focuser clean; this will insure many years of trouble-free use. Rarely needed, the timing belt between the gears can be adjusted. The hex screw opposite the thumb friction adjustment is used. Adjust it so that it is snug but doesn't pull the belt tight. Move the focus knob one full revolution to check.

Filter Slide
Keep your filter slide clean for best performance. The spring détente can be adjusted with a long slot screwdriver but the focuser will need to be removed first. Remove the hex drive set screw to expose the slot drive détente below. Proper adjustment will give a subtle stop at each filter position. Over-tightening will require so much twisting force to change filters that the image will be lost in the eyepiece.

Spider
Check the spider for equal tensioning by tapping each vane and listening for a similar ring, or press lightly and check for equal displacement, which will be small. Tighten the appropriate screw if necessary.

Secondary Holder
Inspect the nuts on the mounting stud for tightness and the four screws that retain the shroud that holds the secondary mirror. Check for any obvious damage, especially after rough travel.

Altitude Bearing Teflon Pads
Clean the surface of the Teflon pads with fine sandpaper or a razor blade held vertically if they become dirty. Clean the laminate bearing surface on the altitude bearings if dirty, using window cleaner or alcohol. Check the six mounting screws on each altitude bearing to be sure they are snug.

Primary Mirror Cell
Adjust the sling if necessary to center the primary in the mirror box. Inspect the mounting hardware for anything that may have loosened. Inspect the battery connections and be sure to charge the batteries every 2-3 months, even if not used.

Rocker Box
Remove the ground board and inspect the laminate bearing surface. Unusual wear at the inside or outside of the bearing contact area would indicate the need to shim the bearing axle for uniform contact. After adjustment, lay the ground board on the bottom of the rocker box and check the bearing contact by sighting along the rocker box bottom with a bright light or flashlight.

Azimuth Bearings
Without removing the bearing from the axle, remove any surface rust from the surface of the bearing with steel wool or ScotchBright. This light surface rust is normal with a steel bearing race.

Transport Wheels
Inspect for loose hardware and proper tire inflation.

Cleaning Optics

Today's precision optics are manufactured from a wide range of glass substrates and can have one of a vast number of vacuum applied optical coatings to enhance its performance. Only a clean optic will give its optimum resolution, contrast and transmission. With proper care and preventative measures, an optical surface will only need to be cleaned on an infrequent basis.

STEP 1 Prevention
Protecting optics from dust, moisture and aerosols (liquids that condense on surfaces from the air) reduces the need for cleaning. When cleaning is necessary, protected optics are much easier to clean. Investment in dew caps, telescope covers (such as ***AstroSystems***' telescope cover), equipment cases and eyepiece caps will be repaid many times over in performance, life of the coatings and instrument value.

STEP 2 Non-contact Cleaning
Dust and lint can easily be removed with a duster or brush. Use the brush only to loosen particles, then puffs of air to lift and remove them. This step is the most effective and safest form of cleaning and can be performed almost anywhere. A high pressure air duster or compressor are also ideal for removing dust. Abrasive dust is the most harmful contaminant because it can easily cause sleeks and scratches if rubbed against the surface.

STEP 3 Contact Cleaning
Small optics: Eyepieces, binoculars and filters require the most frequent cleaning due to contamination with body oils, make-up or fingerprints. It is recommended that these optical parts NOT be disassembled, only the accessible lens surfaces be cleaned. First, remove dust as described above, then put a drop of lens cleaner or alcohol in the center of the lens. Using a cotton swab, lightly swirl it onto the surface. Slowly rotate the swab to pick up debris and discard frequently. Cotton swabs give excellent control for getting to the edges but be sure not to let liquid wick into the space between the lens and it's cell. Second, before the lens dries, swab the surface lightly with a clean dry cotton swab or ball, using a circular motion. Use another fresh cotton swab or ball to lightly brush the lens dry. Should any streaking remain, repeat the above process using a drop of alcohol. Some multi-coated surfaces may still show streaking. Pure condensed water from your breath and a new swab will remove any last traces of contaminant.

Mirrors: Mirrors (and disassembled lens elements) can be completely immersed for safer, more effective cleaning. You will need a sink or large plastic tub (invest in one if you own a large mirror) towels, detergent (unscented) and a gallon of distilled water. Make sure your wash basin is clean and well rinsed, and then place a towel on the bottom. Remove jewelry from your hands and wrists and loose items from your shirt pockets. Pre-mix a capful of ordinary dishwashing detergent in a pint of warm water. The preferred type of detergent is unscented with no additives, such as hand softeners. Place the optic in the tub or sink and run lukewarm water over the surface for a few minutes. This helps loosen particles. Plug the sink, place the optic back in and fill to a depth of one inch over the surface with lukewarm water. Add the detergent and let the optic soak for 10-15 minutes.

<u>DON'T LEAVE THE OPTIC UNATTENDED</u> and never allow the solution to dry on the optic by having the water accidentally drain away. Use a cotton ball in a gloved hand and agitate the solution to remove air bubbles on the mirror's surface. NEVER apply force; let the solution do the work. You can move a cotton swab over the surface using only the force of the saturated cotton ball against the optic. Drain the cleaning solution and immediately rinse well with lukewarm tap water, then a final splash with distilled water. The final splash with distilled water displaces the tap water so any remaining drops will leave a minimal spot after drying. Place the mirror upright on a towel to dry. To hasten drying and help avoid water marks, you can dab up large remaining drops with the corner of a paper towel. Resist the urge to touch or blot the surface.

Large Optics: Large (18"+) mirrors can be cleaned in place in the TeleKit by hinging the mirror cell for easy access. Cleaning in place has the advantage of lessening the liability of handling a heavy, wet and expensive optic. Tip the mirror box so the mirror is vertical or nearly so and place a towel along the bottom of the mirror box to catch any liquid. Using an atomizer (the type sold for misting plants) filled with distilled water, wet the entire surface. Several wetting cycles will loosen and remove most dust and grit. Now tip the mirror box so the mirror is horizontal and place towels around the entire mirror. Using a second atomizer wet the surface with detergent solution. After a 5-10 minute, soak time use a cotton ball to move the solution around on the mirror. Do not use pressure, only the weight of the saturated cotton balls. Tip the mirror back up to vertical and rinse thoroughly with the distilled water mister. Use the corner of a paper towel to dab up remaining drops or use an Air Duster or compressed air to blow remaining droplets off the edge. Remove the towels and keep the mirror vertical to dry.

Difficult Contaminants Some aerosols, such as those emitted from plastics, plants (pollen or pine trees), cooking or automobiles can condense on the optical surface and form very stubborn deposits not easily removed by detergent. If a haze or deposits are left after the detergent cleaning step, it may be necessary to soak the surface in a solvent. Denatured alcohol (ethyl) is the safest while acetone may be more effective. Before proceeding please read these precautions.

Both solvents are very flammable, use only in a well-ventilated area away from any ignition source.
Both solvents may attack, soften or dissolve paints, plastics or finishes.
Both solvents need to be chemical grade or better to evaporate without leaving residue. Paint grade is <u>NOT</u> sufficient.

Wet a cotton swab with the solvent and using light pressure, test a small area at the edge of the mirror. If the solvents do not remove the deposit, it is recommended that the optic be sent to an optical coating company for cleaning or recoating. If the solvents remove the contaminants, place the optic on a cushioned, solvent resistant surface; porcelain, metal, glass or polyethylene. Cover the surface with soft tissue or paper towels. Wet the paper and then cover the surface with a polyethylene sheet. This technique wets the surface without using excessive amounts of solvent and minimizes evaporation so the surface won't dry and the personal exposure and fire risk is low. After 5-10 minutes, check the surface. Once the contaminant is removed, rinse with distilled water and dry as above. Both acetone and alcohol are soluble in water.

