

**ASTRO-PHYSICS**

# **900GTO GERMAN EQUATORIAL WITH SERVO MOTOR DRIVE**



**ASTRO-PHYSICS, INC**  
11250 Forest Hills Road  
Rockford, IL 61115  
Telephone: (815)-282-1513  
Fax: (815)-282-9847  
[support@astro-physics.com](mailto:support@astro-physics.com)  
[www.astro-physics.com](http://www.astro-physics.com)

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MODEL 900GTO PARTS LIST	5
FEATURES AND SPECIFICATIONS	5
INTRODUCTION	6
Why Polar Alignment is Important	6
Compensation for the Earth's rotation	6
ASSEMBLY INSTRUCTIONS	7
Before You Leave Home	8
Gross Latitude Adjustment	8
Attach Pier Adapter to Pier Post	9
Assemble Pier (purchased separately)	10
Assemble Polar Axis Assembly to Pier or Tripod	10
Altitude and Azimuth Adjustments - Rough polar alignment	10
Assemble Declination Axis	11
Removing Declination Axis at the End of your Observing Session	12
Attach Mounting Plate (purchased separately)	12
Assemble Counterweight Shaft	12
Attach Mounting Rings (purchased separately)	12
Fine Polar Alignment	12
Methods for fine polar alignment	12
Altitude and Azimuth Adjustments	13
DAMPER KNOBS AND CLUTCH KNOBS	13
R.A. and Dec. Damper Knobs	13
R.A. and Dec. Clutch Knobs	13
Balancing Your Telescope	14
SERVO MOTOR DRIVE	15
GTO Control Box - GTOCP2	15
R.A. and Dec. Cable Connections	15
12V Connector	15
POWER Indicator Light	15
KEYPAD Connector	16
RS-232 Connectors	16
FOCUS Connector	16
RETICLE Connector	16
AUTOGUIDER Connector	16
+6V Connector	16
N and S Switch	16
Prevent the Cables From Tangling	17
900 Motor Cables	17
Accessory Cables	17
Removing the GTO Control Box From 900 Mount	18
GTO KEYPAD CONTROLLER OPERATION	18

MOUNT CARE AND ALIGNMENT	18
ADDITIONAL TIPS AND SUPPORT	19
TROUBLESHOOTING	19
RECOMMENDED READING FROM OUR STAFF:	20
INSTALLATION OF ENCODERS AND ENCODER HOUSINGS -900 MOUNT	21
Fitting Declination Encoder Housing	21
Fitting Right Ascension Encoder Housing	22
Periodic Maintenance	22

# **ASTRO-PHYSICS**

## **900GTO GERMAN EQUATORIAL WITH SERVO MOTOR DRIVE**

### **MODEL 900GTO PARTS LIST**

- 1 Polar axis assembly (right ascension-R.A.) with GTO Control Box (Model GTOCP2)
- 1 Declination (Dec.) axis assembly
- 1 Pier top adapter with six (6) 5/16-18 x 5/8" button head screws  
(this plate may be attached to your pier post if you ordered one)
- 1 Stainless counterweight shaft with washer stop and black plastic knob (knob has 5/16 thread)
- 1 Y cable – R.A. portion is 12.5" long and Dec portion is 37.5" long
- 1 D.C. power cord (cigarette lighter adapter on one end) - 8' long
- 1 GTO Keypad controller with 15' coiled cable
- 1 *DigitalSky Voice™* Software (CD-ROM)
- 1 Hex key set
- 2 8-32 Thumbscrews (substitute for set screws to allow quick disconnect of GTO control box)

In order to assemble your mount fully, you will need the following items sold separately: mounting plate, 8" O.D. pier, counterweights, and portable rechargeable battery pack (or 110 to 12V DC converter). Several sizes and types are available for your selection. Many of these items will be discussed throughout these instructions. Several additional options are available:

Polar Alignment Scope – for quick and easy polar alignment

Santa Barbara Instrument Group CCD Imaging cameras, STV, ST-4 Autoguider or other imaging camera- if you plan to pursue CCD imaging or astrophotography

Pier accessory trays for 8" pier and support bars - handy to keep your eyepieces close at hand

Mounted encoders - you will need these if you plan to use digital setting circles. Keep in mind that these 4000-step encoders, which read the position of the shaft are very coarse (324 arc seconds) while the encoder that is built into the servo motor itself is 0.05 arc seconds.

Wedge - allows use from 0-20 degrees.

### **FEATURES AND SPECIFICATIONS**

R.A. worm wheel:	7.2", 225 tooth aluminum	Azimuth adjustment:	Approximately 14 degrees
Dec. worm wheel:	6", 225 tooth aluminum	Setting circles:	Porter Slip Ring design, engraved
Worm gear:	Brass	Right ascension:	4-minute increments, pointer
R.A. shaft:	2.2" diameter	Declination:	1-degree increments, pointer
R.A. thrust surface:	7.0" diameter	Motors:	Zero-cogging servo motors
Dec. shaft:	1.75" diameter	Power Consumption:	0.4 amps at the sidereal rate
Dec. thrust surface:	6.0" diameter	Power requirements:	2 amps both motors slewing
Counterweight shaft:	13.25" useable length, 1.875" diameter stainless steel, removable	Weight of mount:	12 VDC, range 11.5 to 15 total -50 lbs.
Latitude range:	20 to 68 degrees with or without polar scope or encoders attached (if you are above 65° you will have to remove one pier top knob)	Dec axis -15 lbs. R.A axis - 25 lbs. counterweight shaft -10 lbs.	

# INTRODUCTION

The 900GTO German equatorial was designed to meet the needs of the advanced observer who requires a mount with maximum strength and rigidity and minimum weight. The excess material in both axes has been carved out while retaining a heavily ribbed structure for internal strength and rigidity. A unique dovetail was machined into the mating surfaces of the R.A. and Dec axes. This feature allows quick and easy assembly in the field without any tools.

The DC servo motor drive with GTO computer system, including the keypad controller with its digital display screen and *DigitalSky Voice* software offer extraordinary sophistication for today's observer. Whether you enjoy visual astronomy exclusively or plan an aggressive astrophotography or CCD imaging program, this mount will allow you to maximize your night out under the stars.

The advanced keypad features allow you to slew automatically to objects in a wide range of databases as well as any R.A./Dec coordinate. A large selection of common names for stars and other objects makes your selection a snap. The rapid slew rate of 5 degrees per second (1200x) allows you to locate objects very quickly and accurately. You will be very pleased with the intuitive operation of this controller. There are no complicated sequences of keystrokes to remember. It is so easy to use that even if you don't use it for a few months, you will feel at home with the keypad very quickly.

*DigitalSky Voice* software provides additional capabilities to control the movement of your telescope by using two-way verbal communication with a microphone or by a few clicks of your computer mouse (or touchpad). You can remain at the eyepiece while you direct your telescope with verbal commands. There is no need to put a flashlight in your mouth to see the keyboard. You have total control with your voice and/or mouse. Voice control also allows you to retain your dark adaptation.

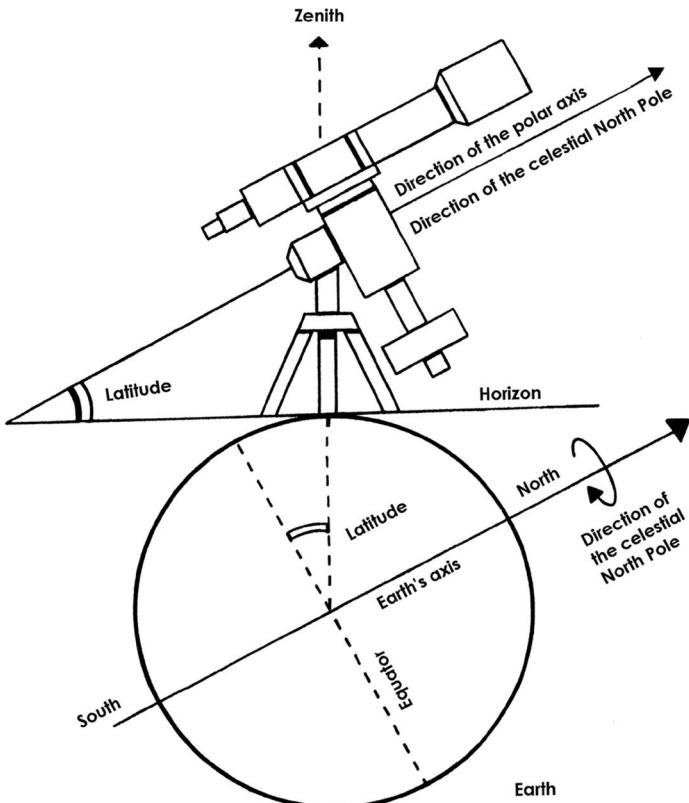
The 900 is equally at home in a permanent observatory or as a portable mounting for remote star parties thanks to the ease with which the two axes come apart. This is the perfect mount for a mid-size refractor, Newtonian, Cassegrain or astrograph.

