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Woods Hole Oceanographic Institution

A Passive Capture Latch for ODYSSEY-Class AUVs

by

M. F. Bowen

June 12, 1998

Technical Report

Funding was provided by the Office of Naval Research under Grant No. N000-14-95-1-1316

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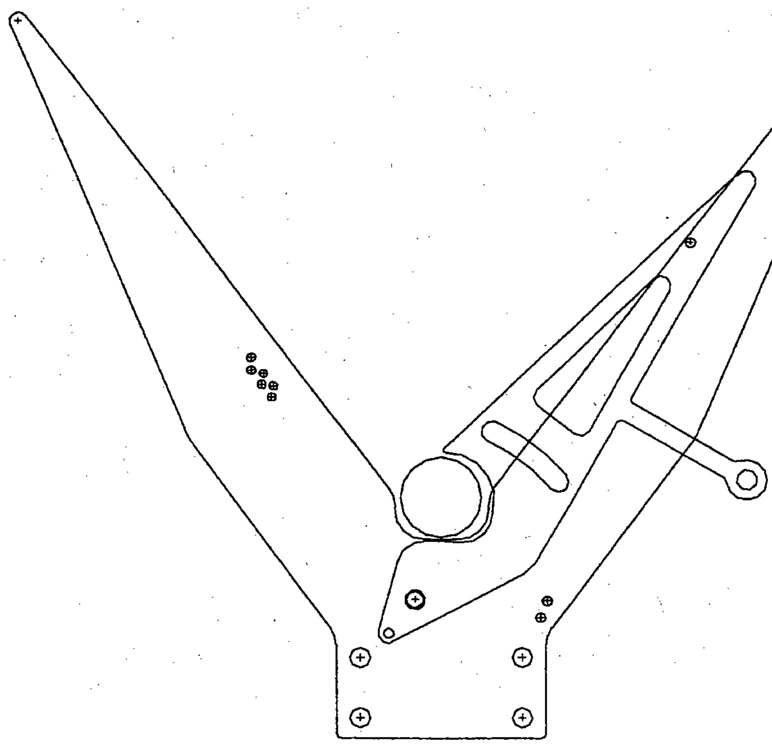

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Approved for Distribution:

Dr. Timothy Stanton

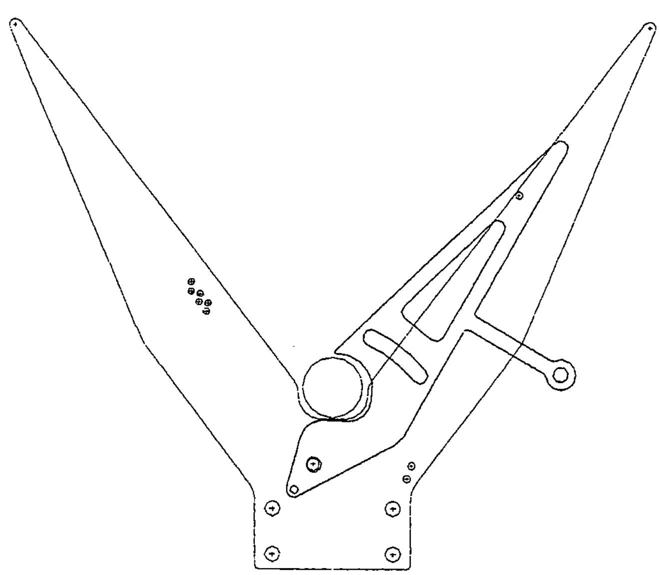
Department of Applied Ocean Physics and Engineering

A Passive Capture Latch for ODYSSEY Class Autonomous Underwater Vehicles

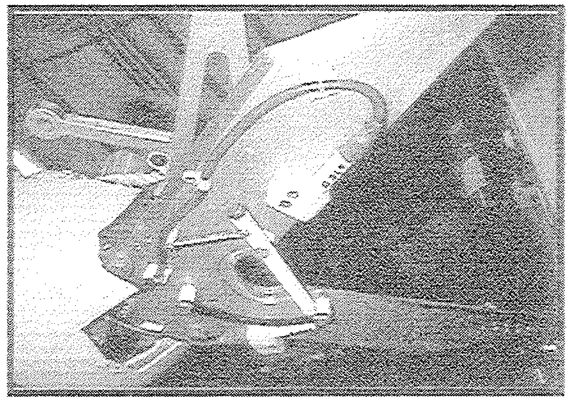
Prepared By:
M. F. Bowen

Version 1.0

12 June 1998



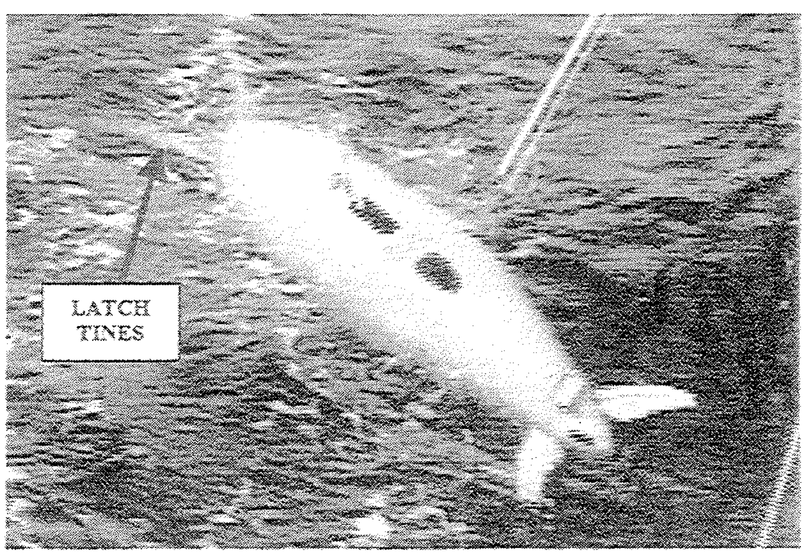
A Passive Capture Latch for ODYSSEY Class AUVs



Electro-Mechanical Design, Fabrication and Operation for the MIT Sea Grant Autonomous Ocean Sampling Network (AOSN)