Appendix 1

Optical Tables

Diameter	Intercept (L1)	Intercept (L2)
16	11.6	12.2
17.5-18	12.6	13.2

L1	Intercept - secondary to focal plane (Feathertouch or Phase 4 focuser)
L2	Intercept - secondary to focal plane (Moonlite focuser)
D	Diameter of primary mirror
F	Focal length of primary mirror
N	Minor axis of secondary mirror
I	Illuminated image size - 100%
%Ob	Obstruction ratio (N/D)
S1	Separation of primary and secondary using L1 (F – L1)
S2	Separation of primary and secondary using L2 (F – L2)

f / 4

D	F	N	I	%Ob	S1	S2
16	64.0	3.5	.67	21.8	52.4	51.8
17.5	70.0	3.5	.42	20.0	57.4	56.8
18	72.0	3.5	.42	19.4	59.4	58.8

f / 4.2

D	F	N	I	%Ob	S1	S2
16	67.2	3.1	.35	19.4	55.6	55.0
17.5	73.5	3.5	.60	20.0	60.9	60.3
18	75.6	3.5	.60	19.4	63.0	62.4

f / 4.5

D	F	N	I	%Ob	S1	S2
16	72.0	3.1	.56	19.4	60.4	59.8
17.5	78.75	3.1	.35	17.7	66.1	65.5
18	81.0	3.1	.35	17.2	68.4	67.8

f / 5

D	F	N	I	%Ob	S1	S2
16	80.0	2.6	.27	16.2	68.4	67.8
17.5	87.5	3.1	.67	17.7	74.9	74.3
18	90.0	3.1	.67	17.2	77.4	76.8

f / 5.5

D	F	N	I	%Ob	S1	S2
16	96.00	2.1	.13	13.3	84.40	83.8
17.5	96.25	2.6	.35	14.8	83.65	
18	99.0	2.6	.35	14.4	64.80	

f / 6

D	F	N	I	%Ob	S1	S2
16	88.0	2.6	.50	16.2	76.4	75.8
17.5	105	2.6	.56	14.8	92.4	
18	108	2.6	.56	14.4	95.40	

Maximum eyepiece focal length (mm) at a given exit pupil **(see Page 12, 84)**

	7mm	6.5mm	6mm
F/ratio			
4.0	28	26	24
4.25	30	28	26
4.5	32	29	27
4.75	34	31	29
5.0	35	32	30
5.25	37	34	32
5.5	39	36	33
5.75	40	37	34
6.0	42	38	36
6.25	44	40	37
6.5	46	43	39

Minimum magnification at a given exit pupil **(see Page 12, 84)**

	7mm	6.5mm	6mm
16	58	63	68
17.5	63	68	74
18	65	70	76

Parts List

(See Page 96 for hardware description and abbreviations)

TK#	Item		TK#	Item	
Upper Cage Assembly					
1	Upper ring	(1)	**21**	Fastening plate	(4) 2.5 x 3 x 3/8 Ply
2	Lower ring	(1)	**22**	Cam lever	(4) Black Aluminum
3	Separator bars	(4) 3/4 x 12"	**26**	Washers	(8) 1/4" fender ss
4	Light baffle	(1) 12.6 x 51.5" laminate (16")	**27**	Truss Plugs	(8) 0.9" x 1" Dowel
4	Light Baffle	(1) 13.1 x 57.8" laminate (18")	**30**	Fastening blocks	(4) 1.25 x 3" x 3/4" Ply
5	Focuser	(1) Phase 4 or optional	**32**	Mount Screw	(2) #8 x 1.25" FH ss
6	Spider	(1) _____"	**33**	Spring	(4) 2.1# Zn/steel
7	Sec. holder	(1) ______"	**34**	Knob	(2) Counterweight knob
8	Foc mt. scr.	(2) #10 x 1" FH ss	**38**	Mount Bolts	(2) 1/4-20 x 1.75" FH ss
9a	Spider screws	(4) #10-32 x 1.5"-1.75" PH ss	**39**	Support Bar	(1) 1/2" x 1.3" x 12.9"-13.3"
10	Washers	(4) #10 ss	**82**	Washer	(2) 1/4" flat washer
11	Glue dowel	(24) 5/16	**156**	Screws	(8) #10 x 1" FH SS
12	Tape	(2)	**196**	Nut	(2) 1/4-20 ss
13	Screws	(4) #4 x 3/8 pan/phil ss			
Filter Slide					
40-67	Filter Slide	(1) 1/8 Ply	**58**	Mount Screw Eye	(4) #6 x 1" Zn/steel
45	Baffle Supports	(2) 0.25 x 0.3r	177d	Screws	(4) #8 x 1.25" PB
Primary Mirror Cell					
70-71	Frame	(1)	**78**	Ring/Tape	(1)
72	U Channel	(3) 1 x 1/2	**80**	Collimation Bolts	(3) 3/8 x1.5"SHCSss
73	Flotation Pads	(6) Al Triangles	**82**	Washer	(3) 1/4" Flat
74	Pad Points	(18)	**84**	Screw	(3) #10-32 x 1/2" FH
75	Pad Machine Screws	(6) #10-32 x 3/4 FH ss	**85**	Nut	(3) 3/8-16 Square ss
76	Finish Washers	(6) #10 x 0.6 OD ss	**86**	Knob	(3) "T" handle, 3/8"
77	Nuts	(6) #10 ss	**87**	Nut	(3) 3/8" Hex nut ss
Location Posts/ Travel Supports			**Sling Assembly**		
90	Location Post	(3) 1.5" x	**82**	**Washer**	**(2) 1/4" ss**
91b	Retainer	(3) 3/8 x 2" wood	**95a**	Sling Assembly	(1) Cable/Eyebolts
92	Screws	(3) #14 x 2" ss	**100a**	Sling Posts	(2) 1.5" x ___
93	Travel Support	(3)	**118a**	Sling Retainer	(2) 4 loop/2 hook
94	Travel Cushion	(3) 1.5" Pad	**196**	Nut	(2) 1/4" ss
Mirror Cell Mount Hardware					
101	Pivot	(2) 0.75 x 2.0"	**99**	Washer	(2) 5/16 washer ss
102	Mount Screws	(4) 5/16" x 1.5"-2" lag	**106**	Bolt	(2) 5/16 x 3"
104	Mount Block	(2) 1.4 triangle BB	**145**	T-nut	(2) 5/16" T-nut
Mirror Cover					
110	Cover	(1) 3/8" Plywood	**116**	Handle Screws	(4) #8 x 1/2" FH
115	Handle	(1) Black Steel pull	**118**	Velcro	(2) 4" hook & loop
			218	Felt Pad	(3) 3/4" Felt Pad
Fan Circuit					
13	Control Board Screws	(4) #4 x 3/8" PH	**125-6**	Jumper Wire	(1)
120	Control Board	(1)	**128a**	Fan Mount Screws	(8) #6 x 3/4" PH
121	Fan(s)	(2) 60mm 12v Fan	**137**	Wire Holder	(4) Plastic/nail
122	Batteries	(2) 6V Gel Cell			

