CHARA TECHNICAL REPORT

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# CHARA Telescope Specifications and Description: A Supplement the CHARA Engineering Drawings

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## 1. INTRODUCTION TO THE CHARA ARRAY PROJECT

The Center for High Angular Resolution Astronomy (CHARA) of Georgia State University will build a facility for optical/infrared multi-telescope interferometry, called the CHARA Array. This array will consist of initially five (with a goal of seven) telescopes distributed over an area approximately 350 m across. The light beams from the individual telescopes will be transported through evacuated pipes to a central laboratory, which will contain optical delay lines, beam combination optics, and detection systems. The facility will consist of these components plus the associated buildings and support equipment, and will be located at the Mount Wilson Observatory in southern California. The CHARA Array is funded by Georgia State University and the National Science Foundation.

## 2. INTRODUCTION TO THIS DOCUMENT

The CHARA Array will employ five optical telescopes at a site on Mount Wilson in southern California. Each telescope will be housed separately and operated remotely from a central laboratory. Light from each telescope will be directed through vacuum pipes to additional optics and instrumentation at a central laboratory where the light from all telescopes will be combined and processed.

Each telescope will be altitude-azimuth (alt-az) style with 1-meter diameter primary mirrors. The light beam will be made afocal (collimated) by the secondary mirror and reduced 8:1 in diameter. The remaining mirrors in the telescope will be flats to direct the collimated beam out of the telescope toward the central laboratory. The telescopes will be mounted on a CHARA-supplied concrete pad relatively close to ground level.

The mechanical hardware needed for each telescope is the subject of this document. Information given here supplements CHARA engineering drawings that specify the parts and assemblies to be produced. A complete list of drawings is given in Table 2.

Information is organized to assist prospective suppliers to bid on any of three tasks:

- A. Completion of one or more of the subassemblies described in Section 4.

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- B. Assembly of all mechanical subassemblies as described in Section 5.
- C. Completion of both Tasks A and B.

Section 3 provides further information and general specifications that will apply to Sections 4 and 5.

### 2.1. Definitions/Abbreviations

The following definitions/abbreviations are used in this document

- Mirrors may sometimes be referred to by their position in the optical train, e.g. the primary mirror as M1, the secondary mirror as M2, etc.
- TBD means "To be determined."
- c.g. means "center of gravity."
- OSS means "Optics Support Structure," a term applied to the telescope structure that rotates about the altitude axis (see below) and supports the M1, M2, and M3 assemblies. Sometimes called the "telescope tube."
- "Altitude axis" is the horizontal axis of rotation for the telescope.
- "Azimuth axis" is the vertical axis of rotation for the main telescope fork which supports the OSS.
- CTE means "Coefficient of Thermal Expansion."
- "Zenith-pointing" is the orientation that the OSS will have when M1 is pointed directly to zenith on the sky.
- "Horizon-pointing" is the orientation the OSS will have when rotated 90° away from the zenith-pointing position.

## 3. GENERAL INFORMATION AND SPECIFICATIONS

The referenced drawings and this document are believed to provide sufficient information for fabrication of the parts and proper assembly by a qualified supplier. In the event of conflict between this document and the drawings, the drawings will govern, however, the supplier shall immediately notify CHARA of all such conflicts.

CHARA retains responsibility for design functionality of parts and telescope subassemblies described by the drawings. Suppliers of parts and assemblies shall be responsible for workmanship and compliance with specifications on the drawings or in this document. Errors or apparent inconsistencies in the drawings or specifications shall be referred immediately by the supplier to CHARA for disposition.

All functional tests specified in Sections 4 and 5 shall be completed in the presence of a CHARA representative. Tests will be performed at the supplier's facility at a time acceptable to both CHARA and the supplier. Where necessary and indicated in Section 4 and 5, CHARA will provide electrical/electronic controls for the tests. If tests results are unsatisfactory to CHARA, a joint investigation shall be made by the supplier and CHARA to determine the cause. If the cause is due to design flaws, CHARA will be responsible for the cost of corrective action. If the cause is due to parts made/assembled differently than the drawing specifications, the supplier shall be responsible for the cost of corrective action.

Hereafter, the manufacturer of any/all of the parts and mechanical subassemblies described in Section 4 will be referred to as the "Subassembly Vendor" or "SV." The supplier of assembly services described in Section 5 will be referred to as the "Assembly Vendor" or "AV."

In general, item designation on the drawings may be:

- A number preceded by a "dash" (e.g., -2), in which case, the item is graphically described on the drawing or in a separate detail on another sheet.
- Encircled numbers, in which case, the item is described in the materials list.

Manufacture of each subassembly will require mechanical fabrication of parts, procurement of materials/commercial parts, and assembly. Installation of electrical/electronic components such as motors or limit switches will be required for some subassemblies.

Certain commercial components required in the subassemblies will be purchased by CHARA and shipped to the SV prior to assembly. The CHARA- supplied items are indicated where appropriate in each subsection of Section 4 and also on the "CHARA-Supplied Parts List" (see Table 1). All remaining commercial components and materials specified in this document or on the drawings shall be purchased by the SV with no substitutions without prior approval from CHARA. Reasonable justifications for substitutions may be lower cost with equivalent performance, better performance, or unavailability of the specified component. As a convenience to the SV and AV, copies of relevant catalog pages for the major commercial components, including those to be supplied by CHARA, are provided in a supplement.

Fastener hardware shall be of stainless steel unless otherwise specified.

All steel parts shall be made from mild steel (e.g. 1018 or 1020 steel or ASTM A36) except where noted.

Water condensation may occur during telescope operation, hence, all parts shall be protected from corrosion due to water. Exposed surfaces of parts subject to rust and corrosion shall be painted or coated according to drawing specification. In the absence of drawing specification, aluminum parts shall be black anodized and steel parts shall be painted using "Rust- Oleum" Water Based Epoxy 5300 System/equivalent. Two primer coats shall be applied followed by a top coat of "Rust-Oleum" 5392 White.

Where plating/painting is required, the SV shall prevent plating/painting in threaded holes and critical surfaces that interface to other parts.

Most hole locations are dimensioned to 3-place decimal accuracy for convenience of the SV in case numerical machine control is used and to ensure that mating parts can be assembled properly. Looser tolerances (i.e., 2-place decimal accuracy) will be allowed for these hole patterns if it is shown that proper assembly can be achieved.

# 4. TELESCOPE SUBASSEMBLY DESCRIPTION AND SPECIFICATIONS

The major telescope subassemblies are specified/described in the following subsections. For any subassembly involving an optical element, neither the SV or AV is required to supply the optic. Mirror mountings for M3, M4, M5, and M6 are TBD. Each subsection lists specific SV requirements separate from descriptive information that follows. The descriptive information is provided to facilitate understanding of the drawings and the function served by the individual parts/subassemblies.