In order to maximize your pleasure on your first night out, we recommend that you familiarize yourself with the assembly and basic operation of the mount indoors. The temperature will be comfortable, the mosquitoes at bay, and you'll have enough light to see the illustrations and read the manual. Please take particular note of counterbalancing, use of the clutches and operation of the keypad controller.

## Why Polar Alignment is Important

### Compensation for the Earth's rotation

If you were to take a long exposure photograph with Polaris (often called the North Star) in the center of the field, you would discover that all stars seem to revolve around Polaris. This effect is due to the rotation of the earth on its axis. Motor driven equatorial mounts were designed to compensate for the earth's rotation by moving the telescope at the same rate and opposite to the earth's rotation. When the polar axis of the telescope is pointed at the celestial pole (polar aligned) as shown in the diagram, the mount will follow (track) the motions of the sun, moon, planets and stars. As a result, the object that you are observing will appear motionless as you observe through the eyepiece or take astrophotos.



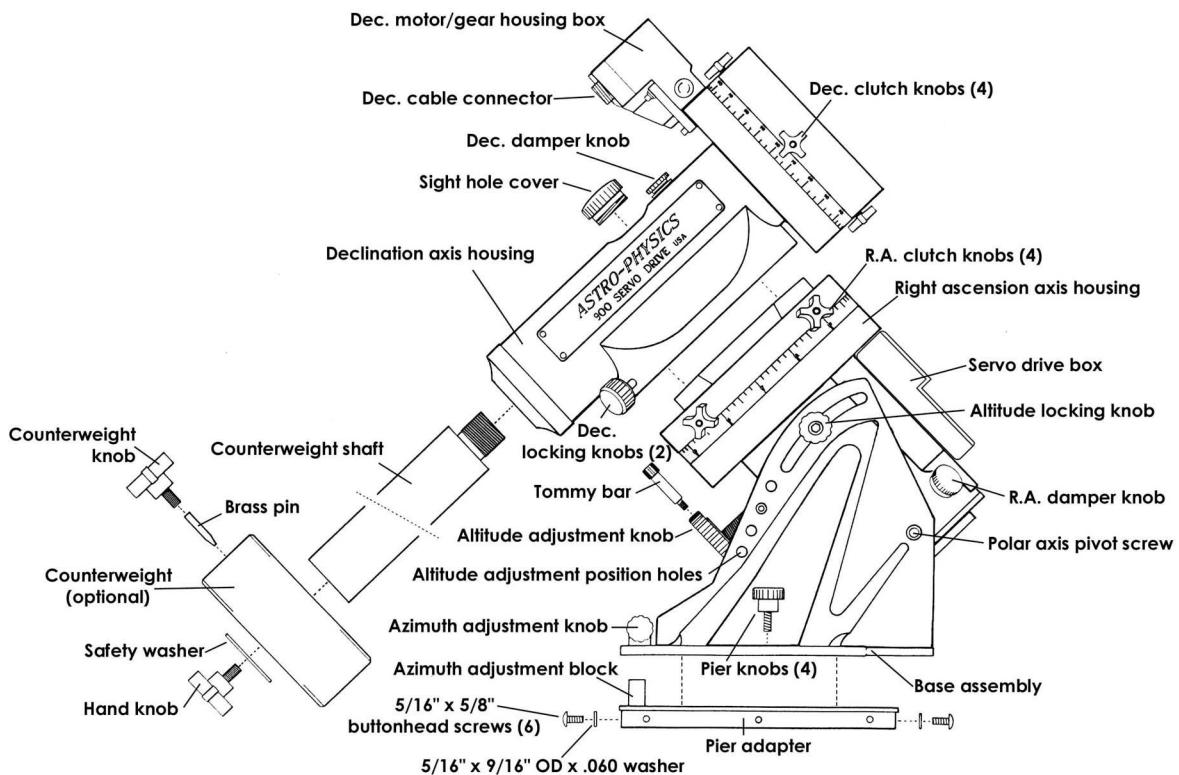
## ASSEMBLY INSTRUCTIONS

Please read all instructions before attempting to set up your 900GTO mount. The model 900 is very rugged, however like any precision instrument, it can be damaged by improper use and handling. Please refer to the following illustrations. The parts are labeled so that we can establish common terminology.

The following terms and abbreviations are used interchangeably in these instructions:

polar axis = right ascension axis = R.A. axis = R.A. housing

declination axis = dec. axis = dec. housing



## Before You Leave Home

Since most of us must set up our instruments in the dark, in the cold or while battling mosquitoes, a bit of preplanning and organization is important. There are few simple things that can be accomplished in the comfort of your home before heading outside.

### Gross Latitude Adjustment

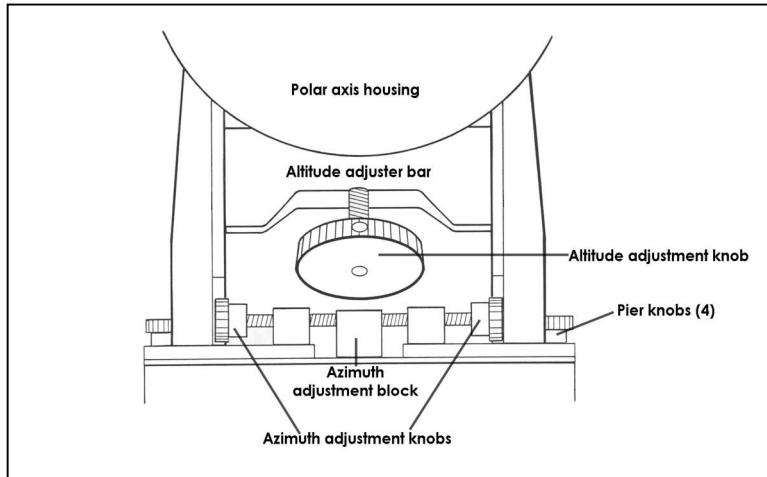
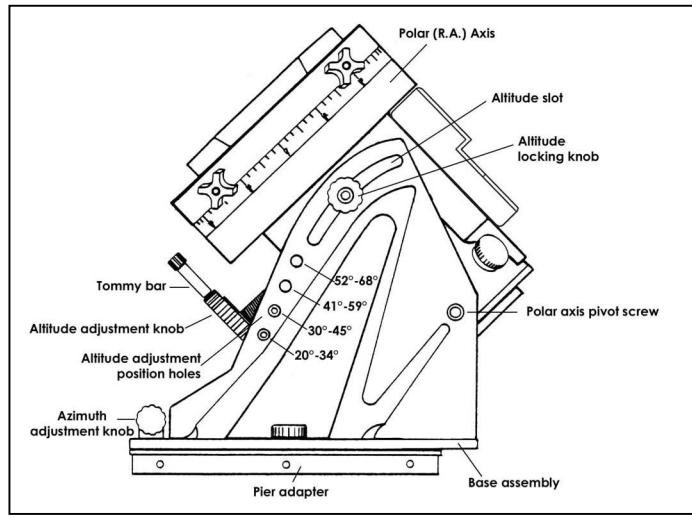
The latitude range of the 900 mount is approximately 20-68 degrees. Since most astronomers typically observe within one latitude range, this adjustment is made just once, if at all. Prior to shipment, we preset the mount to your latitude range for your convenience. If you travel to another observing location, determine the latitude of your observing site and make the appropriate adjustment. If you live in or plan to travel to locations that are 0-20 degrees latitude, we recommend our wedge (900WDG).

