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NBS TECHNICAL NOTE 395

Design for a Variable-Output-Coupling Far-Infrared Michelson Laser

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NBS TECHNICAL NOTE 395

ISSUED JANUARY 1971

Nat. Bur. Stand. (U.S.), Tech. Note 395, 23 pages (Jan. 1971)
CODEN: NBTNA

Design for a Variable-Output-Coupling Far-Infrared Michelson Laser

J. S. Wells, K. M. Evenson, L. M. Matarrese,
D. A. Jennings, and G. L. Wichman

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DESIGN FOR A VARIABLE-OUTPUT-COUPLING FAR-INFRARED MICHELSON LASER

J. S. Wells, K. M. Evenson, L. M. Matarrese,
D. A. Jennings, and G. L. Wichman

A technique for varying the coupling of power from far-infrared gas lasers and the design and construction of these lasers are described. The coupling method is based on Michelson's interferometric principle and permits a continuously variable coupling of the available power from the laser. The present laser design is the result of evolution over the last year and a half.

Key words: HCN lasers; H_2O lasers; infrared lasers; variable coupling lasers.

The first section of this note describes a method for extracting energy from far infrared gas lasers that has none of the disadvantages of the usual hole-coupling schemes. The second section includes detailed drawings of the laser and some construction explanations.

The energy extraction method employs a Michelson interferometer configuration with a polyethylene or polypropylene beam splitter. A simple film beam splitter had been previously used by the group at NPL(1). The configuration is similar to the Smith(2) mode selector with the beam splitter perpendicular to that in the Smith design, and the use of identical mirrors at the beam splitter end. Some of the advantages are: (1) Diffraction losses are kept to a minimum because the full internal beam diameter is utilized. (2) Mode distortion is minimized. (3) The coupling may be continuously adjusted from zero to four times that of a simple beam splitter. (4) The output coupling is easily varied. (5) Line identification is simplified, as will be explained in a later part of the note. (6) The output beam is linearly polarized, a useful feature in some applications, such as in coupling to the whisker diodes used in frequency measurements.[3] (7) Finally, the device is relatively easy and inexpensive to build.

Figure 1 shows the design we have successfully employed for H_2O and HCN lasers operating from 28 to 373μm. The flat mirrors A and B can be translated by micrometer heads with a resolution of about 0.2μm. Mirror B serves to tune the resonator B-C. Mirror A varies the power coupled out of the polyethylene lens (the lens may be replaced by a flat window if a focused beam is not desired,) by varying the relative phase of the waves returning to the beam splitter from mirrors A and B. Since resonator AC has such a low Q, frequency pulling by AC is negligible. The dielectric beam splitter, which is set at an angle of 45^{o} to the laser tube axis, is a taut polyethylene or polypropylene membrance of such a thickness that provides constructive interference of the beams reflected from each of its surfaces. This thickness is an odd multiple of

$$t = 1/4\,\lambda_0 (n^2 - 1/2)^{-1/2}\,, \tag{1}$$

where λ_0 is the vacuum wavelength of the laser radiation, and n is the refractive index of the beam splitter material (about 1.5). For example, our HCN laser ($\lambda_0 = 337\,\mu m = 13.3$ mil) has a membrane 2.5 mil thick. The H_2O laser ($\lambda_0 = 28\,\mu m = 1.1$ mil) uses a membrane approximately 0.6 mil thick, which is about 3 times the value given by Eq. (1), since we were unable to obtain thinner polyethylene or polypropylene film of suitable quality.

As an example of the operation of the coupling control, we show in figure 2 recorder traces of the power coupled out of an HCN laser (337μm) as function of displacement of mirror A, with laser tube current as parameter. When the two waves recombining on the beam splitter are 180° out of phase, there is practically complete cancellation of the output at current setting. Halfway between, where constructive interference is at a maximum, the laser is actually overcoupled, a desirable condition since one is then sure of obtaining maximum laser output at some intermediate setting of mirror A. If the laser gain is not high enough, there will be no oscillation in the overcoupled region. This is seen in figure 2 at laser currents of less than 0.2A, and is the normal situation with the 78- and 118-μm lines of the H_2O laser. (The water vapor laser only lases on the 28μm line unless the three mirrors are all precisely aligned.) The table shows the powers we have been able to obtain from various lasers using this coupling method.

The side mirror has also proved useful in simplifying line identification. With mirror B fixed, one need only measure the translation of mirror A from one 180° phase point to the next as on figure 2.

The power relectivity of the film at these wavelengths is about 4% so that the maximum fraction of power coupled out of the laser is about 16%. This can be increased even more, if the laser gain permits, by using a compound beam splitter, - that is two parallel membranes with the appropriate interspace between them.

A disadvantage of this scheme which we have noticed is the tendency for drumhead resonances to appear in the membrane if the plasma current is modulated. These can be eliminated, but at a sacrifice of output power, by using a much thicker membrane.

Construction notes and detailed drawings comprise the remainder of this note.

The vacuum seals involve O-rings which have been lightly greased. The laser tube has O-rings clamped between a flat surface and a 45° chamfered surface which causes a seal between the O-ring and the glass and at the same time allows the glass to slide as it heats and expands in length. A similar detail allows the micrometer rods to pass thru on O-ring seal. The cathode and anode seals contact O-rings which rest on a 30 mm flared section of glass with differential pressure performing the previous function of the clamp. Other O-ring seals are in conventional grooves.

Epoxy is used to provide a seal at the interface of a ground glass donut and the curved mirror, C. Epoxy (or type W black wax of the low pressure variety) is also used to fasten the mirrors A and B to aluminum mounting disks which are attached to coupling rods to the micrometers.

Pairs of ball bushings (supporting the rods to which hold the mirrors) were quite effective in insuring proper translation of the mirrors. Two ball bushings were needed to overcome the changing torque and resulting mirror tipping as the relatively massive mirror was moved axially.

The beam splitter polyethylene is kitchen variety wrapping material. Typically this material will have dents and imperfections when taken from the container. Our technique is to stretch this tightly and attach it to a frame with two-sided adhesive tape, then heat it slightly with a hot air gun until the dents and imperfections disappear. It is then attached to the beam splitter frame with rubber cement.

The laser is aligned by tightening screws which compress the O-rings separating the laser proper from supports for the mirrors. Once the laser is aligned optically, three reference screws are tightened and used as stops for automatic alignment after subsequent laser disassembly and reassembly.

The water cooled cathodes are constructed almost entirely from standard copper plumbing items; the lone exception is the item into which the 1/4" water lines feed. A standard quick connect makes the water seal at the upper end. This permits one to change the insert (consisting of the inner pipe with the reducer hard soldered to it) by merely changing one soft solder joint and redoing it. Under certain discharge conditions, an electron beam from the cathode has melted a hole in the glass. This possibility has been eliminated by placing a semicircular stainless steel insert about 3cm. long below the cathode.

We have found the following alignment procedure to be very useful:

1. Align the end mirrors B and C with a 6328 Å laser or sighting down the bore and use the reference screws to precisely reposition the first mirror aligned. If mirror C is aligned first, mirror A may be aligned at the same time as mirror B by causing reflected laser light from mirror A to be superposed on that from B

and the beam splitter at some distance from the laser. Mirror C is then accurately repositioned by the reference screws.

2. With the laser oscillating on the 337μm line for HCN or 28μm line for the H_2O laser, mirrors B and C are alternately slightly readjusted until the output power is maximized.

3. Liquid crystal is positioned at the focal point of the polyethylene lens for the final adjustment. Mirror A is adjusted until beams from mirrors A and B are superposed as evidenced by a single spot rather than two on the liquid crystal. Another manifestation of this alignment is the absence of interference fringes on the liquid crystal when it is held next to the polyethylene lens rather than at its focal point. After this step is completed, a detector is placed at the focal point and mirror A is very finely aligned to give the maximum fluctuation in the output signal as mirror A is translated. The laser then should be properly aligned.

We would like to thank V. Lecinski for the fine draftsmanship and K. Gebert for his contributions regarding the cathode construction.

Table: Powers available from H_2O and HCN Michelson Lasers. The lasers were 8 meters long and of folded confocal geometry. The power was measured with an "aquadag" blackened copper cone calorimeter.

Laser	λ	Inside Diameter	Power	Gas Mixtures
HCN	337 μm	133 mm	150 mW*	Ammonia and methane
HCN	311 μm	133 mm	50 mW*	"
H_2O	118 μm	75 mm	20 mW	H_2O vapor and hydrogen
H_2O	79 μm	75 mm	15 mW	"
H_2O	78 μm	75 mm	40 mW	"
H_2O	28 μm	37 mm	450 mW (Multimode)	"

* The HCN laser discharge was adjusted for maximum spectral purity and not maximum gain. Good spectral purity is evidenced by stationary striations in the methane and ammonia discharge.

REFERENCES

1. J. E. Chamberlain, et. al. Infrared Physics 6, 195 (1966)
2. P. W. Smith, IEEE J. Quantum Electronics, QEI, 343 (1965)
3. K. M. Evenson, J. S. Wells and L. M. Matarrese, Appl. Phys. Letters, 16, 251 (1970).
4. Born and Wolf, Principles of Optics, Permagon Press (1959) p. 281

