SPACE SHUTTLE SOLID ROCKET MOTOR PROFILE MEASURING DEVICE (PMD)

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As a result of the space shuttle accident, a solid rocket motor redesign team was created at Marshall Space Flight Center, Alabama. One of the results of this team's efforts was the design, development, and testing of a device to accurately measure, record, and plot the diameters and deviations of the machined, mating surfaces of the solid rocket motor assembly interfaces commonly referred to as "field joints". This device, SRM Profile Measuring Device (PMD), P/N 97M50225, figure No. 1, has been developed, calibrated, tested, and is currently in operational use at Morton Thiokol Inc. (MTI), Brigham City, Utah, and is also scheduled for use at Kennedy Space Center. A description of the PMD is as follows:

The SRM PMD is an electromechanical tool used for measuring and recording the profile and diameters of the solid rocket motor segments, both Tang and Clevis ends. This system consists of a crossbeam assembly that mounts to the SRM segment using the existing assembly pin holes. The mounting configuration is such that the tool can be used to measure Clevis up/Tang down or Clevis up/Tang up.

The crossbeam assembly supports a radius measuring arm assembly that contains a digital electronic gauge, a resolver (for angular measurement), a gear train drive assembly (for rotating the above), and an adjustable counterweight. The crossbeam assembly is composed of four similar legs that interface at the center for ease of operations and mobility. The crossbeam assembly only needs to be mounted within plus or minus 1 inch of the SRM segment center and may remain in place during shaping operations. The crossbeam assembly weighs approximately 152 pounds. (See figure 1.) The associated electronics and plotter/printer system is packaged in an electronics cart, and is in turn, connected to the measuring system by a remote cable. (See figures 1-20.)

During measuring operations, the system functions as follows:

The digital linear gauge measures the relative distance on the SRM joint to a point at the approximate center of the SRM segment. (This point is also the center rotation of the

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resolver/shaft and radius arm assembly.) The radius arm assembly and resolver are driven radially by a servomotor gear train assembly (1,000:1 ratio), while radial deviations and angular positions are being stored. Measuring speed is approximately 2 inches per second. An offset circle (based on the true diameter of the SRM segment) is plotted. The data obtained previously is then processed to give a least square fit to the true offset circle. These differences are then plotted at 15 degree increments. A hard copy, for record, of the deviations is then printed. This copy is printed 1:1 scale or up to 5:1 scale. This tool is calibrated and results checked by the use of a helium neon laser system, as shown in figure 20.

Development testing and calibration procedures were developed at MSFC from June 1987 through September 1987. In September of 1987 the PMD, along with the laser calibration equipment, was shipped to MTI, in order to measure the first flight segments for shuttle flight STS-26, prior to propellant loading. As a result of these measuring operations, some segments of the first flight SRB's were switched in order to guarantee an interference fit at the mating field joints. Also, during October 1987 and November 1987, the qualifications SRM's were measured. Typical measurement results are shown in figures 18 and 19.

During November 1987, the MSFC PMD and calibration equipment was formally turned over to MTI and two additional PMD's are being procured for MTI usage.