## 4.1. Telescope Secondary and Top End Assembly

**Ref:** Dwgs. CHARA 2 (1 sheet)
including: CHARA 3 (2 sheets),
CHARA 4 (1 sheet),
CHARA 5 (9 sheets)

CHARA 2 shows the secondary mirror assembly (CHARA 5) attached by struts to its main supporting frame (CHARA 3) which will be attached to the rest of the telescope at its four corners.

### 4.1.1. Subassembly Vendor (SV) Requirements

The SV shall procure/build and assemble all of the hardware in compliance with CHARA 2 and Section 3 except the secondary mirror. The following items will be supplied by CHARA to the SV for inclusion in the assembly as shown on the appropriate drawings:

- Item 30, CHARA 5 - Mike Driver w. Piezoelectric Positioner
- Item 31, CHARA 5 - High Accuracy Feedback Scale (See Note A, next pg.)
- Item 32, CHARA 5 - Pillow Block

In addition to the above, CHARA will provide the necessary control system and power supplies to operate the Mike Drivers, Piezoelectric Positioners, and Feedback Scale to enable the following functional tests of the CHARA 2 assembly in both zenith-pointing and horizon-pointing orientations:

1. Motorized focus adjustment of $\pm$ 12 mm to be achieved by simultaneously operating all three Mike Drivers.
2. Motorized tilt adjustment of approximately $\pm$ 1° obtained by operating individual Mike Drivers.
3. Rapid tip-tilt motions using Piezoelectric Positioners installed in the ends of the Mike Drivers.

Functional tests will be regarded as successful if the motions specified appear to be smooth, without excessive friction or mechanical interference, and the clearances between moving parts do not exceed specifications.

**Note A:** Installation and alignment of the focus encoder feedback scale (Item 31, CHARA 5) will require careful adjustment. In operation, the encoder will monitor focus motion of ± 12 mm about the mid-point of the scale. Throughout this motion, proper spacing will be required between the stationary read head and the moving linear scale of the encoder. The manufacturer's specification for this spacing is 2.5 mm ± 0.3 mm (See Spec. Sheet for Sony Scale Unit SH10-007C1A — See also Note 5, CHARA 5). Encoder alignment may also entail centration (radial adjustment) of the focus tube using the adjustable defining rollers (See description in Section 4.2.2). Care should be taken not to cause interference between the encoder linear scale attached to the focus tube and its read head.

### 4.1.2. Secondary Top End Assembly (Descriptive Information)

CHARA 2 shows the secondary mirror focus and positioning assembly (CHARA 5) attached by tensioned struts to its main supporting frame (CHARA 3). The frame will connect to the telescope OSS at its four corners. In particular, the connection will be at the four 1.375" diameter tapped holes at the corners of the support frame which will accept attachment hardware for 0.75" diameter invar support rods that are part of the main OSS.

The outer ends of the support struts are provided with threaded shaft extensions (Item 6, CHARA 2) that pass through bracket assemblies. Tensioning of the struts and positioning of the secondary mirror should be accomplished by compressing springs (Items 17, 18, CHARA 2) with the telescope in the zenith-pointing attitude. The locking nuts (Item 22, CHARA 2) should be loose during initial strut tensioning and positioning of the central mirror assembly. A modest tension should exist in the upper struts (e.g., Approximately 0.75" compression of Item 17 which has a spring rate of 155 lb/in). After the secondary is properly positioned, the lock nuts should be tightened carefully to avoid shifting the mirror position. Compression of the springs may then be relaxed.

In addition to the adjustments for mirror tilt and centration made by manually adjusting the struts, the secondary mirror cell (and mirror when it is installed) will be capable of the movements listed below:

1. Motorized focus adjustment of ± 12 mm. The focus actuators specified on CHARA 5 (Item 30) have 25 mm nominal travel (See Spec. Sheet for Physik Instrumente, DC Mike Drives, Model MŒ225.20). Focus motion will be achieved by simultaneously operating all three focus actuators.

2. Motorized tilt adjustment of approximately ± 1°. This motion will be accomplished by operating individual focus actuators.

3. Rapid tip-tilt motions using piezo actuators installed in the ends of the motorized focus actuators (End piece Option P-250-20 made by Physik Instrumente).

Wiring from the actuators and position encoder will be routed out of the secondary assembly through a wiring duct (Item 14, CHARA 2) attached to one strut.

At final assembly, the secondary mirror will be bonded to an invar mount plate (Item 2, CHARA 5) which will be screwed to the main mirror cell (Item 3, CHARA 5). A threaded "flex pin" (Item 16 CHARA 5) made of 304 stainless steel will be screwed into the mirror cell at one end and brazed into a "tilt-limiter" (Item 4, CHARA 5) at the other. The "tilt-limiter" will be clamped and pinned inside the focus tube. Compressing the spring

(Item 33, CHARA 5) at the upper end of the focus tube will draw the mirror cell against the three focus actuators that will then govern its position and tilt angle.

In the zenith pointing telescope position, the weight of the mirror, mount plate, mirror cell, "tilt-limiter," focus tube, etc will act downward while the spring force will act upward. The combined weight acting downward is estimated be about 8 lbs. The spring rate specified is 8.3 lb/in which means that the spring must be compressed a minimum of 1" to offset the weight, plus another 0.5" (12 mm) to allow for focus travel in the direction that reduces spring compression. In effect, this will apply between 4-5 lbs force to the end of each focus actuator, well within the 22 lb rated load capacity.

Lateral (radial) position of the mirror cell relative to the focus tube will be governed by a thin flex plate (Item 5, CHARA 5). The flex plate, which will have three 'legs" 120° apart, will be bonded at its center to the "tilt- limiter" and attached at the end of each "leg" to the mirror cell by means of a stand-off and clamping screw. Since the "tilt-limiter" will be clamped inside the central tube, the mirror cell will be connected rigidly to the central tube in the radial direction while flexibility of the three "legs" in the axial direction will allow small angular tilts to occur. Angular tilt will be possible because both the central "flex pin" and the flex plate allow small angular compliances.

The "flex pin" will maintain a stiff axial connection between the mirror cell and the focus tube and will transmit the spring force to the mirror cell. The slender portion of the flex pin is estimated to withstand more than 100 lbs before yielding (304 stainless steel has a yield strength of 42,000 psi in the annealed condition). The moment required to bend the pin through 1° is estimated to be less than 0.7 in-lb.

The function of the "tilt-limiter" will be to limit the amount of angular motion of the mirror cell. At assembly, the mirror cell will be positioned such that it may tilt approximately ± 0.030" measured at and governed by the shoulder screws (Item 36, CHARA 5) passing through the cell. In the event that one of the focus actuators should go out of control and extend to its limit, the mirror cell will tilt through about 0.030" clearance until a shoulder screw contacts the "tilt-limiter" which then will prevent further angular travel. In that situation, further movement of the mirror cell will cause no damage to the lateral support flex plate or the "flex pin." If the actuator should retract completely, the "tilt-limiter" again would prevent excessive angular motion, but in this case, the mirror cell will not follow the actuator tip. The actuator tip would simply retract away from the tip-tilt plate.