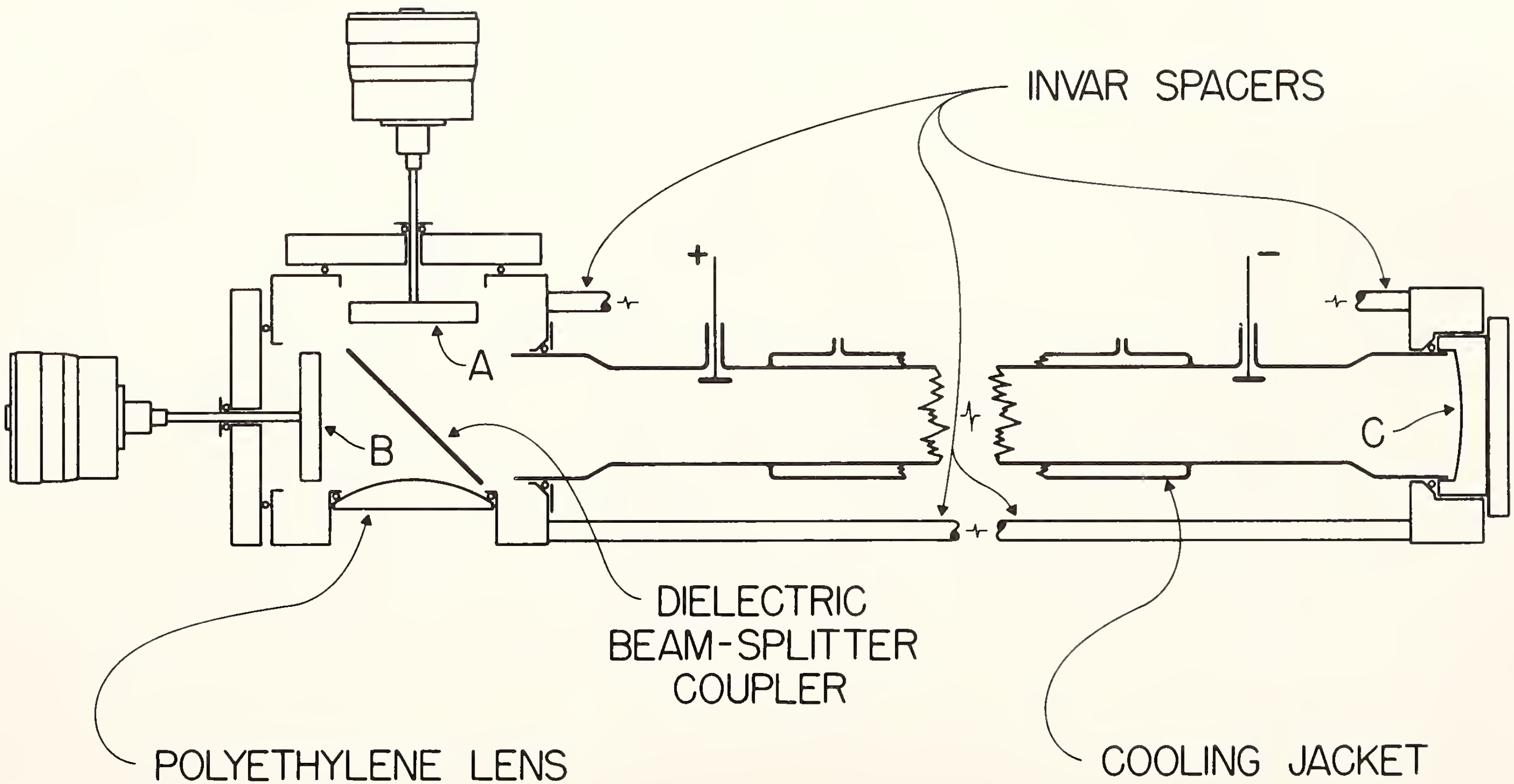

Figure 1. Schematic drawing of HCN and H_2O variable coupling far infrared laser. The HCN Laser does not have a cooling jacket.

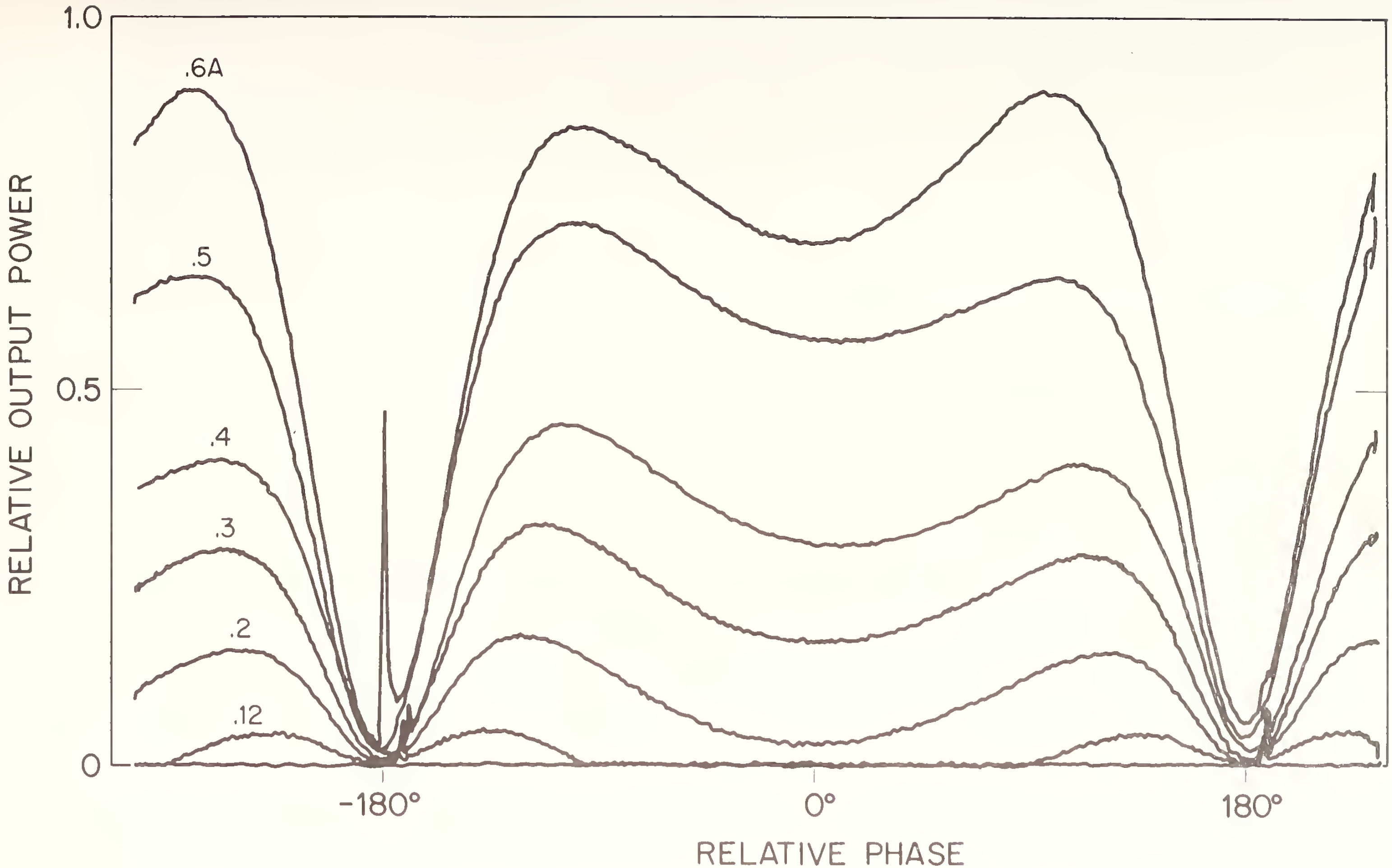

Figure 2. Recorder traces of power coupled out of an HCN laser (337µm) by the device of figure 1 as a function of the relative phase of the waves reflected from mirrors A and B. The parameter is laser tube current. A power meter was connected to the Y-axis of the recorder, and a transducer giving a signal proportional to the displacement of mirror A, to the X-axis. The transient spikes appearing at the 180° positions are caused by mode jumping in the laser.

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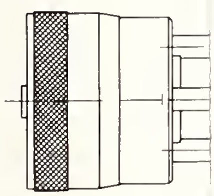
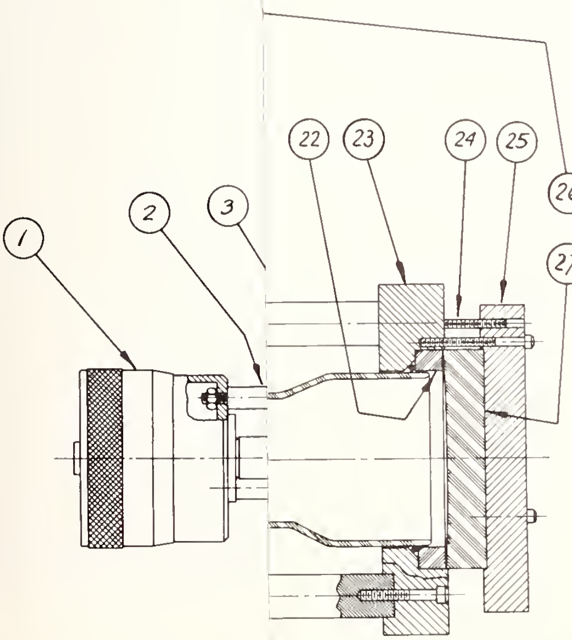


LIST OF STOCK PARTS

NOMENCLATURE	NO REQ'D
O-RING PARKER No. 2-118	2
O-RING PARKER No. 2-349	2
O-RING PARKER No. 2-344	2
O-RING PARKER No. 2-246	1
O-RING PARKER No. 2-245	1
O-RING PARKER No. 2-10	2
STEEL SET SCREW, #8-32 UNC 1½ LONG (SPECIAL), FLAT POINT	3
STEEL SCREW, #10-32 UNF HEX. SOCKET HEAD, 2¼ LONG	3
BRASS SCREW, #10-32 UNF ROUND HEAD, ½ LONG (FOR ANODE)	1
STEEL SET SCREW, #6-32 UNC 3/8 LONG, FLAT POINT	2
STEEL SCREW, #10-32 UNF HEX. SOCKET HEAD, 1" LONG	8
STEEL STUD SCREW, ¼-20 UNC 1 3/8 LONG	4
STEEL SCREW, ¼-20 UNC HEX. SOCKET HEAD, 1½ LONG	8
STEEL SET SCREW, #8-32 UNC 1" LONG, FLAT POINT	6
STEEL SCREW, #10-32 UNF HEX. SOCKET HEAD, 1 3/8 LONG	10
BRASS SCREW, #6-32 UNC FILLISTER HEAD, 3/8 LONG	6
STEEL SPLIT SHAFT CLAMP (.250 I.D.)	2
NYLON SCREW, #6-32 UNC FILLISTER HEAD, 3/8 LONG	6
BALL BUSHING (.250 I.D.) CAT. No. A-4812 (THOMSON)	4
MICROMETER L.S. STARRETT #469 MH (METRIC) RANGE: 0-25mm	2
BRASS OR STEEL HEX. NUT ¼-28 UNF	6