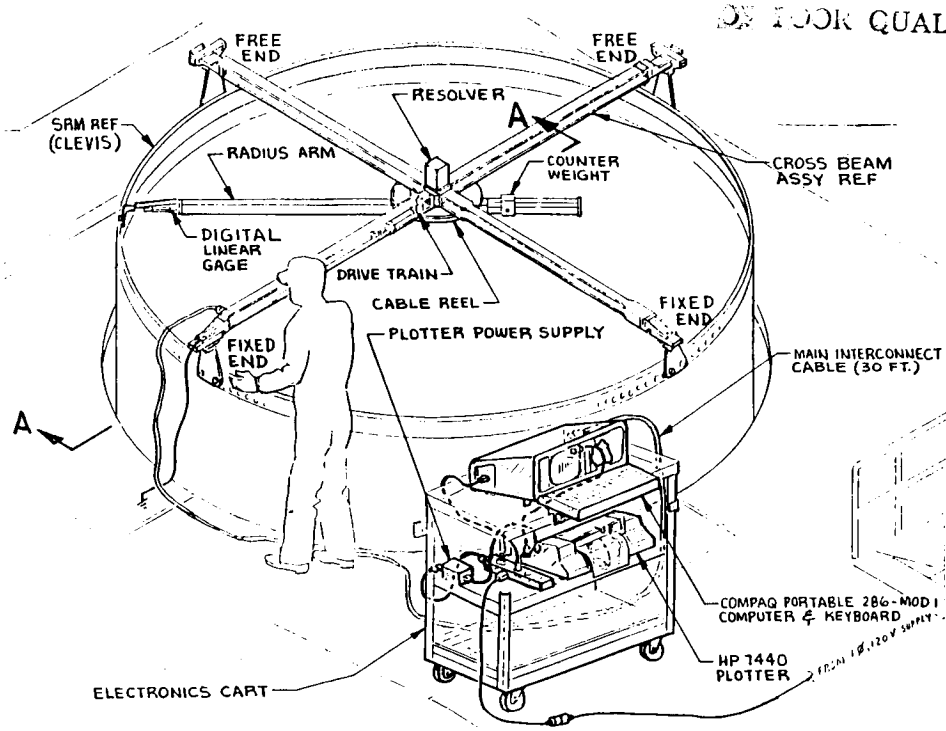


Figure 1. SRM Measuring Tool Assembly, P/N 97M50225

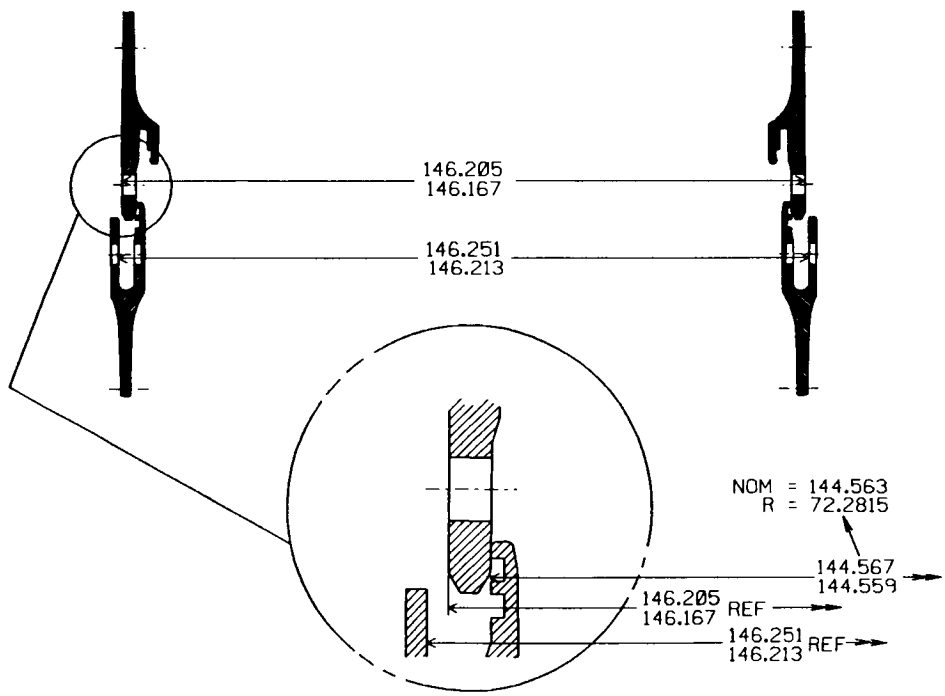


Figure 2. Flight Field Joint

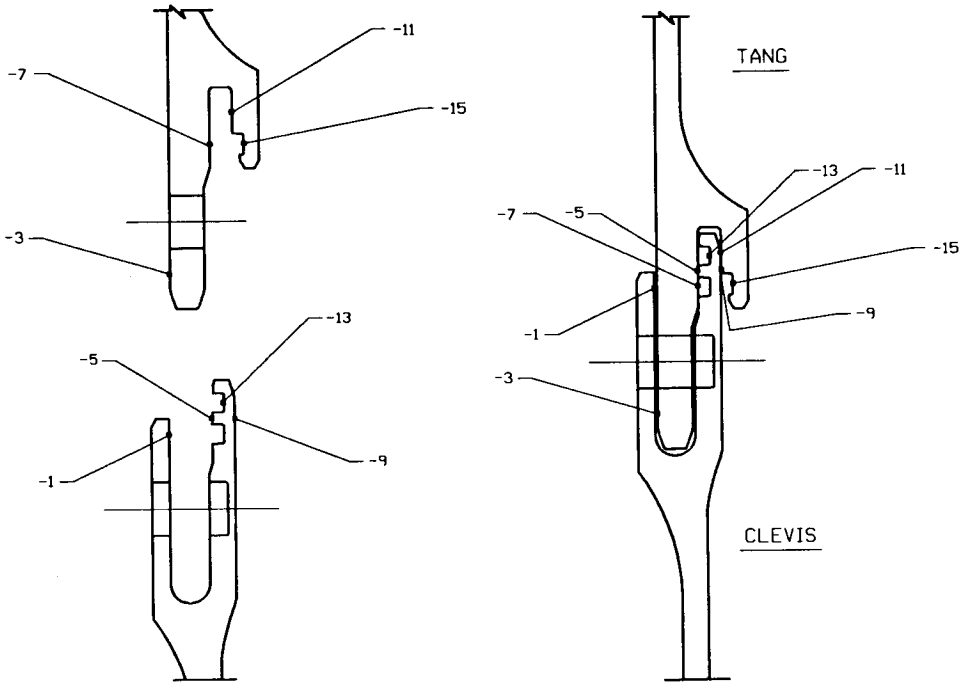


Figure 2A. Joint Surfaces to be Measured

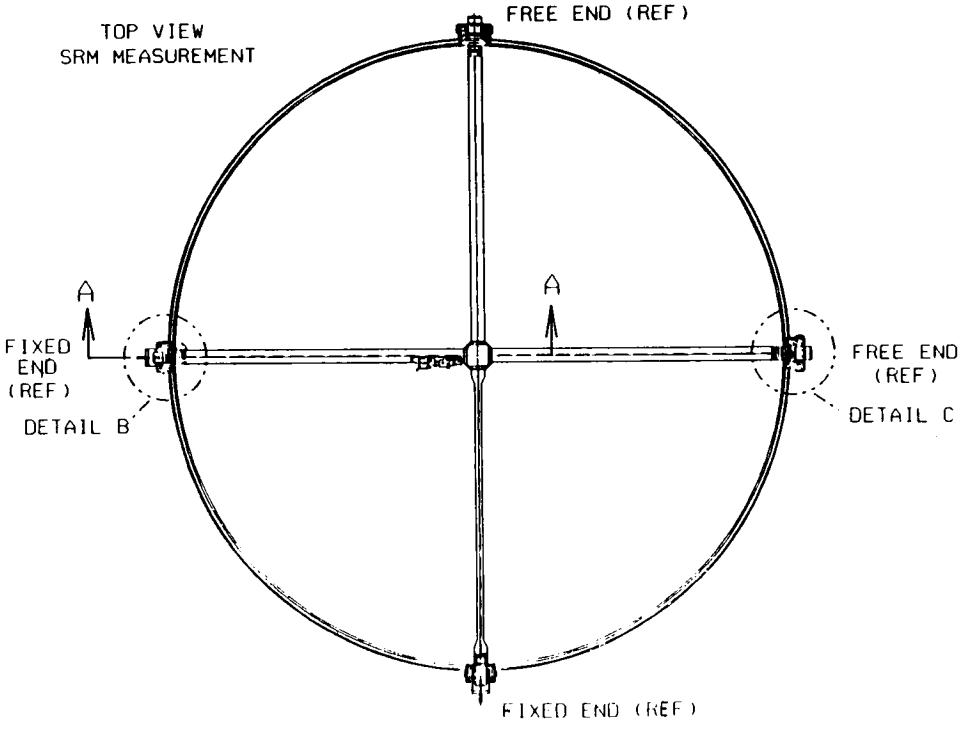


Figure 3. SRM Profile Measuring Tool

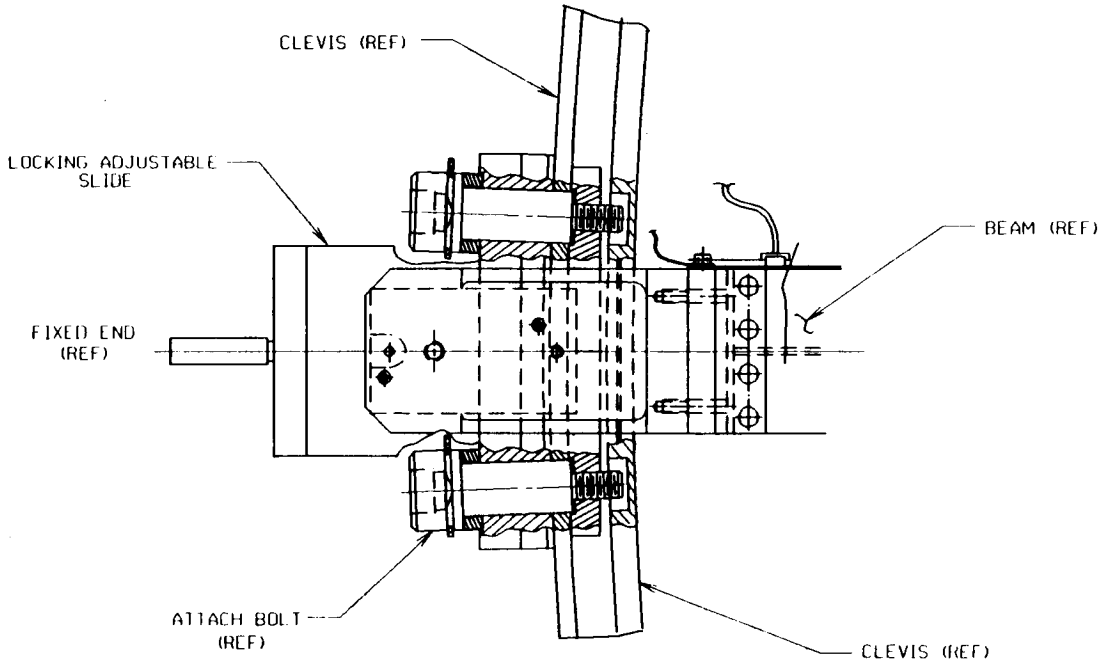


