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OPERATION OF THE AST/RO MOTORIZED SECONDARY MOUNT

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This memorandum describes the operation of the motorized secondary mirror mount on AST/RO. This mount was installed in early December 1998. The mount and the weldment attaching it to the telescope structure were designed and constructed at the SAO Central Engineering department under the direction of Peter Cheimets. The mount mechanism and electronics are essentially identical to those used to operate the secondary mirror on the Submillimeter Array antennas. The controller is a NEAT-300 series programmable stepping motor controller from New England Affiliated Technologies (620 Essex St., Lawrence, MA 01841 tel: 508-685-4900). The manual for this controller is in a grey looseleaf binder. The controller may be connected to a terminal or computer through an RS232 connection on the rear panel (default 9600 baud). The mirror mover has stepper motors and incremental position encoders on three perpendicular axes. There are no tilt adjustments: tilt alignment of the primary and secondary mirrors is accomplished by adjusting the primary mirror.

The three axes are called x (or 0), y (or 1) and z (or 2). Standing in front of the secondary mirror, with one's back to the primary mirror, the $+x$ motion is upwards, parallel to the mirror surface, $+y$ motion is to the right, parallel to the elevation axis, and $+z$ motion moves the mirror back, away from the primary mirror. z-axis motion is a focus adjustment for the telescope. One step of stepper motor motion (one "count") is 0.5 microns, and positive steps move the mirror in the positive direction. The encoders, however, have different scales for each axis: one x encoder step is -1.0 microns; one y encoder step is -2.0 microns; one z encoder step is $+0.5$ microns. The minus signs on the x and y axes mean that motion in the $+$ axis direction decrements the encoder. This unfortunate sign reversal means that the NEAT-300 controller cannot close the loop on these encoder axes (the `MP` command doesn't work on the x and y axes). The stepper motor step count is accurate, however, and the position can be verified by reading the encoder with the `RE` command. The x encoder reading should be multiplied by -2 to get motor steps, and the y encoder reading should be multiplied by -4 to get motor steps.

When using this device, it is crucial to be aware that IT IS POSSIBLE TO DRIVE THE SECONDARY MIRROR INTO THE TERTIARY CHOPPER MIRROR UNDER COMPUTER CONTROL, and that this hazard is in fact present during the normal initialization sequence of the secondary mirror mover. The position encoders are incremental encoders. This means that the encoder counts and stepper motor counts are lost (reset to zero) after loss of power to the NEAT-300 unit, and the encoder and stepper counts must be rezeroed by moving to one of the limits. Unfortunately, none of the limits can be reached without striking the tertiary, when the tertiary is in its normal, centered position. If the tertiary is moved to its counterclockwise stop (the surface of the tertiary more horizontal than usual), then the secondary can be moved to the "$+-+$" limit (positive x limit, negative y limit, positive z limit).

The following program has been loaded as "Program 1". MAKE SURE THE TERTIARY IS SAFELY OUT OF THE WAY (moved to its counterclockwise stop) PRIOR TO EXECUTING THIS PROGARM. This program will execute when the thumbwheel switch on the front of the NEAT-300 is set to "01" and the "START" button is pushed. Since this program is dangerous and will execute at the push of a button, THE THUMBWHEEL SHOULD NORMALLY BE LEFT SET TO "00", so that an accidental push of the "START" button will not lead to disaster. After a master reset of the NEAT-300, this program will have to be reloaded (see manual).

```
LIMP 1,1,1;
VI 2000,2000,2000;
VF 10000,10000,10000;
HF 2000,2000,2000;
HI 1000,1000,1000;
AC 50000,50000,50000;
HA 2000,2000,2000;
IC 0;
MH 1,0,1;
MA -25600,15100,-37200;
SE 0,0,0;
SP 0,0,0;
SD
SO 1;
```

The `LIMP` statement sets the limit switches for positive logic. The following six statements slow down the motor speeds and accelerations—these numbers are not optimized, but give acceptable results. The `IC` statement reduces the motor holding current to prevent whining noises. The `MH` statement sends the mirror to the "$+-+$" limit. The `MA` makes an absolute move to a position close to the position of the secondary during the winter of 1998. The files describing the measuring rod values before and after the installation of the mirror mount and mover are `/home/ingalls/progs/talign/record.txt.reremount10` and `/home/ingalls/progs/talign/record.txt.98newsecmount15`, respectively. The `SE` and `SP` commands reset the encoder and stepper counts to zero at this position. If the power to the NEAT-300 is turned off and on when the secondary is in this position, the position of the secondary probably will not have moved and the state of these counters will again be set to zero, returning the system to almost the same state as before power loss. Programs making incremental moves from this nominal center (e.g. `MA 0,0,-2000`; a 1 millimeter motion of the secondary towards the primary), will work and not be dangerous to the tertiary. Of course if power is lost while the mirror is offset from the nominal center position, the encoder and stepper counts will be lost as well, and the TERTIARY WILL HAVE TO BE MOVED and the secondary reinitialized with the above program. The last statement of the program `SO 1`, sets a bit which is reset to `0` at power-up of the NEAT-300 unit. This provides a test for power continuity—if the command `RO` returns a `1`, then power has been on continuously; if `RO` returns a `0`, then power has been off and the counts may be wrong.