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ANGLES ± ½

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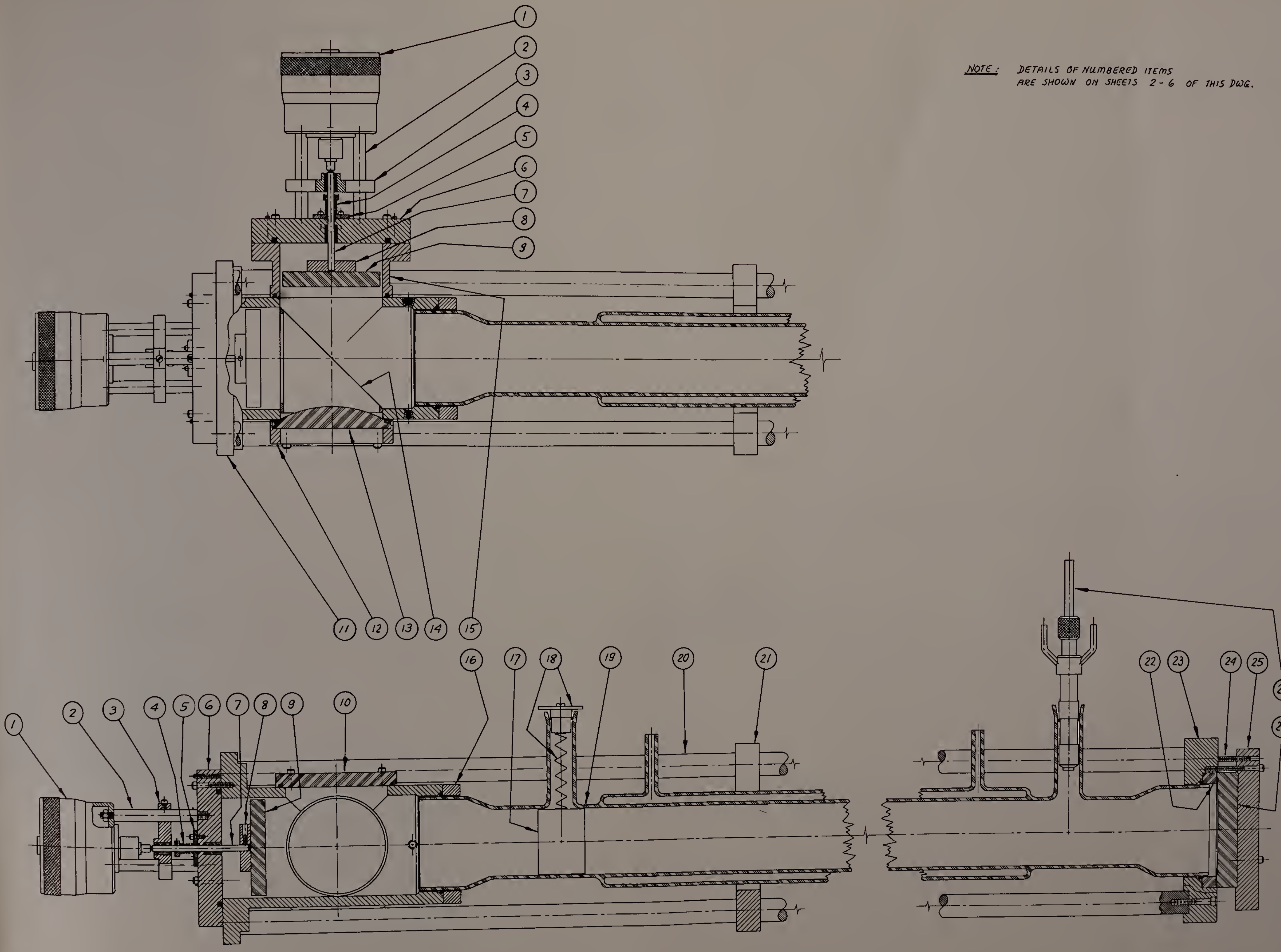

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NOMENCLATURE	NO REQ'D
O-RING PARKER No. 2 - 118	2
O - RING PARKER No. 2 - 349	2
O - RING PARKER No. 2 - 344	2
O-RING PARKER No. 2-246	1
O-RING PARKER No. 2-245	1
O-RING PARKER No. 2 - 10	2
STEEL SET SCREW, # 8-32 UNC 1½ LONG (SPECIAL), FLAT POINT	3
STEEL SCREW, #10 - 32 UNF HEX. SOCKET HEAD, 2¼ LONG	3
BRASS SCREW, #10 - 32 UNF ROUND HEAD, ½ LONG (FOR ANODE)	1
STEEL SET SCREW, # 6-32 UNC 3/8 LONG, FLAT POINT	2
STEEL SCREW, # 10 -32 UNF HEX. SOCKET HEAD, 1" LONG	8
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STEEL SET SCREW, # 8-32 UNC 1" LONG, FLAT POINT	6
STEEL SCREW, # 10-32 UNF HEX. SOCKET HEAD, 1 3/8 LONG	10
BRASS SCREW, # 6 - 32 UNC FILLISTER HEAD, 3/8 LONG	6
STEEL SPLIT SHAFT CLAMP (.250 I.D.)	2
NYLON SCREW, # 6 - 32 UNC FILLISTER HEAD, 3/8 LONG	6
BALL BUSHING (.250 I.D.) CAT. No. A - 4812 (THOMSON)	4
MICROMETER L.S. STARRETT # 469 MH (METRIC) RANGE: 0-25mm	2
BRASS OR STEEL HEX. NUT ¼ - 28 UNF	6

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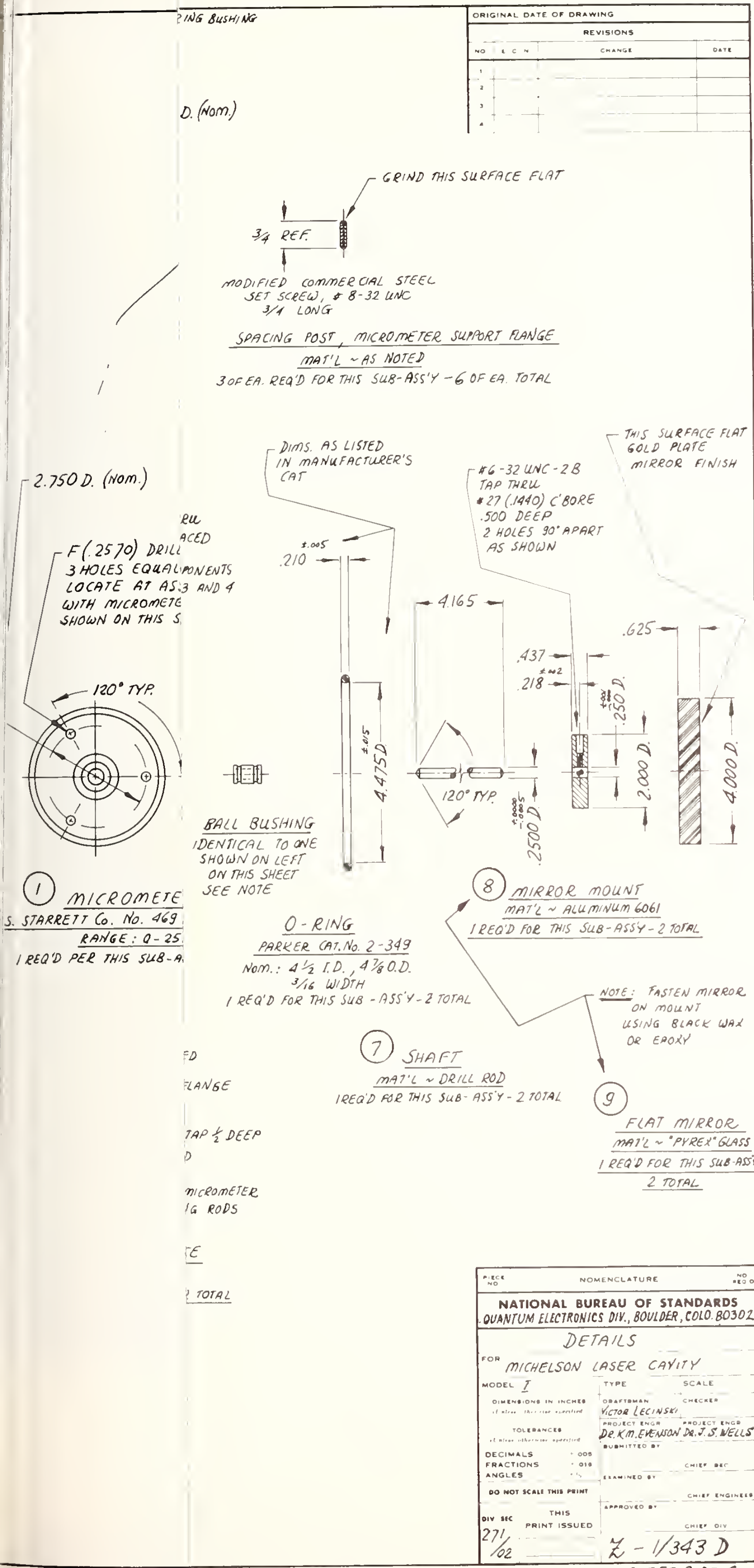