Axial (focus) motion of the focus tube requires special mounting arrangements for the focus tube. At the lower end, a set of three rollers will define the lateral (radial) position of the focus tube. The rollers will be 120° apart and mounted in adjustable brackets attached to the focus housing structure (Item 27, CHARA 5). One of the brackets will be provided with a pivot and spring-plunger to apply force to the central tube causing it to be pressed against the other two rollers. In this way, the focus tube will be able to move axially while its position is maintained in the radial direction. Adjustment of the brackets may be done for purposes of encoder alignment and, within the limits of encoder spacing, to make small lateral changes in the secondary mirror position.

The upper end of the focus tube will pass through a Teflon-lined bushing built into a self-aligning pillow block assembly (Item 32, CHARA 5). A small amount of clearance between the tube and the bushing will exist (e.g., 0.001" radial clearance) to allow axial travel to occur freely. Although this means, in principle, that the tube can tilt slightly at the upper end, it is unlikely to occur because the compression spring will inhibit lateral motion of the tube. Furthermore, any lateral motion occurring at the upper end is de-magnified considerably at the lower end.

Focus position will be sensed by means of a Sony SH10 High Accuracy Feedback Scale. This device will have a total measuring range of 70 mm with resolution down to 0.1 micron. Only the middle 25 mm of this range will be used. The sensing head will be attached to the focus tube while the stationary scale will be attached to the square tube of the focus housing. Output of the device is a quadrature square wave, similar to outputs from typical rotary encoders. A 5v DC power input is required.

Tip-tilt motion of the mirror will be accomplished by using the piezo attachments on the ends of the focus actuators. In actual operation, the piezos should be driven so as to rotate the tip-tilt plate about an axis in the plane of the piezo tips. This will minimize movement of the focus tube, a condition to be avoided, if possible. Effectively, this means controlling all three piezo actuators simultaneously, a condition likely to be required anyway.

## 4.2. Strut, Midframe, & Top Frame Assemblies

**Ref:** Dwgs. CHARA 7 (6 sheet)

including: CHARA 6 (2 sheets)

CHARA 7 illustrates the midframe assembly and struts for the OSS. CHARA 6 describes the top frame which attaches at the top of the upper struts and connects to the CHARA 2 secondary mirror assembly. The primary mirror cell assembly (CHARA 8) attaches at the bottom of the lower struts. The altitude bearings attach to the midframe, but are not part of the CHARA 7 subassembly (See Sections 4.6 & 4.7). Taken altogether, these assemblies comprise the OSS.

### 4.2.1. Subassembly Vendor (SV) Requirements

The SV shall make/procure all hardware in compliance with CHARA 7 (including CHARA 6) and Section 3. The SV should note the requirements on CHARA 6 to fill the frame with lead as part of the fabrication process. There are no functional tests required for this subassembly.

### 4.2.2. Strut, Midframe, & Top Frame Ass'y (Descriptive Information

Sheet 6, CHARA 7 illustrates the midframe weldment, Sheet 2 specifies the machining to be done on the weldment. One side of the midframe will provide a machined surface for mounting the "inboard" altitude bearing assembly (CHARA 15). The opposite side will be equipped with a shaft (-6 Item, CHARA 7) passing through the midframe to be supported by a pillow block bearing mounted on the telescope fork (Item 1, CHARA 12). Machined attachment pads welded to the midframe will provide bolt connections for the struts shown on Sheet 3.

Maintaining the distance between the primary and secondary mirrors is critical to good imaging performance of the telescope. For that reason, a system of invar metering rods (-13 Item, CHARA 7) is incorporated in the design of the OSS. As shown in the upper right view on Sheet 1, CHARA 7, a 3/4" diameter invar rod will pass through each corner of the midframe (Some struts have been omitted from this view for clarity). The rods will connect to the secondary support frame at the top through adjustable rod ends (-12 Item, CHARA 7) and to the primary mirror cell at the bottom. The axial weight component of the secondary mirror assembly (CHARA 2) will be carried by the invar rods (i.e., the component acting along the long axis of the OSS). Since invar has an extremely small CTE, the primary-to- secondary spacing will remain almost unaffected by temperature changes during normal operations.

The connection hardware at the top end of the invar rods is designed to allow vertical adjustment of the secondary frame position at assembly.

The connection between the CHARA 6 top frame and the CHARA 2 secondary assembly will be made through a system of eight clamping straps. As shown on Sheet 1, CHARA 6, the clamps (Items 2 & 3, CHARA 6) will be bolted to blocks welded to the main frame (Item 1, CHARA 6). At each corner, ends of the clamps are bolted together to form a split clamp. Short extension tubes welded to the secondary support frame (CHARA 3) will fit into the split clamps. When assembled, the strap (flex plate) portion of the clamps will support lateral loads (i.e., the lateral weight component of CHARA 2 assembly when the telescope points away from zenith) while allowing small displacements of the secondary frame relative to the top frame. Such displacements will be a result of different thermal expansions/contractions between the invar metering rods and the steel struts, etc. comprising the OSS.

Provisions for mounting the M3 assembly are included in this assembly. A 2.5" diameter support column (-14 Item, CHARA 7) will be bolted at its lower end to the central column of the primary mirror cell. The upper end will be stabilized by a system of four struts (-20 Item, CHARA 20) connected to the lower side of the midframe. Connection provisions for the M3 assembly are TBD.

It is intended that the M3 support column will remain in the telescope when the M1 cell is removed during recoating operations of M1. At that time, the lower end bolted flange will be disconnected to allow removal of the cell. To prevent excessive displacement of the column, four cables (- 18 Item, CHARA 7) will be attached between the column and brackets on the midframe. Upon reinstallation of the M1 cell, the cables will be removed.

## 4.3. Primary Mirror Cell Assembly

**Ref:** Dwgs. CHARA 8 (5 sheets)

including: CHARA 21 (7 sheets) Weldment,

CHARA 22 (4 sheets) Mirror Support (Axial),

CHARA 23 (4 sheets) Bottom Cover,

CHARA 29 (4 sheets) Cover Assy (Top)

CHARA 8 illustrates the assembled M1 support cell. Details for the M1 lateral support are also included in CHARA 8. Following the SV requirements in the next section, each of the assemblies listed above will be discussed.

### 4.3.1. Subassembly Vendor (SV) Requirements

The SV shall make/procure all hardware in compliance with CHARA 8 and Section 3 except the following items to be supplied to the SV by CHARA prior to assembly:

- Item 8, CHARA 29 Gear Motor

The SV shall assemble the M1 cell according to drawing specifications. CHARA retains responsibility for design functionality, however, the following functional tests on the mirror cell assembly shall be made by the SV to show that the hardware has been made correctly:

1. Show that the lateral support assembly illustrated on Sheet 5, CHARA 8 can be firmly clamped to the central tube (-22 item, CHARA 21) by tightening the taper pin (-22 item, CHARA 8) and can then be removed after loosening the taper pin.
2. Show that all pivots in the axial support specified by CHARA 22 work freely without excessive friction or clearance.
3. Show that the lever assembly specified by CHARA 22 can be balanced in both the zenith-pointing and horizon-pointing orientations. This is necessary to prevent unwanted forces due to mechanical imbalance from acting on the primary mirror during operation. In the zenith-pointing orientation, balance is expected to occur as a result of the design. Any imbalance of the various parts about the pivots will be an indication of an error which must be corrected through appropriate action. In the horizon-pointing orientation, imbalance can be offset by adjusting the counterweights (i.e., nuts & washers on the Œ13 parts or the -19 counterweights).
4. Show that the cover assembly specified in CHARA 29 will open and close properly. When completely "open," no part of the slide frames should be less than 20" from the nominal center of the mirror cell assembly (i.e., no obscuration of the 1-m diameter mirror). When fully "closed," no gap should exist between the two slide frames.