The four positions for the altitude adjustments have the following approximate ranges:

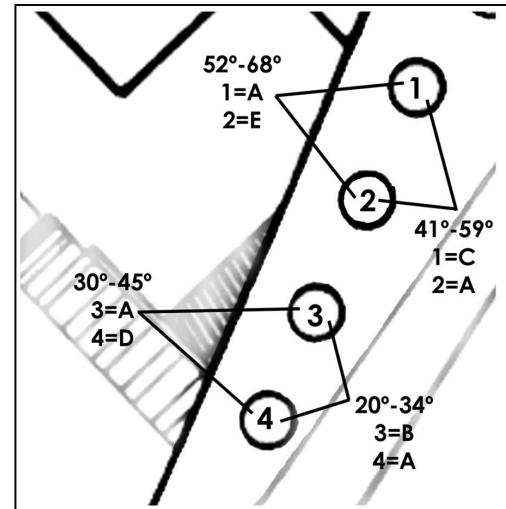
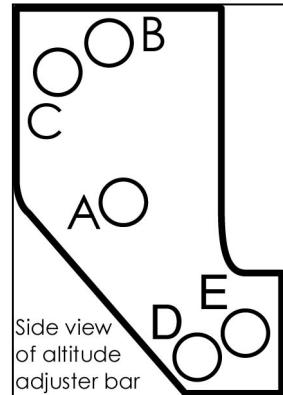
- 52 degrees to 68 degrees latitude - top position
- 41 degrees to 59 degrees latitude - third position
- 30 degrees to 45 degrees latitude - second position
- 20 degrees to 34 degrees latitude - bottom position

#### How to change the position of the altitude adjuster

1. Use only the R.A. axis. DO NOT attempt to make these adjustments with the declination axis in place and certainly not with an instrument fully mounted.
2. Loosen both altitude-locking knobs about 1 turn.
3. Locate the side of the polar axis that does not have the motor/gear housing box. Loosen (about 1 turn) the polar axis pivot screw and altitude adjuster bar fixing screws on this side only. With your hand, push the polar axis upwards so that the altitude-locking knobs are positioned at the top of the altitude slot (this is the maximum altitude position). Some resistance will be felt with this operation as you are pushing against the weight of the polar housing and the resistance of the remaining polar axis pivot screw (which has not been loosened).
4. Before attempting to move the altitude adjuster bar, you must tighten the altitude-locking knob on the motor/gear housing side. This will prevent any downward movement of the polar axis during positioning of the altitude adjuster bar.
5. While supporting the altitude adjuster bar, remove the two screws that support it on each side (4 screws in all), but keep the two ends of the bar in contact with the side of the mount, don't remove it completely (this tip is for your convenience).



- Determine the latitude range that you need and position the altitude adjuster bar so that the hole that is marked "A", as shown in the diagram, is located at the appropriate hole position numbered 1-4 in the lower diagram. Note that hole "A" is located at the rounded part of the altitude bar.
- Attach two of the screws (one on either side of the adjuster bar), but do not tighten. Rotate the altitude adjuster bar around this pivot point until the corresponding hole lines up. Consult the diagram to determine which hole of the altitude adjuster bar should be used. Be very careful since the holes marked C and B are very close to one another. The incorrect hole may appear to line up, however it will be slightly off. If you try to attach at the incorrect hole, you may strip the threads of the altitude bar. Exercise the same caution with the D and E holes.
- Once you have located the correct hole, insert the remaining two screws. Lightly tighten so that you still have some ability to move the bar.
- Note that the altitude adjustment knob is attached to a threaded rod that travels through the altitude adjuster bar. Turn the knob so that the altitude adjuster bar is positioned approximately in the middle of the threaded rod. You should see about half of the threaded rod protruding from both sides of the altitude adjuster bar. This will allow you to move the mount fully within the altitude range.
- At the end of the threaded rod mentioned in the last step, you will see a small brass altitude adjuster thrust pad. This is the part that will come in contact with the polar axis as you ease it back into position. Loosen the altitude-locking knob (motor/gear side) and lower the polar axis so that it rests comfortably on this pad. The threaded rod should be positioned at a right angle to the polar axis housing. Firmly tighten the altitude adjustment screws.
- Turn the altitude adjustment knob to raise or lower the polar axis to your approximate observing latitude. Tighten the altitude locking knobs with finger pressure only. You do not need to tighten with the hex key.
- Firmly tighten both polar axis pivot screws with the hex key.



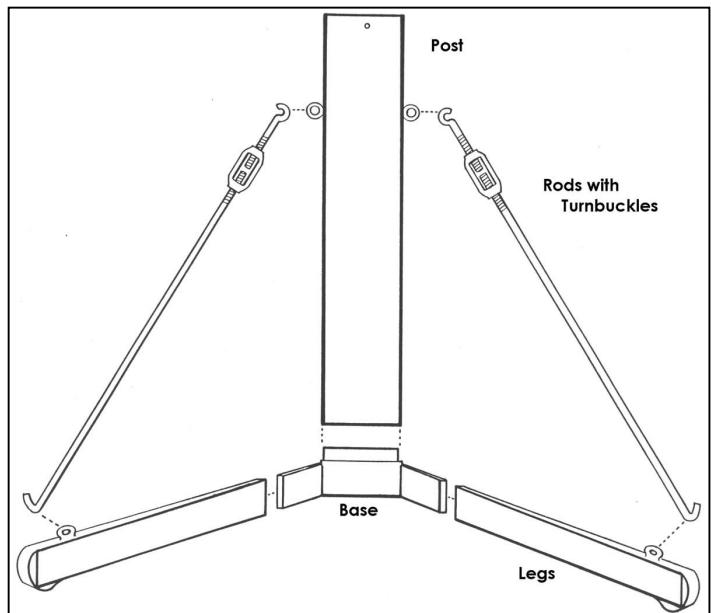
### Attach Pier Adapter to Pier Post

If you purchased the pier from Astro-Physics, the pier top adapter of the 900 may be already attached to the top of the pier. If you are constructing your own pier or tripod, you will need to incorporate this part. The pier adapter was designed to fit into an 8" x 0.125" wall tube with 6 screws threaded into the side or bolted onto a flat surface by using the four countersunk thru-holes (pier adapters from earlier production runs do not have the thru-holes). Note that with the Astro-Physics pier, you can orient the pier adapter so that one of the pier legs faces "north" or "south" as you prefer. If you need an extra Pier Adapter (part # S900PA) for a second pier, they are available for purchase.

## Assemble Pier (purchased separately)

Begin by assembling the portable pier at the desired observing location. Note which direction is north.

1. Slide the three legs onto the nubs of the base and rotate the assembly so that one of the legs points toward north (or south, if that is your preference).
2. Place the pier post on the base orienting the center azimuth block directly north. If you choose to have one leg north, then the pier adapter plate will have to be installed with the azimuth block directly over a turnbuckle. If you have one leg south, the pier adapter plate will have to be installed with the azimuth block over and between two of the pier post turnbuckles.
3. Attach the tension rods. The turnbuckles should be drawn tight until the whole assembly is stiff enough to support your weight without movement.



## Assemble Polar Axis Assembly to Pier or Tripod

In order to track the motion of astronomical objects, the polar axis must be positioned so that an imaginary line drawn through the center of the axis points toward the celestial pole. At this stage of the assembly process, you want to position the mount so that it points roughly north.

1. Remove the four (4) hand knobs on the pier top adapter and keep them close at hand.
2. Prior to lifting the polar axis assembly into place, turn the fine azimuth adjustment knobs so that the space between them is wide enough to allow the center azimuth block to fit easily between them. Ensure both pier top and polar axis assembly mating surfaces are clean and free of dirt.
3. Place the polar axis assembly onto the pier top adapter so that the center azimuth block fits between the fine azimuth adjustment knobs.
4. Move the base of the polar axis assembly so that the threaded holes of the pier top can be seen through each of the four slots.
5. Thread the four hand knobs loosely in place (you will tighten these later after polar alignment).