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RING BUSHING
D. (Nom.)
GRIND THIS SURFACE FLAT
3/4 REF.
MODIFIED COMMERCIAL STEEL SET SCREW, # 8-32 UNC 3/4 LONG
SPACING POST, MICROMETER SUPPORT FLANGE
MAT'L ~ AS NOTED
3 OF EA. REQ'D FOR THIS SUB-ASS'Y – 6 OF EA. TOTAL
2.750 D. (Nom.)
DIMS. AS LISTED IN MANUFACTURER'S CAT
THIS SURFACE FLAT GOLD PLATE MIRROR FINISH
#6-32 UNC-2B TAP THRU
#27 (.1440) C'BORE .500 DEEP
2 HOLES 90° APART AS SHOWN
RU
ACED
F (.2570) DRILL
3 HOLES EQUAL
LOCATE AT AS
WITH MICROMETE
SHOWN ON THIS S
PONENTS
3 AND 4
±.005
.210
4.165
.625
.437
±.002
.218
±.002
.250 D.
120° TYP.
±.015
4.475 D.
120° TYP.
+.0000
–.0005
.2500 D.
2.000 D.
4.000 D.
BALL BUSHING
IDENTICAL TO ONE SHOWN ON LEFT ON THIS SHEET
SEE NOTE
1
MICROMETE
S. STARRETT Co. No. 469
RANGE: 0-25
1 REQ'D PER THIS SUB-A
8
MIRROR MOUNT
MAT'L ~ ALUMINUM 6061
1 REQ'D FOR THIS SUB-ASS'Y – 2 TOTAL
O-RING
PARKER CAT. No. 2-349
Nom.: 4 1/2 I.D., 4 7/8 O.D.
3/16 WIDTH
1 REQ'D FOR THIS SUB-ASS'Y – 2 TOTAL
NOTE: FASTEN MIRROR ON MOUNT USING BLACK WAX OR EPOXY
7
SHAFT
MAT'L ~ DRILL ROD
1 REQ'D FOR THIS SUB-ASS'Y – 2 TOTAL
9
FLAT MIRROR
MAT'L ~ "PYREX" GLASS
1 REQ'D FOR THIS SUB-ASS'Y
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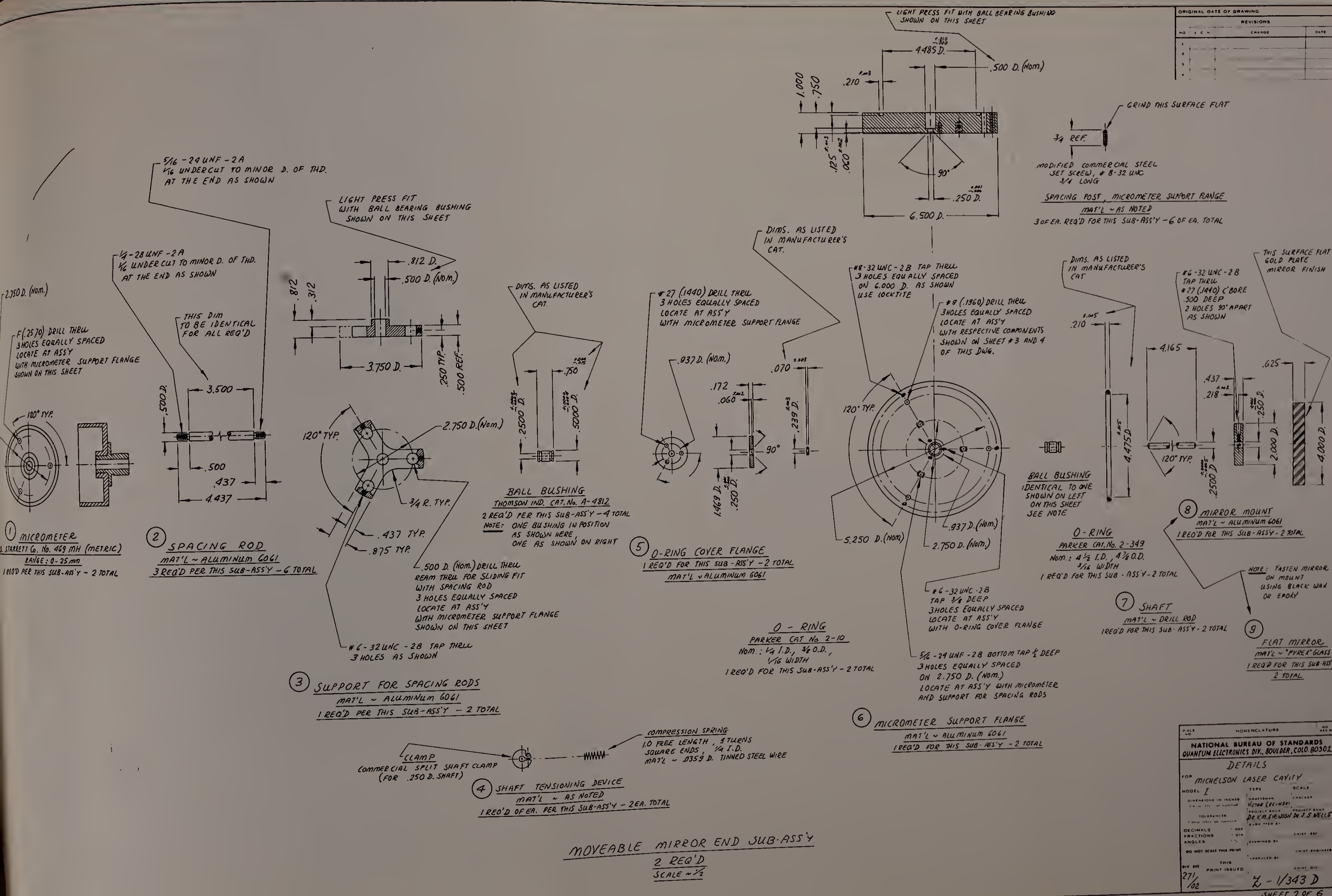
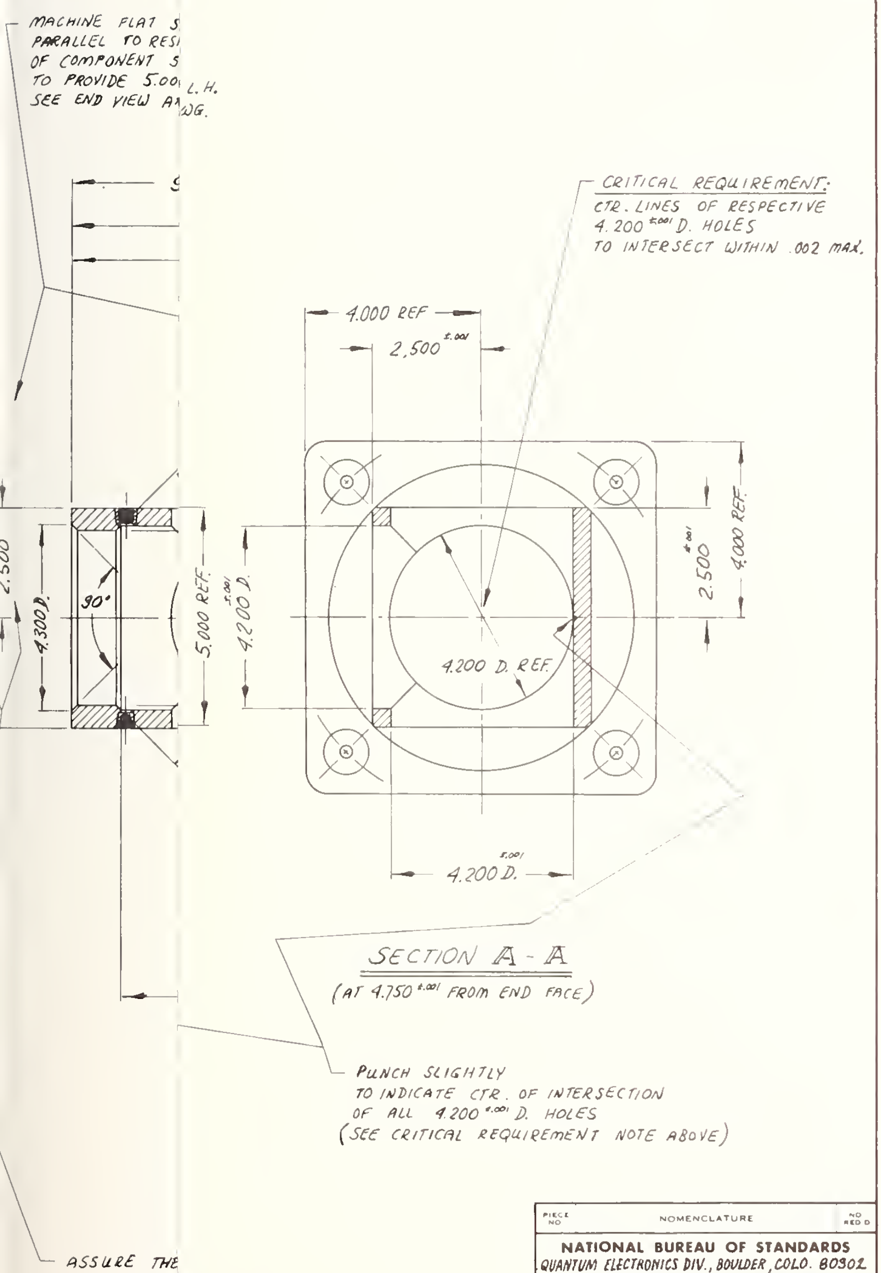


1 MICROMETER
L.S. STARRETT Co. No. 469 MH (METRIC)
RANGE: 0-25 mm
1 REQ'D PER THIS SUB-ASS'Y - 2 TOTAL
F (.2570) DRILL THRU 3 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH MICROMETER SUPPORT FLANGE SHOWN ON THIS SHEET
2.750 D. (Nom.)
120° TYP.
2 SPACING ROD
MAT'L ~ ALUMINUM 6061
3 REQ'D PER THIS SUB-ASS'Y - 6 TOTAL
5/16 - 24 UNF - 2A 1/16 UNDERCUT TO MINOR D. OF THD. AT THE END AS SHOWN
1/4 - 28 UNF - 2A 1/16 UNDERCUT TO MINOR D. OF THD. AT THE END AS SHOWN
THIS DIM TO BE IDENTICAL FOR ALL REQ'D
3.500
.500 D.
.500
.437
4.437
LIGHT PRESS FIT WITH BALL BEARING BUSHING SHOWN ON THIS SHEET
.812 D.
.500 D. (Nom.)
.812
.312
3.750 D.
.250 TYP.
.500 REF.
120° TYP.
2.750 D. (Nom.)
3/4 R. TYP.
.437 TYP.
.875 TYP.
.500 D. (Nom.) DRILL THRU REAM THRU FOR SLIDING FIT WITH SPACING ROD 3 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH MICROMETER SUPPORT FLANGE SHOWN ON THIS SHEET
6 - 32 UNC - 2B TAP THRU 3 HOLES AS SHOWN
3 SUPPORT FOR SPACING RODS
MAT'L ~ ALUMINUM 6061
1 REQ'D PER THIS SUB-ASS'Y - 2 TOTAL
DIMS. AS LISTED IN MANUFACTURER'S CAT.
.750
.2500 D.
.5000 D.
BALL BUSHING
THOMSON IND. CAT. No. A-4812
2 REQ'D PER THIS SUB-ASS'Y - 4 TOTAL
NOTE: ONE BUSHING IN POSITION AS SHOWN HERE, ONE AS SHOWN ON RIGHT
27 (.1440) DRILL THRU 3 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH MICROMETER SUPPORT FLANGE
.937 D. (Nom.)
.172
.060
90°
1.469 D.
.250 D.
5 O-RING COVER FLANGE
1 REQ'D FOR THIS SUB-ASS'Y - 2 TOTAL
MAT'L ~ ALUMINUM 6061
DIMS. AS LISTED IN MANUFACTURER'S CAT.
.070
.239 D.
O - RING
PARKER CAT No. 2-10
Nom.: 1/4 I.D., 3/8 O.D., 1/16 WIDTH
1 REQ'D FOR THIS SUB-ASS'Y - 2 TOTAL
LIGHT PRESS FIT WITH BALL BEARING BUSHING SHOWN ON THIS SHEET
4.485 D.
.500 D. (Nom.)
.210
1.000
.750
.125
.020
90°
.250 D.
6.500 D.
#8-32 UNC - 2B TAP THRU 3 HOLES EQUALLY SPACED ON 6.000 D. AS SHOWN USE LOCKTITE
9 (.1960) DRILL THRU 3 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH RESPECTIVE COMPONENTS SHOWN ON SHEET # 3 AND 4 OF THIS DWG.
120° TYP.
5.250 D. (Nom.)
.937 D. (Nom.)
2.750 D. (Nom.)
6 - 32 UNC - 2B TAP 3/8 DEEP 3 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH O-RING COVER FLANGE
5/16 - 24 UNF - 2B BOTTOM TAP 1/2 DEEP 3 HOLES EQUALLY SPACED ON 2.750 D. (Nom.) LOCATE AT ASS'Y WITH MICROMETER AND SUPPORT FOR SPACING RODS
6 MICROMETER SUPPORT FLANGE
MAT'L ~ ALUMINUM 6061
1 REQ'D FOR THIS SUB-ASS'Y - 2 TOTAL
GRIND THIS SURFACE FLAT
3/4 REF.
MODIFIED COMMERCIAL STEEL SET SCREW, # 8-32 UNC 3/4 LONG
SPACING POST, MICROMETER SUPPORT FLANGE
MAT'L ~ AS NOTED
3 OF EA. REQ'D FOR THIS SUB-ASS'Y - 6 OF EA. TOTAL
BALL BUSHING
IDENTICAL TO ONE SHOWN ON LEFT ON THIS SHEET SEE NOTE
DIMS. AS LISTED IN MANUFACTURER'S CAT
.210
4.475 D.
O - RING
PARKER CAT. No. 2-349
Nom.: 4 1/2 I.D., 4 7/8 O.D. 3/16 WIDTH
1 REQ'D FOR THIS SUB-ASS'Y - 2 TOTAL
4.165
120° TYP.
.2500 D.
7 SHAFT
MAT'L ~ DRILL ROD
1 REQ'D FOR THIS SUB-ASS'Y - 2 TOTAL
6 - 32 UNC - 2B TAP THRU # 27 (.1440) C'BORE .500 DEEP 2 HOLES 90° APART AS SHOWN
.437
.218
.250 D.
2.000 D.
8 MIRROR MOUNT
MAT'L ~ ALUMINUM 6061
1 REQ'D FOR THIS SUB-ASS'Y - 2 TOTAL
THIS SURFACE FLAT GOLD PLATE MIRROR FINISH
.625
4.000 D.
NOTE: FASTEN MIRROR ON MOUNT USING BLACK WAX OR EPOXY
9 FLAT MIRROR
MAT'L ~ "PYREX" GLASS
1 REQ'D FOR THIS SUB-ASS'Y
2 TOTAL
CLAMP
COMMERCIAL SPLIT SHAFT CLAMP (FOR .250 D. SHAFT)
COMPRESSION SPRING
1.0 FREE LENGTH, 5 TURNS SQUARE ENDS, 1/4 I.D.
MAT'L ~ .0359 D. TINNED STEEL WIRE
4 SHAFT TENSIONING DEVICE
MAT'L ~ AS NOTED
1 REQ'D OF EA. PER THIS SUB-ASS'Y - 2 EA. TOTAL
MOVEABLE MIRROR END SUB-ASS'Y
2 REQ'D
SCALE ~ 1/2
ORIGINAL DATE OF DRAWING
REVISIONS
NATIONAL BUREAU OF STANDARDS
QUANTUM ELECTRONICS DIV., BOULDER, COLO. 80302
DETAILS
FOR MICHELSON LASER CAVITY
MODEL I
VICTOR LECINSKI
DR. K.M. EVENSON DR. J.S. WELLS
271/02
Z - 1/343 D
SHEET 2 OF 6