Version 1.0

Contents



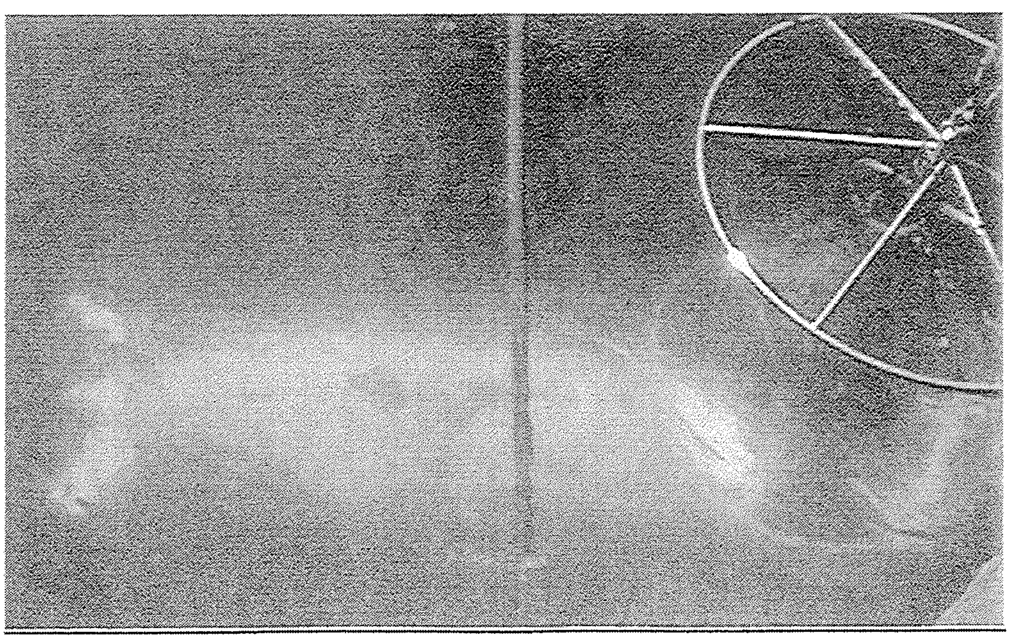
AOSN Autonomous Underwater Vehicle with WHOI Latch

Figures

Abstract

Under subcontract to the Massachusetts Institute of Technology's (MIT) Sea Grant Autonomous Ocean Sampling Network (AOSN) program, the Woods Hole Oceanographic Institution's Deep Submergence Laboratory (WHOI-DSL) produced a passive capture latch for ODYSSEY-class autonomous underwater vehicles (AUVs). The latch is an all-titanium, split tine device, shock-mounted to the bow of the AUV. When the AUV concludes a survey mission and returns to a moored, midwater docking station, the latch leads the AUV's approach and is the first device to collide with the station's vertical docking pole. Latching to the pole is an entirely passive event requiring only forward motion of the AUV. A positive capture indication generated by proximity switches mounted on the device initiates AUV power and data transfer servicing by the station. Unlatching action requires one revolution of a latch motor cam and a brief backing command to the AUV thruster. The possibility of system malfunction was considered in latch design. If for any reason the latched vehicle cannot perform normal unlatching behavior, or the station fails, the latch defaults by securing the AUV to the moored station indefinitely. Two WHOI AUV latches have been used successfully on three offshore engineering test cruises. (195) Keywords: AUV, latch, docking.

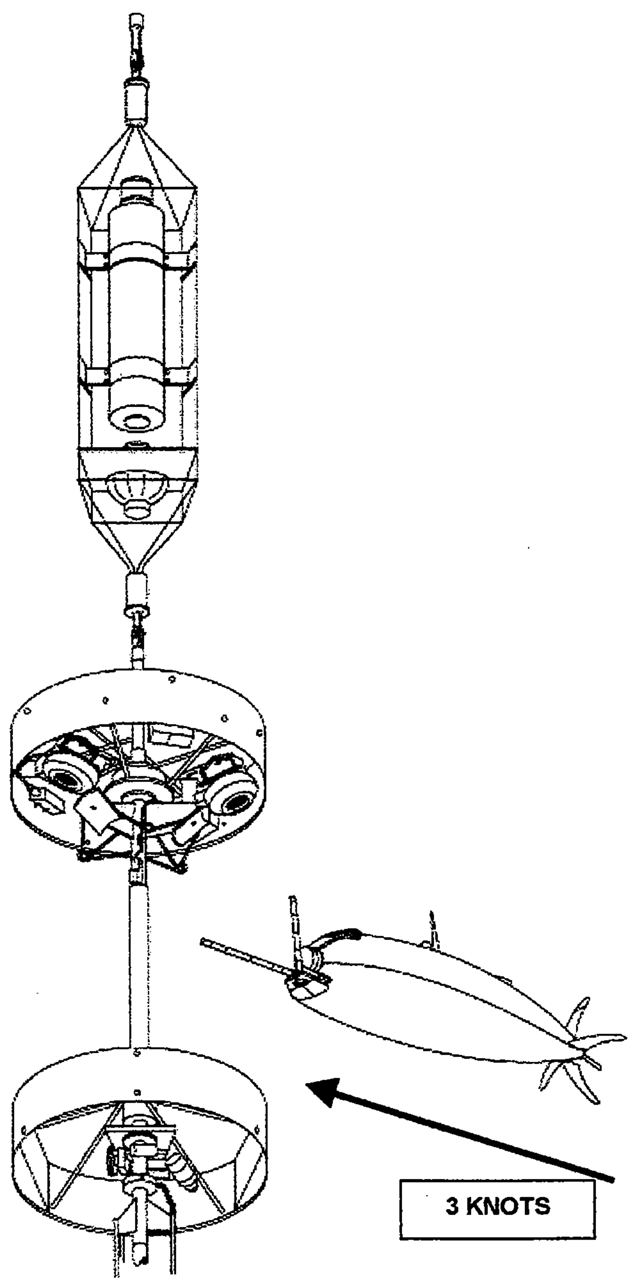
Figure [1] Odyssey AUV latched to Docking Station during testing



1.0 Introduction

The MIT Sea Grant Autonomous Ocean Sampling Network required Odyssey-class AUVs to navigate toward and couple with a midwater docking station suspended by a deep sea mooring system. The AUV, on a pre-programmed survey mission, would terminate its mission by homing in on a mooring beacon and collide with the target, a vertical stainless steel pole comprising the center of the docking station (Figures [1 and 2]). The AUV travels in the horizontal plane at a nominal speed of three knots (1.2 m/sec). A heavy-duty titanium latch was produced by WHOI that could withstand the 1G+ impact with the semi-rigid pole reliably under a wide range of approach conditions. The latch was also capable of retaining the vehicle during a variety of servicing operations, mooring translations and undocking operations prior to a new mission.

