UNIVERSITY OF CALIFORNIA

UCO/LICK OBSERVATORY TECHNICAL REPORTS

NO. 62

MECHANICAL ENGINEERING SAFETY NOTE

LIFTING SLINGS FOR THE HIRES SPECTROGRAPH CORRECTOR OPTICS

BRUCE BIGELOW

(Adapted from ENE-90-998
by Robert Horton)

SANTA CRUZ, CALIFORNIA
JUNE 1992

I. Description — Refer to Drawing (H5261 — H5267)

The Nova sol-gel area uses custom slings to lift the lenses into and out of the sol-gel coating tank. These lifting slings consist of an inner and outer support strap, three locating blocks and locking clips, two locating bars, and two sling connectors. See the Lens Sling Assembly drawings for clarification.

The slings, together with the lifting assembly (AAA-90-100460) and the lifting bracket (AAA-90-100462), are used to lift the optics while in the vertical position. Therefore the loads on the lifting fixture are primarily tensile. The lenses are moved over the coating tank and then the locking clips are removed so that the sol-gel coating is applied evenly over the entire surface of the lens. This safety note requires that the clips are in place whenever a lens is not directly over the tank.

II. Hazards

Failure or misuse of the slings has the potential of causing bodily injury (but not death) and/or damage to high valued equipment ($100K).

The sling supports the optic at head height, in the vertical position, while the operator keeps the optic from rotating. Then the lends is transferred to the sol-gel tank arm. once on the arm, the operator disconnects the lifting assembly that holds the sling onto the crank hook. As the optic is lowered into the tank, the locking clips can be removed. care should be taken that the operator is standing to the side of the optic and the locking clips are not removed until they are at the level of the top of the coating tank. As a safety precaution, the sling should never be directly above personnel and should only be used by qualified operators who are trained in its specific use. When an optic is installed into a sling, a "Makeaclamp," welded to the inner support ring, is used to snug the inner ring around the lens. A torque value of 5 ft-lbs (the value just before the knee on the preload vs. torque curve in this note) is required to snug the lifting fixture around the lens. The preload on the lens is 65 pounds. The normal load on the focusing optic during everyday use is several times higher than this; therefore, this preload is acceptable. Care should be taken when installing the sling onto the lens, the strap should be centered on the lens and should not be allowed to overlap the edges. This precaution will protect the edges of the lens from chipping.

III. Design Calculations

The slings were designed per the LLNL Mechanical Engineering Design Safety Standards (DSS) covering lifting equipment, and all calculations are included in this safety note. If the Lens Lifting Sling were to fail, it could cause personal injury or damage high

value equipment; therefore, it is classified as "high consequence" according to the safety standards, the design load (166 lbs. max.) is 33% higher than the actual optic weight. Therefore the allowable or rate load for the sling is 75% of the design load or 125 lbs.

The calculations include a factor of 2X to account for the jerk effects (expected dynamic load) or seismic load (1g effective vertical loading). The exact loading of this fixture due to a seismic event is unknown because the response spectrum of this fixture is unknown. The maximum acceleration of 1g from the ground level curve in the DSS for category 2 equipment is used as the seismic load and added to the static load of 1g. Including this factor of 2X on the design load, a minimum factor of safety of 3 based on yield is maintained on allowable stresses for material and a minimum factor of 4 based on yield is maintained on all bolts, and the design load is 1.33 times higher than the actual rated load. This results in an overall safety factor of at least eight based on the rate load. Therefore, a vertical acceleration of 7g would be required to reach yield when using this fixture at the rated load. This is deemed an acceptable factor of safety considering that the actual response spectrum is unknown.

It is noted that the seismic curves in the new DOE seismic standard UCRL-15910 differ from those in the present DSS. The maximum acceleration in category 2 of the DSS is 1g, and is lower than the 1.8g in the curve for category III of UCRL-15910. Category III consists of important or low-hazard facilities, but does not consider lower hazards within a facility as in the DSS. Despite this fact, a seismic acceleration 3.9 times greater than the peak of the DOE curve (7g/1.8g) would be required for these fixtures to reach yield. This is also deemed an acceptable factor of safety considering that the actual spectrum is unknown.

IV. Testing and Labeling

The sling will be tested, by using it to lift 150% of the design load while in the vertical position. The overhead crane should be used to support the sling. The test load consists of metal plates that mock the shape, size, and center of the gravity of the primary lens. Slings will be tagged with the following information as appropriate.

Dwg. No.: H5261 — H5267
Load Limit: 125 pounds
Reference: ENE-90-998
Use with AAA-90-100460 and AAA-90-100462
Remarks:
Tested by _____ Date _____

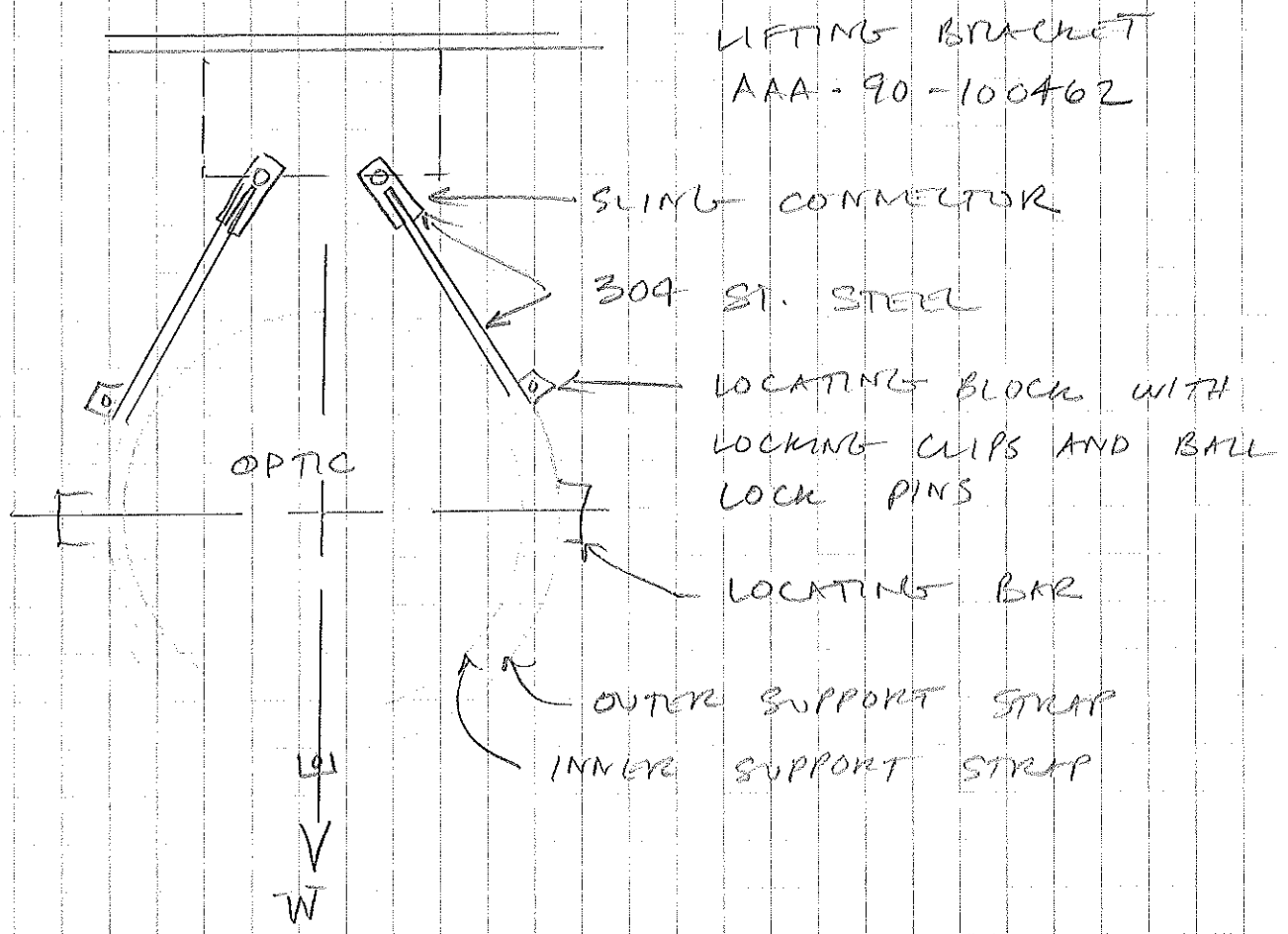
Acknowledgments

Many thanks to Gary Edwards and Greg Tietbohl for assistance with the design of the sol-gel dipping slings and the HIRES optics transport fixtures.

This work was performed under a contract from the California Association for Research in Astronomy (CARA) for design and construction of the high resolution echelle spectrograph (HIRES) for the Keck telescope.

HIMES LENS SLINGS
B. BIGELOW
6-17-92

ADAPTED FROM LLNL LNE-90-998, BY BOB HORTON.



THE SLING SUPPORTS THE OPTIC AS SHOWN. THE LENS CREATES A TENSILE LOAD WHICH IS TRANSFERED TO THE LIFTING BRACKET VIA THE ST. STEEL SLING.

MAXIMUM OPTIC WEIGHT (MENISCUS) @ 125 LBS

DESIGN LOAD IS $\frac{4}{3}(125) = 166$ LBS.

TEST LOAD = 150% OF DESIGN LOAD = 249 LBS.

LOAD DUE TO 2 G EFFECTS = $2 \times 166 = 332$ LBS.

HIRES LENS SLINGS
B. BIGELOW
6-17-92

(2)

AT THE 2·G LOAD, ALL COMPONENTS MUST HAVE A FACTOR OF SAFETY OF AT LEAST 3.0 BASED ON YIELD.

LIST OF COMPONENTS:

1) LOCATING BAR
2) LOCATING BLOCKS
3) LOCATING CLIPS AND BALL LOCK PINS
4) SLING CONNECTORS
5) INNER SUPPORT STRAP
6) OUTER SUPPORT STRAP

STEEL IS TYPE 304 STAINLESS, S_y = 30,000 psi

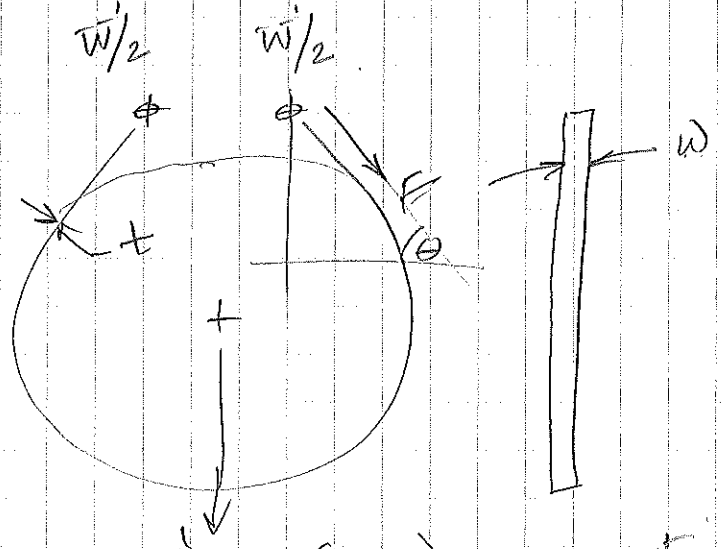
THE LOCATING BARS, LOCATING BLOCKS, LOCKING CLIPS AND BALL LOCK PINS ARE ALL PRECAUTIONARY HARDWARE ADDED TO THE FIXTURE TO RETAIN THE LENSES ONLY IN CASE OF AN EMERGENCY. THEY ARE NOT REQUIRED TO SUPPORT THE LENS, SO CALCULATIONS ARE NOT INCLUDED IN THIS NOTE. ALSO, NOTE THAT THE "MAKE-A-CLAMP" DOES NOT SUPPORT THE OPTIC, BUT ONLY HELPS TO RETAIN THE OPTIC IN THE SLING.