REVISIONS			
NO	L C N	CHANGE	DATE
1			
2			
3			
4			



PIECE NO | NOMENCLATURE | NO REQ'D

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QUANTUM ELECTRONICS DIV., BOULDER, COLO. 80302

DETAILS
FOR MICHELSON LASER CAVITY

MODEL I | TYPE | SCALE

DIMENSIONS IN INCHES (Unless otherwise specified)
DRAFTSMAN: VICTOR LECINSKI | CHECKER
PROJECT ENGR: DR. K.M. EVENSON | PROJECT ENGR: DR. J.S. WELLS

TOLERANCES (Unless otherwise specified)
DECIMALS ± .005
FRACTIONS ± .016
ANGLES ± ½

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EXAMINED BY | CHIEF ENGINEER
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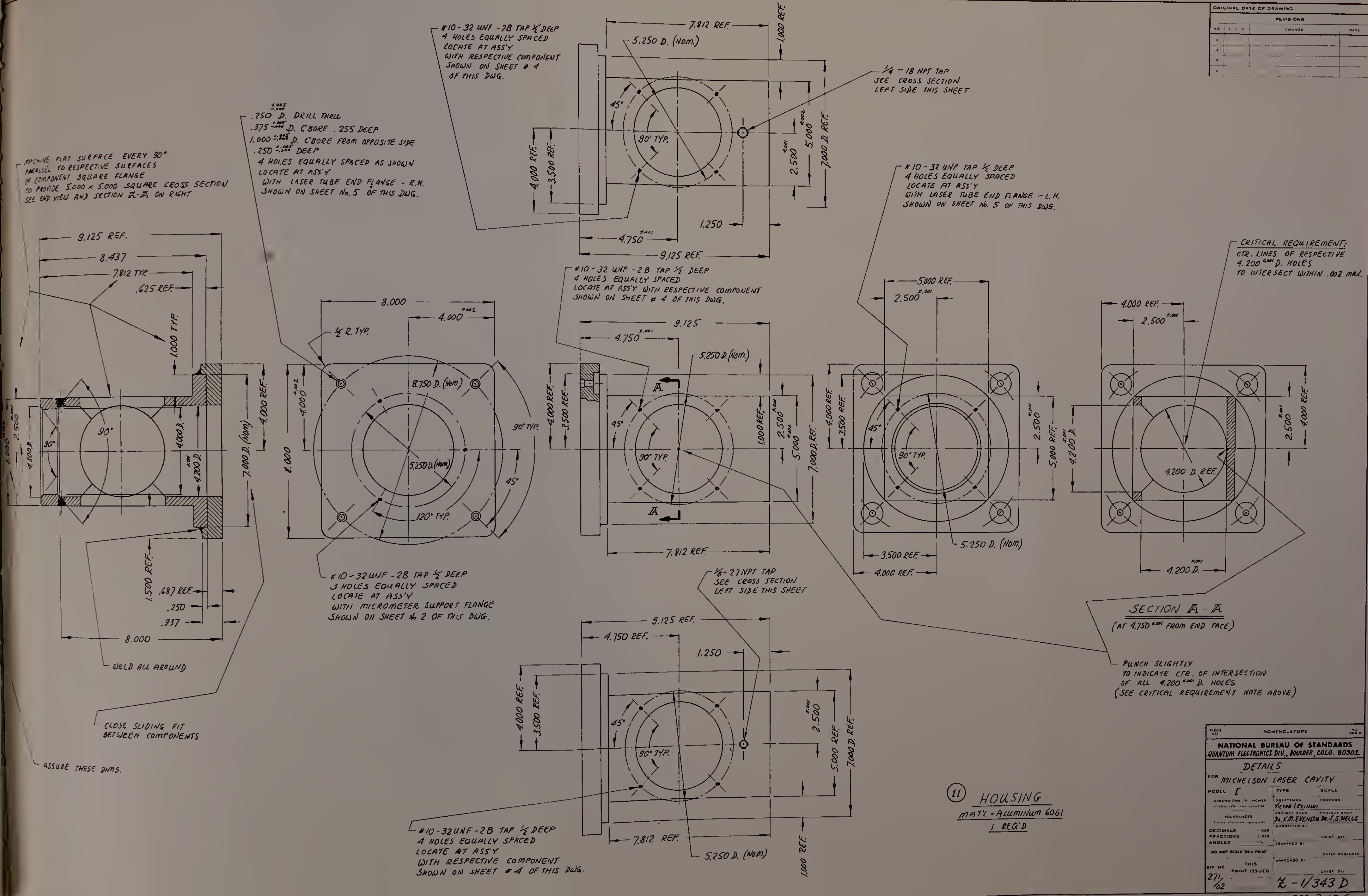

ORIGINAL DATE OF DRAWING

REVISIONS

NO	I C N	CHANGE	DATE
1			
2			
3			
4			

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DETAILS
FOR MICHELSON LASER CAVITY

MODEL I

DRAFTSMAN: VICTOR LECINSKI
PROJECT ENGR: DR. K.M. EVENSON
PROJECT ENGR: DR. J.S. WELLS

DIMENSIONS IN INCHES
TOLERANCES
DECIMALS ±.005
FRACTIONS ±.015
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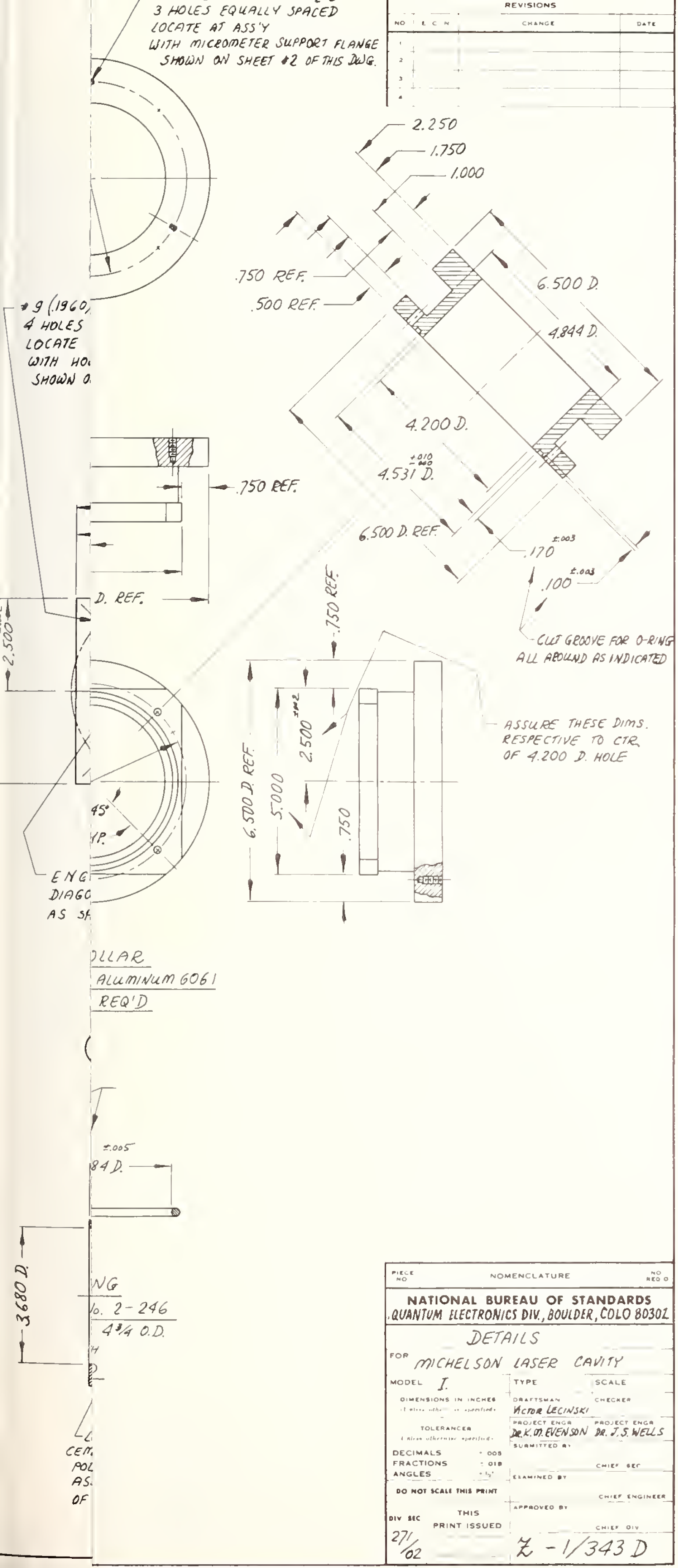
SHEET 3 OF 6