Figure [2] AUV Approach to the Midwater Docking Station



2.0 AUV Docking Latch

2.1 Background and Theory of Operation

The latch specification has gone through several iterations in three years, see Figure [3] below.

Prototype Latch Design	***Advantages***	***Disadvantages***
1) retractable body, hinged tines, detent trigger	hydrodynamic	mechanical complexity
2) fixed body, hinged tines, stiff spring trigger	positive capture	software dependencies
3) fixed body, fixed tines, passive latching, solenoid release	simplicity	high power consumption, poor hydrodynamics
4) fixed body, fixed tines, passive latching, motor and cam release	simplicity	hydrodynamics

The current latch mechanism is shown in plan view in Figure [4] and a photograph of the latch appears in Figure [5]. The latch consists of: a vee-shaped, symmetrical grade 2 titanium body with two fixed tines; a pivoting titanium (pole) capture bar; a titanium capture bar guide; a titanium mount with shock absorption; an isolated stainless steel extension spring; a drive motor with housing, cam and linkage; four pressure-proof magnetic proximity switches; and four magnets.

The latch specification appears in Figure [9]. In the early stages of design, MIT hydrodynamicists were concerned that the "wing-like" shape of the latch would degrade control performance of the vehicle, particularly in pitch. Field operations of the completed design proved that the latch's influence on control was negligible.

Figure [4] Odyssey AUV Docking Latch (see Drawing 156-97-016)

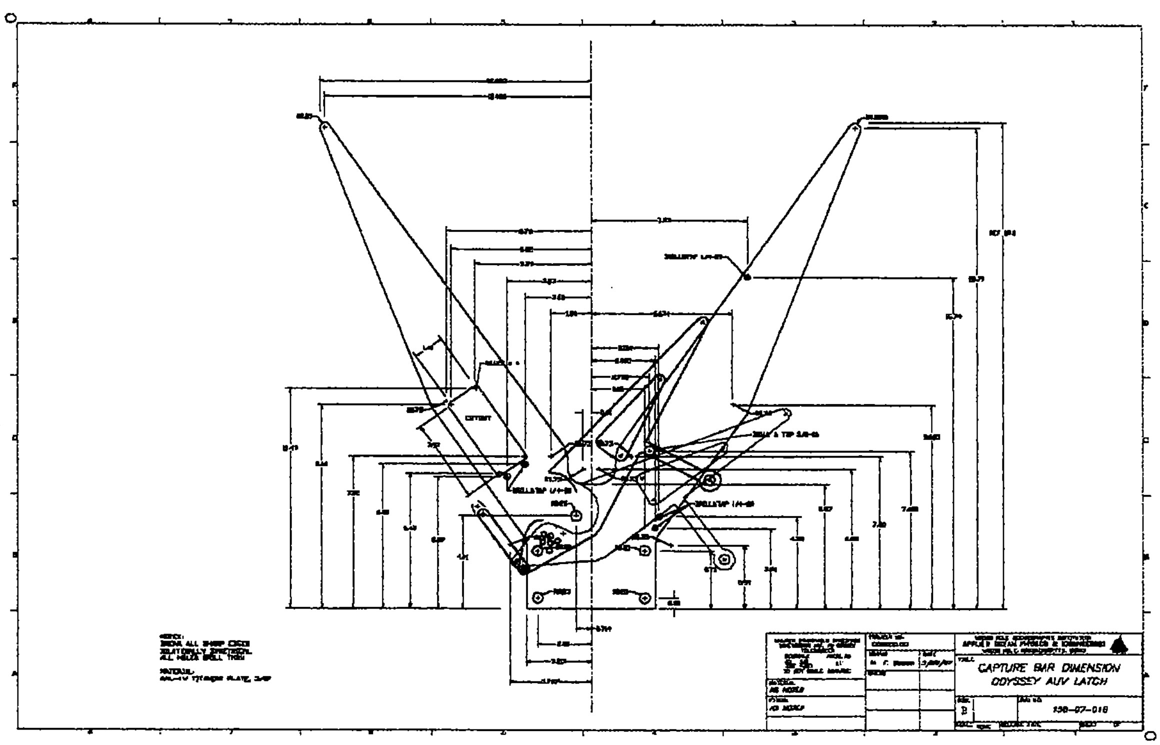


Figure [5] Docking Latch Mounted to Odyssey AUV Bow

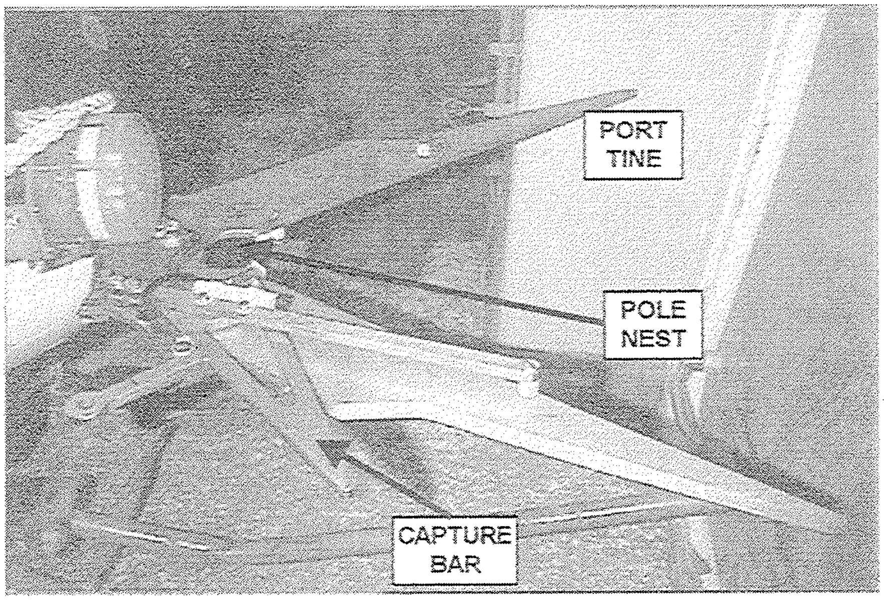


Figure [6] shows a close-up of the latch nest area. Mounted just below and forward of the ultra-short baseline homing array, the latch prohibits the docking pole collision from damaging the brow of the AUV. A manual release loop on the capture bar allows undocking from the docking pole during testing. The wedge-like shape of the capture bar aids in positive latching in "second-bounce" and low-speed docking circumstances.

