Interoffice

National Radio Astronomy Observatory

Very Large Array

May 18, 1981

To: John Findlay
W. Y. Wong
Sidney Smith

From: Bill Horne

12 METER MILLIMETER WAVE TELESCOPE
MEMO No. 37

Subject: Support Bolts for ESSCO Panels

In our meeting of May 12 I was asked to calculate the length of bolt and diameter of bolt required to support the ESSCO panel we presently have during thermal tests of Green Bank. I have done so (rather simplistically) based on a support as shown on E-Systems Dwg.96E20011 (sketch attached) and a 3/8 inch dia. bolt with a minimum length of 6 inches will keep the RMS due to restraint of the back-up structure to somewhat less than 6 microns for a temperature change of 30°F. I am attaching a copy of my calculations; since I don't have a drawing of ESSCO's panel I have assumed a cross-section as shown on the sketch. You will note that I have assumed that the RMS is 1/3 the maximum deflection which is not quite correct for this curve but note that also I haven't taken into consideration that the panel is continuous over the middle support which will reduce the maximum deflection.

May 19, 1981

Note that decrease in length from 6" to 4" will increase max. deflection some 3.4 times; a decrease in length from 6" to 5" will increase the maximum deflection 1.7 times.

After discussion during the meeting of May 19, I have dug out the attached sketches Figure 1 and Figure 2 which were prepared for the 65 meter panel supports. A support similar to Figure 2 could be used for the ESSCO panels. Figure 1 would create a higher moment due to thermal expansion in the panel due to the longer lever arm as shown by the following sketches:

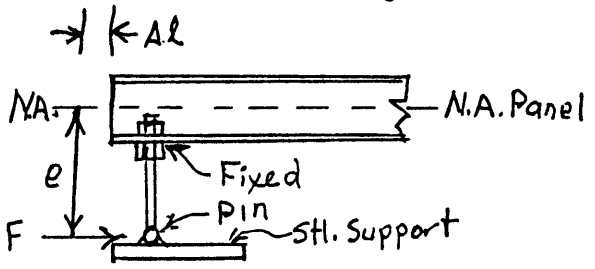


Figure 1

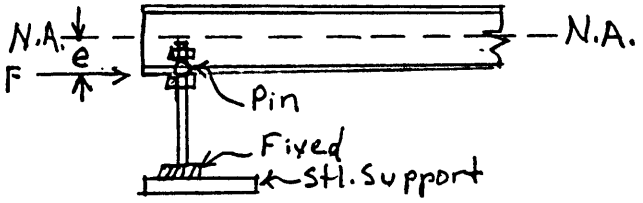


Figure 2

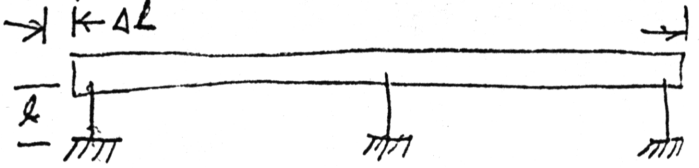
In both cases the bending moment in the panel causing the distortion is equal to the expansion force F (which is constant) times its lever arm "e" but by locating the pin connection (ball joint, spherical washer, etc.) at the bottom of the panel the moment is reduced. Note that for the 65 M panel and Figure 2 the eccentricity is essentially zero.

Analysis of Support bolt ~ Essco Panels (Test)

Bolt dia ~ 3/8 inch Area = 0.11045 in² I = .01553 in⁴

length of panel = 3 M = 9.84252' = 118.1102 inches

since panel has 3 supports assume symetrical and that expansion takes place in both directions from center bolt



assume panel installed at 60°F and temperature change of 30° occurs with steel back-up struct.

$\Delta l = \frac{118.1102}{2} \times 30^\circ \times \frac{6.5}{10^6} = 0.011516$ inches $\epsilon_t = \epsilon_t(Al) - \epsilon_t(St) = 6.5 \times 10^{-6}$ in/in/F°

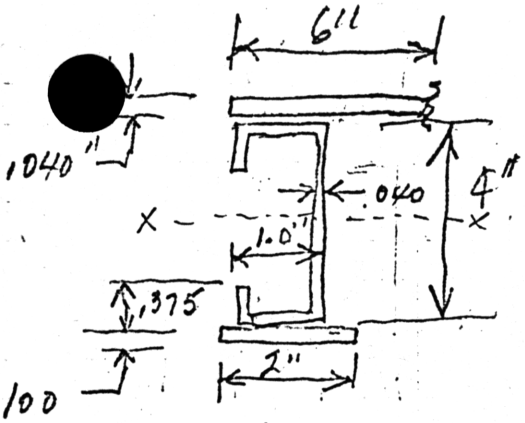
Assume bolt has bottom fixed, top free to rotate