HIRES LENS SLINGS
B. BIGELOW
6-17-92

LIST OF CALCULATIONS:

1) SLING STRAP
2) SLING CONNECTIONS
3) SLING CONNECTORS

— SLING STRAP —



$W' = 2(W_{DES})$

$\sigma = \frac{F}{A}$,

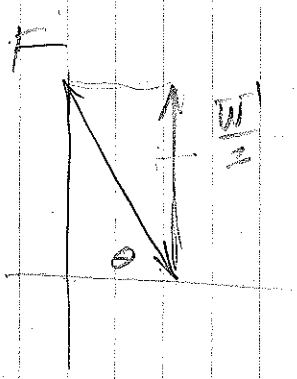
$= \frac{191.7}{(0.875")(0.040")}$

$= 4564.3$ psi

$F.S. = S_y/\sigma = \frac{30000 \text{ psi}}{4564.3}$

$F.S. = 6.57$ O.K.

$w = 0.875"$
$t = 0.048"$
$S_y = 30,000$ psi
$W_{DES} = 166$ lbs.
$W' = 332$ lbs.
$\theta = 60°$



$\frac{W'}{2} \sin\theta = \frac{W'}{2}$

$F = \frac{W'}{2 \sin\theta}$

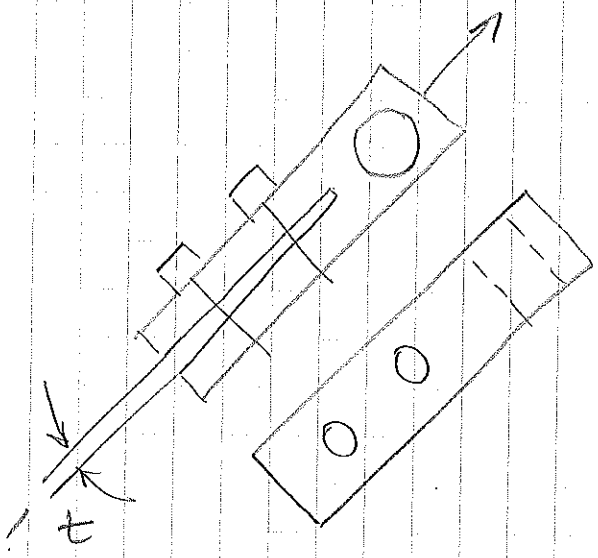
$= \frac{332}{2 \sin 60}$

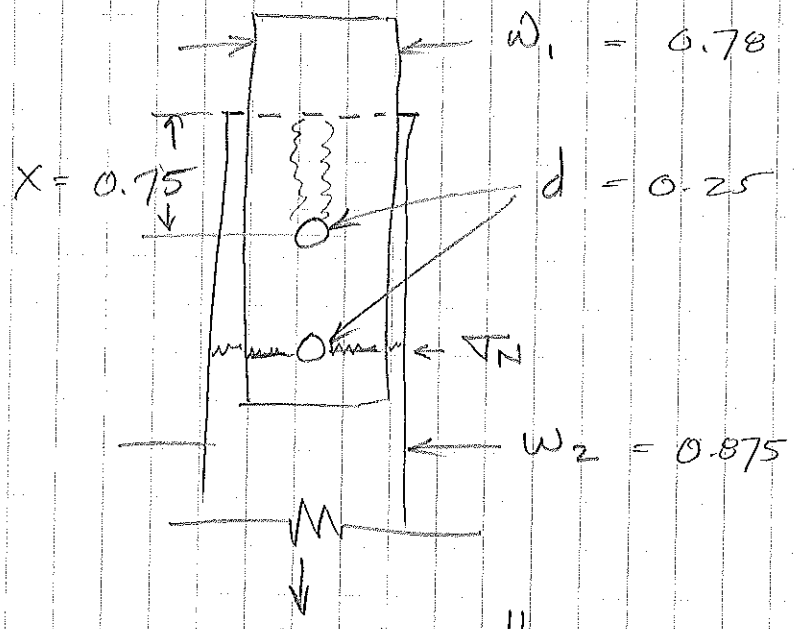
$= 191.7$ lbs.

SLING TENSION OK

HIRES LENS SLINGS
B. BIGELOW
6-17-92

— SLING CONNECTIONS —





— TENSILE STRESS IN STRAP:

$$\sigma_N = \frac{F}{(W_2 - d)(t)} = \frac{192}{(.875 - 0.25)(0.048)} = 6400 \text{ psi}$$

$$F.S. = \frac{S_y}{\sigma_N} = \frac{30,000}{6400} = 4.7 \quad \text{O.K.}$$

— TEAR-OUT SHEAR STRESS IN STRAP:

(USE TOP HOLE ONLY FOR X)

$$\tau_{xy} = \frac{F}{2 \times t} = \frac{192}{2(0.75)(0.048)} = 2667 \text{ psi}$$

$$F.S. = \frac{S_{sy}}{\tau_{xy}}, \quad S_{sy} = 0.577 S_y \rightarrow \frac{(0.577)(30,000)}{2667} = 6.5$$

O.K.

HIRES LENS SLINGS
B. BIGELOW
6-17-92

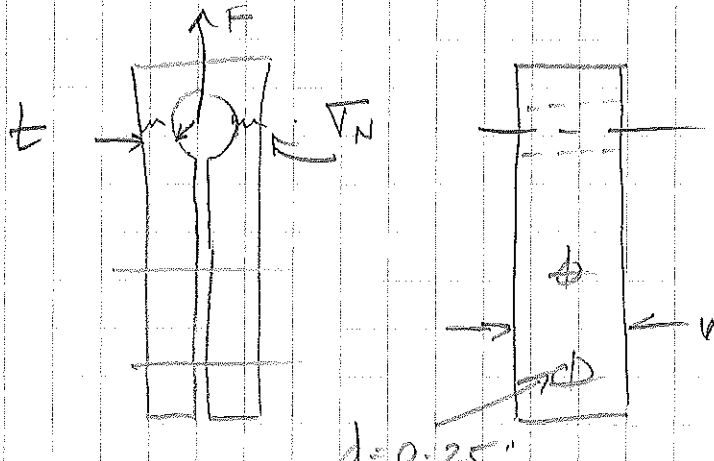
SLING CONNECTIONS CONTINUED —

— BEARING STRESS IN STRAP —

$$\sigma_B = \frac{F}{2(t)(d)} = \frac{192}{2(0.098)(0.25)} = 3000 \text{ psi}$$

$$F.S. = \frac{30{,}000}{3000} = 3.75 \quad \text{OK}$$

— SLING CONNECTORS —



304 ST. STL.

$t = 0.125$
$F = 192$ lbs.
$w = 0.78"$
$d = 0.25"$

— TENSILE STRESS IN CONNECTOR:

$$\sigma_N = \frac{F}{2tw} = \frac{192}{2(0.125)(0.78)} = 985 \text{ psi}$$

$$F.S. = \frac{S_y}{\sigma_N} = \frac{30{,}000}{985} = 30 \quad \text{OK}$$

HIRES LENS SLINGS
B. BIGELOW
6-17-92

– SHEAR STRESS IN FASTENERS:

$$t_{xy} = \frac{F}{N A_f}$$

$F = 192$ lbs,
$N = 2$ 1/4" SHCS
$A_f = \pi(0.125)^2 = 0.0491$

$$= \frac{192}{(2)(0.049)} = 1959 \text{ psi}$$

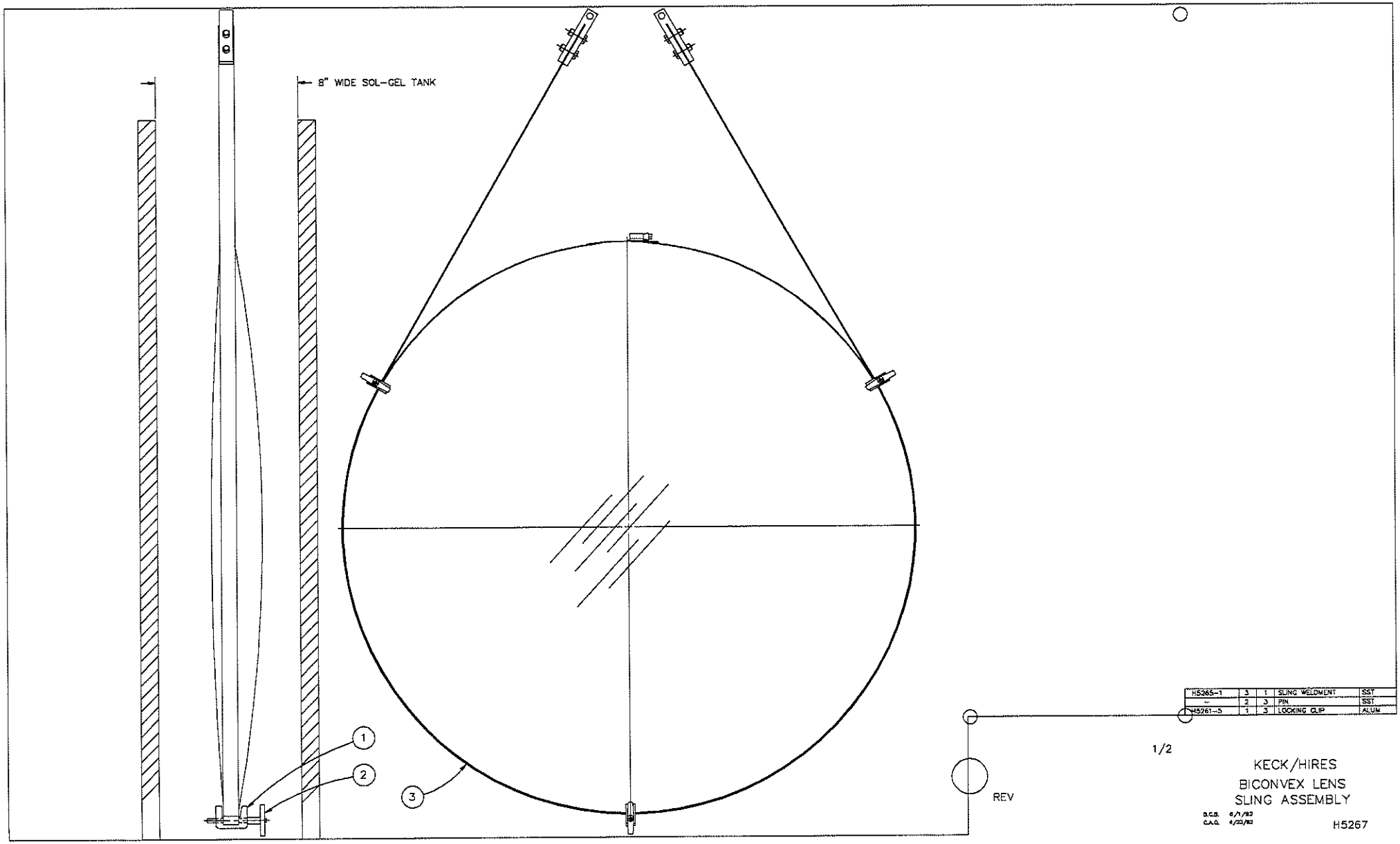
$$F.S. = \frac{S_{ys}}{t_{xy}} =$$

$S_y = 150{,}000$ FOR GR. 8 SHCS

$S_{ys} = 0.577\ S_y$

$$= \frac{(0.577)(150{,}000)}{1959}$$

F.S. = 44 Ok



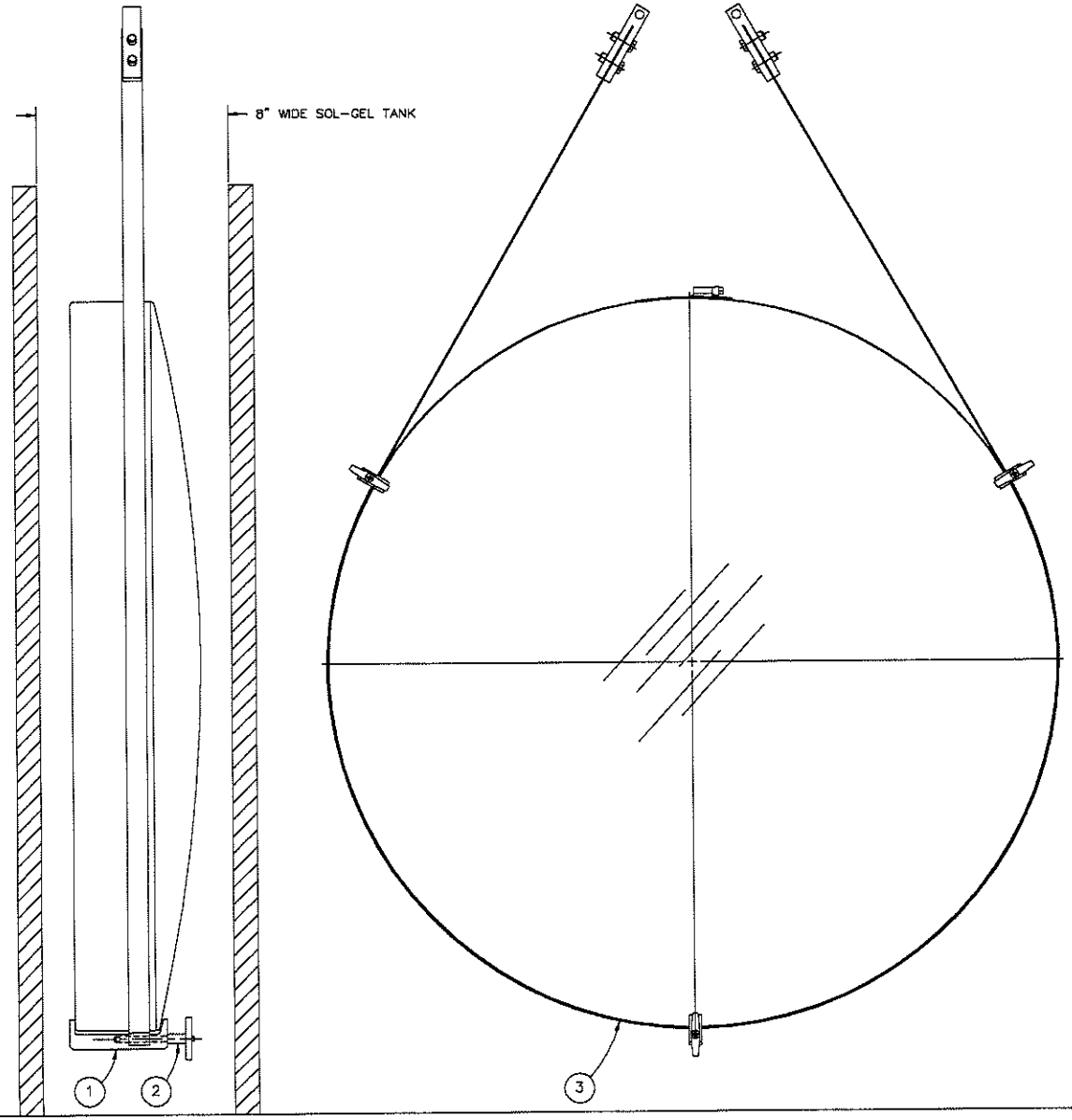
H5265-1	3	1	SLING WELDMENT	SST
—	2	3	PIN	SST
H5261-5	1	3	LOCKING CLIP	ALUM

