NATIONAL RADIO ASTRONOMY OBSERVATORY
Socorro, New Mexico

VLBA Antenna Memo Series No. 5

VLBA Antenna Hard Stops

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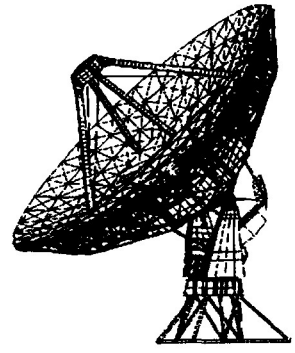
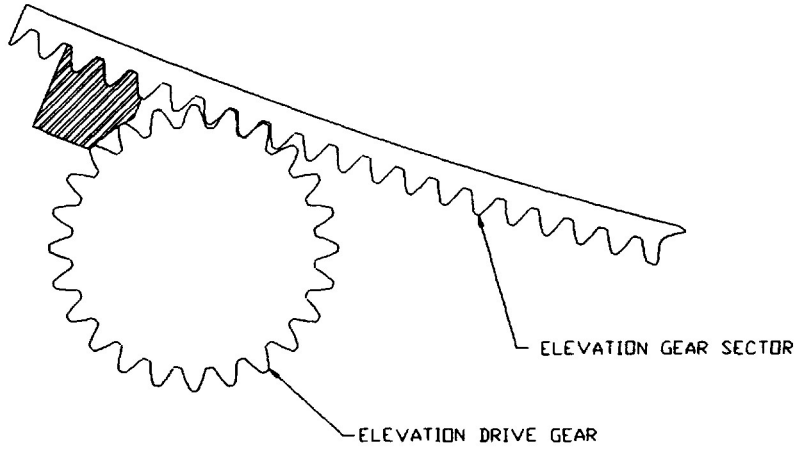
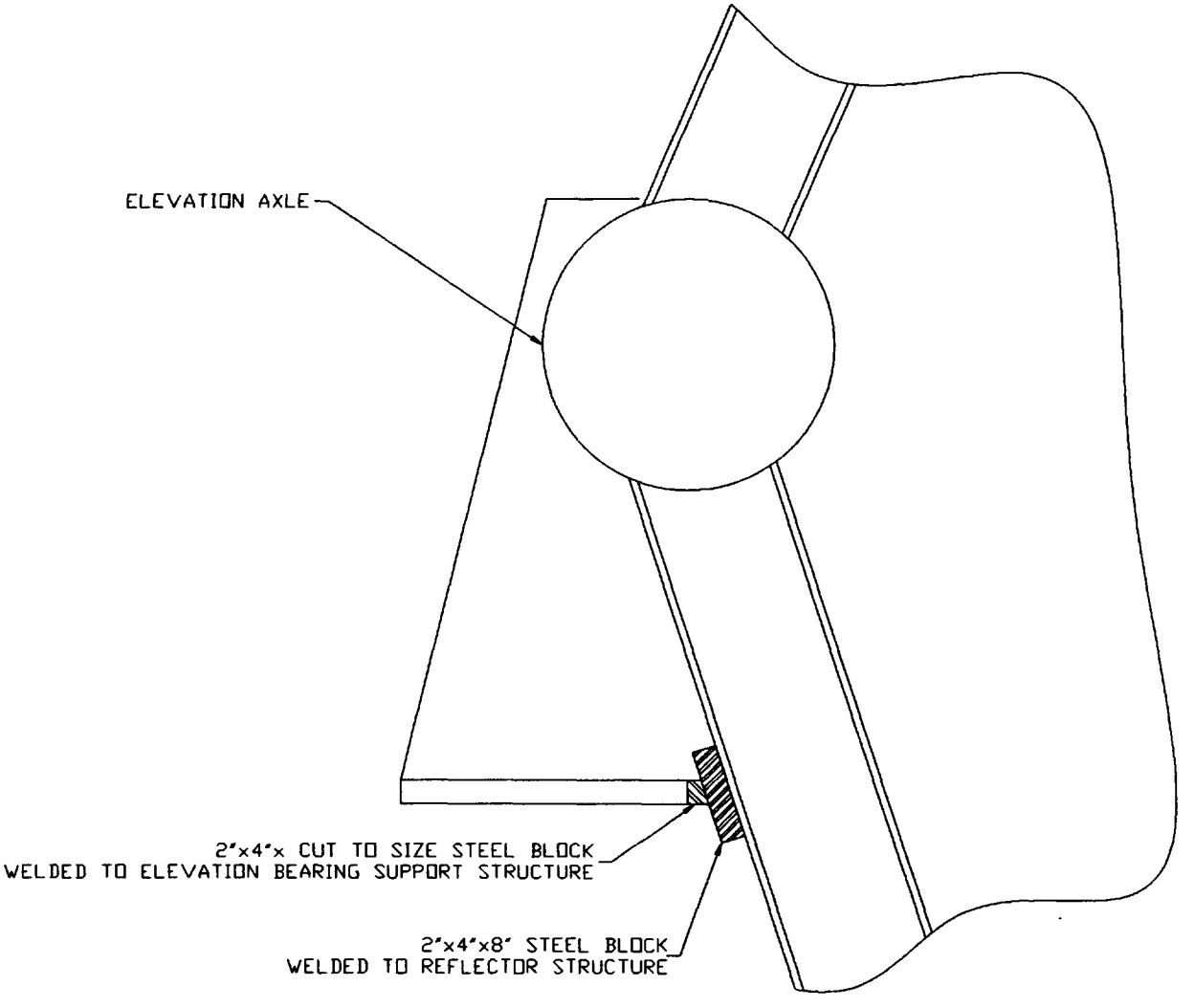