## Altitude and Azimuth Adjustments - Rough polar alignment

For rough polar alignment, your goal is to sight the celestial pole when looking through the polar alignment sight hole in the center of the polar axis. You will need to make altitude (up/down) and azimuth (side-to-side) adjustments to the position of the mount.

We recommend that you do your rough polar alignment with the R.A. axis only since you will be making major adjustments to the position of the mount at this time. The remainder of the mount, telescope and counterweights will add considerable weight and require more hand effort. Later, you will do your final polar alignment with the telescope and counterweights attached, but the adjustments will be small.

1. If the R.A. encoder housing and encoder adapter are installed (part # ENC900 - Mounted Encoders to use with Digital Setting Circles - are available as an optional purchase), you may remove them to complete these steps. Please refer to the section pertaining to encoders later in the manual. Alternatively, you can simply sight up the side of the polar axis to see Polaris.
2. If you examine the polar axis assembly, you will see that the center of the R.A. shaft is hollow. If you have not done so already, loosen (1/2 turn) the four pier knobs.

NOTE: If you have already attached the Dec. axis, remove the sight hole cover and rotate the internal Dec. shaft

by moving the top of the Dec. axis (or the cradle plate if it is attached) to reveal the sight hole that has been drilled into it. Now, you can look through the shaft to the other side.

3. **Azimuth adjustments:** Move the entire pier or tripod east or west until the mount is oriented approximately towards the pole (an imaginary line drawn through the hollow shaft). Use the two fine azimuth adjustment knobs, one on each side of the mount, to make adjustments. You must back off the opposing azimuth knob in order to move the other knob in that direction. Please refer to the diagram.

One turn of the azimuth knob is approximately 0.63 degrees (38 arc minutes)

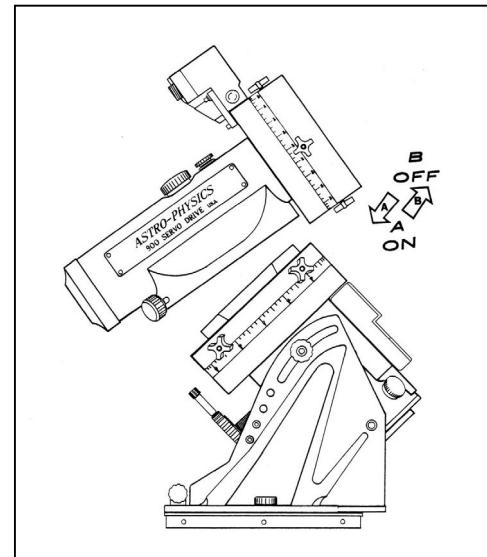
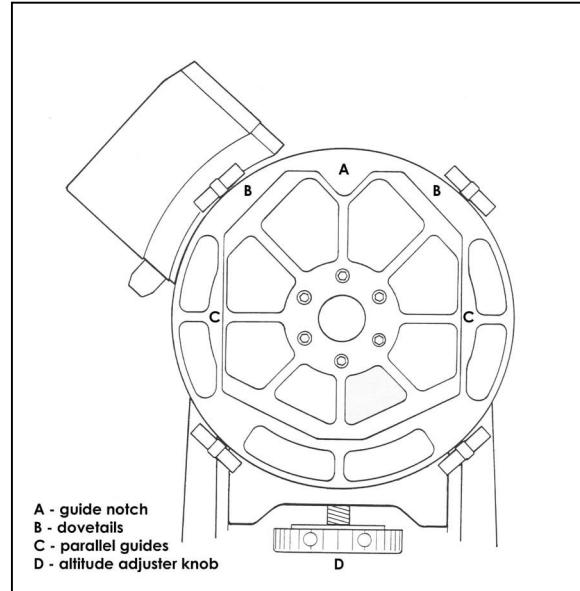
4. **Altitude (latitude) adjustments:** Loosen the altitude locking knobs. Move the polar axis up or down with the large altitude adjustment knob located in the front of the polar axis assembly. The tommy bar can be positioned in any of the threaded holes located in the altitude adjustment knob. Use this bar to help you turn the knob. We have found that using the turnbuckle on the north leg of our pier also can make fine altitude adjustments, if used.

One turn of the altitude knob is approximately 0.64 degrees (38 arc minutes).

5. Continue your azimuth and altitude adjustments until you can sight Polaris in the polar alignment sight hole. At this point, you have achieved a rough polar alignment, which may be sufficient for casual visual observations, if you are not planning to slew to target objects with the keypad. When the R.A. motor is engaged (the power is plugged in), it will compensate for the rotation of the earth and keep the target object within the eyepiece field of view. Your target object will slowly drift since polar alignment at this stage is only approximate. However, you can make corrections with the N-S-E-W buttons of your keypad controller.
6. Tighten the altitude locking knobs by hand.
7. Tighten the pier knobs firmly by hand.

## Assemble Declination Axis

1. Do not have your telescope or counterweights connected to the Dec. axis for either assembly or disassembly of the Dec. and R.A. axes.
  2. Position the R.A. axis as shown in the diagram shown to the right with the guide notch "A" at the top, opposite the altitude adjuster knob. Firmly tighten R.A. clutch knobs.
  3. During shipment, the Dec. axis assembly lock knobs will be fully screwed into the Dec. axis assembly. For correct assembly, these lock knobs should be unscrewed at least 7 full turns and no more than 8.5 full turns. This is between 5/16" and 3/8" out from the "shipped" tightened position. Note: These lock knobs can be completely removed from the Dec. axis assembly with about 9.5 full turns out.
  4. Position the Dec. axis above the R.A. axis as shown in the diagram, a light movement (wiggle) in the downward direction (arrow "A") will help to correctly seat the principle dovetail(s) and parallel guides.
  5. When both Dec. and R.A. assemblies are fully seated, hand tighten both Dec. lock knobs.
  6. Thread the counterweight shaft into the Dec. axis.
  7. Remove the hand knob and safety washer from the base of the counterweight shaft. Add sufficient counterweights (10 or 18 lb. counterweights are purchased separately) to the declination shaft to balance the telescope you intend to use. Always use two hands to attach or move them on the shaft.
  8. Reattach the hand knob and safety washer to the end of the declination shaft. This will help to prevent injury if someone accidentally loosens the counterweight knob.
- NOTE: Firm tightening of the counterweight knob will not damage the surface of the counterweight shaft. The pin that



tightens against the stainless counterweight shaft is constructed of brass. Likewise, the bronze sleeve that has been press-fit into the center of the counterweight will prevent marring of the shaft as you move the counterweight up and down.

### **Removing Declination Axis at the End of your Observing Session**

1. Unscrew the lock knobs 5.5 to 7 full turns (this is still 5/16" to 3/8" out from the fully tightened position) and slide/tilt the Dec. axis assembly in an upward direction (arrow "B").
2. For transport/storage we recommend fully tightening the lock knobs.

### **Attach Mounting Plate (*purchased separately*)**

Several mounting plates are available for the 900 mount. If you own more than one instrument, you may need more than one plate. Attach your mounting plate with the screws provided with the plate. It is important to use the proper screws, please refer to the separate instruction sheet entitled "*Mounting Plate Fastener Chart*."

### **Assemble Counterweight Shaft**

**IMPORTANT:** Always attach the counterweights before mounting the telescope to the cradle plate to prevent sudden movement of an unbalanced tube assembly, which may cause damage or injury. Remember counterweights are heavy and will hurt if they fall on your foot.

1. Thread counterweight shaft onto the Dec. axis.
2. Remove the hand knob and washer from the base of the counterweight shaft. Add sufficient counterweights (10 or 18 lb. counterweights are available) to the counterweight shaft to balance the telescope you intend to use. Always use two hands to attach or move them on the shaft. Reattach the hand knob and washer to the end of the counterweight shaft. This will help to prevent injury if someone accidentally loosens the counterweight knob.