Figure 4. SRM Profile Measuring Tool, Detail B

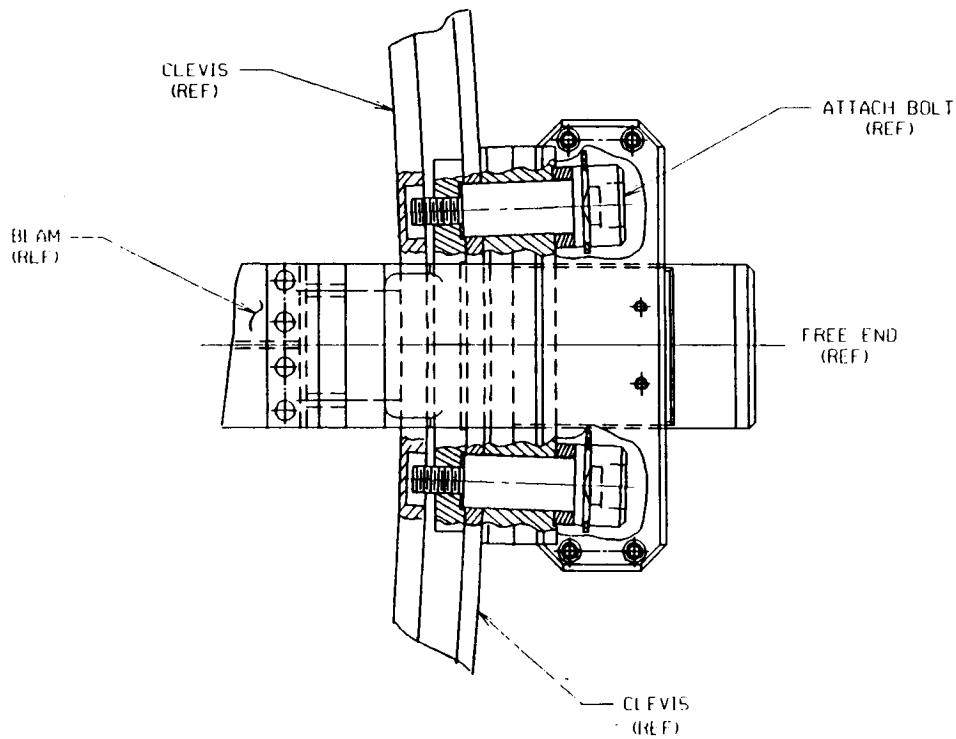


Figure 5. SRM Profile Measuring Tool, Detail C

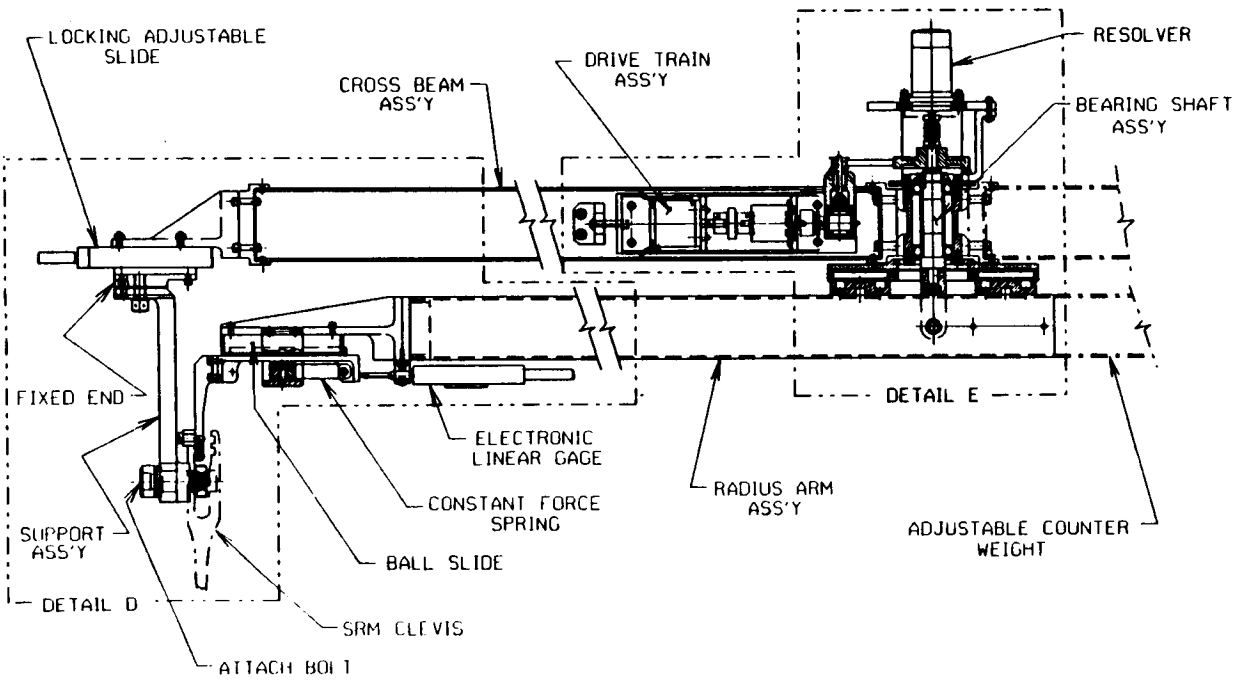


Figure 6. SRM Profile Measuring Tool, View A-A
(Clevis Measurement)

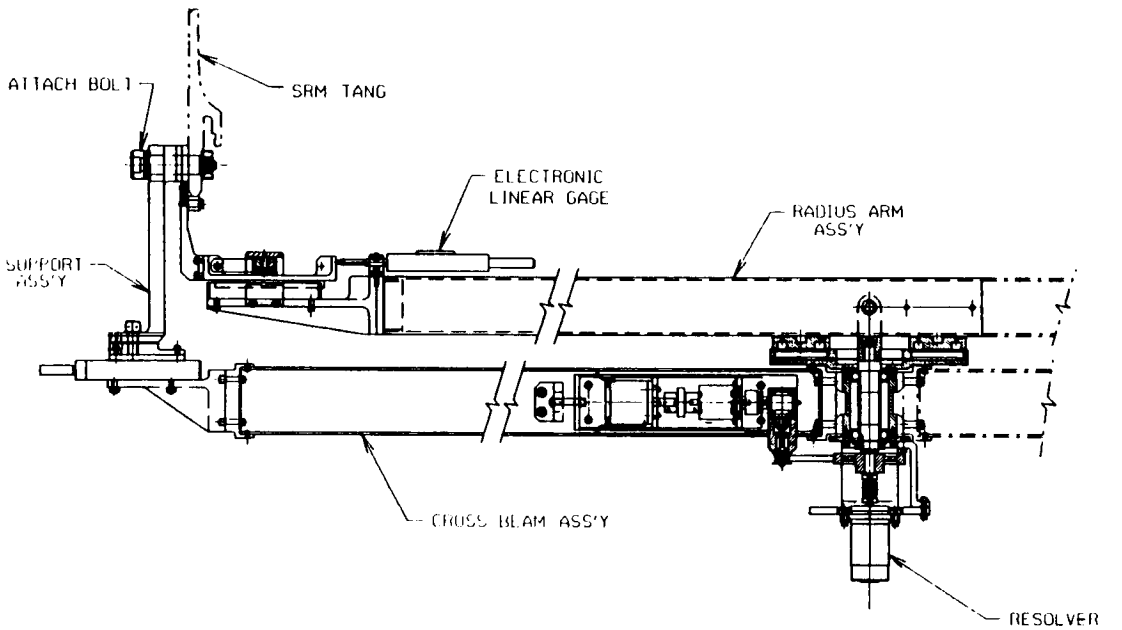


Figure 7. SRM Profile Measuring Tool, View A-A
(Tang Measurement)