1/2

KECK/HIRES
BICONVEX LENS
SLING ASSEMBLY

D.C.S. 6/1/92
C.A.Q. 6/22/92

H5267



H5264-1	3	1	SLING WELDMENT	SST
—	2	3	PIN	SST
H5261-2	1	3	LOCKING CLIP	ALUM

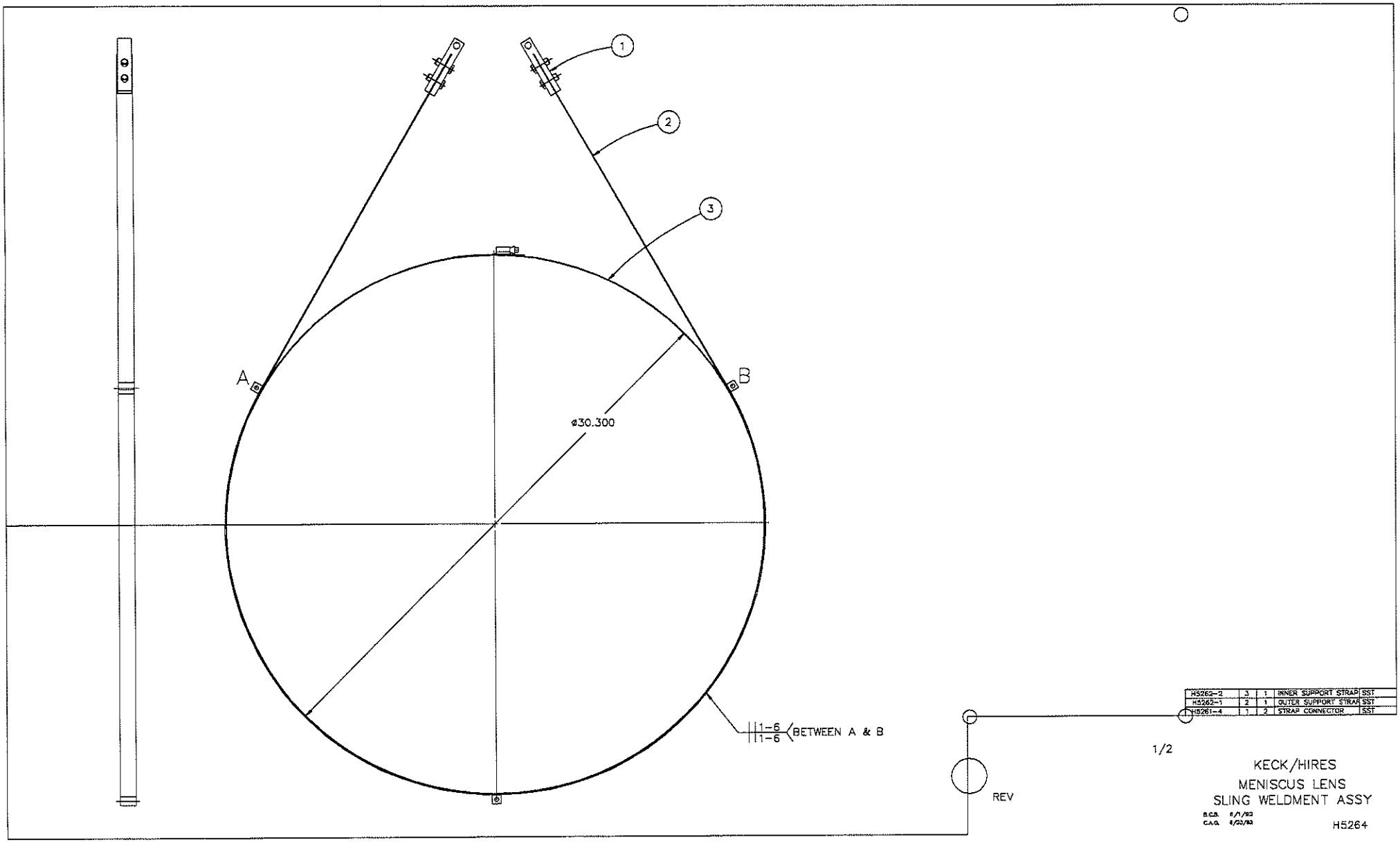
REV

1/2

KECK/HIRES
MENISCUS LENS
SLING ASSEMBLY

S.C.B. 6/1/92
C.A.O. 6/23/92

H5265



H5262-2	3	1	INNER SUPPORT STRAP	SST
H5262-1	2	1	OUTER SUPPORT STRAP	SST
H5261-4	1	2	STRAP CONNECTOR	SST

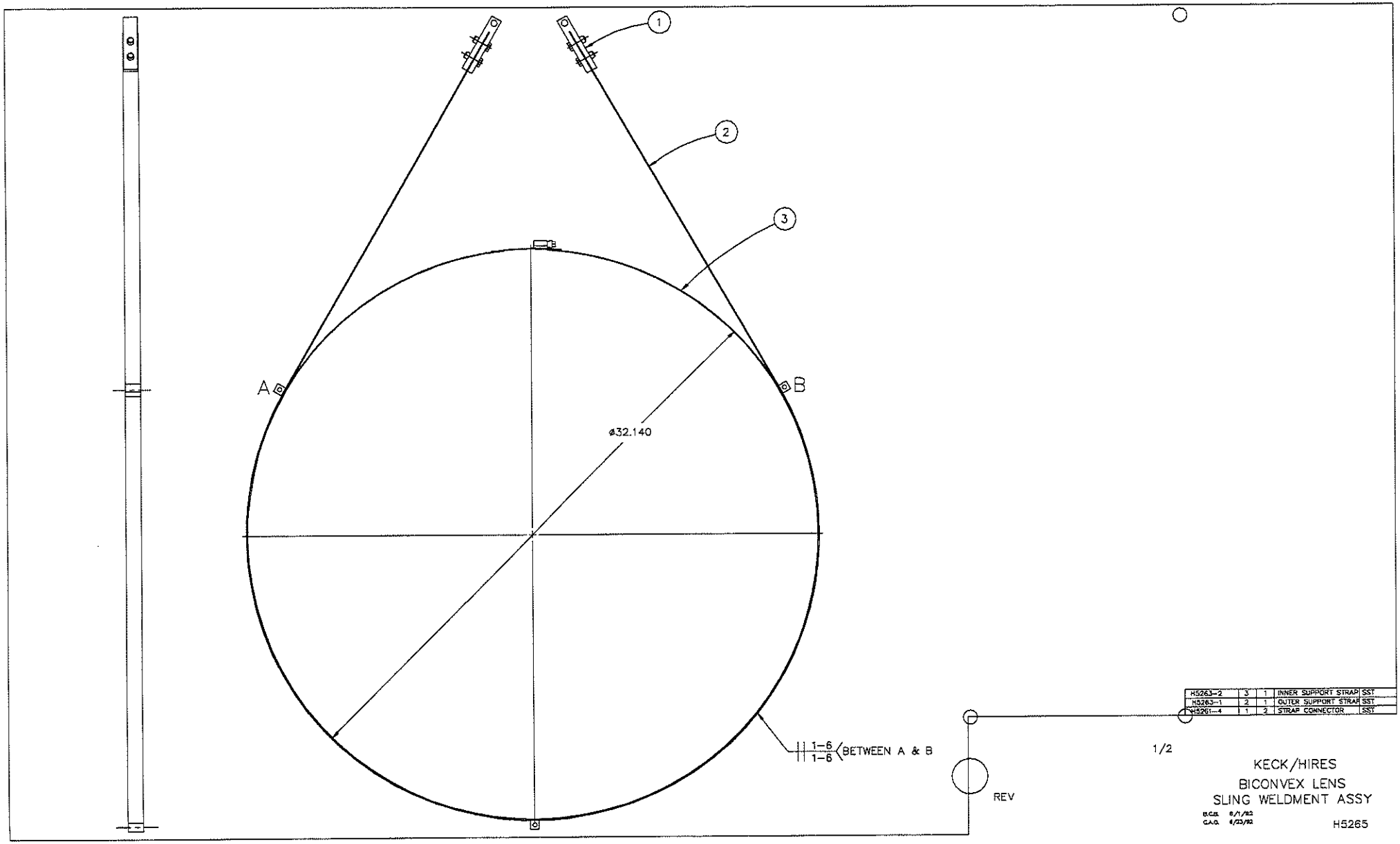
REV

1/2

KECK/HIRES
MENISCUS LENS
SLING WELDMENT ASSY

B.C.D. 6/1/93
C.A.D. 6/03/93

H5264



H5263-2	3	1	INNER SUPPORT STRAP	SST
H5263-1	2	1	OUTER SUPPORT STRAP	SST
H5261-4	1	2	STRAP CONNECTOR	SST

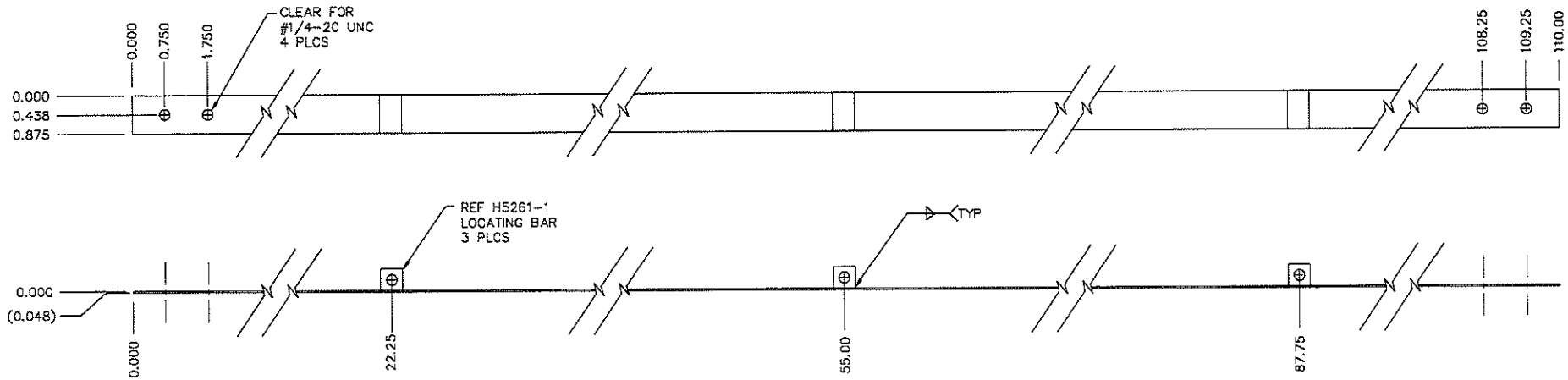
REV

1/2

KECK/HIRES
BICONVEX LENS
SLING WELDMENT ASSY

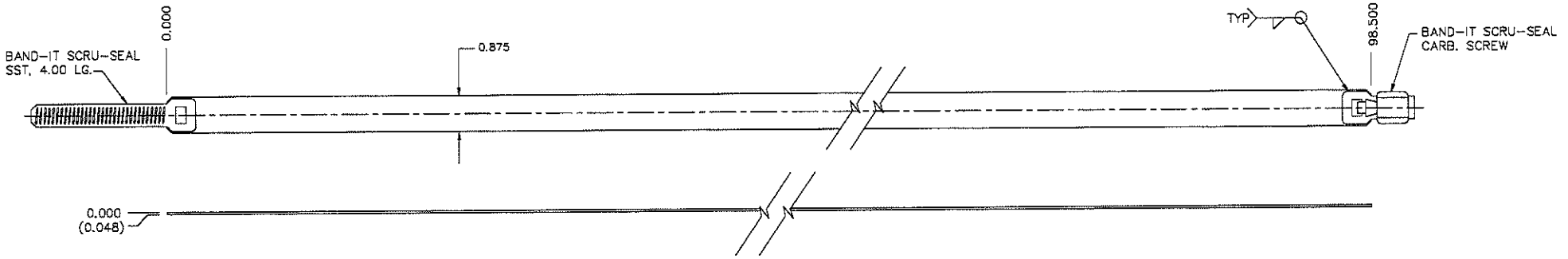
B.C.S. 6/1/92
C.A.D. 6/23/92

H5265



(-1) OUTER SUPPORT STRAP

1 REQ'D
STAINLESS STEEL, 20 GA (0.048)



(-2) INNER SUPPORT STRAP

1 REQ'D
STAINLESS STEEL 304, 20 GA (0.048)

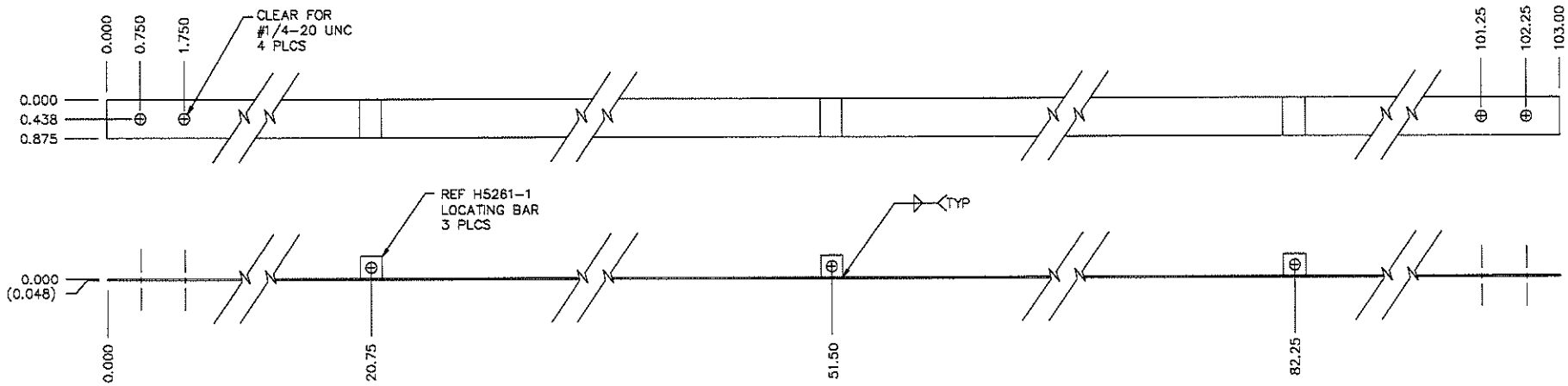
FULL

REV			
A	7/1/92	CAG	UPDATE PER AS-BUILT

KECK/HIRES
BICONVEX LENS
SLING DETAILS

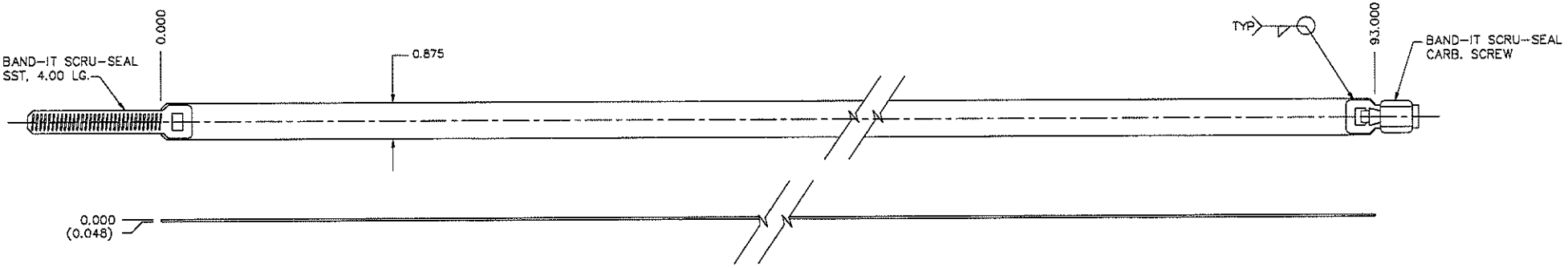
B.C.B. 6/1/92
C.A.G. 6/22/92

H5263.A



(-1) OUTER SUPPORT STRAP

1 REQ'D
STAINLESS STEEL 304, 20 GA (0.048)



(-2) INNER SUPPORT STRAP

1 REQ'D
STAINLESS STEEL 304, 20 GA (0.048)