Figure [6] Docking Latch Detail

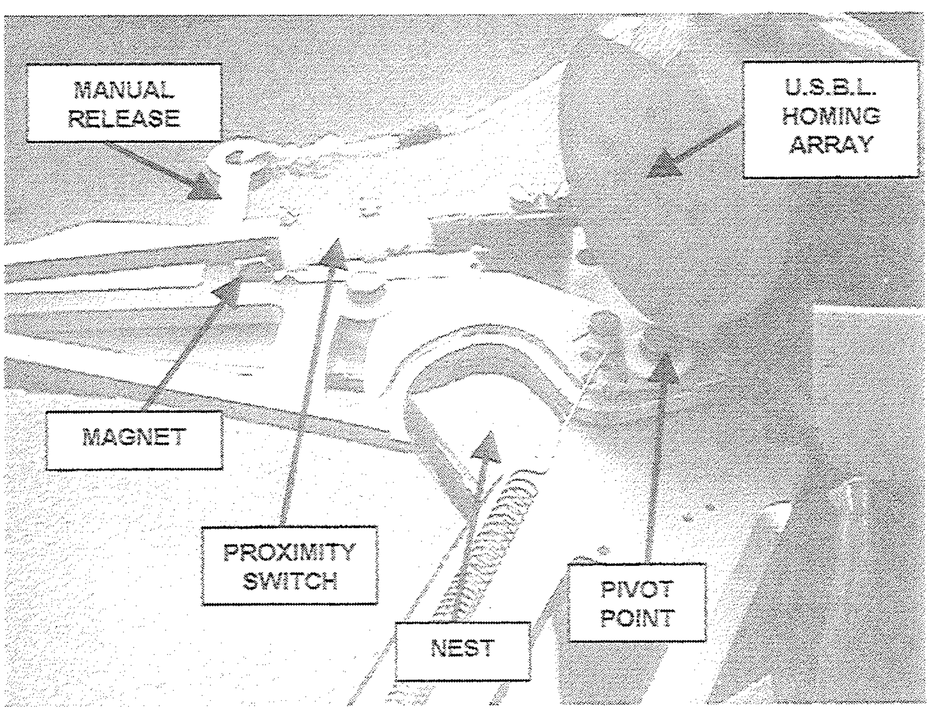
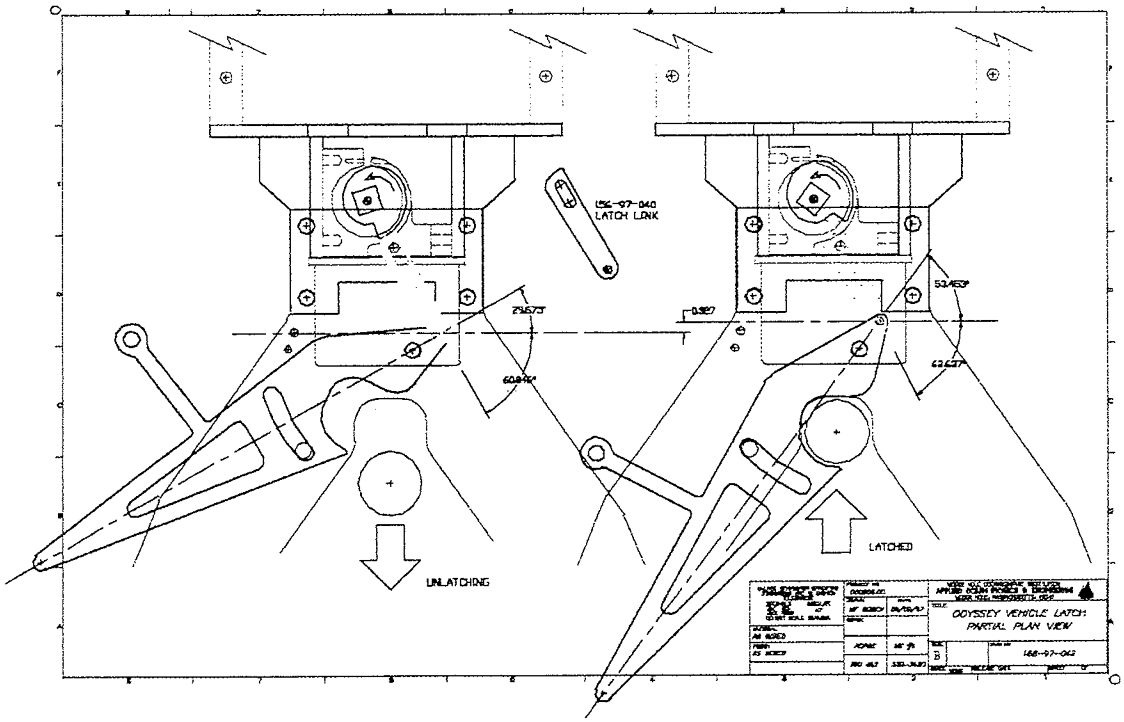
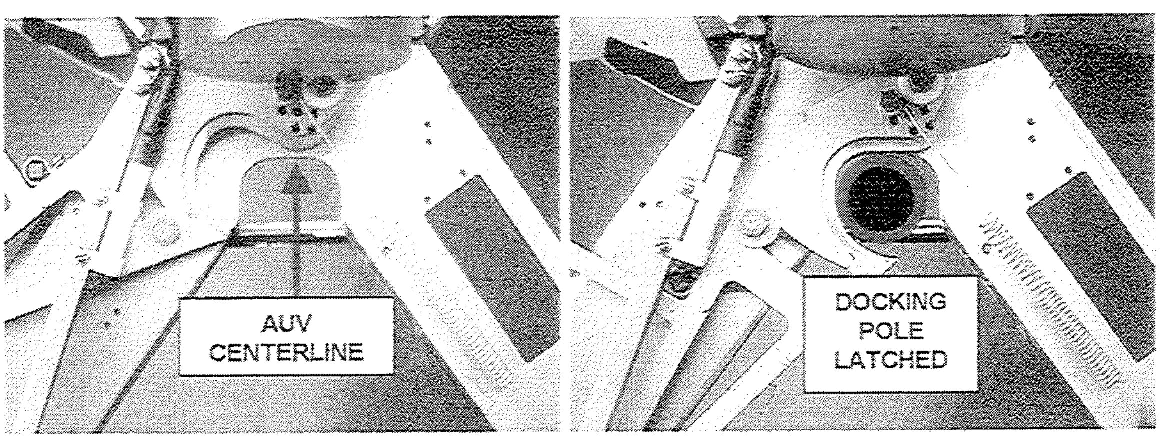