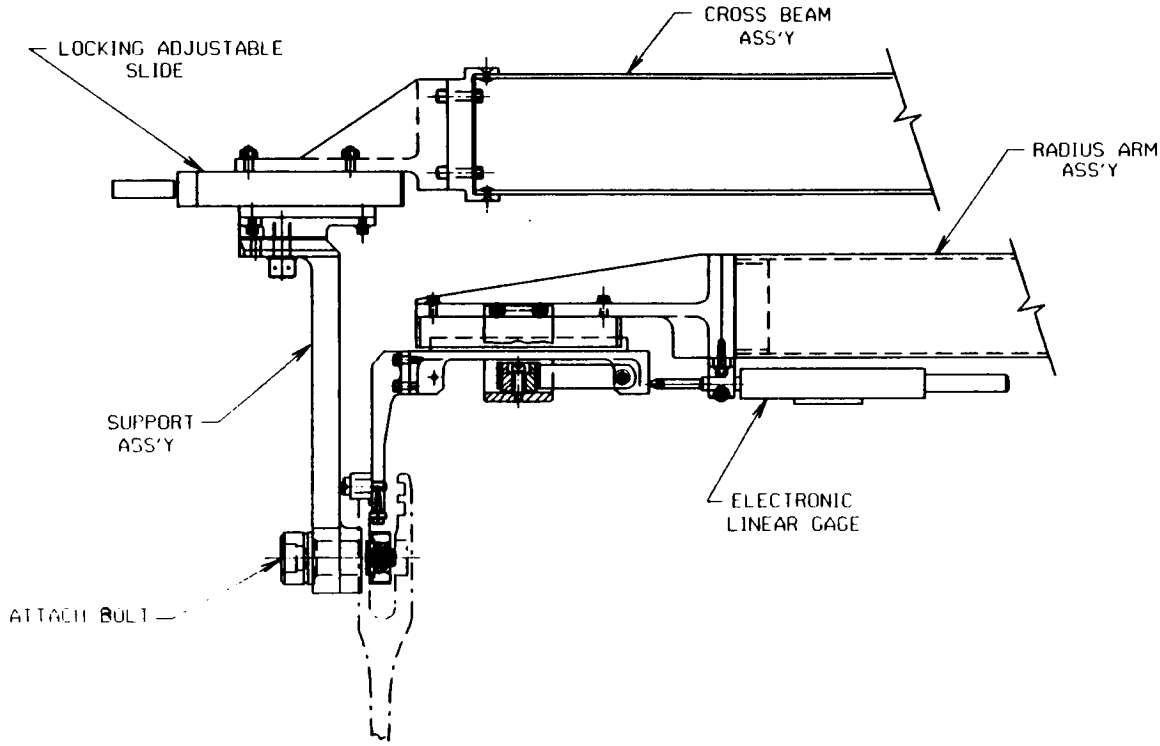


Figure 8. SRM Profile Measuring Tool, Detail D

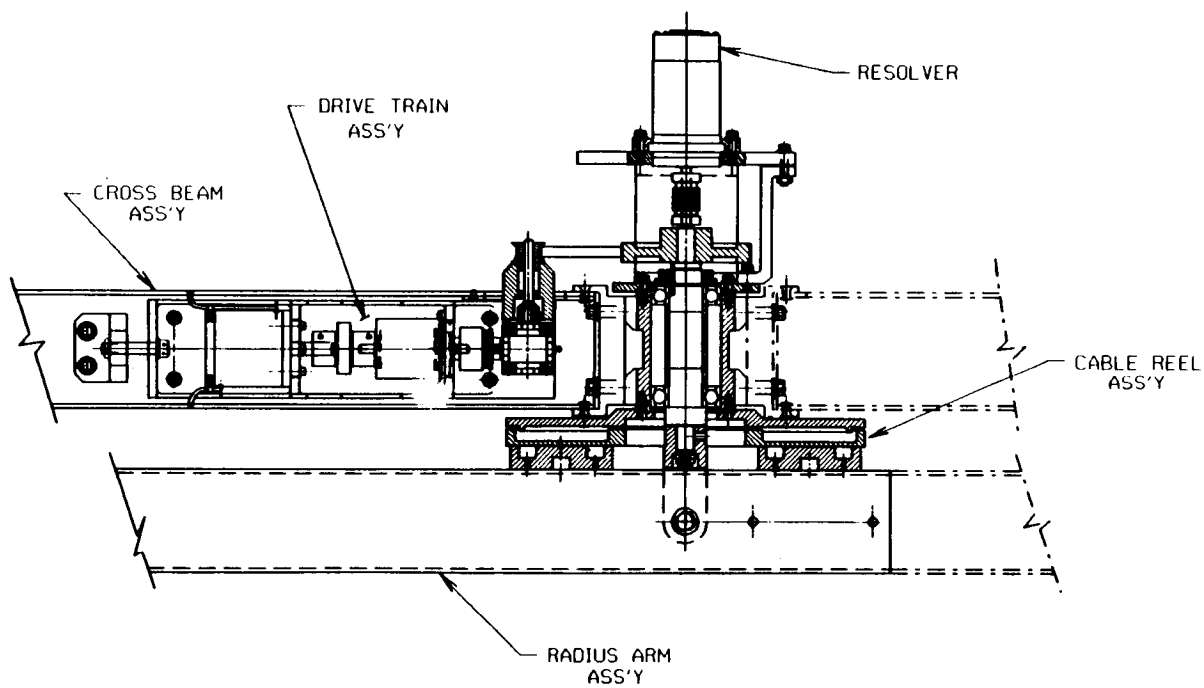


Figure 9. SRM Profile Measuring Tool, Detail E

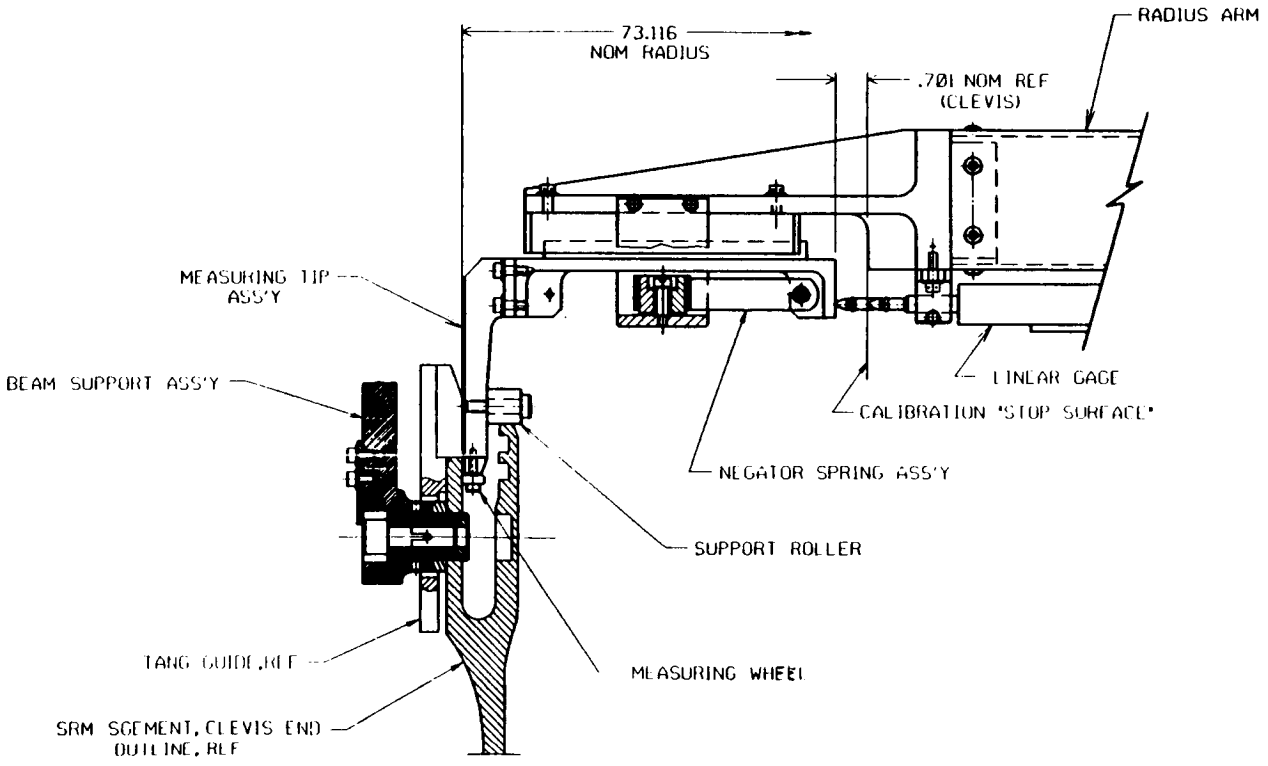


Figure 10. SRM Profile Measuring Tool, 