TK#	Item	Number	TK#	Item	Number
Recharge Circuit					
129-31	Auto recharge		**135**	Float Charger	(1) Wall Chg 12V-float
Lower Truss Tube Fastener					
140	Truss Bracket	(8) ¼" x 1.5" angle	**149b**	Tube Connector	(8) truss tube dia.
146	Knob	(8) ¼-20 black	**151**	Bolt	(8) 1/4" x 1.5" FH
148a	Bolt	(8) 1/4-20 x 1.5" TH ss	**152**	T-Nut	(8) 1/4" -20 x 9/16"
Altitude Bearing					
8	Stop Screw	(2) #10 x 1.25" FH	**154**	Formica	(2) 1" x 35" Ebony Star
116	Teflon screws	(8) #8 x 1/2" FH ss	**154a**	Laminate	(2) 1" x ___"
150	Alt bearing	(2) 22" dia. x 0.95" th.	**155a**	Teflon pads	(4) 1.1 x 2"
151a	Mount bolt	(12) #10-32 x 1" FH ss	**153**	Bearing Stop	(2) nylon washer
Mirror Box					
157	Gusset	(4)	**230**	Back panel	(1)
231	Front panel	(1)	**232**	Side panels	(2)
Rocker Box					
145	"T" Nut	(4) 5/16" Zinc (in sides)			
170	Side panel	(2)	**174**	Laminate	(1)
171	Front stiffener	(1)	**175c**	Pivot bushing	(1) 1/2 x 3/4 Bronze
172	Back panel	(1)	**177d**	Bottom Screws	(16) #6 x 1.25" PB
173a	Bottom panel	(1)	**179a**	Glue spacer	(1)
Ground Board					
"A"	Ground Board	(1) round	**182**	Bearing	(8) Roller
"A"	Foot	(2) w/ bearing clearance	**186c**	Pivot Bolt	(1) 3/8" x 1.5" brass
"A"	Foot	(7) foot	**187b**	Bearing axle	(2) 5/16" x 3"
87	Nut	(1) 3/8" Jam Nut ss	**189a**	Pivot Bolt Set	(1) #8-32 x 5/16 set SS
99	Washer	(2) 5/16" Washer ss	**194**	Locator Dowel	(6) 1/4" x 2"
116	Bearing screw	(1) #8 x 1/2"	**195b**	Foot wear pad	(3) Laminate 4.1" x 4.1"
155a	Teflon Bearing	(1) 3/16" x 1.5" sq. teflon	**197a**	Hex Key	(1) 5/64"
178	T-nut	(1) 3/8"	**220**	Washer	(1) 3/8" ss
Transport Wheels					
99	Washer	(4) 5/16"	**213**	Washers	(2) 5/8 Flat
142	Knobs	(4) Wood Knobs	**214**	Nuts	(2) 5/8" Hex
144	Washer	(8) 5/16" nylon	**215a**	Bolt	(4) 5/16" x 3.5"
145a	T nut	(4) 5/16"	**217**	Jam Nuts	(4) 5/16" ss
210	Handles	(2) Wood 60"	**218**	PVC pads	(8) 3/4" dia. black
211	Wheels	(2) 10 x 1.75 pnu.	**219**	Nuts	(2) 5/8" Nylock
212	Wheel bolt	(2) 5/8 x 5" carriage			
Light Shroud					
200	Light Shroud	(1) Black Lycra			
Truss Tubes					
222	Truss Tubes	(8) 1.0" OD x 0.049"	**221**	Heat Shrink	(8) 1" Polyolefin
218b	Velcro hook	(1) 6" w/ special adhesive			
Adhesive Kit					
300	Epoxy	(1) FE-0004A 8oz.	**305**	Nitrile Gloves	(4) X-large
301	Hardener	(1) FE-0004B 8oz.	**306**	Beaker	(3) 100ml tri-pour
304	App. Brush	(3) 1/2" flux	**307**	Mix Sticks	(8) "Popsicle"

Appendix 3

Hardware Description

Many types of hardware are used in the TeleKit. The following list gives a short description, the abbreviation used in this manual and a drawing. Generally the primary types of screw are machine bolts, wood screws and sheet metal screws. Machine bolts have a uniform pitch to the threads and are used with a nut or machine threads, they are also sometimes called machine screws when they are a smaller size. Wood screws have sharp threads and a thicker unthreaded section near the head. Sheet metal screws are fully threaded and are usually not as pointed as wood screws. Sheet metal screws can be used in wood if a proper pilot hole is made.

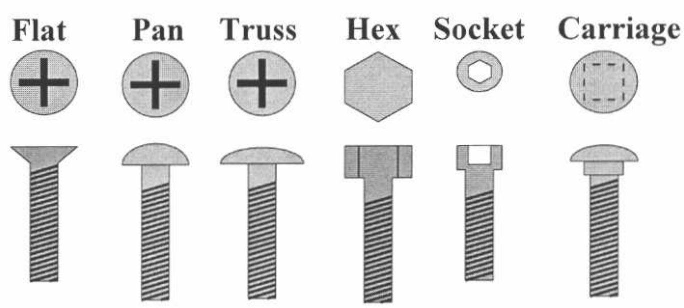
TeleKit Hardware and their Abbreviations

Material

Stainless Steel	ss
Steel with Zinc Coating	Zn/steel

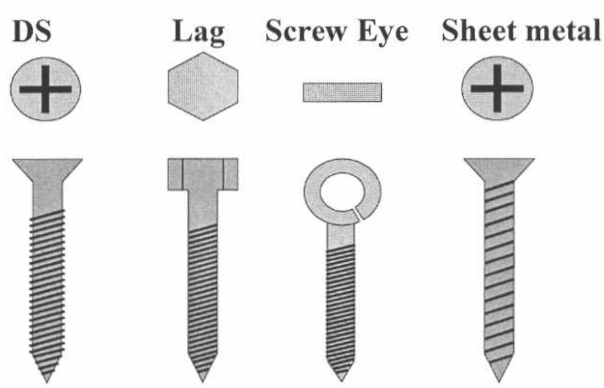
Bolts

Flat Head	FH
Pan Head	PH
Hex Head	HH
Socket Head	SH
Carriage Bolt	CB



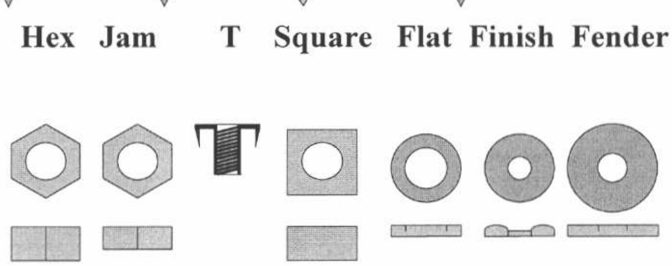
Screws

Deck Screw	DS
Lag Screw	Lag
Screw Eye	Screw Eye
Sheet metal	SM



Nuts / Washers

Hex Nut	Hex Nut-Jam
T Nut	Nylock Nut
Square Nut	
Flat washer	Finish Washer
Fender washer	



The Nylock nut is not shown, it is like a standard hex nut but with a nylon thread-lock insert.

Appendix 4

Router Primer

The simplest and most consistent way to complete the rounding over of the plywood edges as well as flush trimming the finger joints on the TeleKit is with a router. Routers are simple tools, an electric motor that spins a cutting bit at very high speeds. They date from about 1915 and have not changed conceptually, just improved power as motor technology has progressed. The topics to be addressed below are safety, feed direction, bit selection and specific use on the TeleKit.

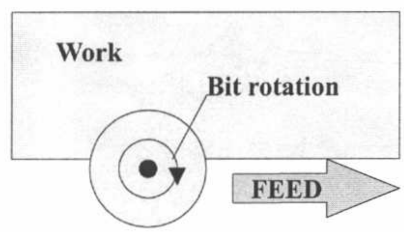
Safety

Routers are inherently safe when compared to saws and drills because of the small exposed bit. Still, any sharp object spinning at 10,000-30,000 rpm deserves respect.

1. Avoid loose clothes, hair and jewelry.
2. Remove the electrical plug when changing bits.
3. Never pick up a router from the work while the bit is still spinning.
4. Never start the router when the bit is touching the work.
5. Don't let the router base tip as you cut.

Feed Direction

Always move the router in the correct direction. Router bits rotate in a clockwise direction as seen from above. In principle, you want to move, or "feed" the router in the same direction as the cutting edge of the bit.

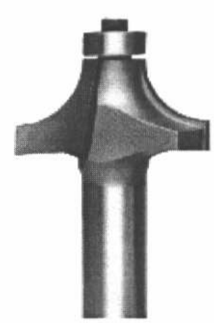


Bit Selection

Router bits are available in high-speed steel or with Tungsten Carbide inserts. We highly recommend purchasing new carbide bits. For this small investment you will obtain smooth, consistent cuts with less resistance and little to no veneer tear-out. Carbide bits will also come with a bearing on the tip of the bit, adding to the smooth, consistent cut and avoids any surface marring.

TeleKit Suggestions

We recommend using a flush-trim bit on the finger joints before sanding. This gives a smooth finish over the finger joints and allows sanding to progress quickly. The finger joint corners can be radiused with a 1/4"-3/8" radius round-over bit. All other exposed edges can be finished with a 1/8" or 3/16" radius round-over bit, depending on your preference. Our suggestion is a 1/4" radius on the ground board, mirror box and rocker box and 3/8" radius on the mirror box and rocker box finger joints. There are a few areas that offer a challenge where the two radiuses meet, such as the transition on the rocker box where the finger joints stop midway along the edge. Here it is easiest to rout the entire edge with the smaller radius and then do just the finger joints with the larger radius. Use a pencil mark to help you see where to stop the larger radius and then blend the two together by sanding.