### 4.3.2. Mirror Cell Assy. & Details (Descriptive Information)

**Ref:** Dwg. CHARA 8

The assembly shown on sheet 1 will support and protect M1. The safety clips shown on sheet 2 (-2 and -3 items) will restrain M1 in case of earthquake or tipping the cell beyond a horizon-pointing attitude. The top portion of the -3 safety clip also serves to support the drive shafts for the mirror cover (See Section 4.3.5) The spacer blocks shown on sheet 2 (-4 item) will be the attachment points for struts connected to the rest of the telescope. Sheets 3-5 specify the lateral support hardware for M1.

The lateral support will carry the weight component of M1 perpendicular to the optical axis. That component increases from zero when the telescope is zenith-pointing to 100horizon-pointing. The design style of the lateral support is that of a "central post" anchored to the mirror cell. A hub assembly (Sheet 5, CHARA 8) will be mounted inside the central hole of M1. When properly assembled within the M1 hole, the hub will be located by the front and rear mirror surfaces such that nylon spacers (-23 item, CHARA 8) are aligned with the c.g. of the mirror. Reaction forces supporting the mirror will be transmitted from the hub through the spacers. Normally, only the upper spacer will carry any load. The hub will be connected by flex straps (-15 item, CHARA 8) to a clamp mounted onto a steel tube (the "post") which is part of the cell weldment. Strap flexure will allow small movements of M1 to occur without exerting large forces on the mirror when unavoidable thermal and gravitational changes occur.

Orientation of the hub and the central tube clamp must be such that the flex straps are vertical when M1 is horizon-pointing. Maximum tensile stress in the straps under that condition is estimated to be about 9,000 psi which is well within the yield strength of annealed 303 stainless steel (approx. 35,000 psi)

The SV is not required to install the lateral support in M1 or to perform any bonding operations involving M1.

### 4.3.3. Weldment & Machining Primary Cell (Descriptive Information)

**Ref:** Dwg. CHARA 21

CHARA 21 describes a machined weldment that will be the principal structure for the mirror cell assembly. In order to facilitate machining operations, the drawings indicate a two-stage welding operation. The first stage is described on Sheet 3 which is then followed by machining operations shown on Sheet 2. The second stage of welding to incorporate reinforcing ribs is shown on Sheet 1. Final machining to obtain dimensions on Sheet 1 follows the second welding stage.

No functional tests are required for this assembly other than dimensional compliance with the drawings.

### 4.3.4. Primary Mirror Support & Details (Descriptive Information)

**Ref:** Dwg. CHARA 22

CHARA 22 shows one of the axial supports for M1 commonly known as a "whiffle-tree." The drawings specify enough parts to build three "whiffle-trees" which will comprise the entire axial support for the mirror. Each "whiffle-tree" will be a system of pivoted mechanical levers with a single connection to the mirror cell and six connections to the rear surface of M1. Thus, the mirror will be directly supported at 18 locations that mechanically connect to the mirror cell at 3 attachment points which will define the mirror position. The component of mirror weight acting parallel to the optical axis will be carried passively on the18 support pads and the pivot locations determine the magnitude of reaction force. In effect, the levers will be a reaction force distribution system.

Vertical position adjustments of M1 may be done using the threaded shafts (-18 Item, CHARA 22) at the ends of the pivot arms (-2 Items). The lever assembly must be balanced in both zenith-pointing and horizon- pointing positions as described in Section 4.3.1.

Functional tests for this assembly are described in Section 4.3.1.

### 4.3.5. Primary Mirror Cell Cover (Bottom) (Descriptive Information)

**Ref:** Dwg CHARA 23 (4 sheets)

CHARA 23 specifies a protective metal cover to be mounted on the bottom side of the mirror cell assembly. It will be constructed of 1/8" thick aluminum sheet. The cover will have two parts; a flat panel (-2 item) and a hexagonal "dish" (-3 assembly). The hexagonal "dish" may be removed independently for maintenance purposes.

There is no functional test required except dimensional compliance with the drawings and the ability to install the cover on the mirror cell.

Since the cover must be mounted to the mirror cell weldment, the SV may find it useful to use the weldment as a fixture during assembly of the six panels comprising the hexagonal "dish."

### 4.3.6. Primary Mirror Cell Cover Assy & Details (Descriptive Information)

**Ref:** Dwg. CHARA 29 (4 sheets)

The function of the hardware shown on CHARA 29 is to protect the primary mirror from contamination when it is not in use. Two biparting, "accordion-fold" fabric covers will be driven toward the mirror center to "close" and cover the mirror. Driving away from center "opens" the cover to completely expose the mirror reflecting surface. CHARA 29 shows one cover "open," the other partially "closed."

The biparting, "accordion-fold" fabric covers ("Gortite") will be purchased from a commercial source (Item 7). Each cover will be mounted between a stationary frame (-2 assembly) attached to the mirror cell and a movable slide frame (-16 or -17 assembly). The slide frame will be mounted on drive shafts (-28). The drive shafts pass through roller-style linear actuators (Item 1) attached to the ends of each slide frame. Rotation of the drive shafts will cause the linear actuators to advance along the shafts. Shaft rotation will, thus, move the slide frames toward or away from the center of the mirror depending on the direction of rotation. A reversible gear motor (Item 8) drives the shafts through a system of chains and sprockets. Limit switches (Item 9) will indicate when the slide frames have reached a fully open or fully closed position.

Due to slight uncertainty concerning the manufactured shape of the "Gortite" covers, after receiving the covers, the SV will be required to determine the number and location of attachment screws connecting them to the stationary and slide frames (Note 3 on CHARA 29).

In the event one end of a slide frame reaches a stop before the other end, shaft rotation will continue until the other end also reaches its stop. Thus, a limit switch will be required to indicate the open/closed position of each end of the two slide frames, a total of eight switches (Four "open" condition , four "closed" condition). The switches will be wired into the drive motor control circuit such that when the motor is actuated, it will continue to run until all four "open" switches are actuated or vice-versa for the "closed" switches.

The linear actuators are designed by the manufacturer to allow the shafts to rotate without damage even when the actuator is prevented from further travel. In case of malfunction such that one of the limit switches fails to actuate properly, the motor will continue to run and after a predetermined period of time, the telescope operator will be signaled to investigate. The signal that a problem exists will be part of the telescope control system.