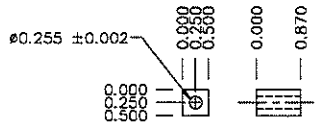
FULL

REV		
A	10/11/82 CAG	UPDATE PER AS-BUILT

KECK/HIRES
MENISCUS LENS
SLING DETAILS

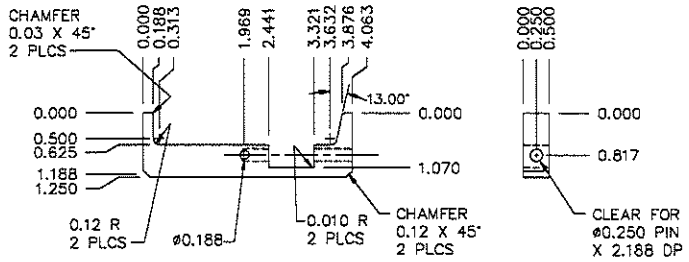
B.C.B. 6/1/82
C.A.G. 6/22/82

H5262.A



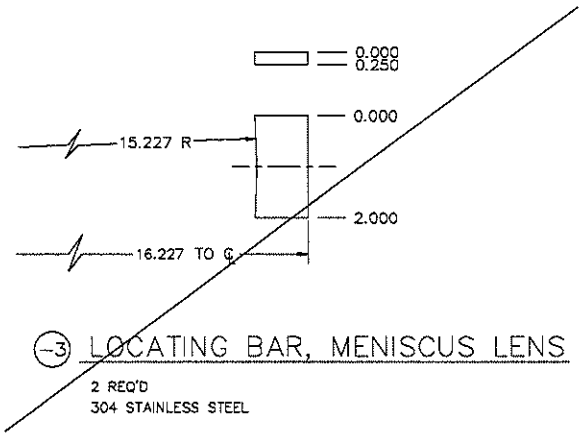
(-1) LOCATING BAR

6 REQ'D
304 STAINLESS STEEL



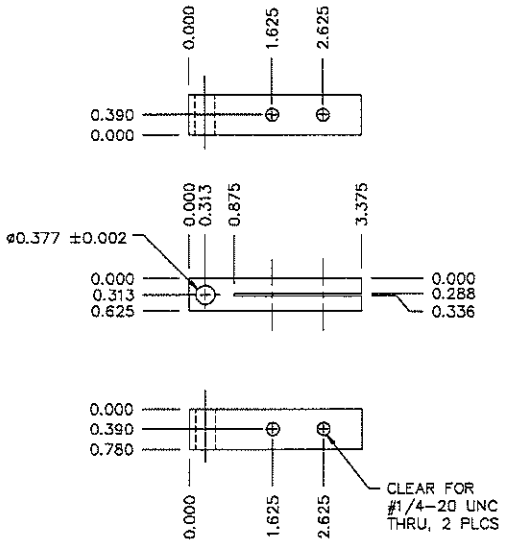
(-2) LOCKING CLIP, MENISCUS LENS

3 REQ'D
ALUMINUM, 6061-T6
BLACK ANODIZE



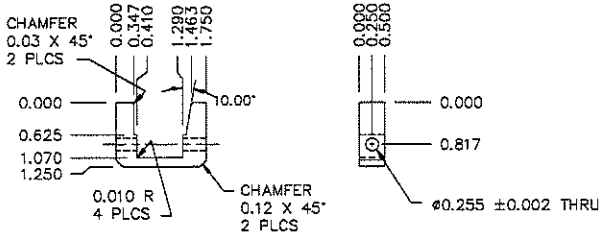
(-3) LOCATING BAR, MENISCUS LENS

2 REQ'D
304 STAINLESS STEEL



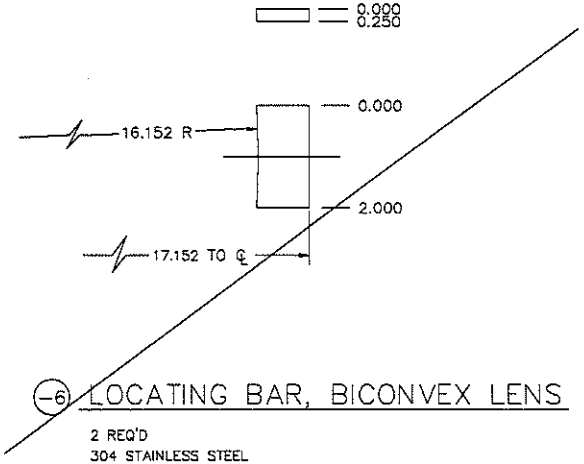
(-4) STRAP CONNECTOR

4 REQ'D
304 STAINLESS STEEL



(-5) LOCKING CLIP, BICONVEX LENS

3 REQ'D
ALUMINUM, 6061-T6
BLACK ANODIZE



(-6) LOCATING BAR, BICONVEX LENS

2 REQ'D
304 STAINLESS STEEL

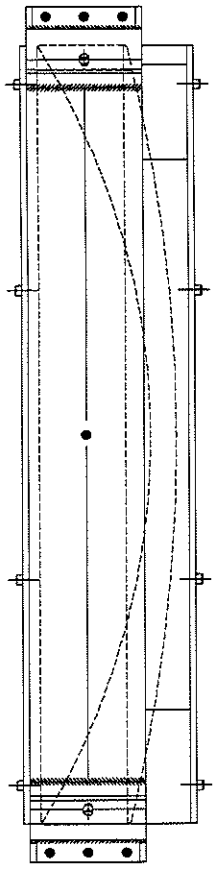
FULL

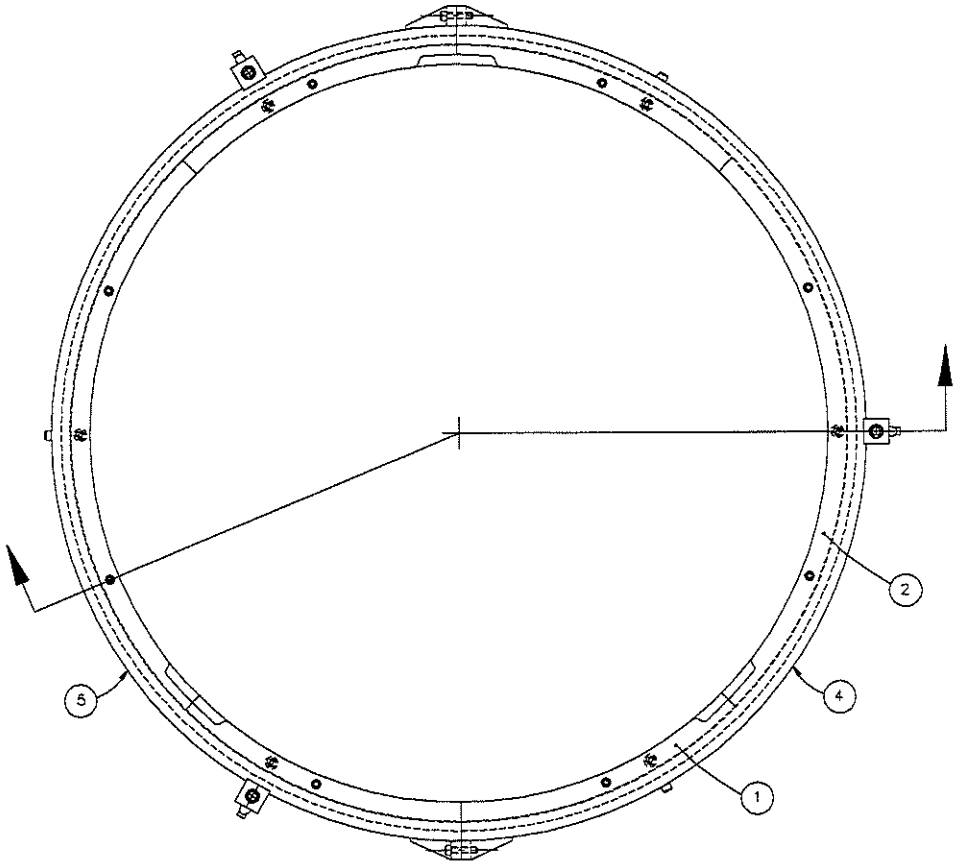
REV

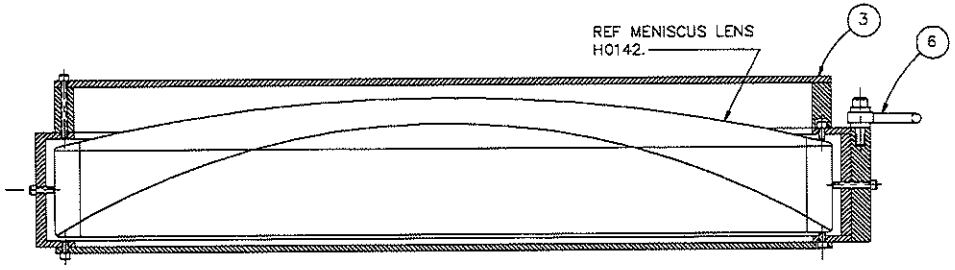
KECK/HIRES
CORRECTOR LENSES
SLING DETAILS

B.C.B. 6/1/92
C.A.C. 6/18/92

H5261







(-1) MENISCUS LENS, TRANSPORT FIX ASSY

1 REQ'D

–	6	3	HOIST RING	
H4246-1	5	1	RING SEGMENT WELD	ALUM
H4245-1	4	1	RING SEGMENT WELD	ALUM
H5244-1	3	2	COVER	LEXAN
H5243-1	2	2	RING SEGMENT	PVC
H5242-1	1	2	RING SEGMENT	PVC

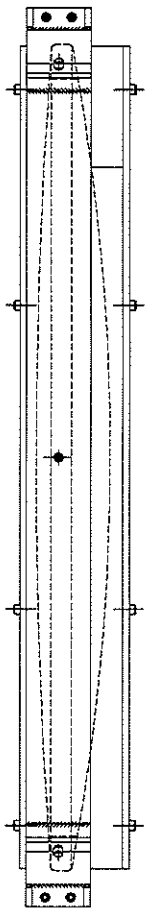
1/2

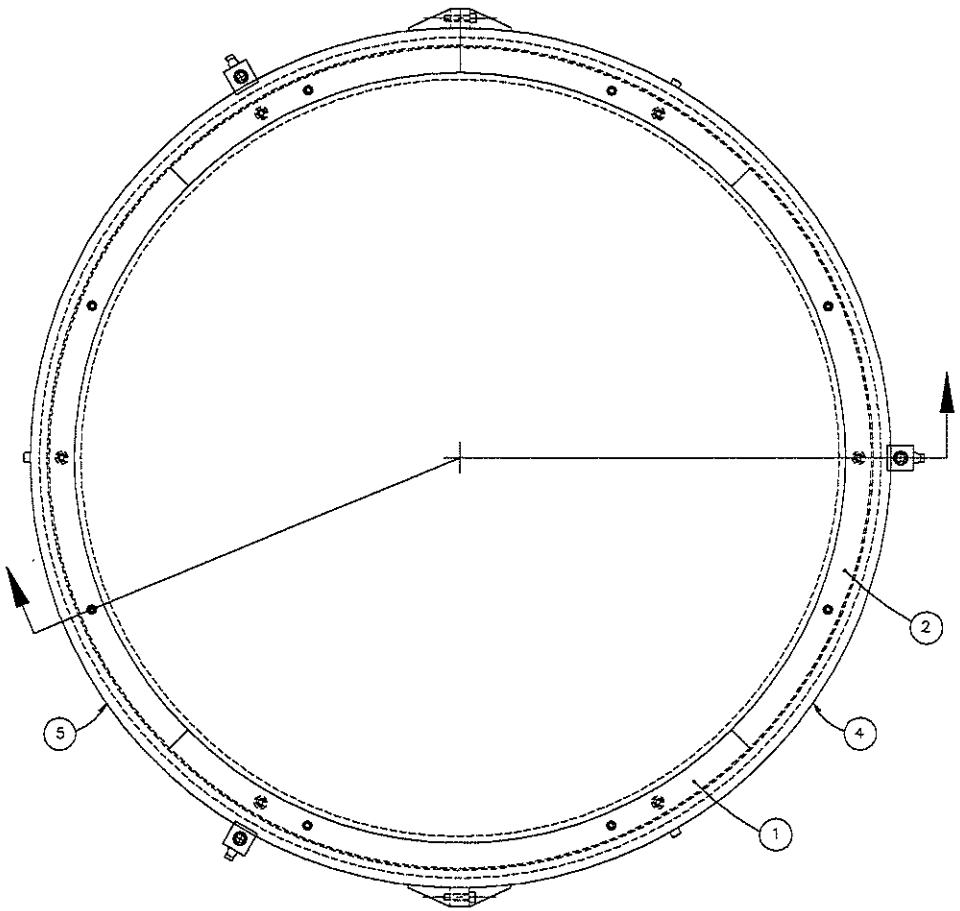
REV		
A	E/W/RD CAD	ADD HOLES TO BOTTOM COVER