A firm tightening of the counterweight knob will not damage the surface of the counterweight shaft. The pin that tightens against the stainless counterweight shaft is constructed of brass. Likewise, the bronze sleeve that has been press fit into the center of the counterweight will prevent marring of the shaft as you move the counterweights.

### **Attach Mounting Rings (*purchased separately*)**

Our flat and ribbed plates are constructed with keyhole slots at the location where your mounting rings attach. This feature enables you to partially loosen the screws on your rings just enough to insert them into the larger part of the keyhole, then slide the rings to the narrow part and tighten them with a hex key. You can even accomplish this with the rings on the scope, although this maneuver may be difficult to accomplish with a large, heavy instrument.

We prefer this keyhole method to the standard way of completely removing the screws and possibly dropping them in the grass.

### **Fine Polar Alignment**

For casual observation, you may skip this section and move to "Operation of the Mounting" [tighten your altitude locking knobs (2) and pier knobs (4) first]. If you plan to use any of the go-to functions of the 900GTO or do astrophotography, you must polar align.

#### **Methods for fine polar alignment**

- Polar Alignment Scope – Our optional polar scope (PASILL3 or earlier models) will allow you to quickly align your mount on the pole stars. The reticle was designed for use in both the Northern and Southern hemispheres. Even users of the GTO computerized mounts will find these polar scopes useful, particularly if your telescope is not orthogonal to the mount (please refer to the keypad manual for a discussion of orthogonality). If you have a polar alignment scope, please read the instructions sheets that come with it.
- GTO Keypad – Please refer to the instruction manual for the GTO Servo Drive and read the section describing the startup sequence. For daytime setup, read the section entitled "Polar Aligning in the Daytime" in the GTO Keypad manual.

- DigitalSky Voice computer program – Please read the corresponding manual.
- JMI Digital Setting Circles – Please read the instructions included with your JMI unit. You must have the encoders installed on your 900 mount (part #900 ENC). Refer to the section of this manual entitled “Installation of Encoders and Encoder Housings – 900 Mount.”
- Star Drift method – Traditionally, this has been regarded as the most accurate method of polar alignment, however it is also the most time consuming. If you are planning long exposure astrophotos, we suggest that you use the polar axis telescope, then tweak the final polar alignment by star drifting. Refer to the GTO Keypad manual for hints on polar aligning using a GTO quick star drift method. Also refer to the Technical Support section of our website for further information. For general information regarding traditional star drift alignment, please refer to the recommended reading list at the end of this manual.

## **Altitude and Azimuth Adjustments**

1. Loosen the altitude - locking knob (2) and pier knobs (4) and refer back to the section on “Altitude and Azimuth Adjustments – Rough Polar Alignment.”
2. Follow one of the methods of polar alignment mentioned above.
3. When polar alignment has been achieved, tighten at these locations (note that the polar axis pivot screws should have been tight throughout the fine polar alignment process):
 

Altitude locking knobs (2) – hand tighten  
Pier knobs (4) – hand tighten
4. For a permanent installation, all knobs in step 3 above may be firmly tightened with the assistance of a hex wrench.

## **DAMPER KNOBS AND CLUTCH KNOBS**

### **R.A. and Dec. Damper Knobs**

The R.A. and Dec. damper knobs are not intended as axis locks. They should be tightened with light finger pressure so that a slight resistance can be felt when pushing an unclutched axis by hand. This really adds to the "feel" at the end of the scope with the drives adjusted correctly.

The purpose of the damper knob is to add a bit of friction to the shaft so that gusty winds do not move the axes in their bearings. If there is the slightest amount of backlash between worm and worm wheel, a wind load could theoretically move the axis back and forth by that backlash amount. Also, in the absence of backlash, there is always a very tiny clearance (.0002") between the shafts and the mating parts. The damper knobs force the shaft to make full contact in 3 places to eliminate the associated play.

### **R.A. and Dec. Clutch Knobs**

1. What do they do?  
The four R.A. and four Dec. clutch knobs have the function of connecting the R.A. and Dec. axes to their respective drive worm wheel gears. Their function is progressive, from no tension (axes free to move - as required during correct balancing of the telescope) to a completely "locked up" state.
2. How can you find out what they really do?  
As shipped, all 900 mounts have all four R.A. and Dec. clutch knobs firmly hand tightened. This will give you a good idea of the maximum tightness (clutch action) that can be achieved by hand effort alone. At this point, you must bear in mind that for optimum performance all four clutch knobs on each axis (R.A. or Dec.) should be tightened evenly with the same tension (i.e. all four half tight, all four fully tight, etc.).

In order to feel the effect of the clutch knobs, you may wish to partially assemble your mount. Fit together the R.A. and Dec. assemblies plus mounting plate and counterweight shaft. Do not put scope and counterweights on at this stage. With the above assembly (with the clutch knobs firmly hand tightened - "as shipped"), you can feel the amount of force needed to move each axis by hand. Grab each end of the telescope mounting plate and move it with a backward and forward movement of the Dec. axis. You will feel considerable resistance to this motion. Perform the same operation on the R.A. axis by moving the counterweight shaft backward and forward. With a well-balanced telescope, the above tightness of the clutch knobs will be sufficient for all normal conditions of use.

Now, mount up and balance your telescope so you can "feel" what this resistance in R.A. and Dec. (movement backwards and forwards) is like when you make these motions from the eyepiece end of your telescope as you would during normal use when slewing (pushing) by hand to acquire an astronomical object within the field of view of your finder or scope.

3. How tight can the clutch be and can you do any damage by pushing against them?

The maximum tightness of this clutch system is 1/3 turn (with a 5/32 allen key) further in than the tension you can achieve with the knobs by hand. You will see that each clutch knob has a 5/32 hex socket for tightening with an allen key. With this extra 1/3 turn on each clutch knob, the axis (axes) will be considered completely "locked up" and you should not attempt to push your scope by hand against this "locked up" resistance, or undue stress will be placed on the worm wheel/worm and bearings.

However, if you are undertaking a very long astrophoto exposure, it is advisable to increase the pressure on each clutch knob (with the 5/32 key) by about 1/8 turn on Dec. and 1/8th turn on R.A. You may safely slew the scope by hand with this tension, however you will notice considerably more effort is required to achieve movement. This is the absolute maximum tension that can be used for hand slewing. As a general rule, if you have a big scope (7" or 8" refractor) with all the accessories, you will need more clutch tension than a 5" or 6" scope.

## Balancing Your Telescope

For proper operation, the telescope must be adequately counterbalanced. Start by balancing the tube assembly.

1. Tighten the 4 R.A. axis clutch knobs.
2. Loosen the 4 Dec. axis clutch knobs (about 3/4 to 1 turn) so that the telescope moves freely about the declination axis. Be careful because if your telescope is significantly out of balance, it may swing rapidly in the out-of-balance direction!
3. Position the R.A. axis so that the counterweights are in their "lowest" position, i.e. the declination axis assembly is in the meridian (this is the classic photographic pose for a German Equatorial).
4. Loosen the tube mounting rings and slide the tube up and down for balancing. This is best done with the tube in the horizontal position. If you are using a Losmandy mounting plate, loosen the hand knobs on the female dovetail plate and slide the Losmandy plate to the desired position.
5. The scope is balanced when it stays put (does not move) with the clutches loose and movement back and forth about the declination axis has the same feel in both directions.
6. Now, tighten the declination axis clutch knobs and position the telescope horizontal and the declination axis horizontal. The center of the counterweights is now the same height as the middle of the tube.
7. Loosen the R.A. clutch knobs. Again, be careful because if your scope is significantly out of balance it may swing rapidly in the out-of-balance direction.
8. Move the counterweight(s) up or down to achieve the correct balance in R.A. Again, movement back and forth about the R.A. axis should have the same feel in both directions.

Try to anticipate any balance problems due to the extra weight of diagonals, heavy eyepieces, finders, solar filters, etc. If the scope moves by itself, when the clutches are loose, then the scope is not counterbalanced adequately. A small amount of imbalance on the East side of the mount is permissible and even desirable for astrophotography and imaging.