An incident occurred at the VLA (VLA Test Memo # 207) where the elevation brake and drive system was disabled by a series of errors and equipment failures. The reflector assembly was thus uncontrolled in elevation and slowly fell from it's stow position to a point where it contacted the antenna yoke structure. Under similar circumstances, it is possible for a VLBA antenna to drive off the end of the gear sector and become totally unrestrained in elevation. If the antenna is not properly counterweighted or is subjected to high winds, this can result in severe damage to the antenna structure. To decrease the possibility of damage from a similar incident, mechanical hard stops will be installed on the VLBA antennas. This memo describes these hard stops and their installation.

The hard stop that keeps the antenna from being driven off the "up side" of the gear sector is simply a 5" long steel block that is welded to the gear sector. This block contacts the teeth of the elevation drive gear and gear sector as shown below when it is driven past the final limit switch. If the antenna is driven into this block by the servo system, an approximately 75,000 lb. load will develop. This load may damage the gearbox and the drive gear. However, this damage is less severe than the damage that can occur if the reflector is driven off the gear sector.



When the reflector is driven past the final limit on the "down side", the reflector contacts the elevation support tubes. These support tubes could be damaged if the reflector is driven into them with excessive force. It is not possible to install a block on the gear sector as was done for the "up limit", because it would interfere with the stow pin. Therefore, Steel plates will be welded to the structure as shown below. These plates will ensure that the reflector structure contacts the elevation bearing support before it contacts the support tubes. The servo system can exert over 200 tons of force on these hard stops if it continues to drive past the limit at full torque. Even with the hard stops it is possible to damage the structure in this kind of failure condition.



APPENDIX A

VLBA Antenna Hard Stop Force Analysis

$DistD := 36 \cdot in$	Distance from axle to down hard stop	
$DistU := 204 \cdot in$	Distance from axle to up hard stop	
$Grm := 737$	Elevation Gearbox Ratio	
$GrS := 26.7$	Elevation sector Gear Ratio	
$Wmax := 50.0 \cdot \frac{mile}{hour}$	Maximum Wind Speed	
$WTC := \frac{149 \cdot ft \cdot lbf}{\left(\frac{mile}{hour}\right)^2}$	Wind Torque Constant	
$Tm := \frac{10 \cdot hp \cdot 1.5}{2450 \cdot \frac{rev}{min}}$	$Tm = 32.156 \cdot lbf\ ft$	Maximum drive motor torque 150%
$Tdrive := 2 \cdot Tm \cdot Grm \cdot GrS$	$Tdrive = 1265517.022 \cdot lbf\ ft$	Maximum torque at axle from drive motors
$TforceD := \frac{Tdrive}{DistD}$	$TforceD = 421839.007 \cdot lbf$	Force on Down hardstop from drive motor
$TforceU := \frac{Tdrive}{DistU}$	$TforceU = 74442.178 \cdot lbf$	Force on Up hardstop from drive motors
$GBforce := \frac{Tm}{6 \cdot in \cdot 2} \cdot Grm$	$GBforce = 23698.821 \cdot lbf$	Force on gear tooth from up hardstop
$TW := WTC \cdot (Wmax)^2$	$TW = 372500 \cdot ft \cdot lbf$	Torque from wind (worst case @ Wmax)
$TWforceD := \frac{TW}{DistD}$	$TWforceD = 124166.667 \cdot lbf$	Force on Down hardstop from wind at Wmax
$TWforceU := \frac{TW}{DistU}$	$TWforceU = 21911.765 \cdot lbf$	Force on Up hardstop from wind at Wmax