$M = Pl$; $\Delta_{max} = \frac{Pl^3}{3EI}$, Calculate force to produce necessary deflection (Δl) in bolt

$.011516 = \frac{Pl^3}{3(30)10^6(1.553)10^{-2}}$; $Pl^3 = 11.5160^{-3})3(30)10^6(1.553)10^{-2}$

$= 11.514(3)30(1.553)10$

$Pl^3 = 160956$



if bolt is 6 inches long

$P = \frac{16095.56}{6^3} = 74.5$ lbs

check bolt 4 inches long

$P = \frac{16095.56}{4^3} = 251$ lbs

Bolt 7 inches long

$P = \frac{16095.56}{7^3} = 46.9$ lbs

Use Bolt 6" long

Calculate I of above section, Find N.A

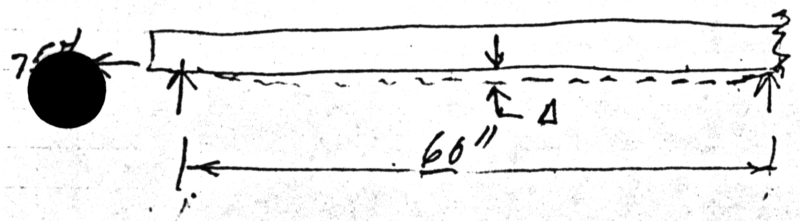
	A	y	Ay	Io	Ad²
B.R	0.200	.05	0.0100	.00017	0.96425
L web	0.160	2.1	0.3660	.21333	.00340
Fl. 1	0.0368	0.120	0.0044	—	.16629
Fl. 2	0.0364	4.020	0.1479	—	.71068
Web 1	0.0150	.2875	0.0043	.00018	.05752
Web 2	0.0150	3.9125	0.0587	.00018	.03682
Top R	0.240	4.120	0.9888	.00003	.75552
	0.7036		1.5801	.21386	2.094428

$\bar{y} = \frac{1.5801}{.7036} = 2.24574$

$I_{xx} = 2.30834$ in⁴

Sheet 1
WHA 5/12/81

Analysis of Support Bolt - Essco Panels



load eccentricity = 2"