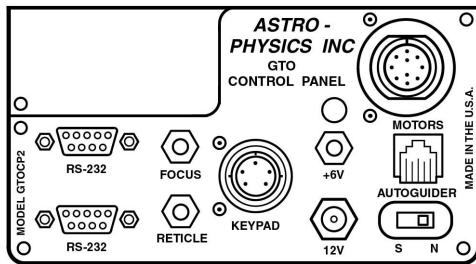
# SERVO MOTOR DRIVE

## GTO Control Box - GTOCP2

The GTO control box contains all of the circuitry to drive the two servomotors and the logic required to circumnavigate the sky. It will be operational and track at the sidereal rate when connected to both motors of the mount and a power source. In order to control the movement of the mount, you will need to connect at least one of these:

- GTO Keypad
- Computer with astronomical software such as *DigitalSky Voice* (included) or planetarium programs such as Software Bisque's *TheSky™*, Nova Astronomics' *The Earth-Centered Universe (ECU)* version 3.1 or later, and Chris Marriot's *Sky Map Pro 6* or later and other programs (all purchased separately).

The GTO Servo Control Box is mounted directly onto the polar axis of the 900 mount. Please remember that this box contains advanced electronics and must be treated with the same care given to other fine equipment. You can see that the unit is built to be rugged, however it is not indestructible.



### R.A. and Dec. Cable Connections

A "Y" cable with 10 pin connectors is included with your mount. Attach the connector from which the two cables emerge to the GTO Control Panel. Attach the short part of the "Y" cable to the R.A. motor housing and the long part of the cable to the Dec. motor housing. Lock all connectors. Refer to the section below for further information about positioning the cables.

### 12V Connector

Place the DC power cord (included with your mount) into the phono plug outlet marked 12V on the GTO Control Panel and lock in place. Plug the cigarette lighter plug end of the cord into your power source. The acceptable voltage range is 11.5 to 15. Suggested power sources include: portable rechargeable battery pack, auto or marine battery, or power supply (filtered and regulated) for 110 volts with a minimum output of 5 amps at 12V DC.

There is no on-off switch. We recommend that you plug the power cable into the servo box after the keypad controller. To turn the unit off, simply disconnect the power cable.

**Considerations for observatory installations:** We suggest that you disconnect your GTO Control Box from 110V when you are not using your mount so that if your observatory experiences a power surge or lightening strike, your mount electronics will not be damaged. If you operate your mount remotely, you will have to leave your power cable connected just as you do for the rest of your electronic equipment. You may want to consider surge protectors or other protective measures to protect from voltage spikes. A disconnect relay to remove power from both the 12 volt and ground wire is highly recommended.

### POWER Indicator Light

This LED will remain illuminated when your power source has sufficient output to drive the motors. If the voltage falls below 10.5 volts, the power light will go out and the motors will stop. The keypad controller will not function properly.

For mounts shipped after 02-25-00: If the LED turns yellow, this means that your motors are overloaded, probably due to an unbalanced load on your mount. Refer to the troubleshooting section of the manual for the solution. Earlier control boxes do not have this feature.

## **KEYPAD Connector**

Attach the 5-pin male connector of the keypad controller and lock in place (push in the knurled ring then turn).

## **RS-232 Connectors**

These serial port connections are used to connect your mount to your PC computer. You must provide your own straight-through (non-crossing) cables with a 9-pin (DB9) male connector to interface with the GTO panel. We have provided the locking posts to secure the cable firmly. If your serial cable does not have a 9-pin connector, you can use a gender changer or adapter to convert it.

When you are controlling the position of the mount with a computer program such as *DigitalSky Voice™* or Software Bisque's *TheSky™*, the microprocessor chip located in the servo drive box will send continual RA and Dec. coordinate data via the cable connections to your computer. When you use the software to give instruction to slew to a new object, the commands (RA and Dec. coordinates) are sent to the mount.

We provide two serial port connections on the mount so that you can use two software programs simultaneously. For instance, you can give verbal commands in *DigitalSky Voice* while using *TheSky* as a planetarium program. Since the mount will update the RA and Dec. coordinates simultaneously, both programs are continually updated with the data from the mount. You can watch the screen display of *TheSky* to see where your telescope is pointing as it slews. This is most effective if you have a reasonably fast computer with plenty of RAM. If you try this with a 100MHz processor and only 32 MB of RAM, the response time will be slow since both programs must be continuously updated with position data.

You must have two serial ports available on your computer to take advantage of this feature. If you use a laptop, you may need to purchase a PCMCIA adapter to gain an additional serial port. Socket Communications offers adapters for many computers. Check out their web site at [www.socketcom.com](http://www.socketcom.com).

## **FOCUS Connector**

Attach the 3.5mm phono plug connector of your JMI Motofocus or other electric focuser (optional accessories) here. Refer to the section regarding focus adjustment in the GTO Keypad Manual for instructions on using the keypad controller to adjust focus. Alternatively, you can verbally control the focus using the Focus Mode of DigitalSky Voice software.

## **RETICLE Connector**

If you wish to use the illuminator cable for our polar alignment scope or plug-in-type guiding eyepiece with an illuminated reticle (available from several manufacturers), insert the 3.5mm phono plug into this connector for power. Reticle brightness can be adjusted with the hand control. Refer to the section pertaining to reticle illuminator adjustment in the GTO Keypad manual for further information.

## **AUTOGUIDER Connector**

This connector interfaces with the RJ-11-6 modular jack of an autoguider cable, purchased separately or as part of a CCD Imaging Camera or Autoguider. The autoguider will be functional and ready to go as soon as you plug it in. Please refer to the appropriate manual from the manufacturer for operation of the autoguider.

We offer cables for all SBIG cameras. Please refer to our price list or call for further information.

## **+6V Connector**

This 6-volt output accepts 3.5mm phono plugs. It is used primarily to power the Pentax 6x7 camera directly from the mount with a cord sold for that purpose (our part # CORD01).

## **N and S Switch**

Select northern (N) or southern (S) hemisphere as needed. When you slide the switch to the opposite position, the tracking direction of the drive will reverse. The power cord must be removed and re-attached to make this work.

## **Prevent the Cables From Tangling**

The movement of the mount across the meridian during slewing functions is calculated so that the cables will not tangle if they are set up properly. In addition to the motor and power cables that are provided with the mount, you may have additional cables for other accessories. These may be powered from the GTO Control Panel or from another power source. We suggest that you position your cabling carefully to avoid a tangled mess. When your cables are set up, move the telescope manually throughout the normal range of movement to be sure that the cables do not catch on anything and that you have enough length. Here are a few pointers:

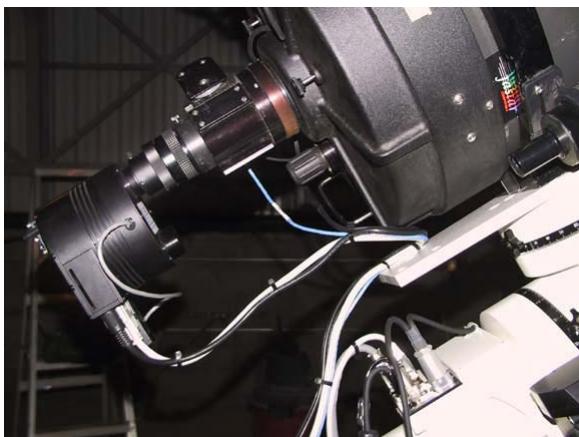


### **900 Motor Cables**

Note that the "Y" cable for the 900 mount originates at the GTO Control Panel connector, then splits into two. The short portion connects to the RA motor box and is not likely to be in the way because this axis remains in the same position. We have provided a cable mount to position the R.A. cable neatly. The longer Dec. portion of the cable must be set up properly to ensure that as the Dec. axis moves, the cable follows smoothly. Please insert this cable into the cable mount in the upper left corner of the GTO Servo Control Box as shown above. When the connector is attached to the Dec. motor box, the cable should be positioned as shown in the photographs.