KECK/HIRES
MENISCUS LENS
TRANSPORT FIXTURE ASSY

B.C.D. 6/1/83
C.A.D. 6/16/83

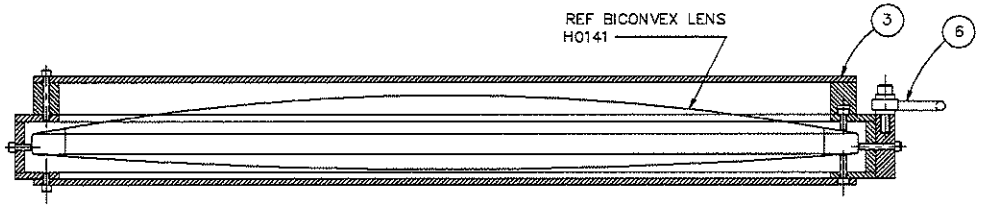
H5247.A





(-1) BICONVEX LENS, TRANSPORT FIX ASSY

1 REQ'D



–	6	3	HOIST RING	
H5253-1	5	1	RING SEGMENT WELD	ALUM
H5252-1	4	1	RING SEGMENT WELD	ALUM
H5251-1	3	2	COVER	LEXAN
H5250-1	2	2	RING SEGMENT	PVC
H5248-1	1	2	RING SEGMENT	PVC