Figure [7] Latch Modes: Unlatching (left) and Latched (right) (see Drawing 156-97-042)



The docking pole enters the latch anywhere between the two fixed tines of the latch body, which are spaced twenty-four inches apart at the forward tips. The tines are angled and direct the pole toward the AUV centerline, taking advantage of the forward motion of the AUV and the relative mobility of the pole. The pole then pushes the capture bar aside and enters a nest in the latch body, where an extension spring closes the capture bar around the pole. The AUV may latch onto the pole anywhere within a one and one half-meter vertical length. When latched (Figure [7 right]), the AUV must remain safely mated to the pole by the latch alone, either temporarily as part of a mission servicing, or indefinitely as the result of an unsuccessful deployment (such as a dock and mooring recovery with the AUV still attached). To unlatch (Figure [7 left]), the motor rotates a cam one revolution and briefly opens the capture bar, allowing the pole to escape the latch nest. Figure [8] below demonstrates the same modes as built.

Figure [8] Latch Modes: Unlatching (left) and Latched (right)



2.2 Latch Specification *Figure [9]*

MECHANICAL

ACCEPTANCE GAP	24 IN
DESIGN, FUNCTIONAL	PASSIVE LATCHING
DESIGN, SHAPE	FIXED, VEE-SHAPED TINES BI-LATERALLY SYMMETRICAL ACTIVE UNLATCHING
FORCE OF IMPACT	</=1.0 VEHICLE G (600 LBS. MASS)
GEARHEAD REDUCTION	1525.7 : 1 (MAXON PLANETARY GP032A057-1526E1A01A)
LATCH, SPEED RANGE	0.3 TO 3.0 KNOTS
LATCH, SPRING FORCE	2 LBS. OR </= 75% BOLLARD THRUST (11 LBS. REF)
LENGTH, MOTOR & CAM	7.5 IN VERTICAL
LENGTH, TINE TO USBL	19.5 IN HORIZONTAL
LENGTH, TINE TO SHOCK MOUNT	25.0 IN HORIZONTAL
MATERIALS	GRADE 2 TITANIUM (SG 4.52) 316 STAINLESS (SG 8.03) DELRIN (SG 1.43) NYLON (SG 1.15)
MOVING PARTS, ACTIVE MODE	MOTOR SHAFT CAPTURE BAR EXTENSION SPRING
MOVING PARTS, PASSIVE MODE	CAPTURE BAR EXTENSION SPRING
OUTSIDE DIAMETER, MOTOR	2.25 IN
UNLATCH, FOLLOWER FORCE	>/= 18 LBS.
UNLATCH, FOLLOWER THROW	0.5 IN
WEIGHT AIR, BODY ASSY	18.6 LBS. (8.45 KG)
WEIGHT AIR, MOTOR ASSY	3.5 LBS. (1.59 KG)
WEIGHT AIR, TOTAL	22.1 LBS. (10.04 KG)
WEIGHT SEAWATER, TOTAL	13.0 LBS. (5.91 KG)

ELECTRICAL

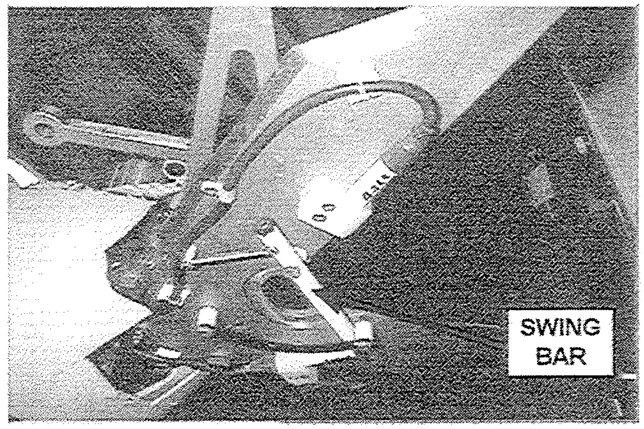
CONDUCTORS	2
CONNECTORS	2 IE XSA-BC, 2 IE RMA-FS
CONSUMPTION, CURRENT	147 MA
CONSUMPTION, POWER	0.76 WATTS
CONSUMPTION, VOLTAGE	12 VDC NOMINAL (RANGE 5-18 VDC)
MAGNETICS	UNMEASURED (MINIMAL)
RPM, MOTOR	4790 (MAXON RE025-055-37EAA200A)
RPM, CAM SHAFT	2.0
SENSING, CAM FOLLOWER	MOVEMENT DETECT MAG SWITCH (N.O.)
SENSING, LATCHING	"POLE PRESENT" MAG SWITCHES (N.O.)
SENSING, UNLATCHING	"POLE ABSENT" MAG SWITCH (N.O.)
SENSING, CAPTURE BAR	MOVEMENT DETECT MAG SWITCH (N.O.)
TORQUE, CAM SHAFT	500 OZ-IN

ENVIRONMENTAL

CAM FUNCTION, READY FOR POLE	90 DEG, 7.5 SEC
CAM FUNCTION, RELEASING POLE	180 DEG, 15.0 SEC
CAM FUNCTION, LATCH OPEN	90 DEG, 7.5 SEC
DEPTH RATING	2000 METERS (3000 PSI)
DUTY CYCLE	20 LATCHING COLLISIONS PER DEPLOYMENT
MTBF	4 MONTH IMMERSION
RETENTION, MAX PITCH	15 DEG UPCURRENT, 10 DEG DOWNCURRENT
RETENTION, POWER LOSS	NO UNLATCH FUNCTION
RETENTION, MAX ROLL	+/- 15 DEG
TEMPERATURE, OPERATING	-15C TO 80C
TEMPERATURE, STORED	-40C TO 80C