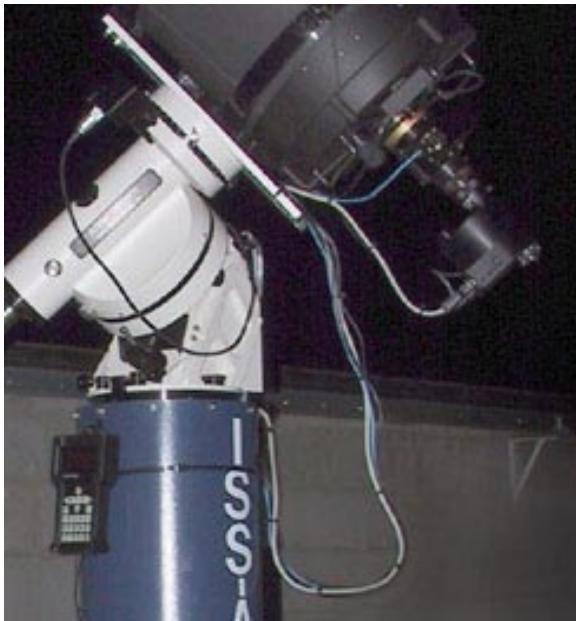
### **Accessory Cables**

Accessories may include Kendrick Dew Removers, CCD cameras and autoguiders, focus motors, illuminated guiding eyepiece reticles, power cords for the Pentax 6x7 camera, etc. As you attach each accessory, carefully assess the best position to assure complete movement as your telescope slews from one side of the mount to the other. If an external power source is used, determine the optimum location for the battery. We prefer to use tie wraps (not glamorous, but effective) or cable ties (from electronic supply store or catalog) to secure our cables to the mount, telescope, and rings or bind them together. Adhesive cable mounts similar to the one that we use for the Dec. cable are an alternative choice. These are available from electronic supply stores. We prefer to use ties since we cannot bear to attach plastic adhesive cable mounts to our telescopes or mounts.



The photo on the left shows how the cables were arranged on the 1200GTO that was installed at a permanent observatory for the International Space Station – Amateur Telescope (ISS-AT) project. This mount is operated remotely and cable management is essential. The same principles apply to the 900GTO. The scope is a modified Celestron C-14 and the accessories included: CCD camera, color filter wheel, remote focuser and Kendrick Dew.

Note how the wire bundle is attached to the mounting plate before looping back to the pier. Attaching the wires securely to the plate prevents any kind of motion or disturbances to the camera during image acquisition and guiding. The loop is made long enough to allow the scope to reach all portions of the sky with plenty to spare. The people who installed system ran the scope all over and reported zero interference.



This photo shows the mount and scope with the wire loop containing all the cables from the CCD camera, color filter wheel, remote focuser and Kendrick Dew Remover. If you look closely, you will notice that the two clutch knobs were removed and replaced with special Allen head bolts. This allowed the Dec cable to slide easily over the axis in all orientations and there was no snagging of the wire anywhere. Please call Astro-Physics if you would like to order these bolts. Do not try to install normal Allen head bolts

For a portable setup, we keep the ties wraps in place as much as possible when we disassemble our equipment. The setup for the next session is much quicker.

### ***Removing the GTO Control Box From 900 Mount***



The GTO control box can be removed easily from the R.A. axis. It is secured by two 8-32 set screws located at the base of the GTO Control Box. Loosen the screws with one of the hex keys from the set included with the mount. Lift the box up from the bottom and tilt so that it frees from the dovetail connection.

Some people have a permanent observatory, yet prefer to store their electronics in their home to keep them clean and free of cobwebs. If you do, you may wish to substitute the 8-32 thumbscrews (included with your mount) for the setscrews. This will allow you to remove and install your GTO control box without tools.

### **GTO KEYPAD CONTROLLER OPERATION**

Please refer to the manual for the GTO Keypad for complete instructions.

### **MOUNT CARE AND ALIGNMENT**

Your 900GTO is a precision instrument with very accurate worm and wheel adjustments. Please be careful if you place the mount on a flat surface, i.e. the ground or trunk of your car. The gear alignment may be affected if the R.A. and Dec. motor/gear box assemblies sustain undue lateral force. This is true of any fine instrument. We suggest that you transport and store the mount in a case or in a well-padded box.

## ADDITIONAL TIPS AND SUPPORT

For additional information regarding the 900GTO, refer to the Technical Support Section of our website. We also encourage you to participate in the ap-gto user group. The members of this group are very knowledgeable about the operation of their mounts, CCD imaging and other related issues. The staff of Astro-Physics also participates and you will find a wealth of information in the archives. To find the group, link from User Groups in our sidebar.

We encourage you to submit your technical support questions directly to Astro-Physics by phone or e-mail: support@astro-physics.com.

## TROUBLESHOOTING

Additional troubleshooting questions are in the GTO Keypad manual. Please refer to them.

### The LED on the GTO Control Box changes from red to yellow and the motors stop or go out completely (for mounts shipped after 02-25-00).

1. The motors are overloaded, probably due to an unbalanced load on your mount.

Rebalance your telescope, and then press one of the N-S-E-W buttons to reset the keypad. Re-enter the last object on your keypad and the scope will slew to the correct position. Even though your motors had stopped, the logic in the control box retained the scope position in memory. As long as you didn't change the pointing position of the scope, you are still calibrated.

If the scope was moved during re-balancing, simply enter a nearby bright star on the hand controller, press GOTO and allow the mount to finish slewing. You can then move the scope manually or with the N-S-E-W buttons to center the star in the eyepiece, and press the #9 RECAL button. This will recalibrate the mount.

*Additional explanation:* The GTO drive circuit includes logic for overload protection to prevent burning out the expensive servomotors in case of severe overload on the two axes. The primary cause is an unbalanced load in R.A. If the extra load opposes the motor rotation, the motor must work harder to track at the sidereal rate and the current will rise to high levels. If the current exceeds the trip point for more than a minute, the logic will shut the motor off and tracking stops. It typically takes about 4 lb. of unbalance to trip the overload, but a very heavy load of scopes, accessories and counterweights on the mount can decrease this unbalance threshold.

2. The voltage of your battery has probably gone below 10.5 volts.
3. The current rating of your AC-DC power supply is too low.

*Additional explanation:* During slewing, the two motors draw up to 3 amps from a 12 volt source. This may increase when the temperature approaches freezing or below. It is recommended that your supply be rated at 5 amps, 12 volts DC minimum (18 volts max.). If you also power other equipment (CCD cameras, dew heaters, etc.) from the same source, you will need a supply capable of up to 10 amps. The more equipment you have, the more current capability you will need. For portable applications, we recommend a heavy-duty marine battery designed for deep discharge applications. The most common problems are due to inadequate power supply.

### The keypad reset (or locked up) when I plugged my CCD camera, PC (or other equipment) into the same battery as the GTO mount was using. The battery has a meter, which shows 12V.

The meter is reading an average and will not show dips. Gel cells have internal resistance, which will cause voltage drop when the load changes. When you connect an additional CCD camera and PC the load will drop below 9 volts and the keypad will reset or it may affect the GTO circuit itself and cause the keypad to lock up.

We recommend that you use a large marine battery that is not a gel cell and hook everything up to it before calibrating the GTO.

### The motors sound louder and more labored in cold weather.

As the temperature drops, we recommend that you reduce your slewing speed to 600x.

If any problems occur, please don't hesitate to contact Astro-Physics for assistance.

## **RECOMMENDED READING FROM OUR STAFF:**

The Backyard Astronomer's Guide, Terence Dickinson and Alan Dyer, Camden House Publishing, 2002

The authors, both former editors of *Astronomy* magazine, offer practical insight into astronomical equipment, finding your way around the sky, polar alignment, using setting circles, and astrophotography. This book provides excellent explanations and is well organized and illustrated.

All About Telescopes, Sam Brown, Edmund Scientific Company, 1975. Excellent information regarding the principles of mount construction and operation, using setting circles, eyepiece projection, etc. Illustrations and formulas galore. Many of the instruments pictured are outdated, however the underlying principles are timeless.