Round-over

Flush-trim

Appendix 5

Tools and Supplies

Here is a list of the tools and supplies necessary to construct the TeleKit. The optional tools are not necessary but will speed the construction and improve consistency of edge rounding and finger joint leveling. If you don't own all of these, you might first try to borrow them. Many of them are relatively inexpensive and you may want to purchase them to start stocking your workshop for future projects.

Bar clamps (8) 30" min.
Drill
Sanding block, sanding sponges
Wrenches - 9/16", 5/8"
Ruler - 12"+
Hammer or mallet
Screwdrivers - Phillips #1, #2 and flat #2
Scissors
Drafting triangle or square
Drill bit set 1/16"-1/4"
Spatula
Utility knife
Tape measure - 10'+
Pliers
Coarse wood file or rasp

Optional Tools

Router
Router bits - flush trim - 1", radius 1/8", 3/16", 1/4"
Random orbital sander
Spray gun and compressor

Supplies

Paper towels
Acetone
Drop cloth - polyethylene or non-porous
Dust mask
Sandpaper (60-80, 120-150 and 220-320 grit)
Lighter or matches
Removable Locktite
Old clothes / apron
Masking tape
Black vinyl tape
Ear plugs/hearing protection
Pencil, permanent marker
Super glue (cyanoacrylate)
Contact cement (laminate type)

Supplied with the TeleKit:

Epoxy kit
Scrap wood
Polyethylene sheet plastic

Finishing Supplies

Polyurethane topcoat (recommended)
Stain (if used)
Flat black paint (aerosol)
Brushes - finish (1) and disposable (2)
Cleaning solvent for finish
Wood putty (birch color)

Appendix 6

Accessories

Finders
Finders are a helpful accessory that make it easy to locate celestial objects. The Telrad, a reflex type finder, does not magnify and appears to project an illuminated reticle at infinity. It is easy to use and makes locating objects fast, as long as there are visible stars within one or two degrees of the object you wish to find. The Telrad is highly recommended and can be used with an optical finder.
Optical finders are helpful in finding faint objects. The most common sizes are 50mm - 80mm and will have a magnification of between 5 and 15 with a typical field of view of 2 to 6 degrees. Finders are most convenient to use when mounted near the eyepiece on the upper cage assembly. AstroSystems makes the "Woody" finder, a 60mm, 9 power wooden tube finder with mounting.

Digital Setting Circles
Most find the speed and accuracy of finding and identifying celestial objects with digital setting circles well worth the price. You'll spend your precious observing time looking at objects rather than looking for them. The two design considerations when using digital setting circles are the display mounting location and clearance of the shaft encoders. Mounting the display is mainly a matter of finding a location that is convenient and positions the display for readability. For best appearance when the display is near the eyepiece, some have run cables around one of the truss poles, making a clean and professional installation.

Light Baffle
A light baffle will help image contrast by keeping stray light out of the front end of the telescope. A baffle will also help prevent dewing of the secondary mirror. A light baffle plugs into the front of the upper cage assembly and can be made out of heavy (1/16") ABS, Kydex, Formica or other opaque plastic. It can also be constructed from sheet metal. For convenience, it can be temporarily fastened into a cylinder with Velcro or snaps and then laid flat for transport. Since it attaches to the very front of the upper cage assembly, it's weight can greatly affect balance and must be taken into consideration when balancing the telescope, (see Page 64).

Observing Tables and Chairs
Tables are a great help when observing. They offer a roomy place to set books, charts and equipment, improving organization and making for a more enjoyable observing experience. Eyepieces and filters will stay organized and clean while being accessible. It's also helpful to have a place to heat food and water. Many observers find a folding camp table to be a good choice for observing. They are sturdy and fold-up for easy transport. Be sure to get one with crossed legs as opposed to straight, which are much more stable. While larger and heavier, the white plastic top tables sold in many department and home supply stores are great. A chair is a great comfort when feeling fatigued. To further enhance what is seen at the eyepiece, an adjustable-height observing chair is hard to beat. They are especially useful when observing objects at lower altitudes.

Dew and Frost Prevention

Ideal conditions for observing are also the best conditions for dew and frost to form. To be out under clear skies with a telescope and not be able to observe because of fogged optical surfaces is a very frustrating experience. It is rare to have the primary mirror dew. It has a large thermal mass and since glass is a poor conductor of heat, the primary mirror will usually remain a few degrees above the air temperature, protecting it from dew. Little can be done if the primary should dew. Any attempt at heating will temporarily destroy its imaging capabilities. Just avoid running cooling fans too long and cover a cold mirror before exposing it to a warm, humid room. When stored in an un-insulated area, constant temperature cycling of a primary mirror can cause dewing and early coating failure. This has been observed in the Northeast and upper Midwest. An 8 - 10 watt bulb below the primary mirror will eliminate this problem and not heat the mirror enough to cause cool-down problems.

The secondary mirror has a small mass, is close to the end of the tube and is more prone to dewing. Extra effort is needed to protect it. The addition of an extra long dew shield on the end of the upper cage assembly helps prevent dewing and benefits light baffling. In areas where dew is heavy, a low-power electrical heater placed behind the secondary will be the solution (see ***AstroSystems*** DewGuard). To run power to a secondary mirror heater, flat tape wires, like the type used to electrify dollhouses, can be applied to the spider or thin (22 gauge) wires attached to the vane edge with super glue.

Dew shields and electrical heating work well for finders. Eyepieces are prone to dewing even more since a warm, moist surface (your eye) is always close. Keeping eyepieces in a covered case when not actively being used helps keep them from cooling off. The disposable type of hand warmer, such as that found in sporting goods stores can be placed in the eyepiece case to gently warm the eyepieces. Placing them in an inside coat pocket will also help. Just be sure to cap or bag the eyepiece so it stays clean. Electrical heating would help, but as of this writing there is little on the market.

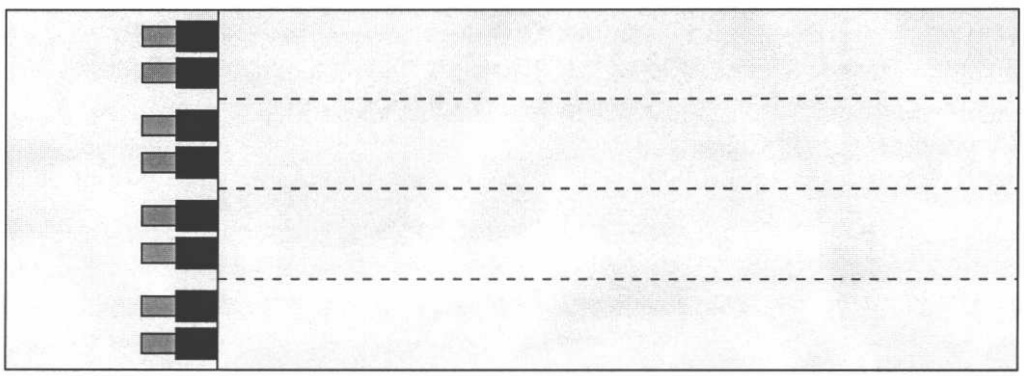
Ladders or Step Stool

A ladders or step stool is a necessary item when using a large aperture Newtonian. The eyepiece can be anywhere from 5 - 7 feet (1.5 – 2.1m) above the ground. The selection of an observing ladder will greatly affect your comfort and safety. This is no place to skimp. Don't grab whatever is in the garage. An observing ladder should extend 18" to 24" above the eyepiece at zenith, giving a convenient hand-hold for improved balance. Make sure the ladder is stable on uneven ground and can be moved around easily. The three-legged ladders used by electricians and fruit pickers offer improved stability and are easier to get close to the eyepiece. A modification that makes observing easier is to add steps between the existing steps. This makes finding the right position for comfort easy for anyone. Eyepieces don't do well in 7-foot drop tests. Stepladders can be used with most telescopes having an 80" or shorter focal length. Use the same guidelines to choose a stepladder as with a ladder and make allowance for shorter adults and children.

A nice safety feature for ladders is to use an LED light source and illuminate the steps, especially the lower ones. The light can be directed onto the step from the step above or a 1/8" acrylic rod can be inlaid into the step and lit from the end to illuminate a strip in the step.