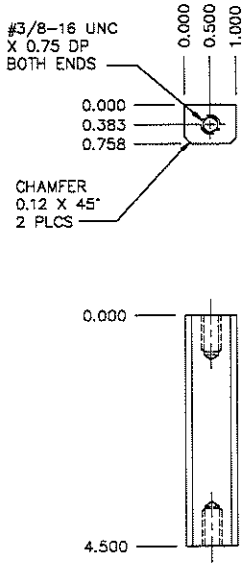
1/2

REV		
A	6/9/92 CAG	ADDED HOLES

KECK/HIRES
BICONVEX LENS
TRANSPORT FIXTURE ASSY

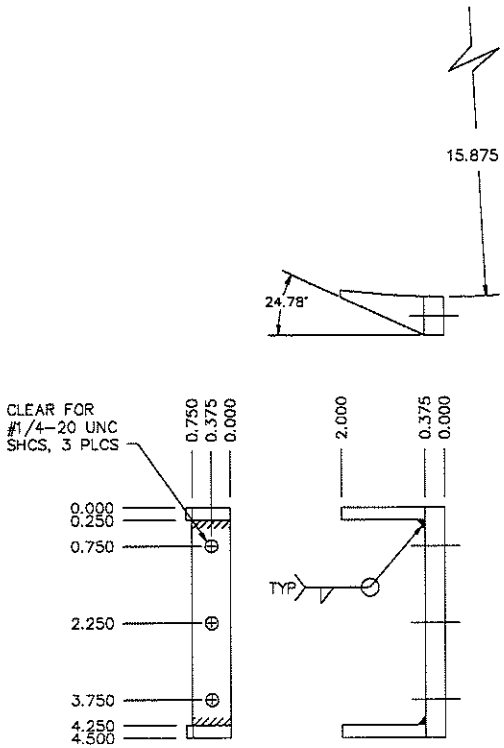
S.C.B. 6/1/92
C.A.G. 6/16/92

H5254.A



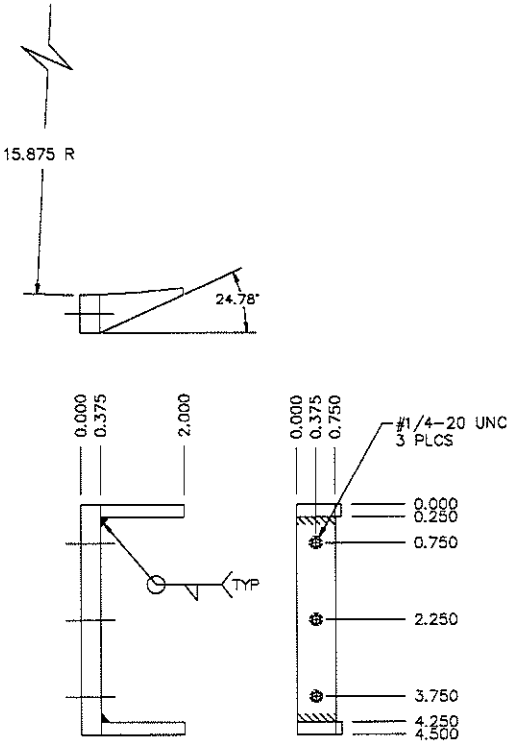
(-1) FLANGE

3 REQ'D
ALUMINUM
ALODYNE COATING



(-2) FLANGE

2 REQ'D
ALUMINUM
ALODYNE COATING



(-3) FLANGE

2 REQ'D
ALUMINUM
ALODYNE COATING

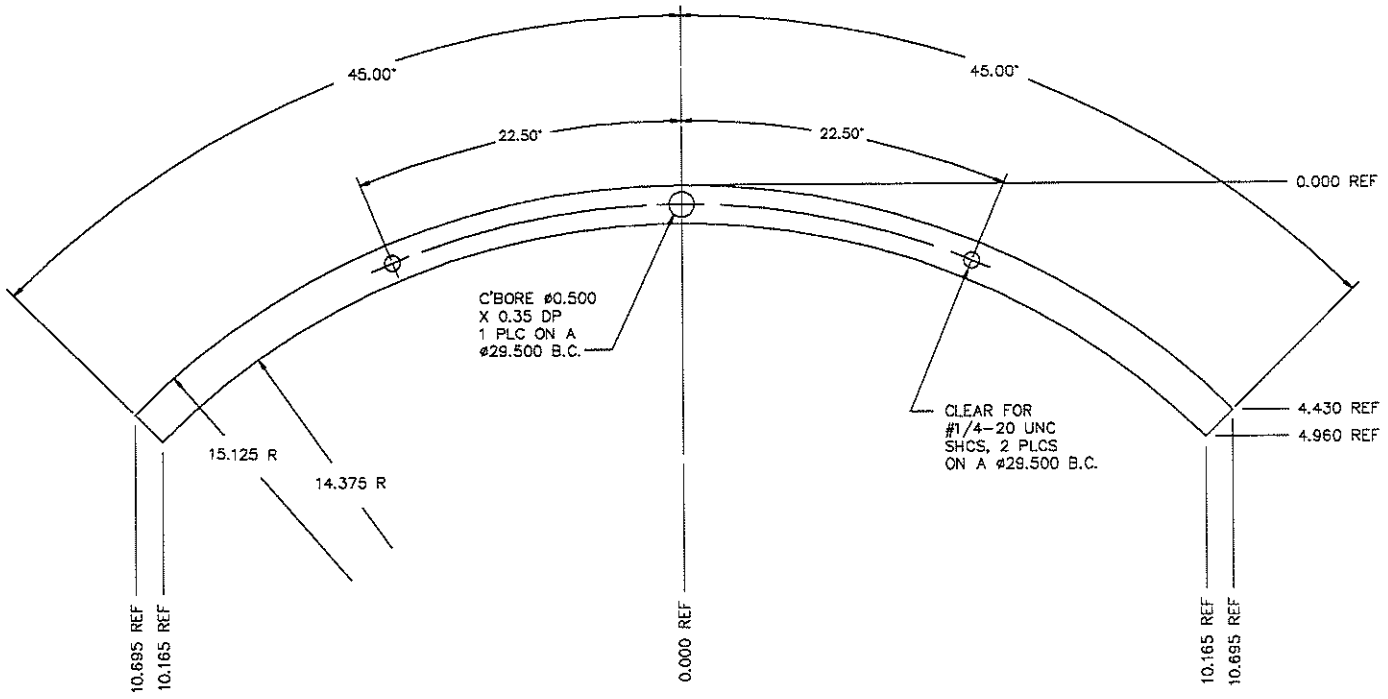
FULL

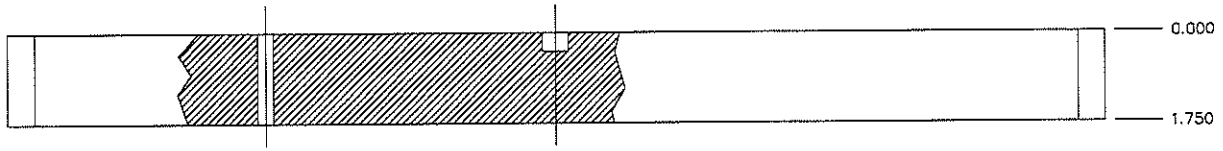
REV

KECK/HIRES
MENISCUS LENS
TRANSPORT FIXTURE DETAILS

B.C.R. 6/1/92
C.A.G. 6/16/92

H5241





-1 RING SEGMENT

2 REQ'D
PVC

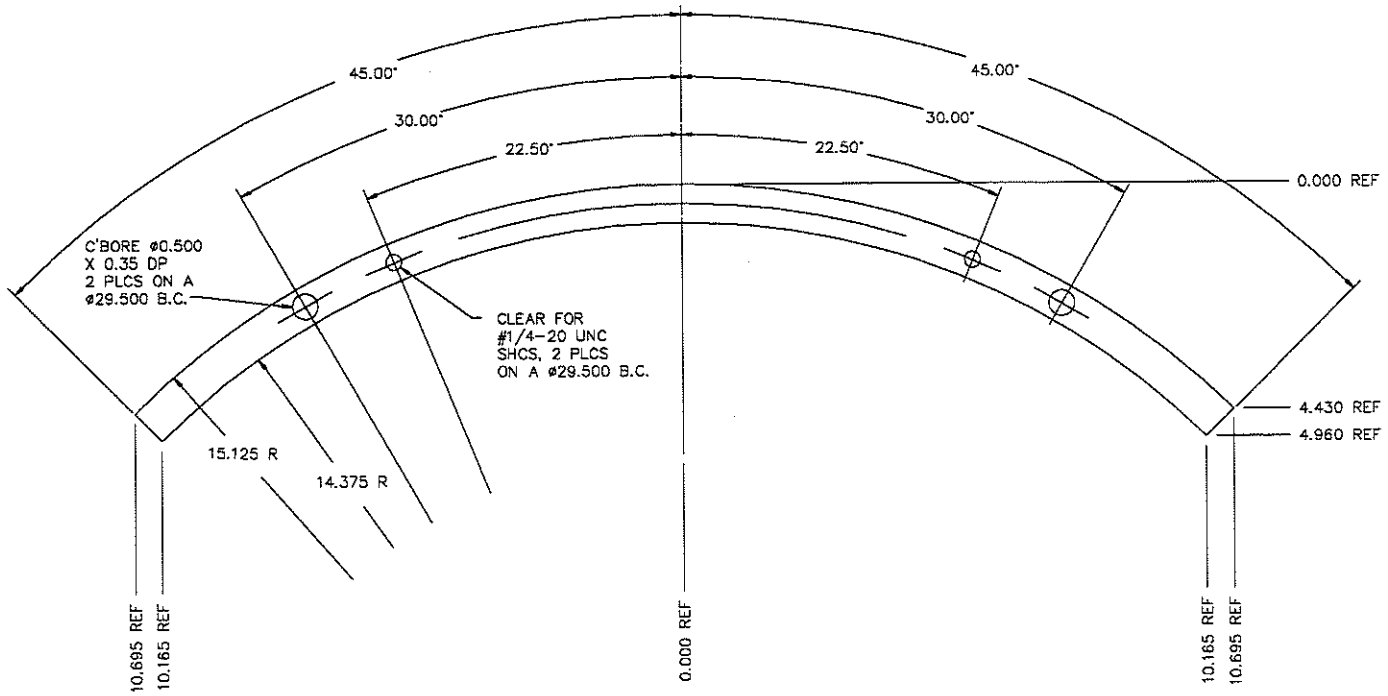
FULL

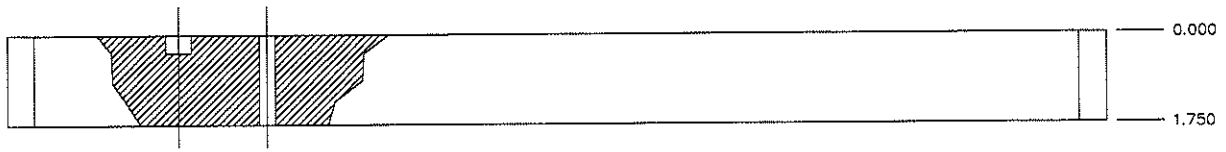
REV

KECK/HIRES
MENISCUS LENS
TRANSPORT FIXTURE DETAILS

SCD 6/1/92
CAD 6/15/92

H5242





(-1) RING SEGMENT

2 REQ'D
PVC

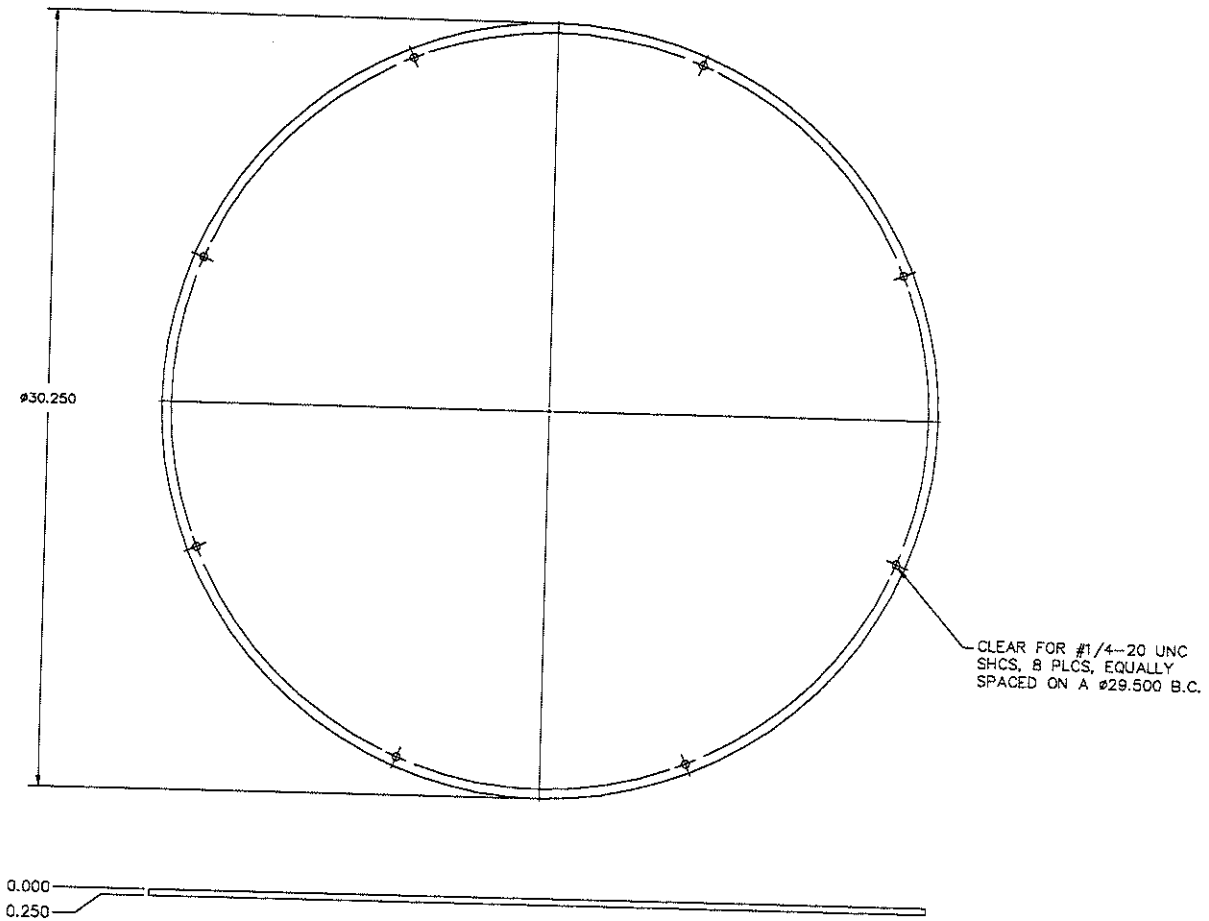
FULL

REV

KECK/HIRES
MENISCUS LENS
TRANSPORT FIXTURE DETAILS

D.C.S. 6/1/92
C.A.G. 6/15/92

H5243



(-1) COVER

2 REQ'D
LEXAN

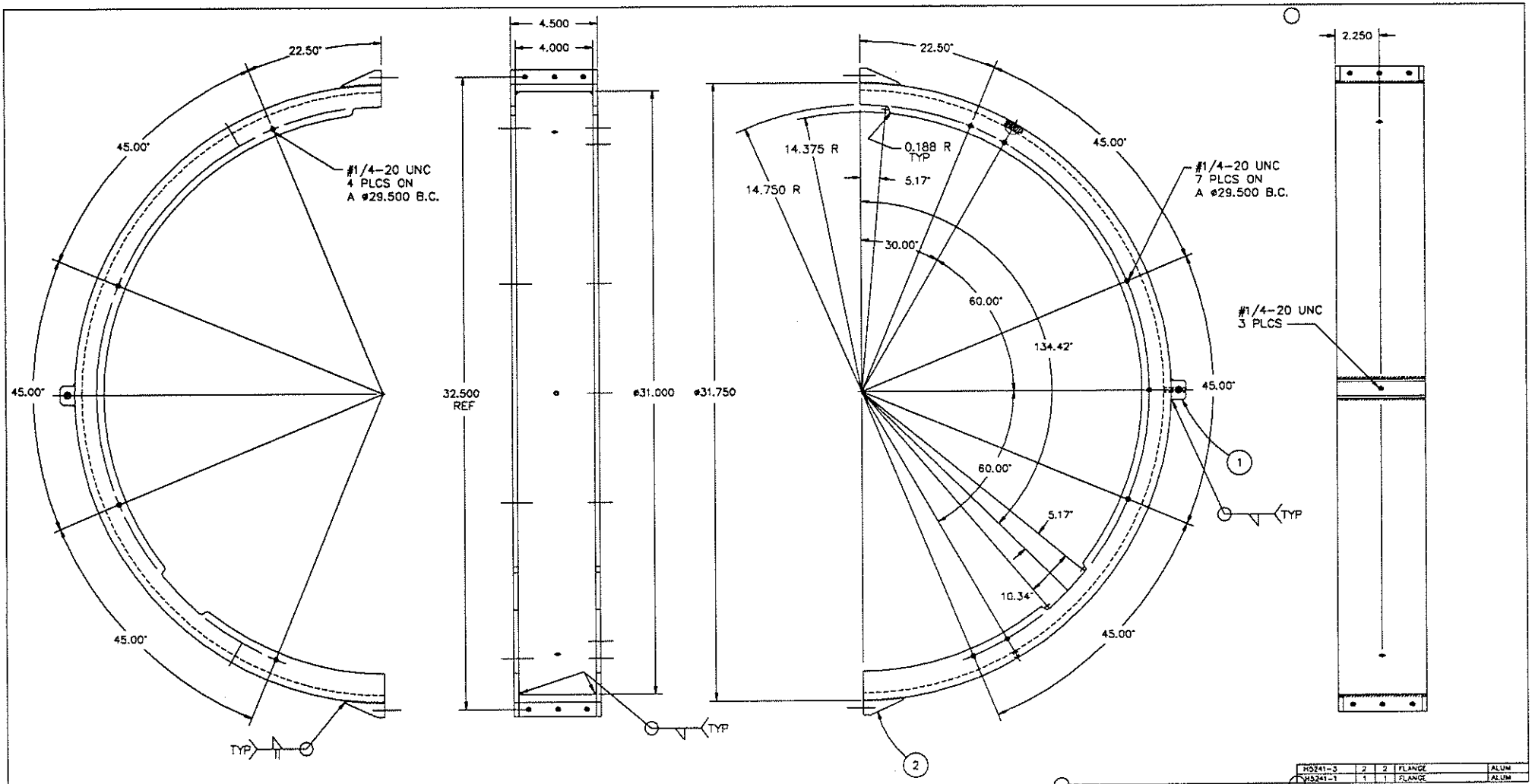
REV

1/2

KECK/HIRES
MENISCUS LENS
TRANSPORT FIXTURE DETAILS

D.C.S. 6/1/92
C.A.D. 6/16/92

H5244



H5241-3	2	2	FLANGE	ALUM
H5241-1	1	1	FLANGE	ALUM

-1 RING SEGMENT WELDMENT

1 REQ'D
ALUMINUM
ALODYNE COATING

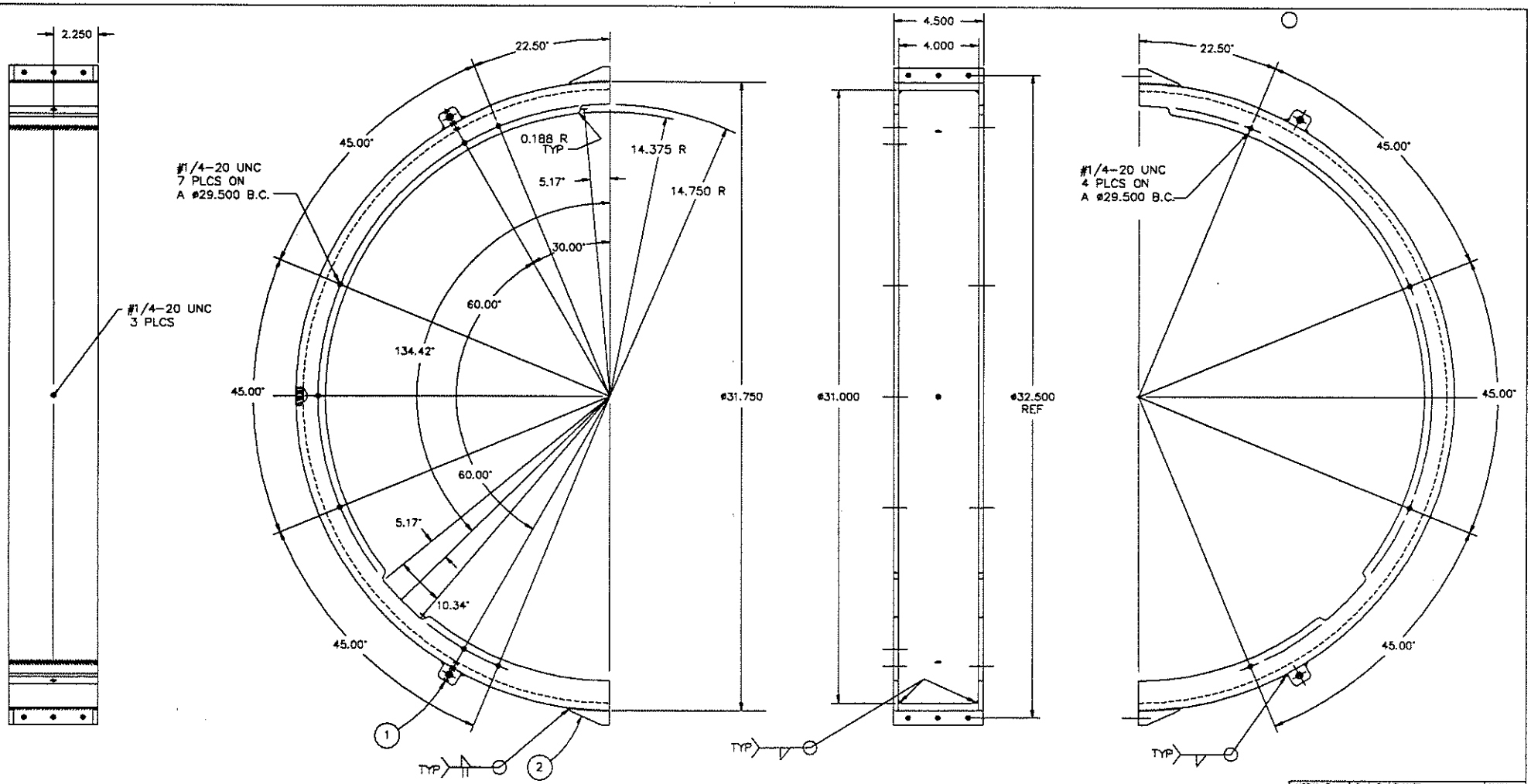
REV

1/2

KECK/HIRES
MENISCUS LENS