As indicated in Section 4.3.1, the SV will be required to show that the cover assembly will open and close properly. When completely open, no part of the slide frames should be less than 20" from the nominal center of the mirror cell assembly (i.e., no obscuration of the mirror). When fully closed, no gap should exist between the two slide frames.

## 4.4. Telescope Base Sub-Assembly

**Ref:** Dwgs. CHARA 10 (3 sheets)

including: CHARA CHARA 25 (2 sheets & CHARA 24) Box Frame,

CHARA 28 (3 sheets) Base Bearing Assy,

CHARA 26 (3 sheets) Torque Tube,

CHARA 27 (1 sheet) Tel Base Detail (Drive Journal),

CHARA 9 (3 sheets) Cable Wrap Assy,

CHARA 30 (3 sheets) Cable Drum Cover,

CHARA 31 (5 sheets) Az Drive Mounting Assy

Sheet 1 of CHARA 10 illustrates the assembled azimuth base including all of the subassemblies listed above plus the CHARA 11 drive assembly described in Section 4.5. Sheet 2 of

CHARA 10 illustrates the arrangement for attaching cable carriers between the torque tube and the cable drum. Sheet 3 of CHARA 10 details support arms for the encoder read heads (-Œ6,- Œ7, -8 Items) and a bumper stop to prevent the torque tube from moving far enough to damage the read heads in case pressure on the drive wheel is released. Following the SV requirements in the next section, each of the assemblies listed above will be discussed.

### 4.4.1. Subassembly Vendor (SV) Requirements

The SV shall make/procure all hardware in compliance with CHARA 10 and Section 3 except:

- The Drive Assembly (CHARA 11) which is specified separately in Section 4.5 of this document. The SV for CHARA 10 will not be required to install this item.
- Item 20, CHARA 19 Encoder (Heidenhain LIDA 105) will not be supplied to the SV for CHARA 10.
- The following items to be supplied to the SV by CHARA:

  Item 17, CHARA 10 Flanged Brg. (SKF FY-2-TM)

  Item 18, CHARA 10 Pillow Block (SKF SYE 2-1/2)

  Item 19, CHARA 10 Cable Carrier (Kabelschlepp 0475MK-RKR-104-1)

  Item 1, CHARA 9 Pillow Block (Flanged Brg.) (SKF FYT 2 FM)

  Item 8, CHARA 28 Sph Roller Thrust Brg. (SKF 29240)

  Item 9, CHARA 28 Seal (CR Services)

  Item 10, CHARA 28 Seal (CR Services)

All bearings shall be lubricated at assembly with a grease suitable for low temperature, low speed operations. SKF LGWM1/Equivalent shall be used.

### 4.4.2. Box Frame Assembly (Descriptive Information)

**Ref:** Dwgs CHARA 24 and CHARA 25

The box frame assembly is the primary supporting structure. The CHARA 25 base frame will connect to the telescope foundation pier. The box frame weldment shown on CHARA 24 completes the basic structure.

For convenience, the "x-y" coordinates for most of the machined holes are tabulated. Since there will be no convenient machined surfaces on CHARA 24 to serve as references for locating some of the holes in the top surfaces, a system of four tooling holes has been specified to establish the "x" and "y" axes.

### 4.4.3. Base Bearing Assembly (Descriptive Information)

**Ref:** Dwg. CHARA 28

This assembly is the main support for azimuth rotation of the telescope. All of the rotating weight of the telescope will rest on the SKF 29240 spherical roller bearing which is central to the assembly. The dynamic load rating of the bearing (120,000 lbs) is several times the anticipated weight of the telescope, so the bearing will be not be highly stressed. The bearing also restrains radial motion of the lower end of the torque tube (CHARA 26). Modest misalignments between the mounting surfaces on the box frame and the torque tube will be accommodated by the spherical races of the bearing.

Bearing lubrication will be required. The bearing should be packed at assembly with a lithium-based grease capable of good lubrication at low temperatures and low rotational speeds. SKF LGWM1 grease/Equivalent is required.

The base bearing assembly may be adjusted in lateral position by means of four adjustment screw blocks (-9 Item, CHARA 10).

### 4.4.4. Torque Tube Assembly (Descriptive Information)

**Ref:** Dwg CHARA 26

The torque tube will be a machined weldment mounted directly atop the base bearing assembly (CHARA 28). The azimuth drive disk (-1 Item, CHARA 27) will be mounted directly on top of the torque tube. The drive disk will ordinarily be pressed against two idler rollers (-3 Item, CHARA 27) which will establish the radial position of the drive disk. Thus, the torque tube will act as a shaft rotating about a vertical (azimuth) axis.

Angular adjustment of the torque tube rotation axis may be done by:

- Adjusting the lateral position of the base bearing assembly at the base of the torque tube, and
- Adjusting/shimming the position of the upper pillow blocks supporting the idler roller shafts (Item 18, CHARA 10).

The lower portion of the torque tube will provide connections and support surfaces for four cable carriers. Wiring, cables, etc. from the rotating part of the telescope will feed through holes in the drive disk, passing through the torque tube out through the cable carriers attached to the -2 Item tube. For further description of the cable wrap, see Section 4.4.6.

Critical machining requirements for the torque tube are based on the need to locate the drive disk in a perpendicular orientation to the axis of rotation. In operation, the drive disk will rotate about the azimuth axis and while doing so, the rim of the disk should not wobble to any significant degree. It is assumed that final machining of the critical top and bottom surfaces of the torque tube will be done with the weldment mounted on the two 7.250" diameter bores. Those bores will serve no other purpose.

### 4.4.5. Telescope Base Details (Drive Disk & Idlers) (Descriptive Info)

**Ref:** Dwg CHARA 27

The drive disk (-1 Item) will be mounted atop the torque tube as described in Section 4.4.4. Each of two idler rollers (-3 Item) will mount atop a shaft (Œ2 Item) that will be supported by pillow block bearings attached to the box frame. The rim surfaces of the idler rollers will be "crowned" to reduce criticality of alignment to the drive disk. The idler rim surfaces will also serve to define the radial position of the drive disk and, hence, the telescope. Pressure exerted by the drive wheel on the drive disk will keep the disk pressed against the idlers. The relatively large diameter of the idler rollers was chosen to decrease the time rate of change in the runout error of the support bearings.

At assembly, the idler rollers should be aligned to the drive disk by:

- Setting the vertical height by adjusting the thickness of the spacer (Item 7, CHARA 10) at the base of the idler roller shaft.
- Adjusting angular orientation by making lateral position adjustments of the flanged pillow blocks (Item 17, CHARA 10) at the base of the idler shafts. Note: It is presumed that the pillow blocks at the upper end of the idler shafts may have been previously positioned as part of setting the torque tube rotation axis and, hence, should not be moved again.

A machined groove in the drive disk will be used for mounting an encoder tape (Item 20, CHARA 10). In particular, the tape will be bonded to the 44.2500" diameter which is the critical surface.