Telescope Covers
Custom telescope covers can be made or purchased to protect the telescope when being moved or during storage. Nylon, canvas or Naugahyde make strong water and dust resistant covers. Many auto upholstery or tent and awning shops will fabricate covers at a reasonable cost. Look for them in the Yellow Pages. A lightweight, reflective cover will protect and help minimize heat gain during the daytime while the telescope is set up in the field, see ***AstroSystems*** telescope cover.

Truss Tube Case
A case to store and transport the truss tube is a nice addition to the TeleKit. It will protect the trusses, especially the upper cage fasteners, during transport. It can be fabricated from heavy upholstery cloth or nylon. These cases are available through ***AstroSystems***.



Cage Case
A protective case to stow the cage is great insurance for the cage. Keep your cage safe and dust free and protect the sensitive parts like focuser, filters and secondary mirror. See ***AstroSystems*** cage case.

Transport Case
A cover to protect your telescope while disassembled in the field or while being transported is another great investment. These are especially useful if the telescope is transported in an open truck or trailer. Ideally the construction is a durable water and dust resistant shell with a soft liner. See ***AstroSystems*** transport case.

Eyepiece and Equipment Cases
It is a good investment to purchase (or build) sturdy cases for peripheral equipment such as a finder, Telrad, eyepieces, filters, flashlights, collimating tools, books, charts, etc. The case will protect your valuables by keeping dust and moisture off and it is easier to keep everything organized. Eyepiece case lids can be kept closed to keep the eyepieces not in use from cooling off. This will help to eliminate eyelens dewing. Many types, sizes and styles are available, just be sure they will travel well and have sufficient foam or padding inside. Some manufacturers offer watertight cases that have an o-ring seal. Small suitcases or briefcases can also be converted to equipment cases. Sources are photographic supply houses, flea markets and discount stores.

Appendix 7

ATM Resources

Books - Telescope Building

	Author	Publisher
Advanced Telescope Making 1+2	Allan Mackintosh	Willmann-Bell
Amateur Telescope Making 1, 2+3	Albert Ingalls	Willmann-Bell
Build Your Own Telescope	Richard Berry	Willmann-Bell
The Dobsonian Telescope	Kriege, Berry	Willmann-Bell
How to Make a Telescope	Jean Texereau	Willmann-Bell
Lightweight Giants	Steve Overholt	Owl Books
Newtonian Notes	Peter Francis	Kenneth Novak
Star Ware	Philip S. Harrington	John Wiley & Sons
Telescope Optics	Rutten and Van Verooij	Willmann-Bell
Unusual Telescopes	Peter L. Manley	Cambridge
User Friendly Sidewalk Telescope	John L. Dobson	Everything in the Universe

Books/Guides - Observing

	Author	Publisher
Atlas of the Moon	Rukl	Sky Publishing
Burnham's Celestial Handbook 1, 2, 3	Robert Burnham	Sky Publishing
Deep Sky Field Guide to Uranometria	Cragin, Lucyk, Rappaport	Willmann-Bell
Messier Objects 1 & 2	Watson	Sky Spot
Observe - The Messier Objects	Holyoke	Astronomical League
Observe - The Herschel Objects	Ancient City A.C.	Astronomical League
Sky Atlas 2000.0 Companion	Strong, Sinnott	Sky Publishing
Star Testing Astronomical Telescopes	Harold Suiter	Willmann-Bell

Star Charts - Observing

	Author	Publisher
Bright Star Atlas	Wil Tirion	Willmann-Bell*
Pocket Sky Atlas	Wil Tirion	Sky Publishing **
Millennium Star Atlas		Sky Publishing
Night Sky Observers Guide 1&2	Kepple/Sanner	Willmann-Bell
Sky Atlas 2000.0 (Deluxe, Desk)	Wil Tirion	Sky Publishing*
Uranometria - 1 & 2	Tirion, Rappaport, Lovi	Willmann-Bell
Astroatlas	Herald, Bobroff	HB2000 Publications

* Available laminated through ***AstroSystems***

** Available through ***AstroSystems*** with water resistant coating

Magazines

Magazines		Publisher
Astronomy		Kalmbach Publishing
Amateur Astronomy	Vol. 1 - 61	Amateur Astronomy
Amateur Telescope Making Journal*	Vol. 1 - 18	Captains Nautical
Sky & Telescope		Sky Publishing
Telescope Making*	Vol. 1 - 46	Kalmbach Publishing

*out of print

Software

"Newt" + "Scope"	Newtonian Telescope Optimization	AstroSystems, Inc.
The Sky	Star Chart/Telescope Interface	Software Bisque

Web Sites

AstroSystems, Inc.	www.astrosystems.biz
Springfield Telescope Makers	www.stellafane.com/
Tallahassee Astronomical Society	www.stargazers.org/links.htm
Mel Bartels	www.efn.org/~mbartels/

Optics

Astrosystems Optics	Parabolic Primary Mirrors	10" - 24"	970-284-9471
Terry Ostahowski, Optician			
Galaxy Optics	Parabolic Primary Mirrors	18" - 25"	719-395-8242
Pegasus Optics	Parabolic Primary Mirrors	12.5" - 24"	830-538-9499
Swayze Optical	Parabolic Primary Mirrors	12.5" - 25"	503-777-7980
Zambuto Optics	Parabolic Primary Mirrors	10" - 24"	360-446-0734

Appendix 8

TeleKit Modifications / Additions

This is a listing of some of the modifications and additions submitted by TeleKit owners. This list will continue to expand and include construction details.

Upper Cage Light Baffle
A plastic or laminate extension plugged into the front of the upper cage may help with off-axis light when using extreme wide angle eyepieces and can also help with balance and dew protection.

Upper Cage Handle
A plastic or metal handle mounted on the upper cage for a consistent place for grasping the cage to move the telescope.

Off-axis Mask
A lightweight, easily removed off-axis mask for the front of the telescope. This allows easy removal and installation for changing conditions and your viewing preferences. It is especially helpful for viewing the moon.

Dew Removal
Use resistive heaters for eyepieces and finder and the ***AstroSystems*** secondary heater to protect the secondary mirror.

Electrical
A volt meter to know battery level.
Auxiliary batteries for extra capacity.
Solar battery charger, for daytime recharging.
Computer interface with the telescope's digital setting circles.

Telescope Drive or Equatorial Platform
Several companies offer an equatorial platform for up to 1-hour tracking. Several systems for visually driving the telescope are adaptable to the TeleKit and AstroSystems has a retrofit kit to install an alt/az tracking system with GOTO capability.

Optical Finder
An optical finder is an auxiliary telescope with a low power and wide field. Great views of large (> 1 degree) objects can be had in a finder, making it a very functional addition. It can be mounted on the upper cage or on a support from the mirror box if it is heavy.

Eyepiece Holder
Matching Baltic Birch mounted on the rocker box to hold eyepieces or accessories.

Decorative Additions
Wood inlay or graphics
Name plaque
Two-tone or multi-tone stain

Appendix 9

References

Books	Author	Publisher
How to Make a Telescope	Jean Texereau	Willmann-Bell
Telescope Optics	Rutten and Van Verooij	Willmann-Bell
Lightweight Giants	Steve Overholt	Owl Books
Newtonian Notes**	Peter Francis	Kenneth Novak
Star Testing Astronomical Telescopes	Harold Suiter	Willmann-Bell
The Dobsonian Telescope	David Kriege, Richard Berry	Willmann-Bell
Advanced Telescope Making	Allan Mackintosh	Willmann-Bell
Amateur Telescope Making	Albert Ingalls	Willmann-Bell
Astro Filters**	R.F. Barbera, Charles Capen	Optica b/c

Magazines

Astronomy	**Kalmbach Publishing**
"The New Generation of Dobsonians"	4/89, Pages 62 - 67
Amateur Astronomy	***Amateur Astronomy Magazine***
Volumes 1-61	
Amateur Telescope Making Journal*	**Captains Nautical Supplies**
Volumes 1-16	
Astronomy Technology Today	**Stuart Parkerson**
Volumes 1-32	
Sky & Telescope	**Sky Publishing**
"Keeping Warm Under Winter Stars"	2/93, Pages 28 - 29
"Vision and the Amateur Astronomer"	4/84, Pages 321 - 324
"Truss Flexure"	2/94
Telescope Making*	**Kalmbach Publishing**
"Newtonian Telescopes"	#9, Pages 6 - 13
"An Extremely Portable 17 1/2 "Dobsonian"	#17, Pages 4 - 5
"Teflon Telescope Bearings"	#21, Pages 44 - 47
"The Eye, Your Window to the Universe"	#25, Pages 4 - 8
"Supertune Your Telescope"	#39, Pages 16 - 20
"A Lightweight 30" Dobsonian"	#44, Pages 20 - 25

** Out of print

INDEX

AstroSystems Observing List (northern hemisphere)

Spring (R.A. 9 - 15hr.)