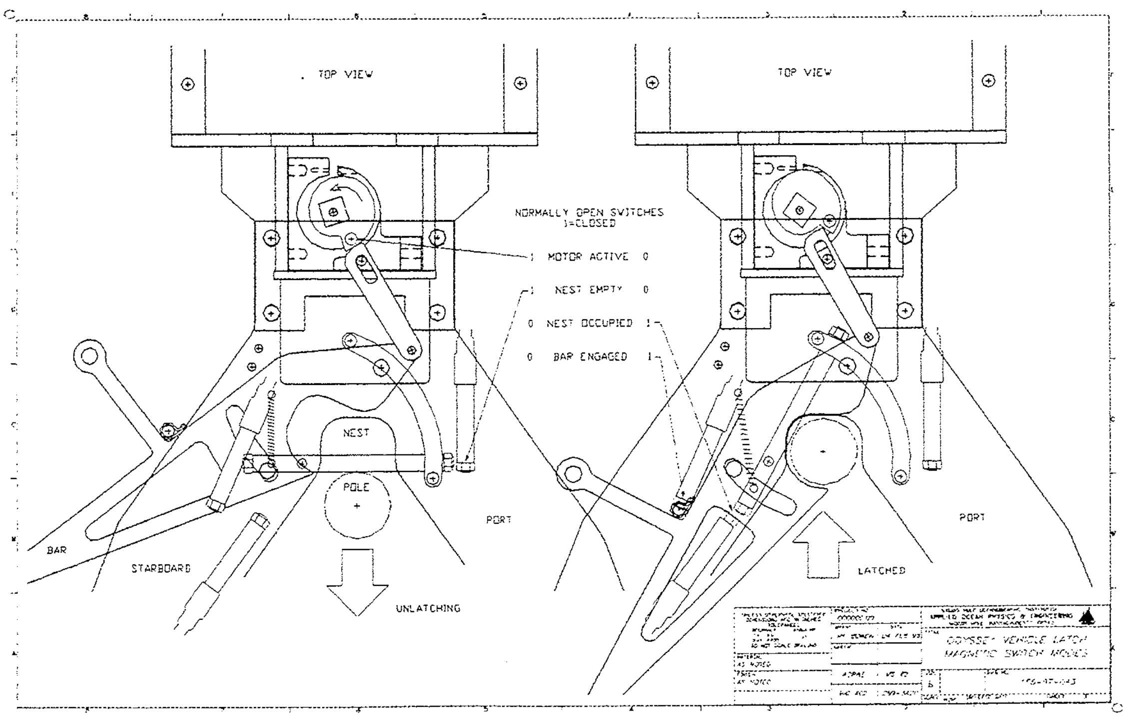
2.3 Magnetic Switch Harness

Figure [10] Vehicle Magnetic Switches



A portion of the vehicle magnetic switch harness appears in a picture taken from below a latch in Figure [10]. The location of the four switches and four matching magnets appears in Figure [11]. The function of these sensors is to indicate to the vehicle, and its behavior software, exactly what state the latch is in at any time during servicing at the Docking Station or between missions away from the Station. One magnet indicates the state of the motor, which can open the capture bar. Another switch indicates whether the capture bar is open or closed. Two switches are located at either end of a plastic swing bar. One indicates if the bar has been moved away from the nest and a pole is present (docked and latched). A second indicates whether the swing bar has sprung across the pole nest whenever the latch is off the pole (undocked and pole absent).

Figure [11] Magnetic Switch Locations on Vehicle Latch (see Drawing 156-97-043)



2.4 Performance Analysis

There are two working latches mounted onto Odyssey AUVs at the writing of this report. One of the two has been field tested prior to this cruise and has successfully latched and unlatched from a docking pole more than fifty cycles. Both latches have been wet tested with vehicles and a docking pole under controlled circumstances at WHOI. During this cruise to the Labrador Sea the latch capture bar was disabled for all missions to the Docking Station.

During this cruise one magnetic switch harness failed once due to seawater intrusion and was replaced by a spare harness.

2.5 Proposed Improvements and Modifications

2.5.1 Latch

This fixed-tine latching device will probably not change significantly in the short-term nor for the duration of the AOSN project. As the fourth revision of the original specification, this design has proven to be easily maintained, functional, immune to prolonged immersion, robust and reliable.

2.5.2 Specialized Recovery Device

The inherent strength of the titanium latch and bow mount was demonstrated by accident during the October engineering test cruise when the lifting bail on a deployed vehicle parted. A lifting hook and line was attached to the port latch tine and the AUV was retrieved vertically without further damage.

In response to this emergency scenario, a custom recovery tool was designed by WHOI and two were fabricated. The device is shown in Figures [12] and [13]. Known as the "staple", it can be hung over the ship's side at the end of a long stab stick and jammed into the latch where two hooks engage the outboard edge of the latch tines. The vehicle can then be safely lifted vertically out of the water by the tines in situations of high freeboard and high seastates. The staple has not been tested offshore to date.

2.5.3 Acoustically Active Latch Tines

A recommendation has been made for the long-term that the two outer tine tips be hollowed out and fitted with a revised version of the homing head elements. This scheme would give the piezo array the advantage of a wide separation, and the mechanical protection of a metal shell.