97M50380-1, Clevis Outer Leg I.D. With Tang Guide

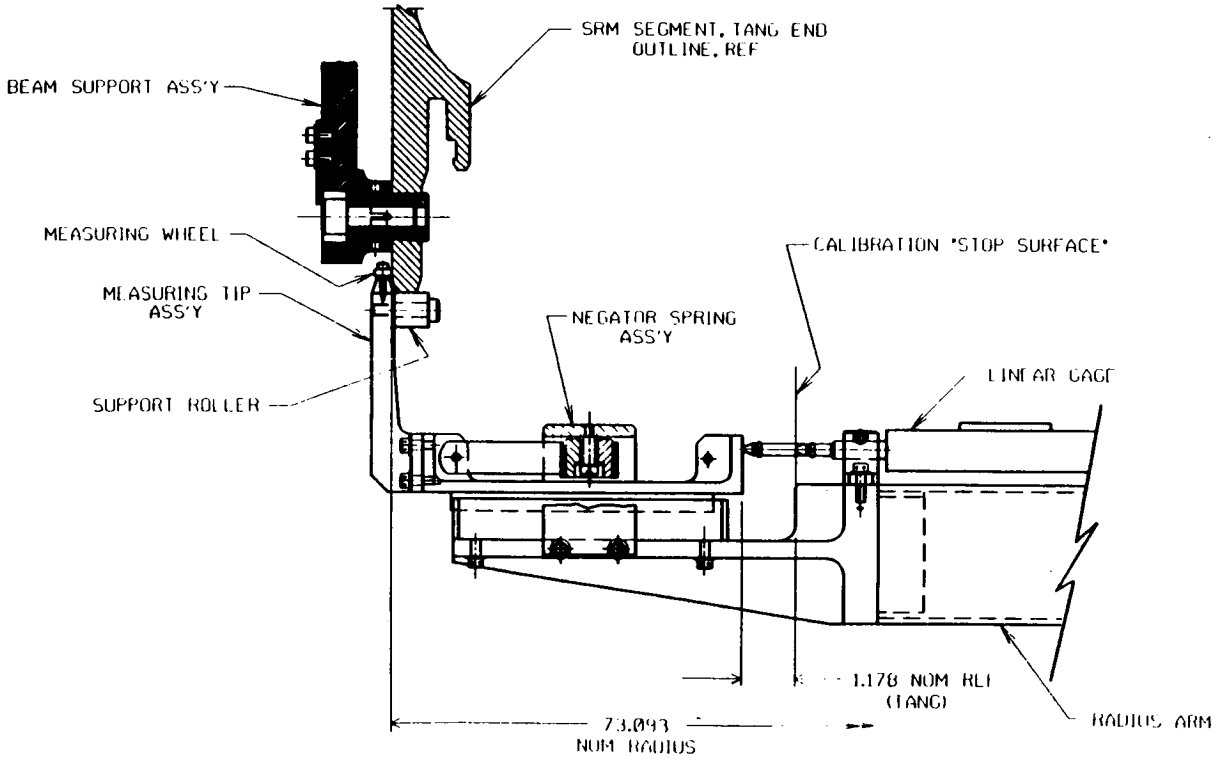


Figure 11. SRM Profile Measuring Tool, 97M50380-3, Tang Outer Leg O.D.

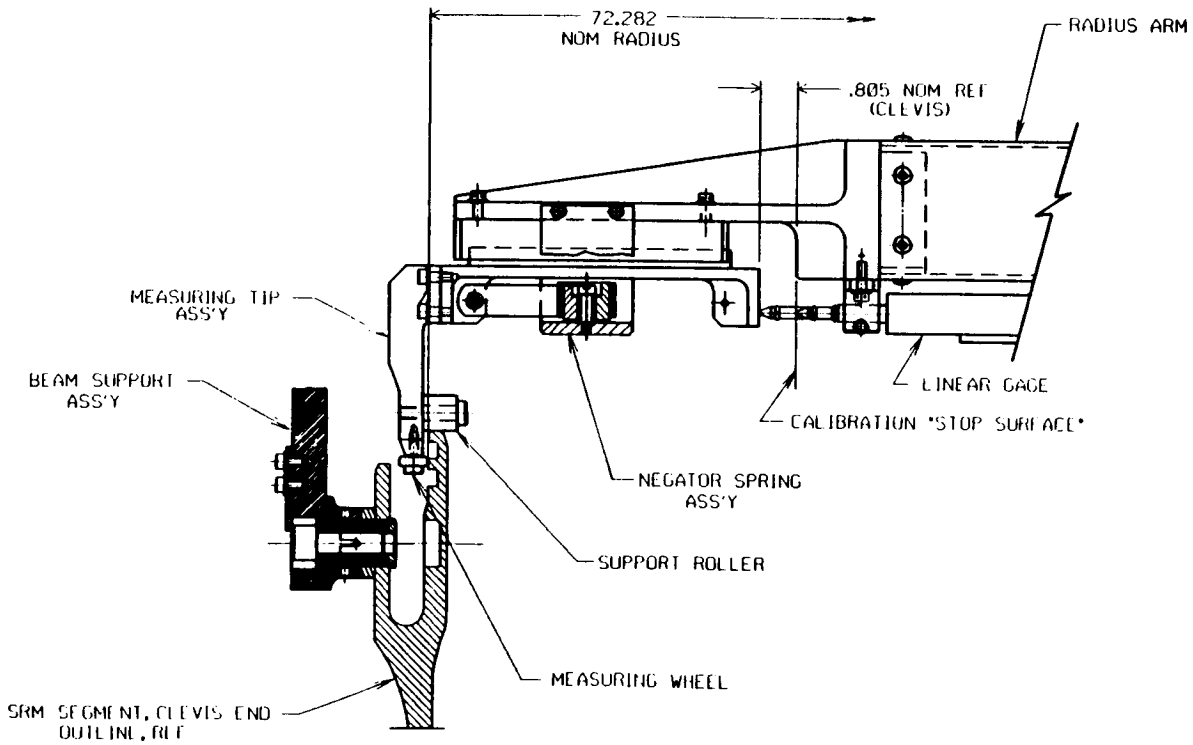


Figure 12. SRM Profile Measuring Tool, 97M50380-5, Clevis Inner Leg O.D.