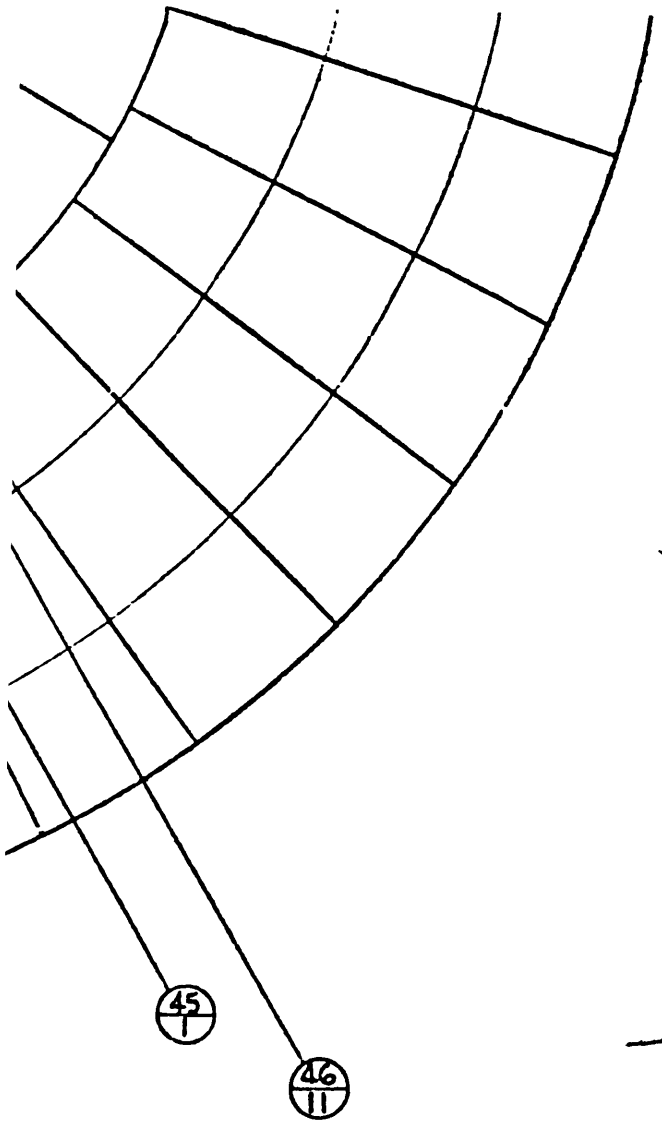
$M = 2 \times 75 = 150$ inlbs

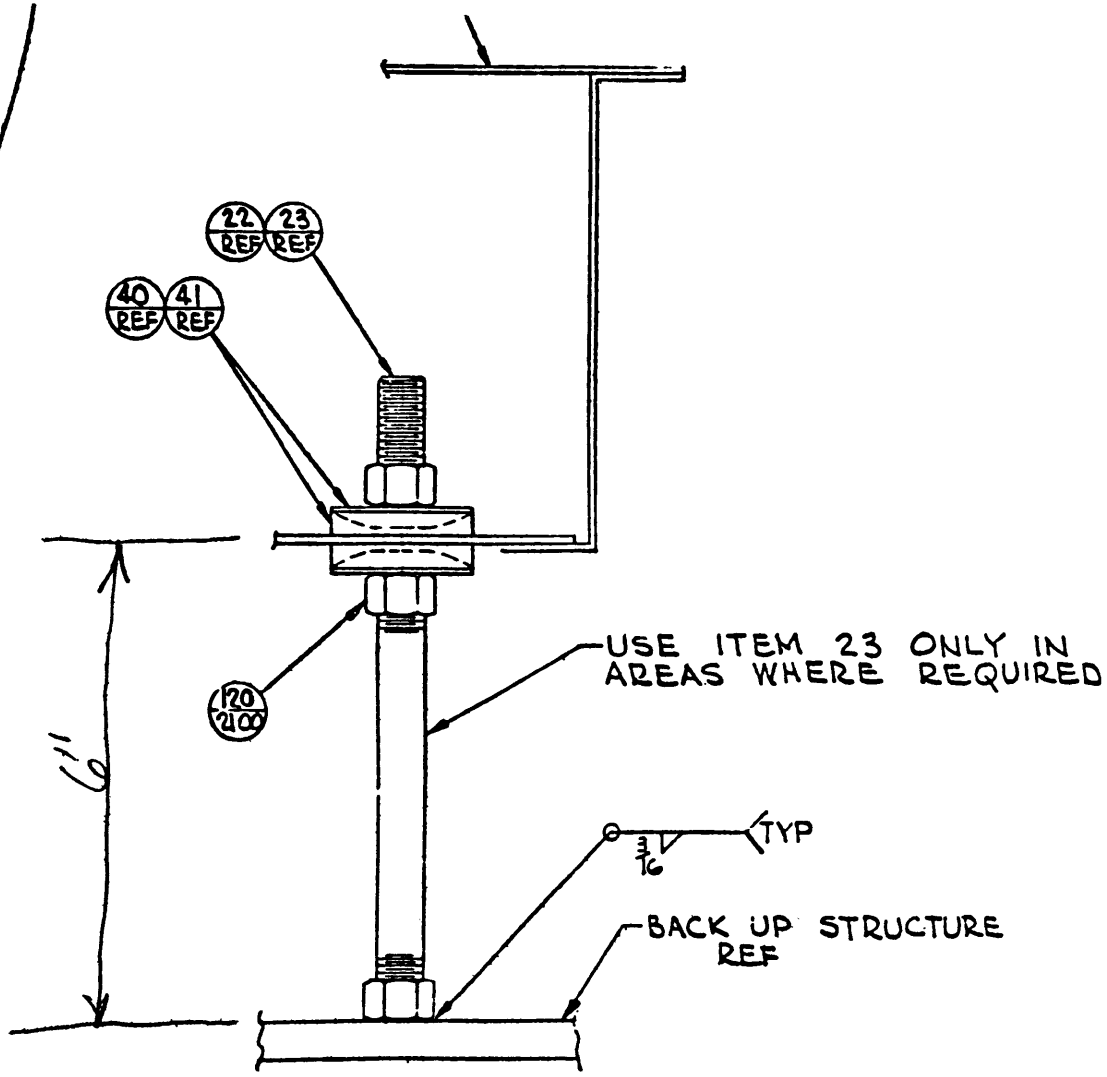
$$\Delta = \frac{M}{EI} \times \frac{\ell}{2} \times \frac{\ell}{4} = \frac{150(30)(30)}{10(10^6)2.3083(8)} = \frac{150(900)}{2.3083(8)10^6} = .000731 \text{ inches}$$