3 HOLES EQUALLY SPACED
LOCATE AT ASS'Y
WITH MICROMETER SUPPORT FLANGE
SHOWN ON SHEET #2 OF THIS DWG.
REVISIONS
NO
E.C.N.
CHANGE
DATE
2.250
1.750
1.000
.750 REF.
.500 REF.
6.500 D.
4.844 D.
4.200 D.
±.010 −.000
4.531 D.
6.500 D. REF.
±.003
.170
±.003
.100
CUT GROOVE FOR O-RING
ALL AROUND AS INDICATED
#9 (.1960)
4 HOLES
LOCATE
WITH HO
SHOWN O
.750 REF.
D. REF.
2.500
.750 REF.
6.500 D. REF.
5.000
2.500
.750
ASSURE THESE DIMS.
RESPECTIVE TO CTR.
OF 4.200 D. HOLE
45°
TYP.
ENG
DIAGO
AS SH
OLLAR
ALUMINUM 6061
REQ'D
±.005
84 D.
3.680 D.
NG
No. 2-246
4 3/4 O.D.
CEN
POL
AS
OF
PIECE NO
NOMENCLATURE
NO REQ'D
NATIONAL BUREAU OF STANDARDS
QUANTUM ELECTRONICS DIV., BOULDER, COLO 80302
DETAILS
FOR MICHELSON LASER CAVITY
MODEL I
TYPE
SCALE
DIMENSIONS IN INCHES
DRAFTSMAN Victor Lecinski
CHECKER
TOLERANCES
PROJECT ENGR DR. K. M. EVENSON
PROJECT ENGR DR. J. S. WELLS
SUBMITTED BY
DECIMALS ±.005
FRACTIONS ±.010
ANGLES
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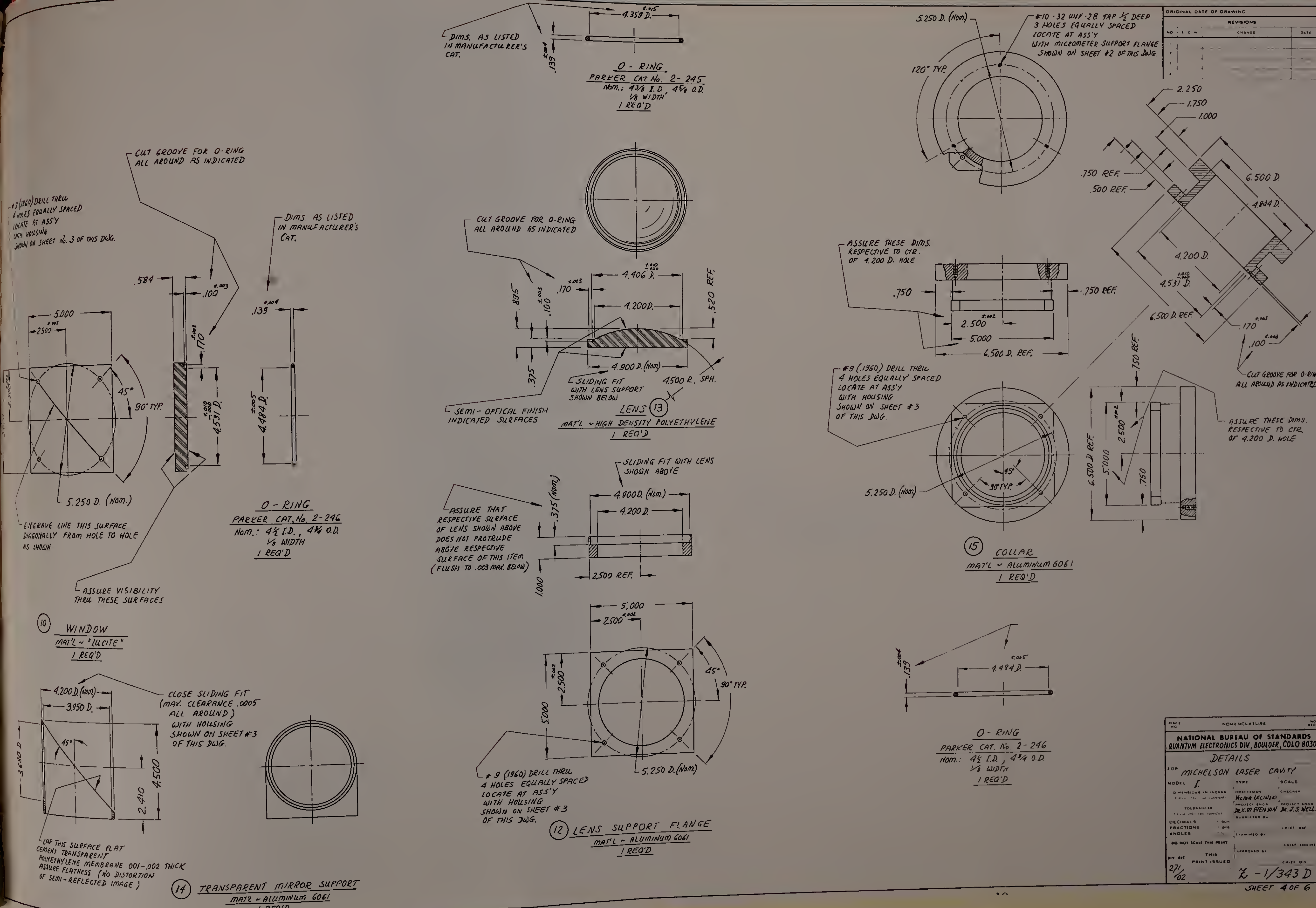

CUT GROOVE FOR O-RING ALL AROUND AS INDICATED
#9 (.1960) DRILL THRU 4 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH HOUSING SHOWN ON SHEET No. 3 OF THIS DWG.
DIMS. AS LISTED IN MANUFACTURER'S CAT.
5.250 D. (Nom.)
ENGRAVE LINE THIS SURFACE DIAGONALLY FROM HOLE TO HOLE AS SHOWN
ASSURE VISIBILITY THRU THESE SURFACES
O-RING
PARKER CAT. No. 2-246
Nom.: 4½ I.D., 4¾ O.D.
⅛ WIDTH
1 REQ'D
10 WINDOW
MAT'L ~ "LUCITE"
1 REQ'D
CLOSE SLIDING FIT (MAX. CLEARANCE .0005 ALL AROUND) WITH HOUSING SHOWN ON SHEET #3 OF THIS DWG.
LAP THIS SURFACE FLAT CEMENT TRANSPARENT POLYETHYLENE MEMBRANE .001-.002 THICK ASSURE FLATNESS (NO DISTORTION OF SEMI-REFLECTED IMAGE)
14 TRANSPARENT MIRROR SUPPORT
MAT'L ~ ALUMINUM 6061
1 REQ'D
O-RING
PARKER CAT. No. 2-245
Nom.: 4⅜ I.D., 4⅝ O.D.
⅛ WIDTH
1 REQ'D
SEMI-OPTICAL FINISH INDICATED SURFACES
SLIDING FIT WITH LENS SUPPORT SHOWN BELOW
LENS 13
MAT'L ~ HIGH DENSITY POLYETHYLENE
1 REQ'D
SLIDING FIT WITH LENS SHOWN ABOVE
ASSURE THAT RESPECTIVE SURFACE OF LENS SHOWN ABOVE DOES NOT PROTRUDE ABOVE RESPECTIVE SURFACE OF THIS ITEM (FLUSH TO .003 MAX. BELOW)
9 (1960) DRILL THRU 4 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH HOUSING SHOWN ON SHEET #3 OF THIS DWG.
12 LENS SUPPORT FLANGE
MAT'L ~ ALUMINUM 6061
1 REQ'D
#10-32 UNF-28 TAP ½ DEEP 3 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH MICROMETER SUPPORT FLANGE SHOWN ON SHEET #2 OF THIS DWG.
ASSURE THESE DIMS. RESPECTIVE TO CTR. OF 4.200 D. HOLE
#9 (.1960) DRILL THRU 4 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH HOUSING SHOWN ON SHEET #3 OF THIS DWG.
CUT GROOVE FOR O-RING ALL AROUND AS INDICATED
15 COLLAR
MAT'L ~ ALUMINUM 6061
1 REQ'D
O-RING
PARKER CAT. No. 2-246
Nom.: 4½ I.D., 4¾ O.D.
⅛ WIDTH
1 REQ'D
ORIGINAL DATE OF DRAWING
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NATIONAL BUREAU OF STANDARDS
QUANTUM ELECTRONICS DIV., BOULDER, COLO 80302
DETAILS
FOR MICHELSON LASER CAVITY
MODEL I
Victor Lecinski
K.M. Evenson
Dr. J.S. Wells
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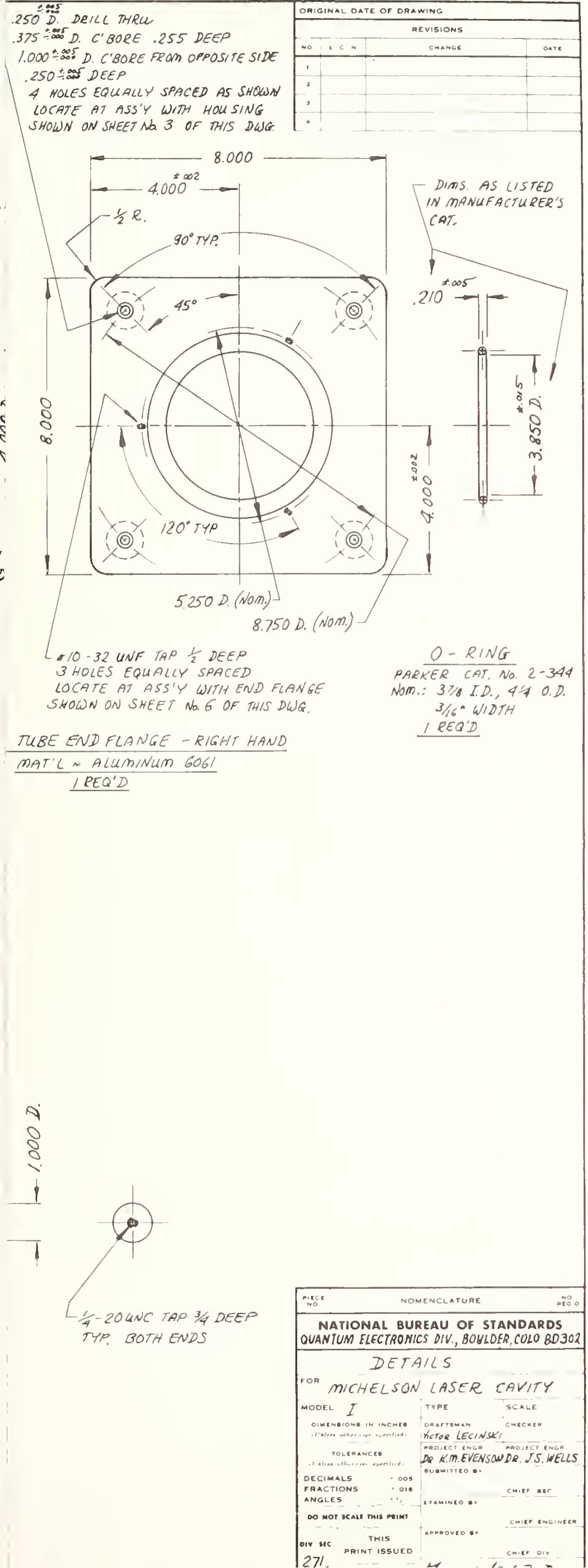
SHEET 4 OF 6