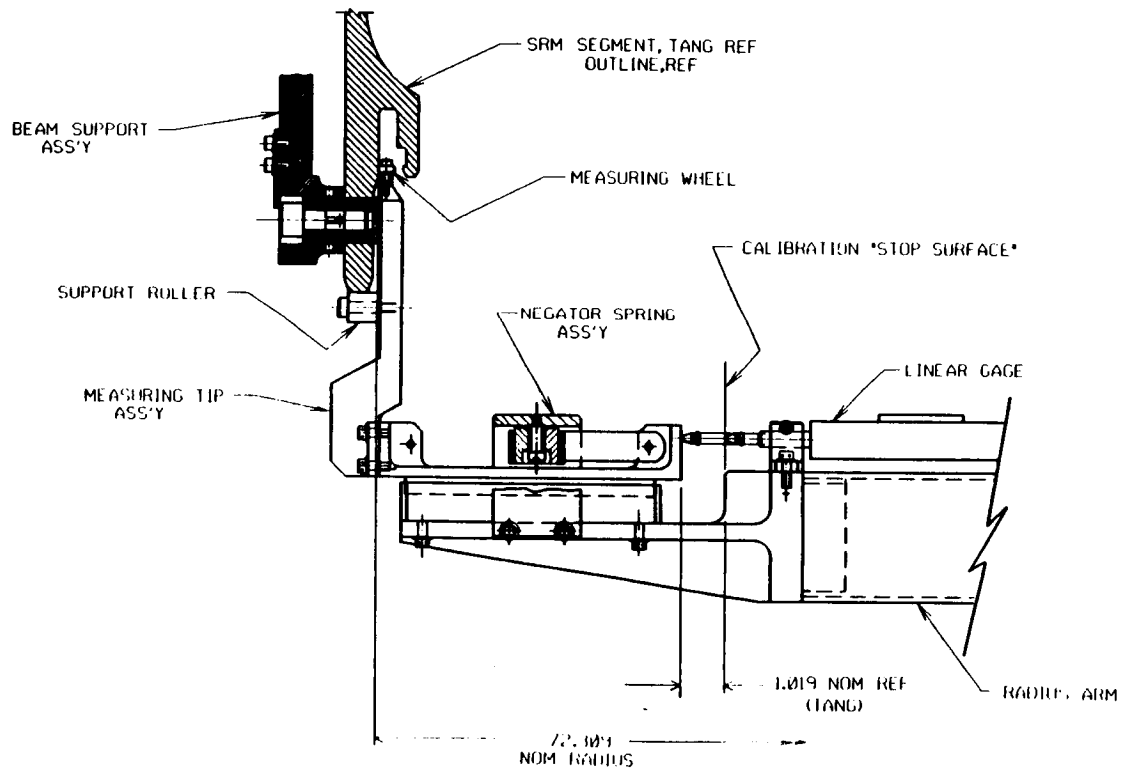


Figure 13. SRM Profile Measuring Tool, 97M50380-7, Tang Outer Leg I.D.

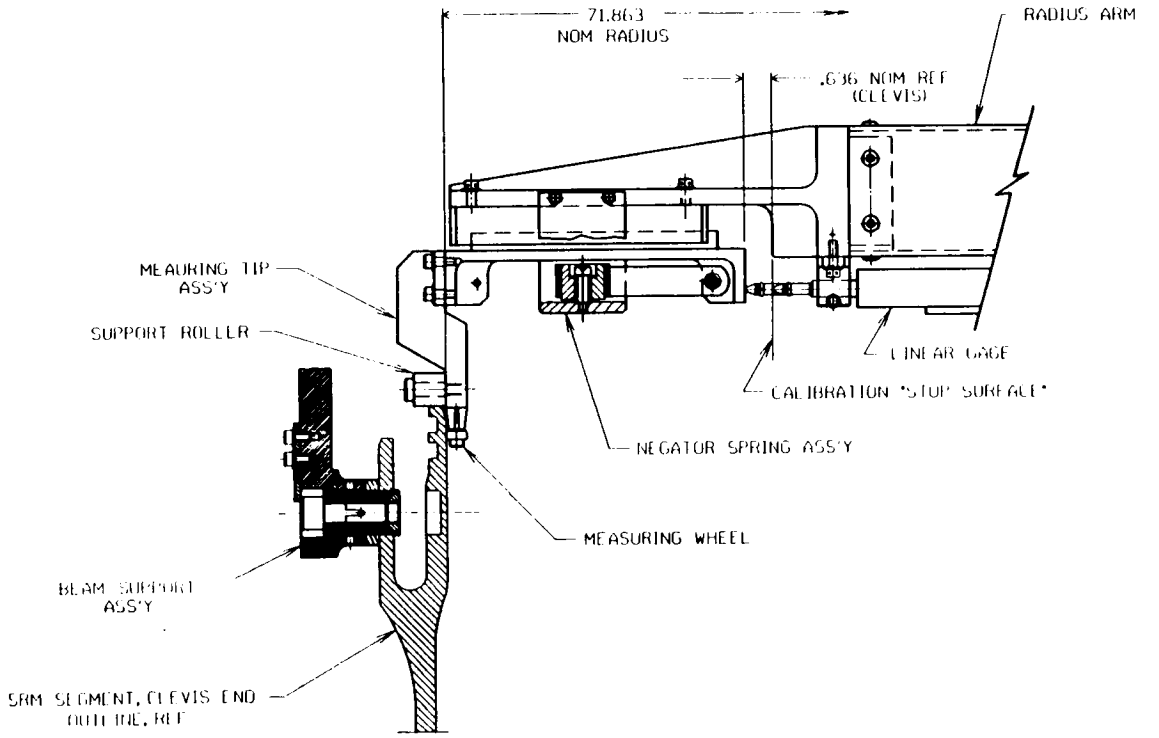


Figure 14. SRM Profile Measuring Tool, 97M50380-9, Clevis Inner Leg I.D.

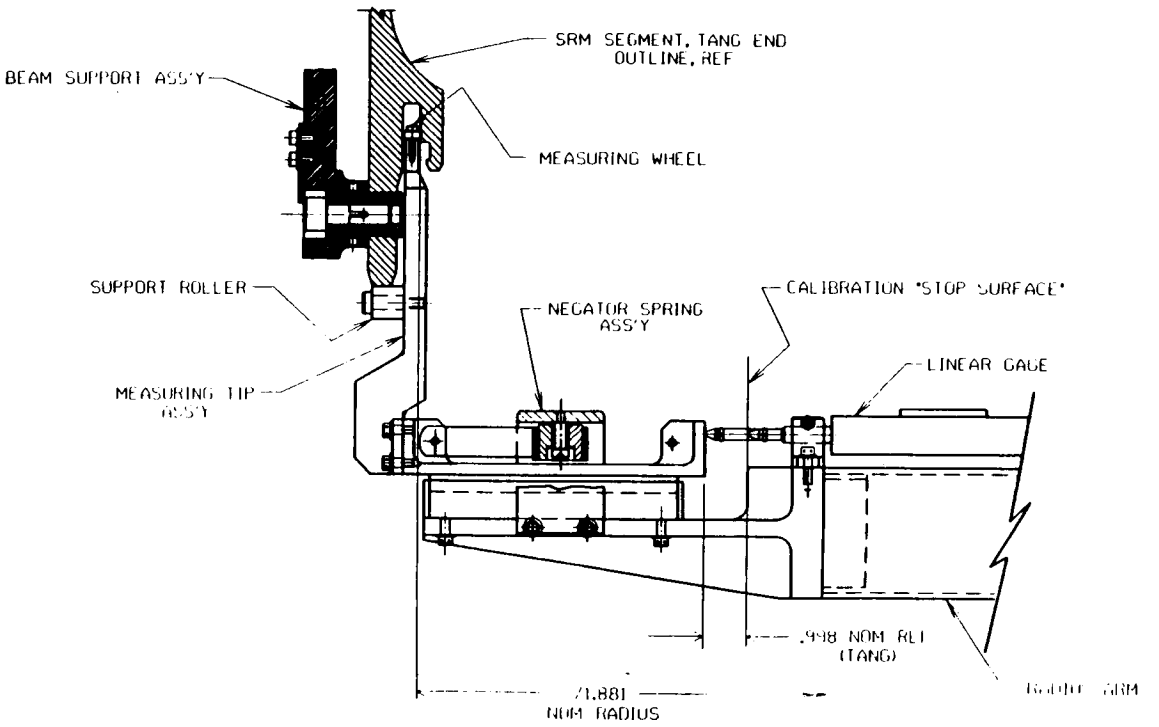


Figure 15. SRM Profile Measuring Tool, 97M50380-11, Tang Inner Leg. I.D.