Figure [12] Recovery Tool for High Freeboards (see Drawing Recovery3.dwg)

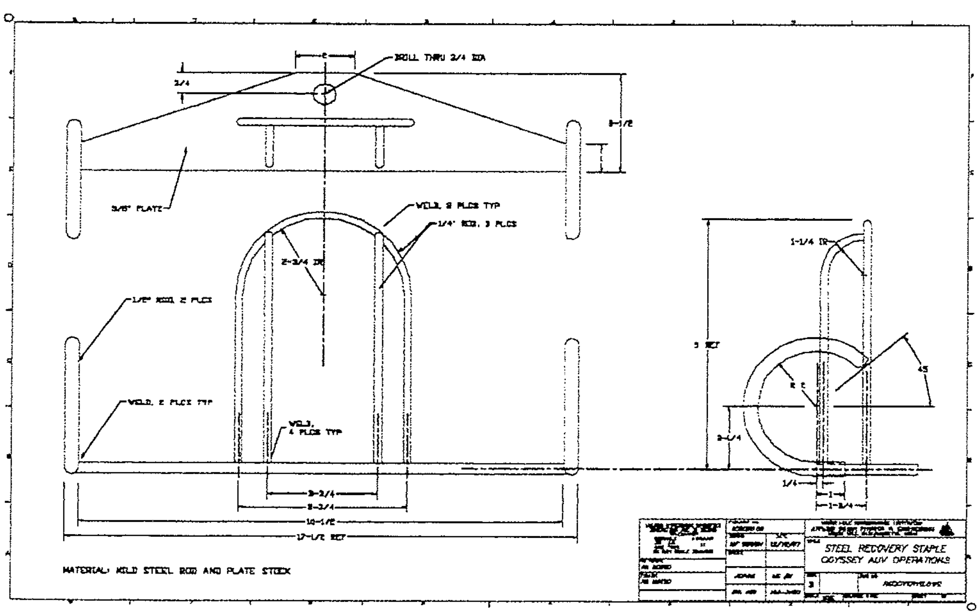
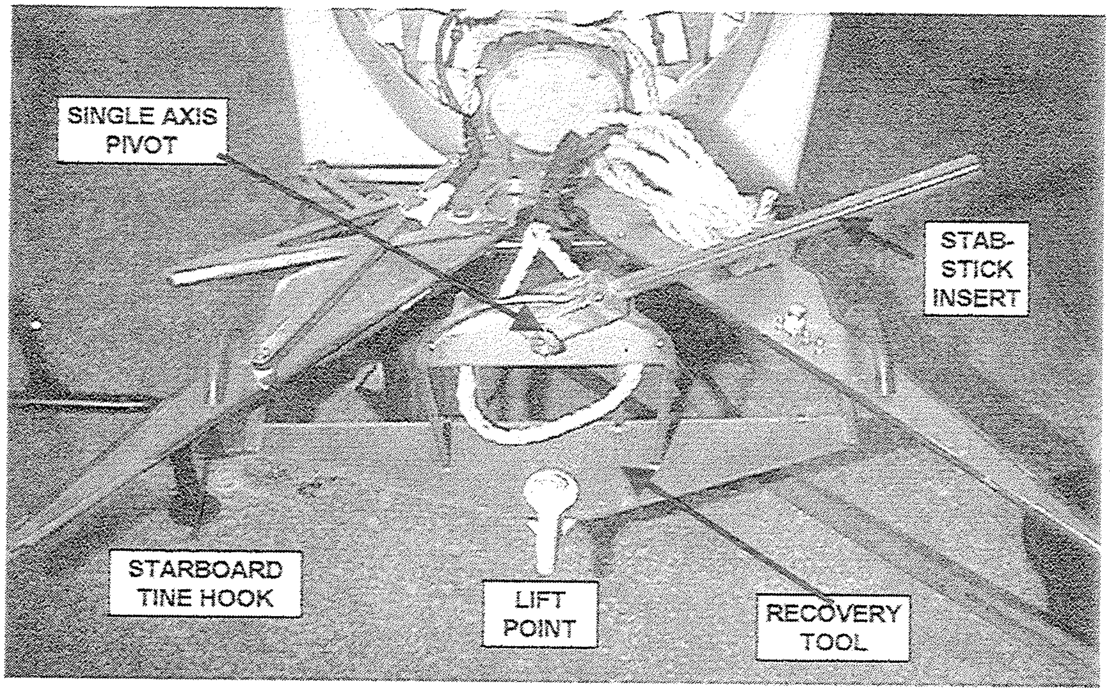


Figure [13] Specialized AUV Recovery Tool in Lifting Position on WHOI Latch



2.6 References

1. Bowen, M.F., Peters, D.B., Singh, H., A Deep Sea Docking Station for ODYSSEY Class AUVs, Woods Hole Oceanographic Institution Blue Cover Technical Report WHOI-98-11, forthcoming, 1998.

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3. Currey, N.S., Aircraft Landing Gear Design: Principles and Practices, Lockheed Aeronautical Systems Company, AIAA Educational Series, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, American Institute of Aeronautics and Astronautics, Inc., Washington, D.C. 20024, ISBN 0930403-41-X, 1988.

4. Currey N.S., Landing Gear Design Handbook, Lockheed-Georgia Company, A Division of Lockheed Corp., Marietta, GA 30063, 1st Edition, January 1982.

5. Dexter, S.C., Handbook Of Oceanographic Engineering Materials, Robert E. Krieger Publishing Company, Malabar, Florida, 1985.