.250 +.005 -.000 D. DRILL THRU
.375 +.005 -.000 D. C'BORE .255 DEEP
1.000 +.005 -.000 D. C'BORE FROM OPPOSITE SIDE
.250 +.005 -.000 DEEP
4 HOLES EQUALLY SPACED AS SHOWN
LOCATE AT ASS'Y WITH HOUSING
SHOWN ON SHEET No. 3 OF THIS DWG.
ORIGINAL DATE OF DRAWING
REVISIONS
NO
L C N
CHANGE
DATE
1
2
3
4
8.000
±.002
4.000
1/2 R.
90° TYP.
45°
120° TYP
8.000
±.002
4.000
5.250 D. (Nom.)
8.750 D. (Nom.)
Dims. AS LISTED
IN MANUFACTURER'S
CAT.
±.005
.210
±.015
3.850 D.
AS LISTED
...FACTURER'S
...T.
±.005
.210
...ING
CAT. No. 2-344
3⅞ I.D., 4¼ O.D
...6" WIDTH
...EQ'D
#10-32 UNF TAP 1/2 DEEP
3 HOLES EQUALLY SPACED
LOCATE AT ASS'Y WITH END FLANGE
SHOWN ON SHEET No. 6 OF THIS DWG.
O - RING
PARKER CAT. No. 2-344
Nom.: 3⅞ I.D., 4¼ O.D.
3/16" WIDTH
1 REQ'D
TUBE END FLANGE - RIGHT HAND
MAT'L ~ ALUMINUM 6061
1 REQ'D
1.000 D.
1/4-20 UNC TAP 3/4 DEEP
TYP. BOTH ENDS
PIECE NO
NOMENCLATURE
NO REQ'D
NATIONAL BUREAU OF STANDARDS
QUANTUM ELECTRONICS DIV., BOULDER, COLO BD302
DETAILS
FOR MICHELSON LASER CAVITY
MODEL I
TYPE
SCALE
DIMENSIONS IN INCHES
DRAFTSMAN
Victor LECINSKI
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PROJECT ENGR
Dr. K.M. EVENSON
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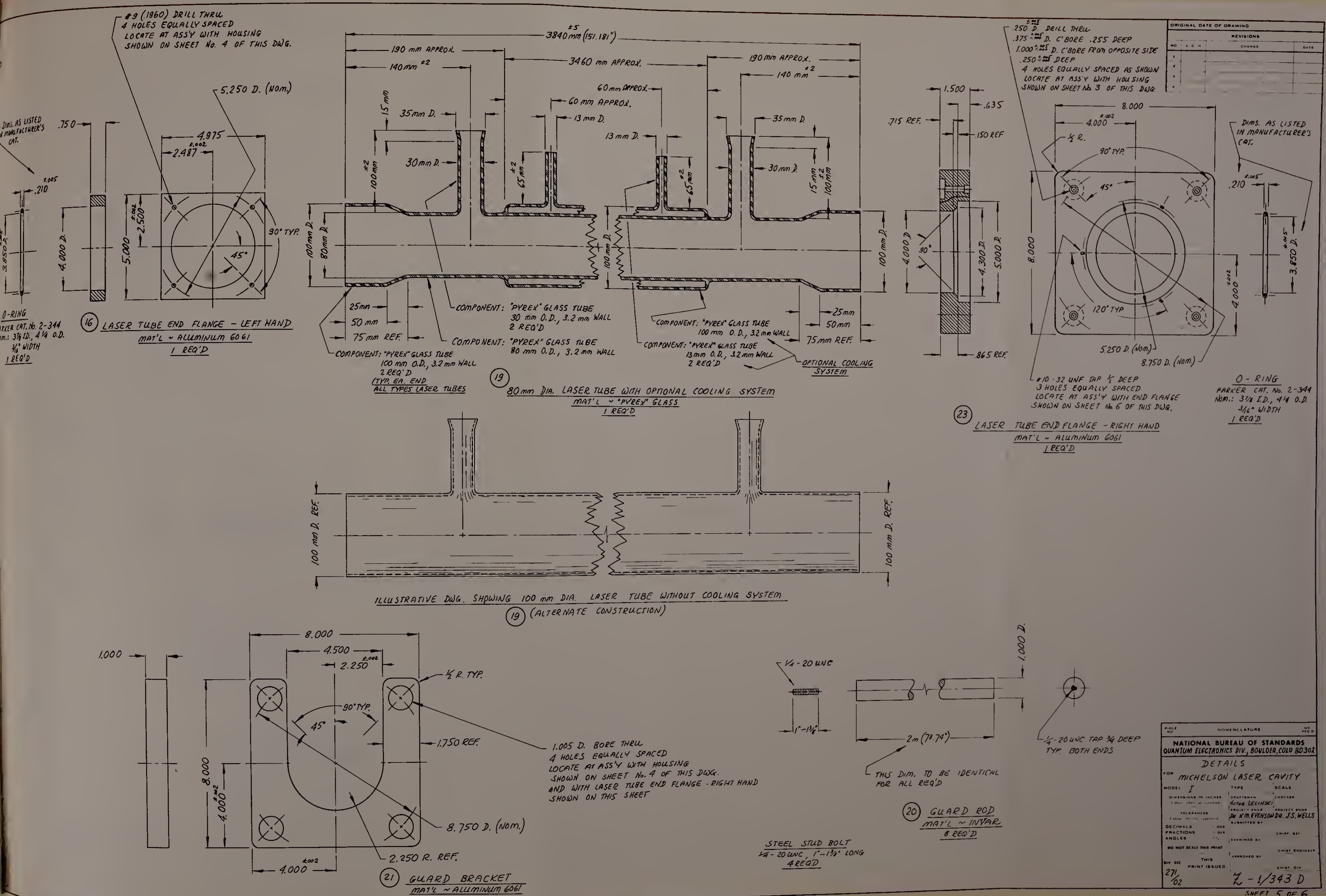

#9 (1960) DRILL THRU
4 HOLES EQUALLY SPACED
LOCATE AT ASS'Y WITH HOUSING
SHOWN ON SHEET No. 4 OF THIS DWG.
5.250 D. (NOM.)
DIMS. AS LISTED IN MANUFACTURER'S CAT.
O-RING
PARKER CAT. No. 2-344
NOM.: 3 7/8 I.D., 4 1/4 O.D.
3/16" WIDTH
1 REQ'D
16 LASER TUBE END FLANGE - LEFT HAND
MAT'L ~ ALUMINUM 6061
1 REQ'D
3840 mm (151.181")
190 mm APPROX.
140 mm
3460 mm APPROX.
60 mm APPROX.
35 mm D.
30 mm D.
13 mm D.
100 mm D.
80 mm D.
COMPONENT: "PYREX" GLASS TUBE 30 mm O.D., 3.2 mm WALL 2 REQ'D
COMPONENT: "PYREX" GLASS TUBE 80 mm O.D., 3.2 mm WALL
COMPONENT: "PYREX" GLASS TUBE 100 mm O.D., 3.2 mm WALL 2 REQ'D (TYP. EA. END ALL TYPES LASER TUBES)
COMPONENT: "PYREX" GLASS TUBE 100 mm O.D., 3.2 mm WALL
COMPONENT: "PYREX" GLASS TUBE 13 mm O.D., 3.2 mm WALL 2 REQ'D
OPTIONAL COOLING SYSTEM
19 80 mm DIA. LASER TUBE WITH OPTIONAL COOLING SYSTEM
MAT'L ~ "PYREX" GLASS
1 REQ'D
.250 D. DRILL THRU
.375 D. C'BORE .255 DEEP
1.000 D. C'BORE FROM OPPOSITE SIDE .250 DEEP
4 HOLES EQUALLY SPACED AS SHOWN
LOCATE AT ASS'Y WITH HOUSING
SHOWN ON SHEET No. 3 OF THIS DWG.
#10-32 UNF TAP 1/2 DEEP
3 HOLES EQUALLY SPACED
LOCATE AT ASS'Y WITH END FLANGE
SHOWN ON SHEET No. 6 OF THIS DWG.
5.250 D. (NOM.)
8.750 D. (NOM.)
23 LASER TUBE END FLANGE - RIGHT HAND
MAT'L ~ ALUMINUM 6061
1 REQ'D
ILLUSTRATIVE DWG. SHOWING 100 mm DIA. LASER TUBE WITHOUT COOLING SYSTEM
19 (ALTERNATE CONSTRUCTION)
100 mm D. REF.
1.005 D. BORE THRU
4 HOLES EQUALLY SPACED
LOCATE AT ASS'Y WITH HOUSING
SHOWN ON SHEET No. 4 OF THIS DWG.
AND WITH LASER TUBE END FLANGE - RIGHT HAND
SHOWN ON THIS SHEET
8.750 D. (NOM.)
2.250 R. REF.
21 GUARD BRACKET
MAT'L ~ ALUMINUM 6061
4 REQ'D
1/4-20 UNC
STEEL STUD BOLT
1/4-20 UNC, 1"-1 3/8" LONG
4 REQ'D
2 m (78.74")
THIS DIM. TO BE IDENTICAL FOR ALL REQ'D
1/4-20 UNC TAP 3/4 DEEP TYP. BOTH ENDS
20 GUARD ROD
MAT'L ~ INVAR
8 REQ'D
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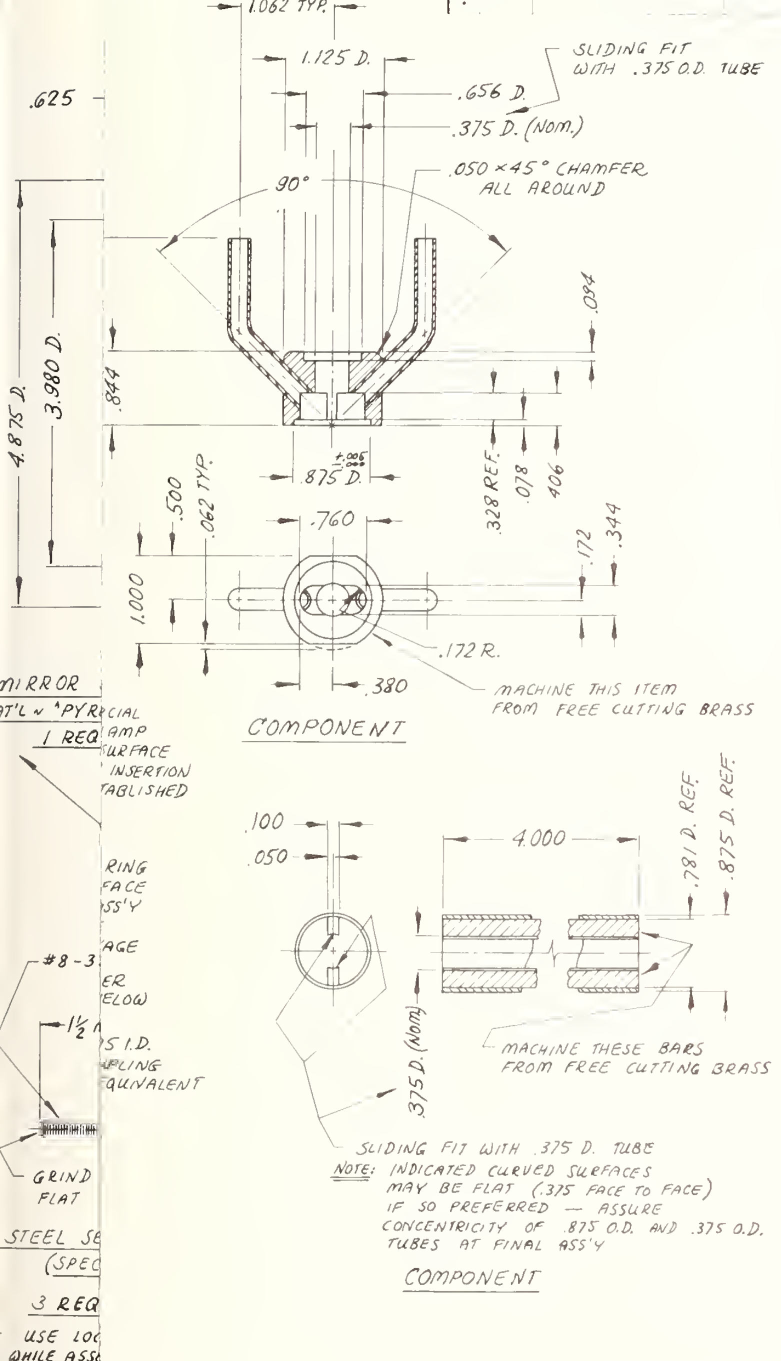
QUANTUM ELECTRONICS DIV., BOULDER, COLO 80302
DETAILS
FOR MICHELSON LASER CAVITY
MODEL I
VICTOR LECINSKI
DR. K.M. EVENSON
DR. J.S. WELLS
27/02
Z - 1/343 D
SHEET 5 OF 6