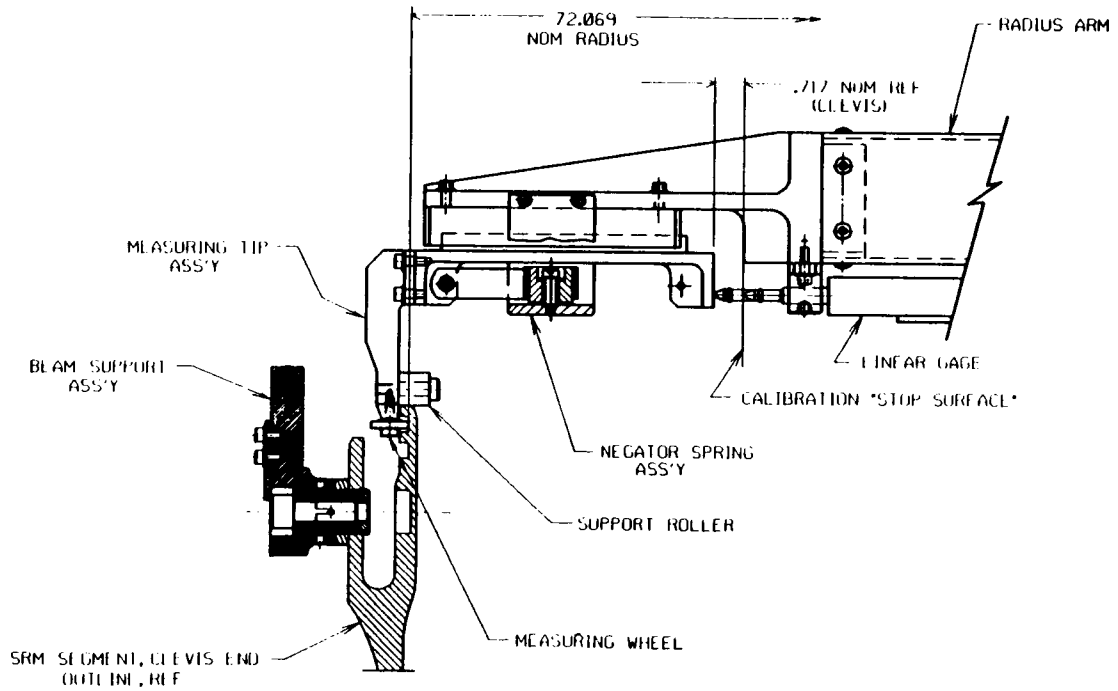


Figure 16. SRM Profile Measuring Tool, 97M50380-13, Clevis Inner Leg O-Ring

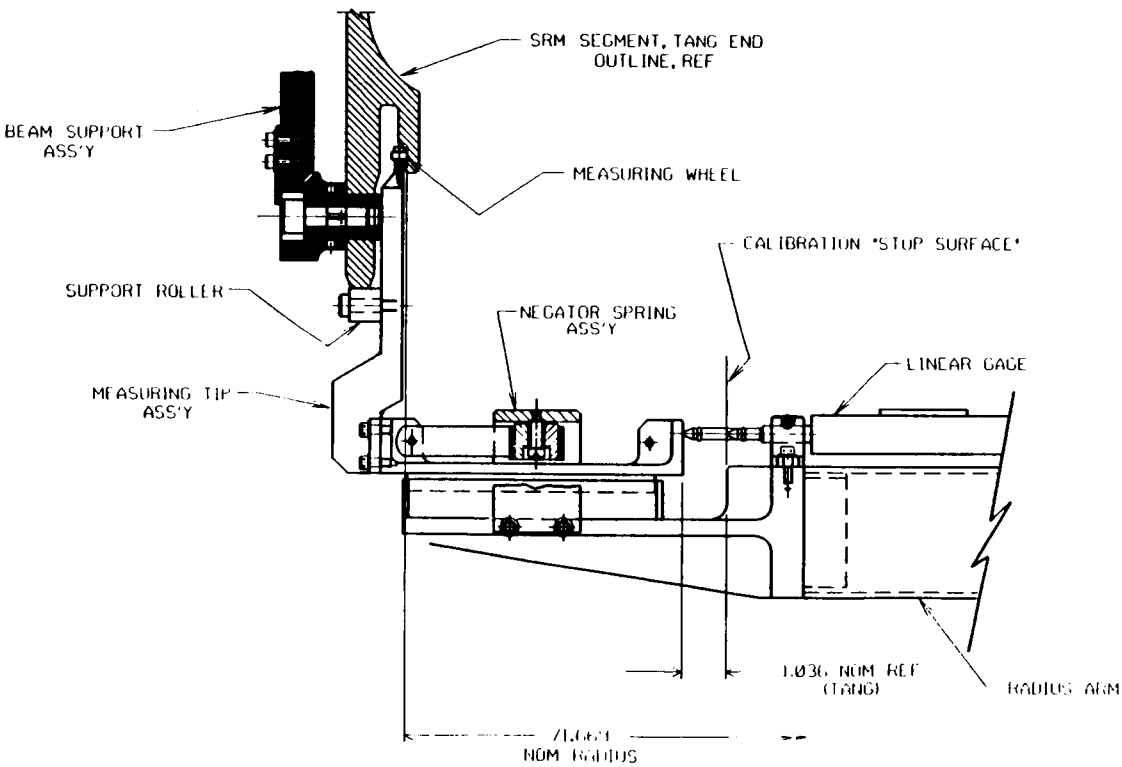
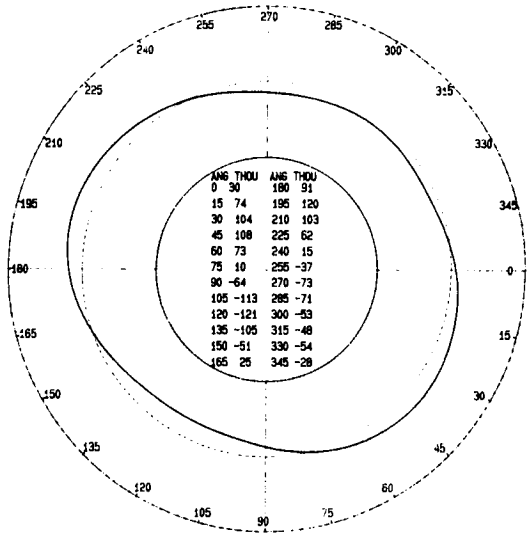
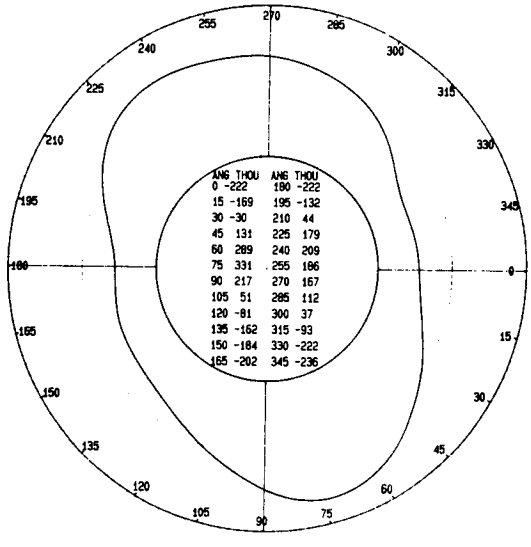