Zinc plating has been specified, however, plating should not be done on the encoder tape mounting surface or the outer rim

### 4.4.6. Cable Wrap Assembly (Descriptive Information)

**Ref:** Dwg CHARA 9

The CHARA 9 cable wrap assembly will be a four-level, cylindrical, drum- like device to wrap/unwrap two/more cable carriers connected to the torque tube (CHARA 26). The cylinder will mount and rotate upon a stationary post (-10 Item). Up to four cable carriers may be installed; a minimum of two are required to operate properly. As shown on Sheet 2, CHARA 10, one cable carrier will be wrapped around the cable drum while another will be wrapped in the opposite direction of the drum section of the torque tube. When the torque tube is rotated in either direction, one or the other of the cable carriers will cause the cable drum to follow in rotation.

At assembly, care should be taken to ensure alignment of the four carrier support levels with the mating carrier levels on the torque tube. The assembly should rotate easily.

### 4.4.7. Cable Drum Cover Assembly (Descriptive Information)

**Ref:** Dwg CHARA 30

The drum covers described by CHARA 30 will serve to protect the cable carriers and also to restrict the carriers to the region between the two cable drums. A close, but non-contacting fit with the rotating drums will be required.

### 4.4.8. Azimuth Drive Mounting Assembly (Descriptive Information)

**Ref:** Dwg CHARA 31 and CHARA 11

CHARA 11 specifies the basic drive unit for both axes of the telescope and is discussed in Section 4.5. CHARA 31 specifies the mounting provisions for the drive unit on the azimuth axis. As shown on Sheet 1, the drive unit will be attached to the end of a rectangular pivot arm (-2 Item, CHARA 31). The other end of the pivot arm will incorporate a flex plate to be bolted to the box frame. In effect, the pivot arm is mounted like a cantilever beam off the box frame. An adjustable vertical post (-7, -8 Items, CHARA 31) will be used to support part of the weight of the drive unit.

In operation, the drive wheel will be pressed against the drive disk by means of spring pressure exerted through a tangent arm (-11 Item, CHARA 31). Runout errors "seen" at the drive wheel-disk interface will be accommodated by spring deflection and bending of the flex plate which will otherwise be a rigid connection to the box frame.

The connection joint between the CHARA 11 drive unit and the pivot arm will allow 2-axis tilt adjustment of the drive wheel relative to the drive disk. At assembly, the drive wheel must be carefully aligned such that its rotation axis is parallel to the drive disk rotation axis. After adjustment, the connection joint bolts will be tightened to achieve a rigid connection.

To restrict relative lateral displacement between the drive wheel and drive disk, a pair of cam followers (Item 9, CHARA 31) mounted on an angle bracket (-16 Item, CHARA 31) will act on the drive disk. The angle bracket will be attached to the CHARA 11 drive unit through a boss plate (-18 Item, CHARA 31). At assembly, the boss plate thickness shall be modified to place the cam followers at the correct height relative to the drive disk. The cam followers will be mounted on eccentric studs that may be rotated to adjust the follower position relative to the drive disk to about 0.030". At assembly, the followers should be adjusted such that minimum clearance exists between the drive disk and the followers without affecting free rotation of the drive disk.

Approximately 550 lbs of preload pressure will be required at the drive wheel/drive disk interface. Two springs (Item 8, CHARA 31) acting on the tangent arm will be compressed to provide the preload pressure. The specified springs (Lee "Hefty" LHL-2000A-4) have nominal spring rates of 300 lb/in and must each produce about 190 lbs force on the tangent arm. Thus, the springs must be compressed approximately 0.63" to achieve the required condition.

## 4.5. Drive Assembly

Ref. Dwg: CHARA 11 (4 sheets)

CHARA 11 describes the main drive units for telescope rotation about the altitude and azimuth axes. The drive is similar for both axes although the mounting bracketry is different on the two axes (See Sections 4.4 & 4.8 for mounting assemblies)

### 4.5.1. Subassembly Vendor (SV) Requirements

The SV shall fabricate and assemble parts in compliance with CHARA 11 and Section 3. Two complete assemblies shall be produced (one for each rotation axis). The following items will be supplied to the SV by CHARA prior to assembly:

Item 1, CHARA 11 Servo Motor (Dynaserve DM-1015B)

Item 2, CHARA 11 Gear Reducer (Dojen 08)

At assembly, the SV shall measure the amount of radial runout at the rim of the bronze drive wheel (-11 Item) and make a best effort to reduce the runout by rotating the bronze wheel to alternate angular positions on the speed reducer (Item 2). The objective will be to offset radial runout of the speed reducer with radial runout of the drive wheel.

### 4.5.2. Drive Assembly Descriptive Information

The drive unit will consist of an 8" diameter (nominal) bronze wheel (-8 item) mounted onto a commercial 24:1 "zero-backlash" speed reducer (Item 2) which will be driven by a commercial servo motor (Item 1). The entire assembly will connect to an adjustable joint which will be used to align the bronze wheel to a 52" diameter driven disk (not part of this assembly). In operation, a preload force will press the drive wheel against the drive disk enough to prevent slippage during normal operation.

The drive motor rotor will connect to the input side of the speed reducer through a collet-style clamp that must be tightened to 435 in-lb (See Spec Sheet for Dojen 08 Speed Reducer). A bearing internal to the speed reducer will withstand the preload applied to the bronze wheel. The input shaft of the speed reducer will be supported on one end by a bearing inside the speed reducer and on the other end by the drive motor bearings. Thus, the end cap supporting the drive stator (-7 item) should not be tightened until the reducer-motor assembly is positioned properly within the drive housing (-8 item). Screws attaching the end cap to the motor should be tightened first, followed by tightening screws connecting the end cap to the housing, followed by loosening and re-tightening of the end cap-to- motor screws. This procedure will minimize stresses on the internal motor bearings.

A hole is provided in the pivot arm (-2 item) to reach the motor wiring. The connecting bracket (-12 item) serves the dual purpose of covering the access hole and providing a place for mounting a wiring connector (TBD).

## 4.6. Telescope Fork Assembly

**Ref:** Dwg CHARA 12

CHARA 12 shows the machined weldment comprising the fork of the telescope. The machined base flange of the fork will be attached directly to the top surface of the azimuth drive disk (-1 Item, CHARA 27). The altitude axis bearings will be mounted on the machined top surfaces of the fork arms.

### 4.6.1. Subassembly Vendor (SV) Requirements

The SV shall fabricate and assemble parts in compliance with CHARA 12 and Section 3. The following items will be supplied to the SV by CHARA prior to assembly:

Item 1, CHARA 12 Sph. Roller Pillow Block (SKF SYE 2-1/2)

The fork arms should be parallel to each other and perpendicular to the machined base flange surface as indicated on CHARA 12. The fork was designed to obtain high stiffness in the front-to-back direction (i.e., in the direction of the long axis of each fork arm)

### 4.6.2. Telescope Fork Assembly (Descriptive Information)

The fork assembly mounting flange will be provided with slightly oversize holes to enable about ± 0.15" lateral adjustment of the fork assembly relative to the azimuth rotation axis. Adjustment will be made using four adjusting screw blocks bolted to the top surface of the azimuth drive disk.