REVISIONS

NO	E C N	CHANGE	DATE
1	'A'	PART No 17 CHANGED WAS STAINLESS STEEL .030 THICK	1 SEP 1970
2			
3			
4			



TO BE HARD SOLDERED
DER IN PLACE AS INDICATED
ASSEMBLY
Y BE EASILY REPLACED

PIECE NO	NOMENCLATURE	NO REQ'D

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QUANTUM ELECTRONICS DIV., BOULDER, COLO. 80302

DETAILS

FOR MICHELSON LASER CAVITY

MODEL I — TYPE — SCALE

DIMENSIONS IN INCHES unless otherwise specified — DRAFTSMAN: VICTOR LECINSKI — CHECKER

TOLERANCES unless otherwise specified — PROJECT ENGR: DR. K.M. EVENSON — PROJECT ENGR: DR. J.S. WELLS

DECIMALS ±.005
FRACTIONS ±.016
ANGLES ±½°

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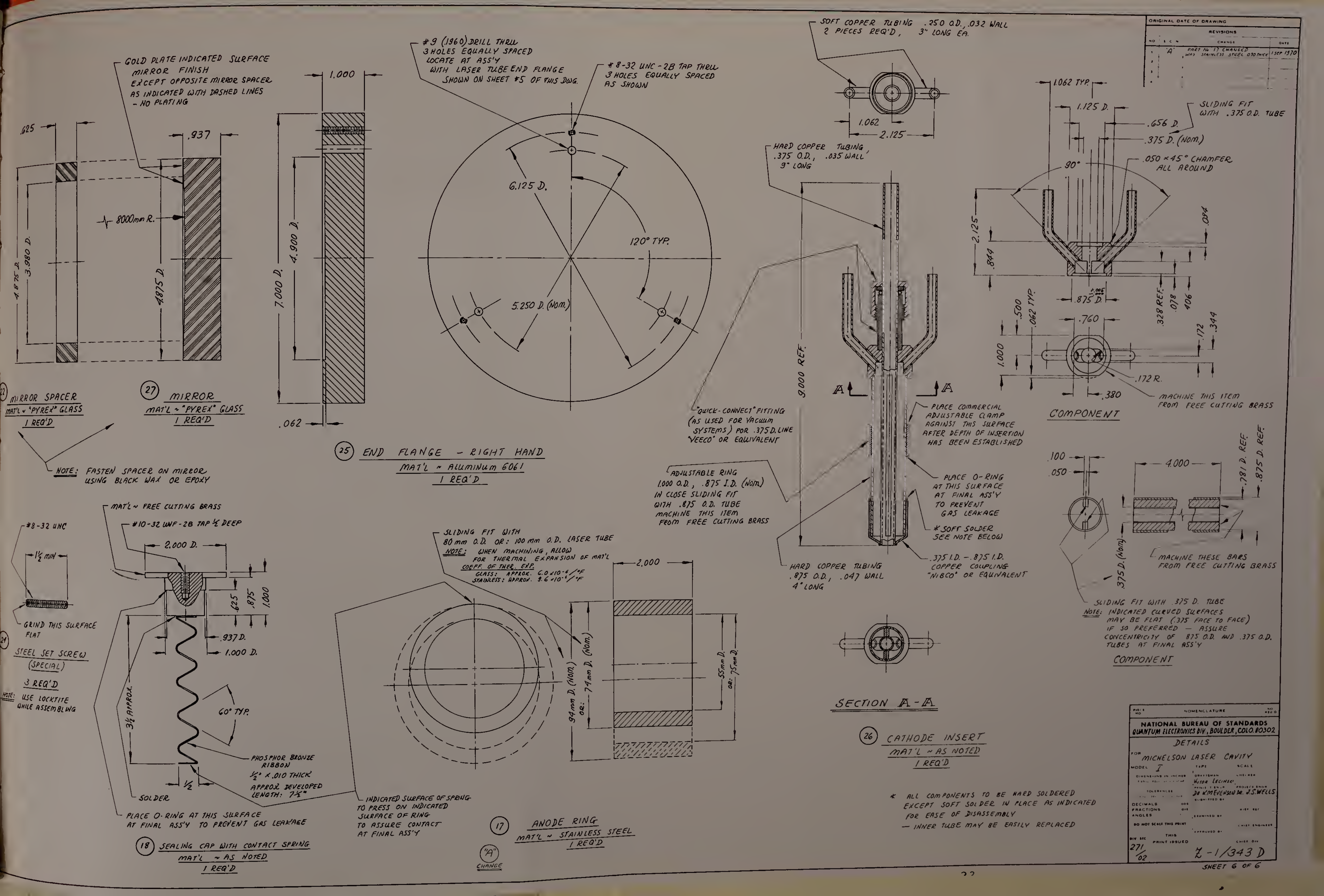

GOLD PLATE INDICATED SURFACE MIRROR FINISH EXCEPT OPPOSITE MIRROR SPACER AS INDICATED WITH DASHED LINES - NO PLATING
8000mm R.
(22) MIRROR SPACER MAT'L ~ "PYREX" GLASS 1 REQ'D
(27) MIRROR MAT'L ~ "PYREX" GLASS 1 REQ'D
NOTE: FASTEN SPACER ON MIRROR USING BLACK WAX OR EPOXY
#9 (1960) DRILL THRU 3 HOLES EQUALLY SPACED LOCATE AT ASS'Y WITH LASER TUBE END FLANGE SHOWN ON SHEET #5 OF THIS DWG.
#8-32 UNC-2B TAP THRU 3 HOLES EQUALLY SPACED AS SHOWN
6.125 D.
120° TYP.
5.250 D. (Nom.)
(25) END FLANGE - RIGHT HAND MAT'L ~ ALUMINUM 6061 1 REQ'D
SOFT COPPER TUBING .250 O.D., .032 WALL 2 PIECES REQ'D, 3" LONG EA.
HARD COPPER TUBING, .375 O.D., .035 WALL 9" LONG
"QUICK-CONNECT" FITTING (AS USED FOR VACUUM SYSTEMS) FOR .375 D. LINE "VEECO" OR EQUIVALENT
PLACE COMMERCIAL ADJUSTABLE CLAMP AGAINST THIS SURFACE AFTER DEPTH OF INSERTION HAS BEEN ESTABLISHED
ADJUSTABLE RING 1.000 O.D., .875 I.D. (Nom.) IN CLOSE SLIDING FIT WITH .875 O.D. TUBE MACHINE THIS ITEM FROM FREE CUTTING BRASS
PLACE O-RING AT THIS SURFACE AT FINAL ASS'Y TO PREVENT GAS LEAKAGE
* SOFT SOLDER SEE NOTE BELOW
HARD COPPER TUBING .875 O.D., .047 WALL 4" LONG
.375 I.D. - .875 I.D. COPPER COUPLING "NIBCO" OR EQUIVALENT
SECTION A-A
(26) CATHODE INSERT MAT'L ~ AS NOTED 1 REQ'D
SLIDING FIT WITH .375 O.D. TUBE
.050 x 45° CHAMFER ALL AROUND
MACHINE THIS ITEM FROM FREE CUTTING BRASS
COMPONENT
MACHINE THESE BARS FROM FREE CUTTING BRASS
SLIDING FIT WITH .375 D. TUBE
NOTE: INDICATED CURVED SURFACES MAY BE FLAT (.375 FACE TO FACE) IF SO PREFERRED — ASSURE CONCENTRICITY OF .875 O.D. AND .375 O.D. TUBES AT FINAL ASS'Y
COMPONENT
#8-32 UNC
GRIND THIS SURFACE FLAT
(24) STEEL SET SCREW (SPECIAL) 3 REQ'D
NOTE: USE LOCKTITE WHILE ASSEMBLING
MAT'L ~ FREE CUTTING BRASS
#10-32 UNF-2B TAP 1/2 DEEP
60° TYP.
PHOSPHOR BRONZE RIBBON 1/2" x .010 THICK APPROX. DEVELOPED LENGTH: 7 1/2"
SOLDER
PLACE O-RING AT THIS SURFACE AT FINAL ASS'Y TO PREVENT GAS LEAKAGE
(18) SEALING CAP WITH CONTACT SPRING MAT'L ~ AS NOTED 1 REQ'D
SLIDING FIT WITH 80 mm O.D. OR: 100 mm O.D. LASER TUBE
NOTE: WHEN MACHINING, ALLOW FOR THERMAL EXPANSION OF MAT'L
COEFF. OF THER. EXP. GLASS: APPROX. 6.0×10^{-6} /°F STAINLESS: APPROX. 9.6×10^{-6} /°F
INDICATED SURFACE OF SPRING TO PRESS ON INDICATED SURFACE OF RING TO ASSURE CONTACT AT FINAL ASS'Y
(17) ANODE RING MAT'L ~ STAINLESS STEEL 1 REQ'D
"A" CHANGE
* ALL COMPONENTS TO BE HARD SOLDERED EXCEPT SOFT SOLDER IN PLACE AS INDICATED FOR EASE OF DISASSEMBLY — INNER TUBE MAY BE EASILY REPLACED
ORIGINAL DATE OF DRAWING
REVISIONS
"A" PART No. 17 CHANGED WAS STAINLESS STEEL 0.50 THICK 1 SEP 1970
NATIONAL BUREAU OF STANDARDS QUANTUM ELECTRONICS DIV., BOULDER, COLO. 80302
DETAILS
FOR MICHELSON LASER CAVITY
DR. K.M. EVENSON DR. J.S. WELLS
271/02
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SHEET 6 OF 6

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