Figure 17. SRM Profile Measuring Tool, 97M50380-15, Tang Inner Leg O-Ring



CASE: QN-7 AFT 1U50716-06 SN10R2 J7 RUN 1
FILENAME (DATE+TIME) 11020710.41 TIP 97M50380- 9 CLEVIS
SCALE: 1 INCH ON PLOT= 0.50 INCHES ACTUAL
RADIUS 71.8863 INCHES AT 80.5 DEG F (71.8802 AT 68 DEG F)
DIAMETER 143.7605 INCHES AT 68 DEG F
DIAMETERS 0 DEG: 143.8937 90 DEG: 143.6357
OFFSETS 0: 0.001 90: 0.004
MAX + DEVIATION 0.120 AT 196 DEGREES
MAX - DEVIATION -0.122 AT 118 DEGREES
RMS OUT-OF-ROUND 0.076 INCHES

Figure 18. Clevis Measurement (Surface 9)



CASE: QN-7 FWD 1U52983-01 SN 6 FJ 3 RUN 1
FILENAME (DATE+TIME) 10208716.48 TIP 97M50380-11 TANG
SCALE: 1 INCH ON PLOT= 0.50 INCHES ACTUAL
RADIUS 71.8852 INCHES AT 80.8 DEG F (71.8789 AT 68 DEG F)
DIAMETER 143.7578 INCHES AT 68 DEG F
DIAMETERS 0 DEG: 143.3250 90 DEG: 144.1524
OFFSETS 0: -.003 90: 0.005
MAX + DEVIATION 0.334 AT 73 DEGREES
MAX - DEVIATION -0.239 AT 339 DEGREES
RMS OUT-OF-ROUND 0.180 INCHES

Figure 19. Tang Measurement (Surface 11)

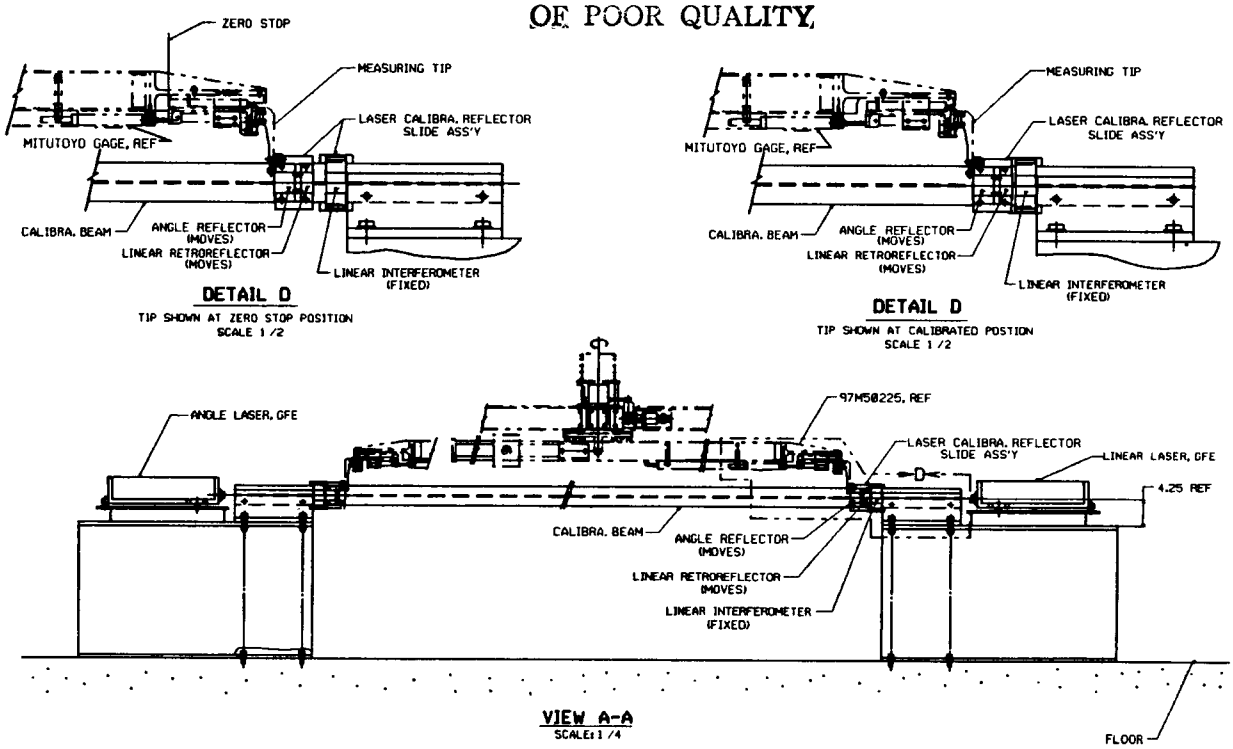


Figure 20. Laser Calibration

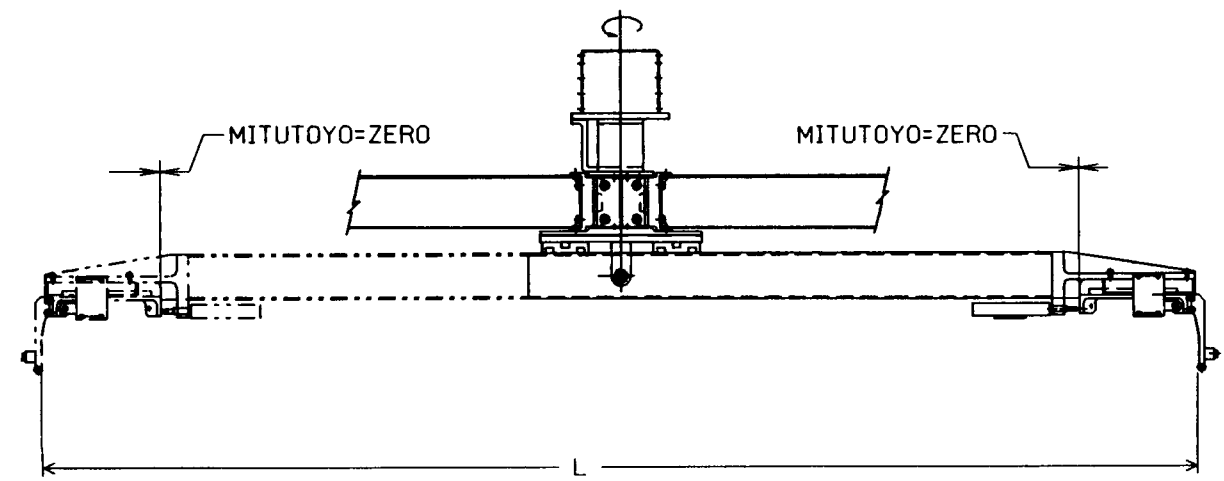


Figure 21. Radius Arm Calibration