NGC	(M)	Name	Const.	Type	Dist.(ly.)	Vmag	Size (min.)	R.A	Dec.
3031	(81)	Bode's Nebula	Uma	SG	12M	6.8	26 x 14	09 55.6	+69 04
3034	(82)	Cigar Galaxy	Uma	IG	12M	8.4	11.2 x 4.6	09 55.8	+69 41
3115		Spindle Galaxy	Sex	EG	30M	9.1	8 x 3	10 05.2	-07 43
3132		Eight Burst Nebula	Vel	PN	2	8.2	0.5	10 07	-40 26
3227		Spiral	Leo	SG		10.2	4 x 2	10 20.7	+20 07
3242		Ghost of Jupiter	Hya	PN	2800	7.8	20.8	10 24.8	-18 38
3587	(97)	Owl Nebula	UMa	PN	2000	9.9	2.8	11 14.8	+55 01
3623/27/28	(65,66)	Leo Trio	Leo	SG	35M	10/9/9.3		11 16	+13 23
4038/9		The Antennae	Cor	IG		10.3	2.6 x 1.8	12 02	-18 51
4565		Bernice's Hair Clip	Com	SG	31M	9.6	15.5 x 1.9	12 36.2	+25 59
4567/8		Siamese Twins	Vir	IG		11.3/10.8	3x2.5/5x2.4	12 36	+11 15
4594	(104)	Sombrero Galaxy	Vir	SG	50M	8	7x2	12 37.3	-11 21
4826	(64)	Black-eye Galaxy	Com	SG	12M	8	8x4	12 54.3	+21 57
5055	(63)	Sunflower Galaxy	Cvn	SG	43M	9.3	12 x 7.2	13 16.2	+41 58
5128		Centaurus A	Cen	EG		7.0	18x14	13 25.5	-43 01
5139		Omega Centauri	Cen	GC		3.6	36	13 26.8	-47 29
5194/5	(51)	Whirlpool Galaxy	Cvn	SG	43M	9	12 x 6	13 27.8	+47 27
5272	(3)	Globular Cluster	Cvn	GC	42000	6.4	16	13 42.2	+28 23
5457	(101)	Pinwheel Galaxy	Uma	SG	27M	10.0	22		
Mel 111		Coma Berenices Cluster	Com	OC		1.8	275	12 25	+26 00
IC 2574		Coddington's Galaxy	Uma	S+		10.4	13' x 6'	10 28.4	+68 25

Double Stars Spring (R.A. 9 - 15hr.)

Name	Common Name/ Description	Dist (ly.)	Magnitudes		Sep. "	Color Δ	Color	R.A.	Dec.
ι Cancri	Iota Cancri		4.0	6.6	30.4	4	Y/B	08 46.7	+28 46
38 Lyn			3.9	6.4	2.7	2		09 18.8	+36 48
38 Lyn			3.8	6.2	2.6	2		09 18.8	+36 48
α Leo	Regulus		1.4	8.2	175	2	Y/P	10 08.4	+11 58
γ Leo	Algieba		2.3	3.5	4.5	0		10 20.0	+19 50
54 Leo			4.5	6.3	6.3	2	B/G	10 55.6	+24 45

Spring - continued (R.A. 9 - 15hr.)

Double Stars

Name	Common Name/ Description		Dist (ly.)	Magnitudes		Sep. "	Color Δ	Color	R.A.	Dec.
γ Leo	Algieba	Ko, G7		2.4	3.6	4.6	0	Y/Y	10 20.0	+19 50
ξ Crv		B9, K2		3.0	8.5	25	2	Y/Lil	12 29.9	-16 31
24 Com		K2, A9		5.1	6.3	20	3	O/B	12 35.1	+18 23
γ Virginis	Porrima	"Cosmic egg"		3.5	3.5	1.5	0		12 41.7	-01 27
35 Com				5.0	6.6	20.6	4	Y/P	12 53.3	+21 14
α CVn	Cor Caroli	AO, FO	110	2.9	5.5	19	0	B/B	12 56.0	+38 19
ζ U Maj	Mizar	AB A2, A1	78	2.3	3.9	14.4	0	B/B	13 23.9	+54 56
	Alcor	AC A2, A5		2.2	4.0	709	0	B/B		
ε Bootis	Izar	KO, A2	210	2.6	4.9	2.9	3	Y/G	14 45.0	+27 04
α Librae		A3, F4		2.8	5.2	230	1	Y/BW	14 50.8	-16 01
ζ Boo		G8, K4		4.8	7.0	6.3	3	Y/P	14 51.4	+19 06

Stars and Asterisms

Name	Common Name	Dist (ly.)	Mag.	Color	B-V	R.A.	Dec.	Notes
V Hydra	Carbon Star		6.5-12	Red	5.5	10 51.6	-21 03	Reddest Known
SS Virginis			7.08-9.03	Red	4.2	12 25	+00 47	Carbon Mira type
Y Cvn	La Superba	710	5.0-6.4	Red	2.5	12 45.1	+45 26.4	Very Red
CR 399	The Coathanger		3.6+			19 25	+20 11	Chance alignment
-	The Stargate		6.8-11			12 36.1	-12 03.7	Chance alignment

Summer (R.A. 15 - 21hr.)

NGC	(M)	Name	Const.	Type	Dist.(ly.)	Vmag	Size (min.)	R.A	Dec.
5904	(5)		Ser	GC	29000	5.8	21	15 18.6	+02 05
6118		Blinking Galaxy	Ser	SG		12.1		16 22.0	-02 16
6121	(4)		Sco	GC	9800	7.0	14	16 20.6	-26 24
6205	(13)	Hercules Cluster	Her	GC	25100	6	23	16 39.9	+36 33
6210		Turtle Nebula	Her	PN	4700	9.7	20"	16 44.9	+23 46
6254	(10)		Oph	GC		7.2	8	16 54.5	-04 02
6302		Bug Nebula	Sco	PN	330	9.6	0.8	17 13.7	-37 06
6369		Little Ghost	Oph	PN		11.4	0.6	17 29.3	-23 46
6405	(6)	Butterfly Cluster	Sco	OC	1600	4.2	15	17 40.1	-32 13
6451		Tom Thumb Cluster	Sco	OC			7	17 50.7	-30 13
6514	(20)	Trifid Nebula	Sgr	BN	5200	7.6	29 x 27	17 59.4	-23 02
6523/30	(8)	Lagoon Nebula	Sgr	BN		6	90 x 40	18 00.7	-24 23
6543		Cats Eye Nebula	Dra	PN	4400	8.1	5.8	17 58.6	+66 38
6572		Blue Racquetball	Oph	PN	3500	9.6	18 x 16	18 09.7	+06 50
6611	(16)	Eagle Nebula	Ser	BN/OC		7	35 x 28	18 16.0	-13 48
6618	(17)	Omega Nebula	Sgr	BN/OC	5000	7	46 x 37	18 17.9	-16 12
6656	(22)		Sgr	GC	9800	5.1	33	18 36.4	-23 54
6705	(11)	Wild Duck Cluster	Sct	OC	6100	5.8	14	18 51.1	-06 16
6720	(57)	Ring Nebula	Lyr	PN	2600	9.7	1.1 x 2	18 53.6	+33 02
6741		Phantom Streak	Aql	PN	2350	11.4	0.13	19 02.6	-00 27
6809	(55)		Sgr	GC		6.9	15	19 36.9	-31 03
6818		Little Gem	Sgr	PN	8200	9.3	20"	19 44.0	-14 09
6822		Barnard's Galaxy	Sgr	IG		8.8	10 x 9	19 44.9	-14 48
6826		Blinking Nebula	Cyg	PN	3900	8.8	2.3	19 44.8	+50 31
6853	(27)	Dumbell Nebula	Vul	PN	1100	8	8 x 4	19 57.5	+22 35
6888		Crescent Nebula	Cyg	WR/BN			20 x 10	20 12.0	+38 21
6992/5		Veil Nebula (eastern)	Cyg	SNR			60 x 8	20 56.4	+31 43
6960		Veil Nebula (western)	Cyg	SNR			70 x 6	20 45.7	+30 43
7000		North American Nebula	Cyg	BN			120 x 100	20 58.8	+44 20
B - 59/78		Pipe Nebula	Oph	DN			300 x 60/200 x 140	17 21.0	-27 23
B - 86		Inkspot	Sgr	DN			4'	18 02.7	-27 50
B - 87		Parrot's Head	Sgr	DN			12'	18 04.3	-32 30
Collander 399		Coathanger (Brocchi's cluster)	Vlp	OC		5.1	60'	19 25.4	+20 11
IC 4593		White Eyed Pea	Her	PN		10.7	13"	16 12.2	+12 04
IC 5067/70		Pellican Nebula	Cyg	BN			25' x 10'	20 47.8	+44 22
Mink. 92		Footprint Nebula	Cyg	RN			12" x 6"	19 36.3	+29 33

Summer - continued (R.A. 15 - 21hr.)