Norton's 2000.0 Star Atlas and Reference Handbook, edited by Ian Ridpath, J. Wiley Publishers, 1989. Star maps, information regarding polar alignment of German Equatorial and observing techniques.

# INSTALLATION OF ENCODERS AND ENCODER HOUSINGS -900 MOUNT

## 900ENC (*purchased separately*)

Parts List:

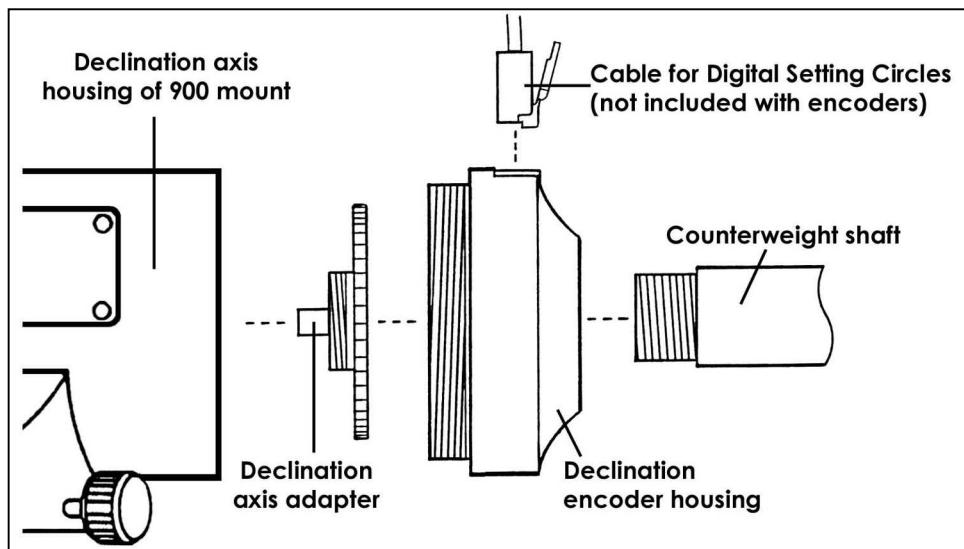
- 1 Right Ascension (R.A.) Encoder housing (black anodized)
- 1 Declination (Dec.) Encoder housing (black anodized)
- 1 R.A. Axis Adapter (clear anodized - silver colored), labeled R.A.
- 1 Dec. Axis Adapter (clear anodized - silver colored), labeled Dec.

To install your encoders, first remove the telescope from your mount. Remove your declination counter weight(s) and declination counterweight shaft.

### Fitting Declination Encoder Housing

If the encoders were purchased with the 900 mount, it is likely that the declination axis adapter and encoder housing have already been installed. No further action will be required, as this encoder will remain in place.

1. If the encoders were purchased separately, the silver-colored Dec. axis adapter may be inside the black Dec. axis encoder housing. If it is, remove it now.
2. Locate the counterweight shaft adapter (the black anodized part that the counterweight threads into) on the Dec. axis. When we assembled the mounts, we threaded this on rather tightly, so you will need some extra leverage to remove it. Locate the hole that was drilled into the part and find some object that you can insert. We suggest that you use one of your allen head wrenches that are wrapped in masking tape so that you do not mar the finish of the part. You may need to apply a good deal of force so it may be easiest to do if the mount is on the pier so that it won't move.
3. Thread the Dec. axis adapter into the end of your Dec. axis. Final tightening should be done with firm hand pressure. Normally the Dec. axis adapter will not be removed.
4. If you look into the black encoder housing, you will see the encoder itself mounted at the rear of the housing. When this installation procedure is complete, the encoder shaft will insert into the center hole of the Dec. axis adapter. This allows the encoder to read the motion of the declination shaft as the declination axis moves.
5. Thread the Dec. encoder housing onto the Dec. axis housing of the 900 mount. You may need to wiggle the encoder housing gently to engage the shaft of the encoder with the hole in the center of the Dec. axis adapter. When the threading is complete, tighten up with firm hand pressure (or insert your special "tool" from above and tighten firmly) since normally this encoder housing will not be removed.
6. The counterweight shaft may now be rethreaded into the rear of the Dec. encoder housing.

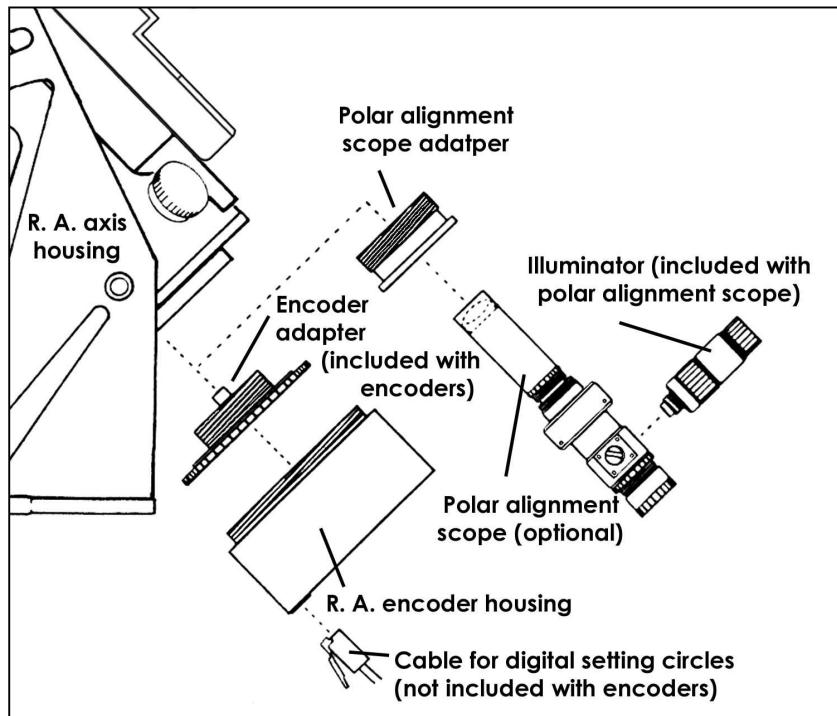


## Fitting Right Ascension Encoder Housing

If the encoders were purchased with the 900 mount, it is likely that the right ascension axis adapter and encoder housing have already been installed. Please continue to read these directions since you may need to remove and reinstall the encoders if you use a polar alignment scope. Since the polar axis telescope and R.A. axis adapter thread into the same location, you will need to switch back and forth between them as needed. If you use the JMI NGC MAX or Mini MAX Digital Setting Circles, you can use the "polar align" mode in these units instead of a polar alignment scope!

Note: The polar alignment scope had been discontinued at the time this manual was written. The manufacturer is no longer producing this product.

1. If the encoders were purchased separately, the silver-colored R.A. axis adapter may be inside the R.A. axis encoder housing. If it is, remove it now.
2. Thread the R.A. axis adapter into the end of your R.A. axis (if your polar alignment scope is fitted you must remove this first along with the polar alignment scope adapter). Use moderate hand pressure to tighten the R.A. adapter since you may need to remove it to install the polar axis telescope at a later time.
3. If you look into the black encoder housing, you will see the encoder itself mounted at the rear of the housing. When this installation procedure is complete, the encoder shaft will insert into the center hole of the R.A. axis adapter. This allows the encoder to read the motion of the R.A. shaft as the right ascension axis moves.
4. Now thread the R.A. encoder housing onto the R.A. axis housing. You may need to wiggle the encoder housing gently to engage the shaft of the encoder (located within the R.A. axis housing) with the hole in the center of the R.A. axis adapter. Again, use moderate hand pressure as you may wish to remove this at some time.
5. The hardware for your encoders is now installed. For actual set-up procedures for Micro MAX, Mini MAX or NGC MAX, digital readouts refer to the relevant operating manual from the manufacturer. We provide some startup tips in our instruction sheet entitled "Using JMI Setting Circles".



## Periodic Maintenance

If you remove the R.A. encoder frequently, you may wish to use a very tiny amount of auto grease on the mating threads.