TRANSPORT FIXTURE DETAILS

S.C.B. 6/1/92
C.A.D. 6/19/92

H5245



H5241-2	2	2	FLANGE	ALUM
H5241-1	1	2	FLANGE	ALUM

(-1) RING SEGMENT WELDMENT

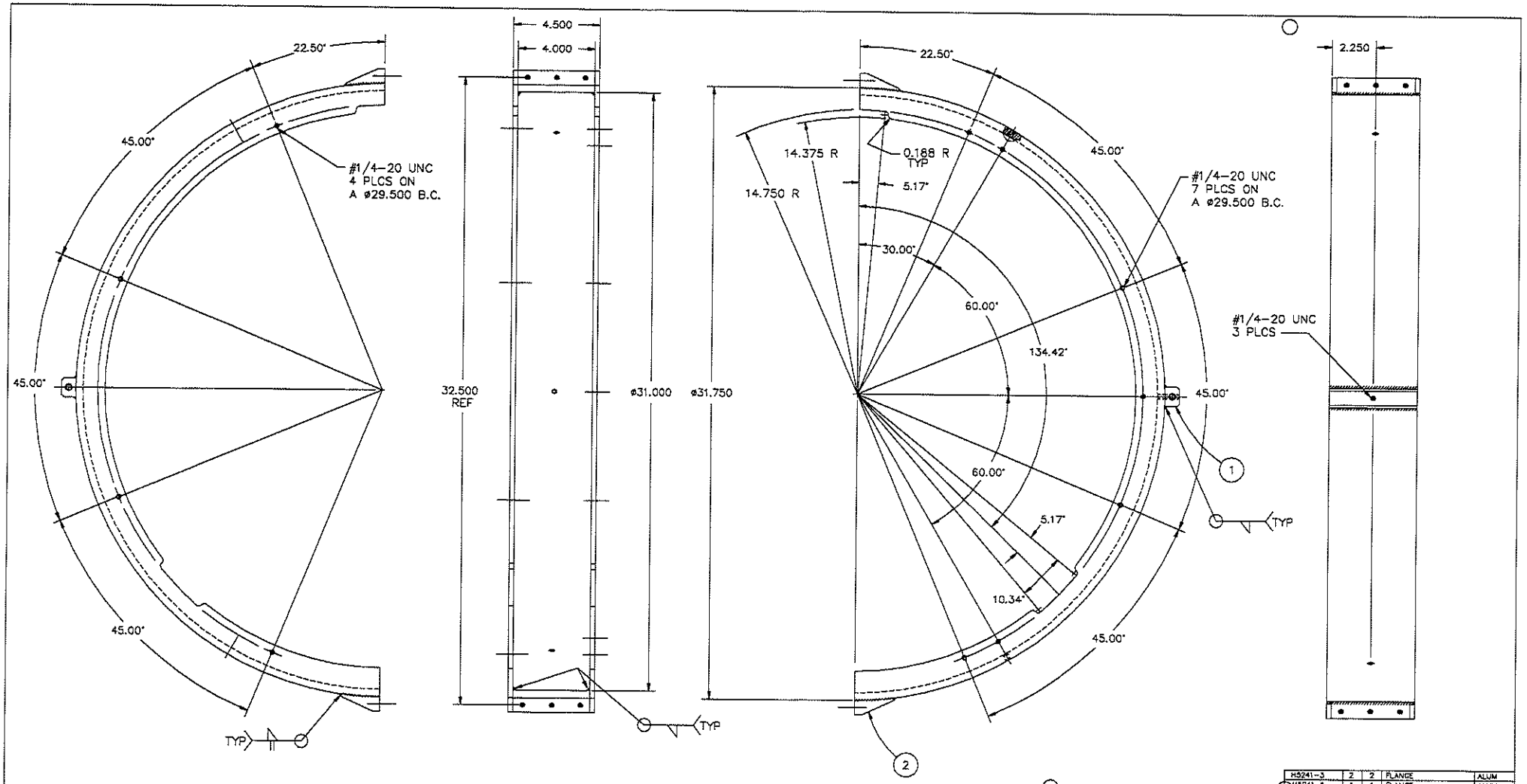
1 REQ'D
ALUMINUM
ALODYNE COATING

REV

1/2

KECK/HIRES
MENISCUS LENS
TRANSPORT FIXTURE DETAILS

H5246



H5241-3	2	2	FLANGE	ALUM
H5241-1	1	1	FLANGE	ALUM

-1 RING SEGMENT WELDMENT

1 REQ'D
ALUMINUM
ALODYNE COATING

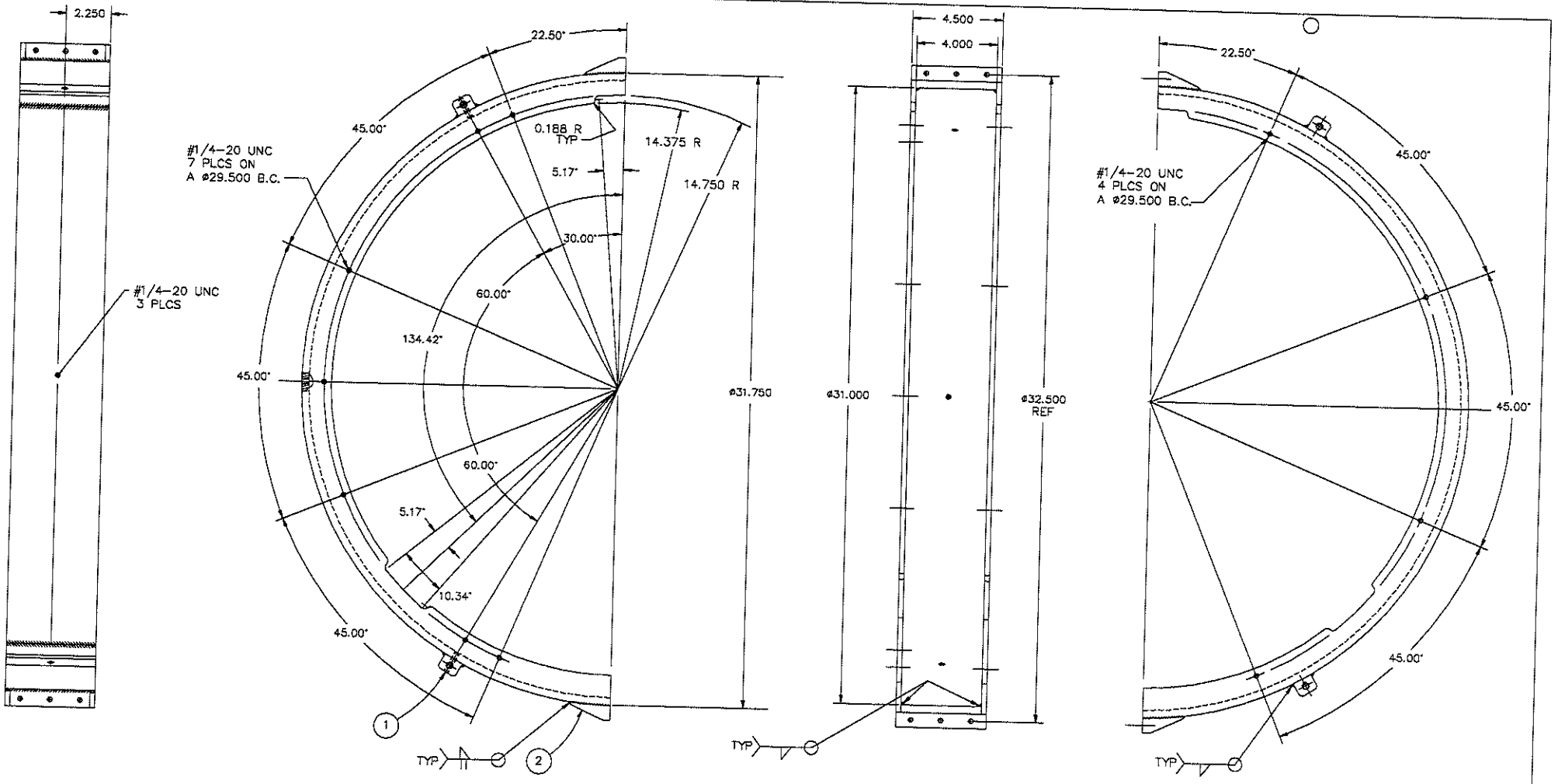
REV

1/2

KECK/HIRES
MENISCUS LENS
TRANSPORT FIXTURE DETAILS

D.C.D. 6/1/93
C.A.Q. 6/16/93

H5245



H5241-2	2	2	FLANGE	ALUM
H5241-1	1	2	FLANGE	ALUM

(-1) RING SEGMENT WELDMENT

1 REQ'D
ALUMINUM
ALODYNE COATING

REV

1/2

KECK/HIRES
MENISCUS LENS
TRANSPORT FIXTURE DETAILS

B.C.B. 6/1/83
G.A.G. 6/16/83

H5246

18 Aug 92

Hi Pat,

Here's LOTR 61. I've set it up for two sided printing, as you will see from the gutter margins and the page headers. There are blank pages now and then as needed so new sections start on odd numbered pages.

There's even a blank page for the back of the green cover page, (which is probably over doing it), and a second title page for the inside title page.

The only oddity, I think, is that I'd like the last page ("Limits Summary") to be on the inside of the back cover.

Many thanks,

Regards,
Ron

P.S. Did like 2 dozen copies for up here.
Ron