Double Stars

Name	Common Name/Description	Dist (ly.)	Magnitudes	Sep. "	Color Diff.	color	R.A.	Dec.
μ Bootis	Triple F2, G1, G1		4.3 7.1 7.6	107, 2.2	1	Y/O/O	15 24.5	+37 23
β Scorpii	Acrab		2.6 4.9	13.6	0	BW/BW	16 05.4	-19 48
κ Her	G8, K1		5.1 6.2	27.4	2	Y/R	16 08.1	+17 03
ν Sco	B3, B9, B8, B9		4.3 5.3 6.6 7.2	1.3 2.4	0	BW	16 12.0	-19 28
α Sco	Antares M1, B2		1.0 5.4	2.5	2	O/G	16 29.6	-26 35
α Herculis	Rasalgethi M5, G5	380	3.5 5.4	4.8	2	O/BG	17 14.6	+14 23
95 Herculis	A5, G8		5.0 5.2	6.3	3	R/G	18 01.5	+21 36
70 Oph	K0, K4		4.2 6.2	4.8	1	Y/R	18 05.5	+0.2 30
ε Lyrae	Double Double A4, F1	160	5.0 6.1	2.4	0		18 44.4	+39 40
ε Lyrae	Double Double A8, F0		5.2 5.4	2.4	0		18 44.4	+39 37
ζ Lyrae	Zeta Lyrae A4, F0		4.3 5.7	41.3	1	Y/G	18 44.8	+37 36
STT 525 Lyr			6.0 7.5	45.8	2		18 54.9	+33 59
θ Ser	A5, A5		4.6 4.9	22.1	0	W/W	18 56.2	+04 12
β Cygni	Albireo B8, K3	390	3.1 5.1	34.4	4	Y/B	19 30.8	+27 58
16 Cygni			5.9 5.8	40	0		19 41.9	+50 32
o Cygni	K2, B9, A5		3.8 4.8 7.0	106/331	3	R/W/B	20 13.6	+46 44
ρ Capricorni	Rho Capricorni		4.8 6.6	256.2	2		20 28.9	-17 49
γ Delphini	Gamma Delphini K1, A2		4.3 5.1	9.3	2	Y/G	20 46.7	+16 07

Stars

Name	Common Name	Dist (ly.)	Mag.	Color	B-V	R.A.	Dec.	Notes
α Scorpius	Antares		0.9-1	Red/Or		16 29.6	-26 35	"Rival of Mars"
V Aquila	(Mira type)		6.6-8.4	Red	4.2	19 04.4	-05 42	Deep Red Carbon
V Corona Borealis			6.9-12.2	Red	4.4	15 49 31	+39 34.3	Carbon Mira type
T Corona Borealis	Blaze Star		2.3-10	Red		15 59.5	+26 00	Recurrent Nova
RS Cygnus			6.5-9.7	Red	3.0	20 13 24	+38 43.7	Carbon Mira type
U Cygnus			6.7-11	Red		20 19.7	+47 55	Strong Color
T Lyrae			7.8-9.6	Red	5.5	18 32.3	+37 00	Carbon Star

Fall **(R.A. 21 - 3hr.)**

NGC	(M)	Name	Const.	Type	Dist.(ly.)	Vmag	Size (min.)	R.A	Dec.
55		Cigar Galaxy				8.1	31 x 6	00 15	-39 13
221	(32)	Andromeda Companion	And	EG	2.9M	8.2	7.6 x 5.8	00 42.7	+40 52
224	(31)	Andromeda Galaxy	And	SG	2.9M	4	160 x 40	00 40.0	+41 00
253		Sculptor Galaxy	Sc	SG	10M	7.7	25 x 7	00 21.0	-25 19
281		Pac Man Nebula	Per	OC/BN		7.0 (p)	35	00 53.2	+56 39
300		Southern Pinwheel	Scl	SG		8.1	20 x 13	00 55	-37 41
457		Owl Cluster (ET)	Cas	OC	7900	6.4	13	01 19.0	+58 20
598	(33)	Pinwheel Galaxy	Tri	SG		5.7	65	01 33.9	+30 39
628	(74)		Pis	SG		9.1	10.5 x 9.5	01 37	+15 47
650/1	(76)	Little Dumbell	Per	PN	2400	10.1	1.1	01 42.4	+51 34
891		Superb edge-on	And	SG		9.9	13.5 x 2.8	02 22.6	+42 21
869-884		Double Cluster	Per	OC	6800	4.3	30 / 30	02 20.0	+57 08
1039	(34)	Open Cluster	And	OC	1400	5.5	35	02 38.8	+42 34
1068	(77)		Cet	SG	60000	8.9	7.1 x 6	02 43	-00 01
1300		Elongated Galaxy	Eri	BSG		10.4	6.5 x 4.3	03 19.7	-19 25
1316		Fornax A	For	IG		8.2	7.1 x 5.5	03 22.7	-37 12
1365		Barred Spiral	For	BSG		9.3	9.8 x 5.5	03 33.6	-36 08
2537/2537a		Bear Paw Galaxy	Lyx	S		11.7	3.1'	08 13.3	+45 59
7009		Saturn Nebula	Aqr	PN	3100	8.0	1.6	21 04.2	-11 22
7078	(15)		Peg	GC	33600	7.0	12	21 27.6	+11 57
7089	(2)		Aqr	GC	37500	7.3	12	21 30.9	-01 03
7293		Helix Nebula	Aqr	PN	520	7.3	13	22 29.6	-20 48
7317		Stephens Quintet	Peg	Group		13.6+		22 36	+33 59
7331		Little Andromeda Galaxy	Peg	SG	4.6M	9.5	11.4 x 4	22 37	+34 25
Sh-2 155		Cave Nebula	Cep	BN			50 x 30	22 56.8	+62 37
7635		Bubble Nebula	Cas	BN			15 x 8	23 20.7	+61 12
7662		Blue Snowball	And	PN	4600	8.6	17 x 14	23 25.5	+42 32
IC 5146		Cocoon Nebula	Cyg	PN			12 x 12	21 53.5	+47 16
Stock 2		Muscleman Cluster	Cas	OC		4.4		02 15	+59 15

Fall **(R.A. 21 - 3hr.)**

Double Stars

Name	Common Name/ Description		Magnitudes			Sep. "	Color Δ	Color	R.A.	Dec.
12 Aquarii			5.8	7.3		2.5	3		21 04	-05 49
61 Cyg	Bessel's Star	K5, K7	5.4	6.1		31	0	O/O	21 06.9	+38 45
δ Aqr		F1, F5	4.4	4.5		1.8	0	GW/GW	22 28.8	-00 01
δ Cephi	Delta Cephi		3.5	6.3		40.9	3	O/B	22 29.2	+58 25
8 Lac	Strong double	B2, B2	5.7	6.3	7.3	22/336	0	B/B	22 35.9	+39 38
94 Aqr		G5, K2	5.3	7.0		12	2	G/R	23 19.1	-13 28
σ Cas		B1, B3	5.0	7.2		2.4	1	B/G	23 59.0	+55 45
Σ 3053			5.9	7.3		15	3		00 02.6	+66 06
η Cassiopeiae	Eta Cassiopia	G0, M0	3.5	7.2		12.9	2	Y/P	00 49.1	+57 49
36 Andromedae			5.5	5.9		1.0	1		00 55.0	+23 38
1 Arietis			5.8	6.6		2.8	3		01 50.1	+22 17
γ Ari	Mesartim	A1, B9	4.5	4.6		7.4	0	BW/W	01 53.5	+19 18
γ Andromedae	Almach	K3, B9, A0	2.3 5.0	6.3		10/0.3	4	Y/B	02 03.9	+42 20
ι Cas		A5, F5, G5	4.6 6.9	9.1		2.8/7.4	2	Y/L/B	02 29.1	+67 24
α Umi	Polaris	F7, F1	1.9/2.1	9.0		18	0	W/W	02 31.8	+89 16
32 Eri		G8, A2	4.8	5.9		6.9	2	Y/G	03 54.3	-02 57