$= .0185$ mm $=$ 18.5 microns

Estimate RMS of $\frac{18.5}{3} = .6$ microns worst, actually it will be less as I have assumed a simple beam for half of the panel, whereas, it is continuous over the middle support which will reduce the Moment at mid-span and thus reduce the maximum deflection

Sheet 2
WGA 5/13/81





ANGULAR INSTL AS REQD

DETAIL SHOWING INSTL & ADJUSTMENT OF PANELS

SCALE: 1/1

INSTALL & ALIGN PER ALIGNMENT SPEC 96520229

E-SYSTEMS INC. Garland Division	SIZE E	CODE IDENT. NO 97871	96E20011
	SCALE 1/40	REV A	SHEET 6

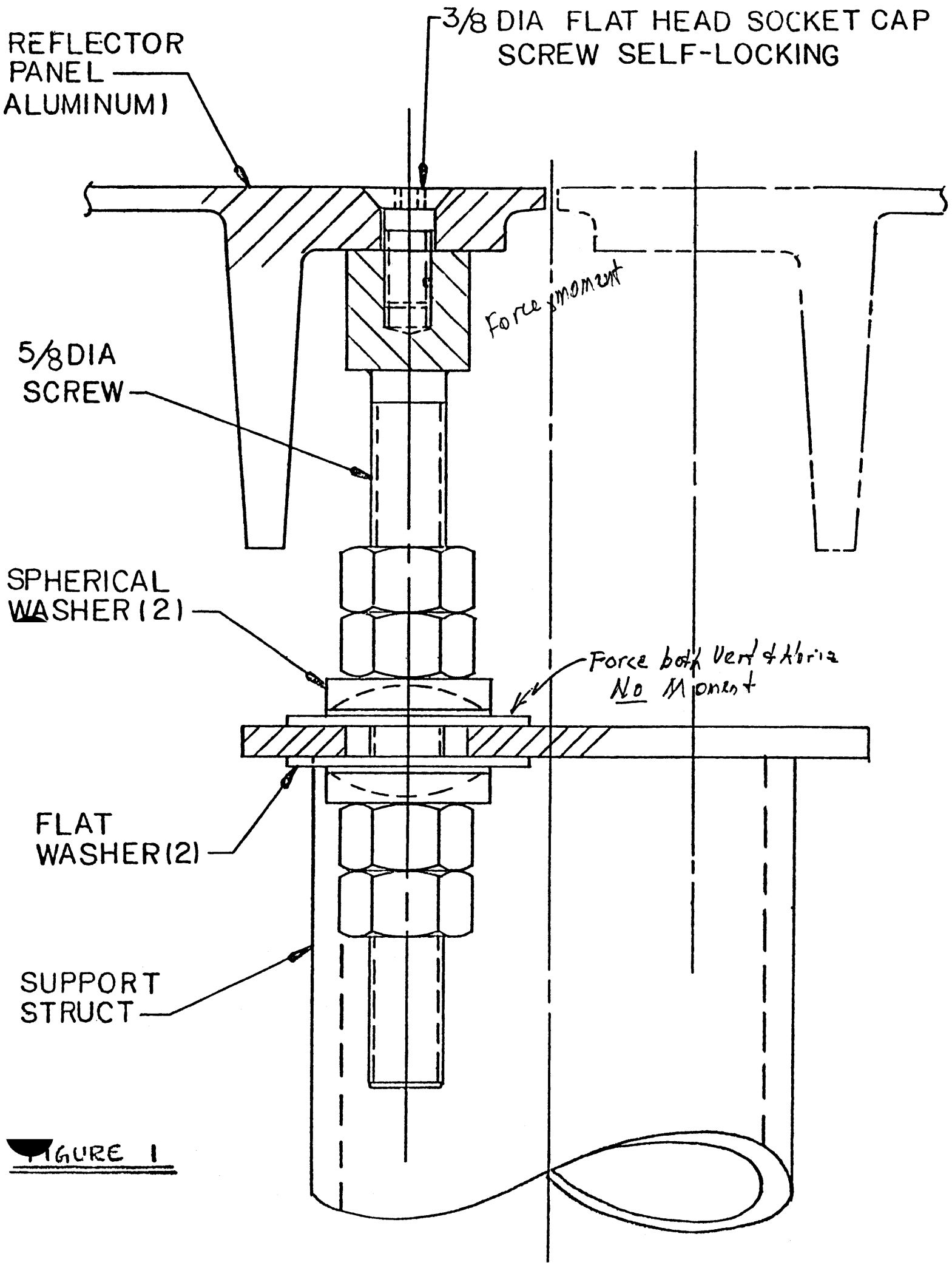

REFLECTOR PANEL ALUMINUM)
3/8 DIA FLAT HEAD SOCKET CAP SCREW SELF-LOCKING
Force moment
5/8 DIA SCREW
SPHERICAL WASHER (2)
Force both Vert & Horiz
No Moment
FLAT WASHER (2)
SUPPORT STRUCT