"Fore-aft" adjustment of the pillow block bearing may be used to move the OSS relative to the fork. If necessary, shims may be installed under the pillow block bearing for vertical adjustment of the OSS altitude axis.

## 4.7. Altitude Bearing & Drive Disk Assy

**Ref:** Dwg CHARA 15

CHARA 15 describes the "inboard" altitude axis bearing assembly and the drive disk (-5 Item) bolted to it..

#### 4.7.1. Subassembly Vendor (SV) Requirements

The SV shall make/procure all hardware in compliance with CHARA 15 and Section 3 except the following items to be supplied to the SV by CHARA:

Item 1, CHARA 15 Ball Bearing Set, Matched (Kaydon KD100ARO)

#### 4.7.2. Altitude Bearing & Drive Disk Assy (Descriptive Information)

The "inboard" altitude bearing assembly is designed to allow a 5" diameter light beam to pass through unobstructed along the altitude axis. A pair of relatively large diameter (Kaydon) bearings with small cross-sections will support both radial and axial loads. These bearings will be "angular- contact" style requiring a small amount of end loading to minimize internal clearances. The bearings specified are a "matched duplex" set which means the bearing races have been ground to provide end loading on the balls when the bearing are clamped together "back-to-back." Care will be required at assembly to ensure proper bearing installation.

Mounting brackets connecting the axle tube to the fork arm will have provisions to allow "fore-aft" and "side-to-side" (along the altitude axis) adjustments of the OSS. Vertical adjustments may be done by shimming under the mounting brackets.

The drive disk will be similar in size to the azimuth axis drive wheel, however, the attachment bolt pattern and the lightweighting holes are different. Also, the altitude drive disk will have no provision for mounting an encoder tape. A full diameter drive disk was specified (instead of a partial sector) to avoid unnecessary unbalance of the OSS. Since only 90° of the disk will ordinarily be used, the disk could be rotated in to a new position in the event of damage to the disk "working region."

### 4.8. Altitude Drive Mounting Assembly

**Ref:** Dwg CHARA 16

CHARA 16 specifies the mounting bracket assembly for the CHARA 11 drive unit on the altitude axis. The entire assembly will be bolted to one of the upright fork arms (CHARA 12). The bronze drive wheel on CHARA 11 will contact the altitude drive disk.

#### 4.8.1. Subassembly Vendor (SV) Requirements

The SV shall make/procure all hardware in compliance with CHARA 16 and Section 3 except:

- The Drive Assembly (CHARA 11) which is specified separately in Section 4.5 of this document. The SV for CHARA 10 will not be required to install this item.

#### 4.8.2. Altitude Drive Mounting (Descriptive Information)

The altitude axis driving arrangement will be similar to the azimuth axis drive except that the drive mounting is different. The CHARA 11 drive unit is identical for both axes. Two-axis tilt adjustment provisions for the bronze drive wheel are also similar. Runout errors "seen" at the drive wheel-drive disk interface will be compensated by minor flexure at the hinge groove near the attachment bolts.

The drive wheel will be preloaded against the drive disk in a manner similar in principle to the azimuth axis drive. The situation differs on the altitude axis, however, because the weight of the drive assembly will act in opposition to the preload springs. For that reason, the specified springs (Item 10, CHARA 16) are stiffer than those for the azimuth axis (i.e, 45 Jlb/in compared to 300 lb/in). Estimated weight of the assembly acting against the springs is approximately 500 lb. To obtain 600 lb preload of the drive wheel against the drive disk is estimated to require approximately 1.1" compression of both preload springs, however, the actual amount of compression should be determined at assembly by first compressing the springs to just offset the drive assembly weight followed by sufficient compression to achieve a 550-600 lb preload.

# 5. TELESCOPE ASSEMBLY

Ref. Dwg: CHARA 1

CHARA 1 illustrates and identifies the major mechanical subassemblies comprising the basic assembled telescope. Each of these subassemblies was described in Section 4. The M3 mirror assembly is not shown and the M4, M5, and M6 assemblies are shown only schematically.

## 5.1. Assembly Vendor (AV) Requirements

The basic task to be done by the AV shall be to receive subassemblies from the SV's, assemble the telescope, verify proper mechanical functions, and perform the alignments/calibrations to be described below. Final testing of the mechanical assembly to be done in the presence of a CHARA representative. The provisions of Section 3 will also apply to the AV.

The AV shall review the requirements and descriptive information for each subassembly given in Section 4 and verify that all functional requirements applicable to the SV have been met. Functional failures shall be reported to CHARA for disposition. The AV shall also verify that all of the parts have been received for each subassembly from the SV's.

**Specific Tasks To Be Done By the Assembly Vendor:**

- A. Assemble all of the subassemblies identified on CHARA 1. Verify that subassemblies fit together as designed without unexpected interference or extreme looseness. Resolve differences from the design with CHARA.

- B. Balance the OSS about the altitude axis according to the following procedure. Install a 310 lb dummy weight in the CHARA 8 primary mirror assembly to simulate the primary mirror. Install a 2 lb weight in the CHARA 2 assembly to simulate the secondary mirror. Determine the balance condition of the assembled OSS and add appropriate counterweights to achieve a balanced condition. It is expected that counterweights will be required in the upper OSS. The preferred method shall be to place the OSS in a zenith-pointing position and add a mixture of lead shot and epoxy binder to the interior of the CHARA 3 support frame. Distribution of the mixture shall be equal among the four sides of the frame. A series of threaded 3/8" holes have been specified in the top surface of the frame for this purpose (If necessary, these holes may be enlarged to facilitate the operation). The threaded holes will also be used for adding trim weights, it necessary, after the optics have been installed and aligned.

- C. Position the CHARA 10 base assembly on a level floor and adjust the torque tube rotation axis to be vertical. The AV shall make a best effort to minimize the angular error (radial runout) and lateral (vertical) wobble measurable at the rim of the 52" diameter azimuth drive disk with respect to the fixed box frame. The goal shall be to reduce radial runout and lateral wobble to ± 0.002" or less for 360° rotation of the drive disk. This procedure may include:

  1) Reducing idler roller runout by adjusting roller orientation relative to the pillow block bearings supporting the idler support shaft.

  2) Minimizing the radial runout error contribution of the azimuth base bearing assembly (CHARA 28) by repositioning the bearing housing relative to the torque tube.

  3) Adjusting/repositioning the azimuth drive disk on the torque tube assembly (CHARA 26)

  4) Installing shims between the azimuth drive disk and the torque tube to reduce lateral (vertical) wobble of the drive disk rim relative to the fixed box frame.

  Residual runout errors of the drive disk, corrected for residual idler roller error, shall be recorded and reported to CHARA.