Stars

Name	Common Name	Dist(ly.)	Mag.	Color B-V	R.A.	Dec.	Notes
VX Andromeda			8.0-9.5	Red	0 19.9	+44 42.6	Carbon Mira type
ε Peg	Herschels Pendulum Star		2.4 8.5	K2	21 44.2	+09 52	Tap the scope and see
LW Cygni	hd208512		8.45-8.78	Red	21 55	+50 30	
μ Cephi	Wm. Hershels Garnet Star	1.3-5.2	3.7-5.0	Red	21 43.5	+58 48	
19 Pisces			4.5-5.3	Red	23 46 24	+3 29.2	
o Ceti	Mira		2.0-10.1	Or	02 19.3	-02 59	332 day period
β Persei	Algol	92.8	2.12-3.4		03 08.2	+40 57	2.87 day period

Winter (R.A. 3 - 9hr.)

NGC	(M)	Name	Const.	Type	Dist.(ly.)	Vmag	Size (min.)	R.A	Dec.
1275		Perseus A	Per	IG		11.6	2.6 x 2	03 19.8	+41 31
1432	(45)	Maia Nebula	Tau	RN	490		50	03 46.1	+24 22
1535		Cleopatra's Eye	Eri	PN	4500	9.4	0.7	04 14.1	-12 44
1554/5		Hind's Variable Nebula	Tau	BN			0.5'	04 21.8	+19 32
1952	(1)	Crab Nebula	Tau	SNR		9	6 x 4	05 34.5	+22 01
1976	(42)	Great Orion Nebula	Ori	BN/OC	1270	5	85 x 60	05 32.9	-05 25
2024		Tank Trak Nebula	Ori	BN			30'	05 41.9	-01 51
2099	(37)	Open Cluster	Aur	OC	4500	6.2	20'	05 49.0	+32 33
2168	(35)		Gem	OC	3000	5.1	28	06 08.9	+24 20
2169		"37" Cluster	Ori	OC		5.9	7	06 08	+13 57
2237-9		Rosette Nebula	Mon	BN			80 x 60	06 32.3	+05 03
2261		Hubble's Variable Nebula	Mon	BN			2 x 1	06 39.2	+08 44
2264		Christmas Tree / Cone	Mon	OC		3.9	30 x 60	06 40	+09 53
2287	(41)	Central Orange Star	Cma	OC		4.5	38	06 46.0	-20 44
2359		Thor's Helmet	CMa	W/R			8	07 17	-13 12
2371/2		Cats Eyes	Gem	PL		13.0		07 26	+29 30
2392		Eskimo Nebula	Gem	PN	3400	9.2	0.2/0.7	07 29.2	+20 55
2419		Intergalactic Wanderer	Lyn	GC		10.3	4.7	07 38.2	+38 53
2438	(46)	Planetary in Open Cluster	Pup	PN/OC		11/7	27	07 39.6	-14 42
		Kemble's Cascade	Cam					03 57.5	+63 04
Abell 21		Medusa Nebula	Gem	PN		10.3	10'	07 29.0	+13 15
B33		Horsehead (in IC434)	Ori	DN			6 x 4	05 40.9	-02 28
CR 140		Tuft in the Tail of the Dog	Cma	OC		3.5	41'	07 23.9	-32 00
IC 405		Flaming Star Nebula	Aur	BN			30 x 19	05 16.2	+34 16
IC 434		Diffuse Nebula					60 x 12	05 38.6	-02 26

Winter (R.A. 3 - 9hr.) Double Stars

Name	Common Name/ Description			Magnitudes		Sep. "	Color Δ	Color	R.A.	Dec.
32 Eri		G8, A2		4.8	5.9	6.9	2	Y/G	03 54.3	-02 57
11-12 Cam				5.2	6.1	178.7	4		05 06.1	+58 58
β Ori	Rigel	B8, B5		0.2	6.8	9.6	0		05 14.5	-08 12
42-45 Ori				4.6	5.2	252	2		05 35.4	-04 50
α Orionis	Betelgeuse			0.4	1.3				05 55.2	+07 36
β Mon	Triple Hershels wonder star		AB	4.6	5.0	7.1	1		06 28.8	-07 02
			BC	5.0	5.4	2.9				
α Cma	Sirius and dwarf			-1.5	8.5	6.7			06 45.1	-16 43

Winter (R.A. 3 - 9hr.)

Double Stars

Name	Common Name/ Description			Dist (ly.)	Magnitudes	Sep. "	Color Δ	Color	R.A.	Dec.
β Ori	Rigel		B8, B5		0.2 6.8	9.6	0	BW/W	05 14.5	-08 12
θ Ori	Trapezium	AB	O7, B1		6.6 7.5	8.8	0	BW/BW	05 35.3	-05 23
	" "	AC	O7, O6		6.6 5.1	13	0	BW/BW		
	" "	AD	O7, B0		6.6 6.4	21	0	BW/BW		
α C Maj	Sirius/Dwarf Companion		A1, DA		-1.5 8.5	6.7	3	BW/O	06 45.1	-16 43
μ C Maj					5.0 7.0	2.8	2		06 56.1	-14 03
H3945 C Maj.	"Winter Albireo"				4.8 6.8	26.6	3	BW/O	07 16.6	-23 18.9
κ Pup			B6, B5		4.4 4.6	9.9	0	W/W	07 38.8	-26 48
α Gem	Castor	ABC	A1, A2, M0	52	1.9 3.0 8.9	4.3 71	2	BW/W/R	07 34.6	+31 53
ξ Cnc	Yellow Triple	AB	F8, F9		5.3 6.3	1.0	0		08 12.2	+17 39
		AC	F8, G5		5.3 6.2	5.9	0			
ι Cancri	Iota Cancer		G8, A3		4.0 6.6	30.6	3	W/Y	08 46.7	+28 46

Stars

Name	Common Name	Dist. (ly.)	Mag.	Color	B-V	R.A.	Dec.	Notes.
R Lep	Hind's Crimson Star	820	V5.9-11	Red	5.5	04 59.6	-14 48	Carbon Mira type
W Cma	Orange		7.0-8			07 08.0	-11 55	
UU Auriga			5.3-6.5	Red	2.6	06 36 33	+38 26.7	

Annual Meteor Showers

Date (Peak)	Name/Radiant	Duration	Peak Rate (#/hr)	Notes
January 4	Quadrantids	1 day	50	Med. speed, bluish, many faint
April 22	η-Lyrids	5 days	15	Fast, bright (Comet Thatcher)
May 4	η-Aquarids	7 days	21	Very fast, persistent trains (Comet Halley)
June 16	Lyrids	11 days	15	Blue, faint
July 25	Capricornids	30 days		Yellow, slow
July 28	δ-Aquarids	30 days	25	Slow, long, yellow
August 1	α-Capricornids	40 days		Yellow
August 10	Perseids	22 days	50-100	Fast, tend to fragment, yellow with bolides
August 20	κ-Cygnids	4 days	12	Bright, fragmenting, many bolides
October 20	Orionids	11 days	30	Fast, persistent trains, colors
November 5	Taurids	55 days	10	Slow, bright (Comet Enke)
November 17	Leonids	4 days	20-20k	Very fast, persistent trains, (Comet Temple-Tuttle)
December 14	Geminids	6 days	60	White, bright (possibly Asteroid Icarus)
December 22	Ursids	2 days	20	Med. speed, bright trail