FIGURE 1

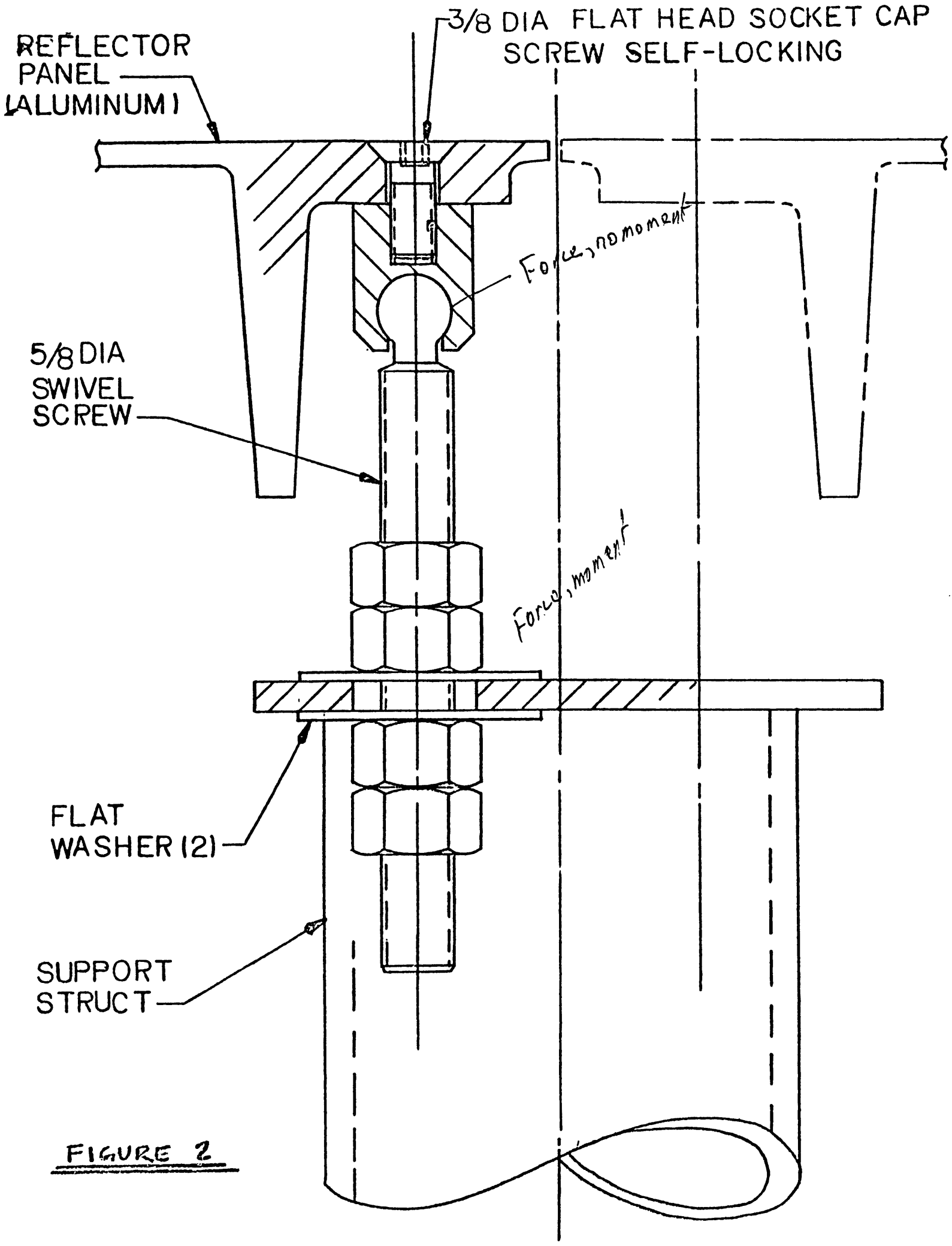

3/8 DIA FLAT HEAD SOCKET CAP SCREW SELF-LOCKING
REFLECTOR PANEL (ALUMINUM)
Force, moment
5/8 DIA SWIVEL SCREW
Force, moment
FLAT WASHER (2)
SUPPORT STRUCT

FIGURE 2