- D. Determine the altitude rotation axis and make any necessary adjustments to make the axis horizontal and intersecting with the azimuth axis within 0.015". A best effort shall be made to make the axes intersect within 0.004".

- E. A best effort shall be made to minimize the radial runout and lateral wobble measured at the rim of the 52" diameter altitude drive disk relative to the fixed box frame. The goal shall be to reduce radial runout and lateral wobble to ± 0.001" or less for 90° rotation of the drive disk. This procedure may include:

  1) Repositioning the drive disk relative to the bearing housing mounting flange.

  2) Installing shims between the altitude drive disk and the disk mounting flange to reduce lateral wobble of the drive disk rim relative to the fixed fork arm.

  Residual runout error values shall be recorded and reported to CHARA.

- F. Align the azimuth idler rollers (-3 Item, CHARA 27) to the azimuth drive disk. The top surfaces of the idler rollers and the drive disk should be nearly coplanar (i.e., within 0.03")

- G. Preload and align the CHARA 11 drive units to their respective 52" diameter drive disks such that the rotational axes of the drive wheel and drive disk are parallel as evidenced by smooth mechanical rotation when the preload force level on the bronze drive wheel (-11 Item, CHARA 11) is approximately 550 lbs (See discussion of spring compressions in Section 4.4.8 and Section 4.8.2). The top surface of the bronze drive wheel will nominally be 1/4" below the top surface of the azimuth drive disk. On the altitude axis, these surfaces will nominally be coaligned.

- H. Install cable carriers (Item 19, CHARA 10) between the CHARA 9 and CHARA 26 assemblies and test mechanical functionality of the azimuth cable wrap assembly. (Note: The carriers may tend to be "floppy" until wiring and cables are inserted. Inclusion of a few typical cables may be necessary for best performance).

- I. After all assembly and alignment procedures are complete, conduct functional rotational tests of the altitude and azimuth drives under power using CHARA-supplied controls to verify that smooth driving action is obtained.
- J. After the telescope mechanical assembly has been tested satisfactorily in the presence of a CHARA representative, dismantle the telescope and prepare it for safe shipment by commercial carrier to the site to be designated by CHARA.

**TABLE 1.** CHARA-Supplied Commercial Components

| Part No. & Description | Qty | Supplier | Order Specification |
|---|---|---|---|
| Item 30, CHARA 5<br>Mike Driver w. Piezoelectric Pos. | 3 | Polytec<br>PI, Inc | DC-MIKE Drive, Model M-224.20<br>w. P-250.20 Piezoelectric Translator. Note:<br>Controller, connectors, & cable extensions<br>for these drivers are required & are TBD. |
| Item 31, CHARA 5<br>High Accuracy<br>Feedback Scale | 1 | Sony | Scale Unit SH 10-007C1A<br>(5 V DC power supply and<br>connecting cable also required) |
| Item 32, CHARA 5<br>Pillow Block | 1 | Rexnord | FX3-2120 Pillow Block w.<br>711-02012-019 insert |
| Item 8, CHARA 29<br>Gear Motor | 1 | Bison | Series 750 AC Right Angle Gearmotor,<br>1/6 HP, 115/230 V, 30:1 gear ratio |
| Item 19, CHARA 10 | 4 | Kabel-<br>Schlepp | Cable Carrier. Varitrak Series MK<br>0475 MK-RKR-104-1. Length to be 183.25"<br>(98 links at pitch = 1.87") Carriers to be<br>provided without bend radius terminators |
| Item 1, CHARA 12 &<br>Item 18, CHARA 10 | 3 | SKF | Spherical Roller Brg Pillow Block<br>SYE 2-1/2 |
| Item 17, CHARA 10 | 2 | SKF | 4-Bolt Flanged Unit (FY 2 TM) |
| Item 1, CHARA 9 | 2 | SKF | 2-Bolt Flanged Unit (FYT 2 FM) |
| Item 8, CHARA 28 | 1 | SKF | Spherical Roller Thrust Bearing SKF 29240 |
| Item 9, CHARA 28 | 1 | CR<br>Services | Bearing Grease Seal. Chicago Rawhide Cat.<br>No. 75054. Item "made to order" due to size. |
| Item 10, CHARA 28 | 1 | CR<br>Services | Bearing Grease Seal. Chicago Rawhide Cat.<br>No. 1150112. Item "made to order" due to size. |
| Item 1, CHARA 11 | 2 | Parker | Dynaserv DM Series Motor<br>Model 1015B. (Note: Controller TBD) |
| Item 2, CHARA 11 | 2 | Mectrol | Dojen Zero Backlash Reducer,<br>Size 08 with 24:1 speed ratio |
| Item 1, CHARA 15 | 1 | Kaydon | Matched set of KD100ARO angular contact<br>bearings (2 bearings), Type A, to be mounted<br>in a face-to-face configuration. |

Refer to Catalog Page Supplement for Supplier Addresses
Quantities shown are for one telescope

**TABLE 2.** CHARA Telescope Drawing List

| Drawing No. | No. of Sheets | Title |
|---|---|---|
| *CHARA 1* | 2 | Telescope Assembly |
| *CHARA 2* | 1 | Telescope Secondary Top End Assy |
| CHARA 3 | 2 | Secondary Frame & Details |
| CHARA 4 | 1 | Secondary Support Fins & Attachment |
| CHARA 5 | 9 | Secondary Focus Assy & Details |
| *CHARA 7* | 6 | Strut & Midframe Assy & Details |
| CHARA 6 | 2 | Telescope Top Frame Assy & Details |
| *CHARA 8* | 5 | Primary Mirror Cell Assy & Details |
| CHARA 21 | 7 | Weldment & Machining-Primary Cell |
| CHARA 22 | 4 | Primary Mirror Support & Details |
| CHARA 23 | 4 | Primary Mirror Cell Cover (Bottom) |
| CHARA 29 | 4 | Primary Mirror Cell Cover Assy & Details |
| *CHARA 10* | 3 | Telescope Base Sub-Assy |
| CHARA 25 | 2 | Box Frame |
| CHARA 24 | 1 | Telescope Base Frame |
| CHARA 28 | 3 | Telescope Base Bearing Assy |
| CHARA 26 | 3 | Torque Tube Assy & Details |
| CHARA 27 | 1 | Telescope Base Details (Drive Disk, etc.) |
| CHARA 9 | 3 | Cable Wrap Assy. Details & Machining |
| CHARA 30 | 3 | Cable Drum Cover Assy |
| CHARA 31 | 5 | Azimuth Drive Mounting Assy |
| *CHARA 11* | 4 | Drive Assy & Details (Azimuth & Altitude) |
| *CHARA 12* | 1 | Telescope Fork Assy.-Weldment & Machining |
| *CHARA 15* | 4 | Altitude Axis Bearing & Drive Wheel Assy |
| *CHARA 16* | 2 | Altitude Drive Mounting Assy |

Underlined numbers are main subassemblies which identify the indented drawings as part of the subassembly. CHARA 1 identifies the main subassemblies.
Note: Drawings for M3, M4, M5 & M6 mirror assemblies not included