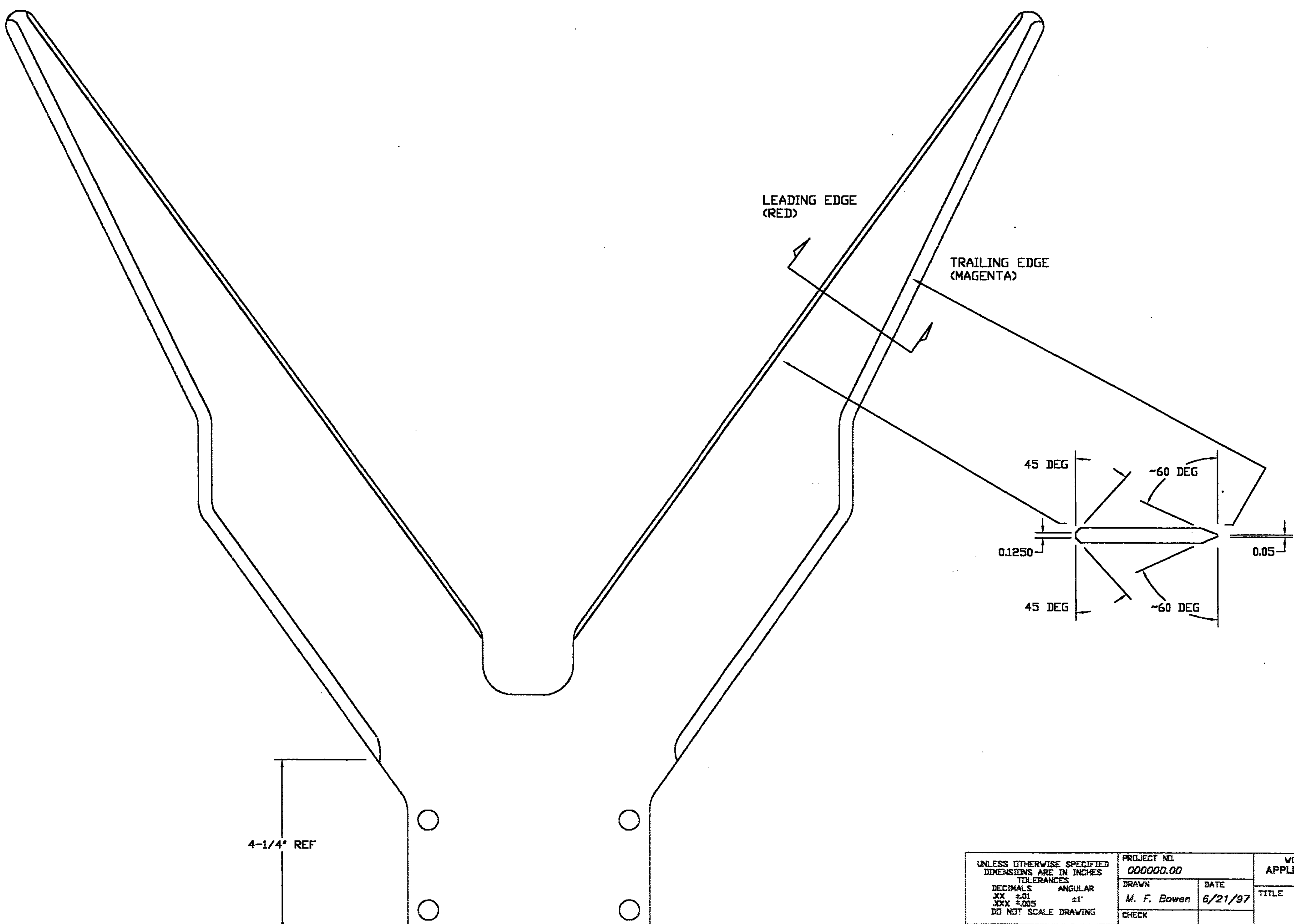
MECHANICAL DRAWINGS

LATCH BODY

CAPTURE BAR

MOUNT

MOTOR



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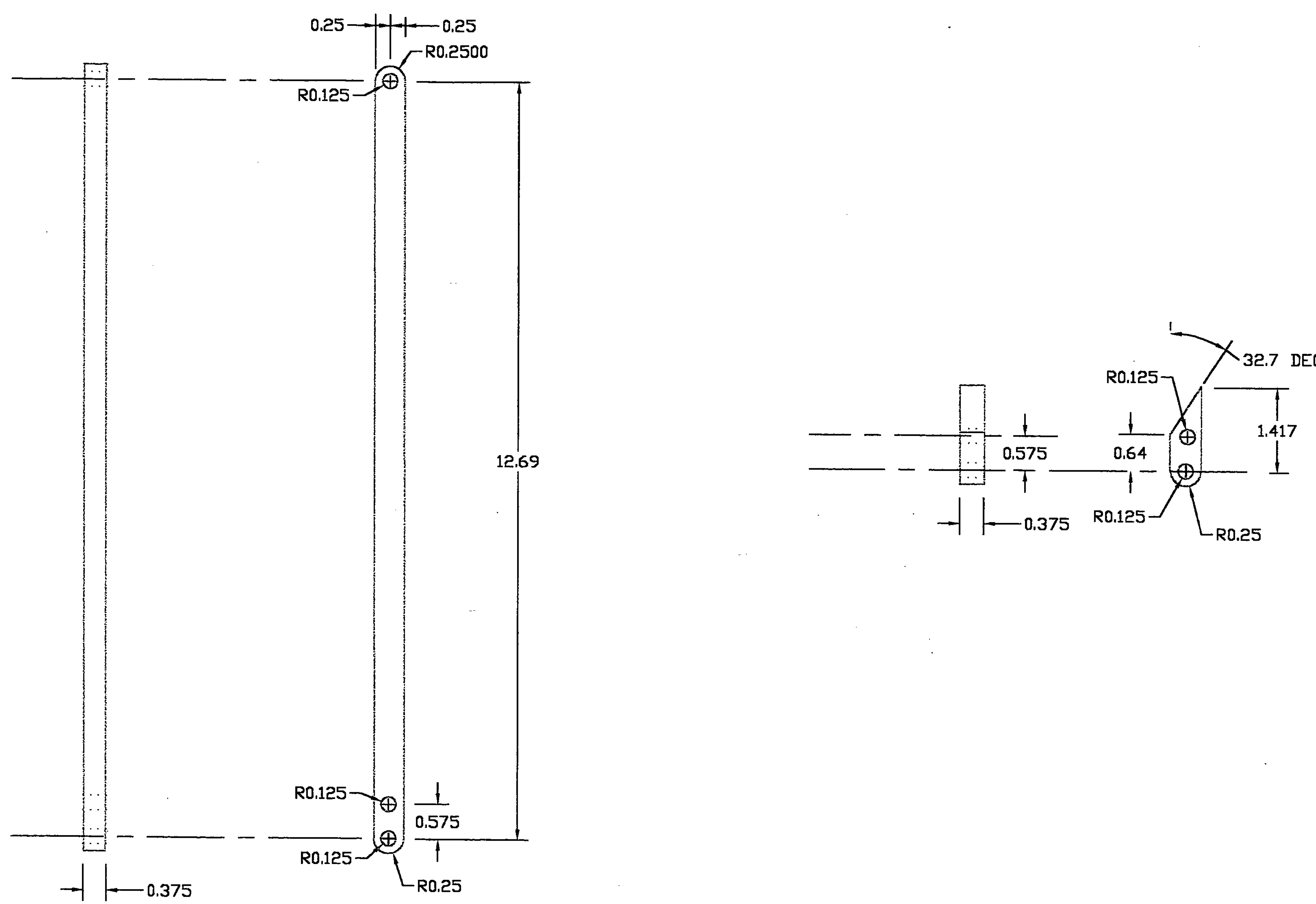

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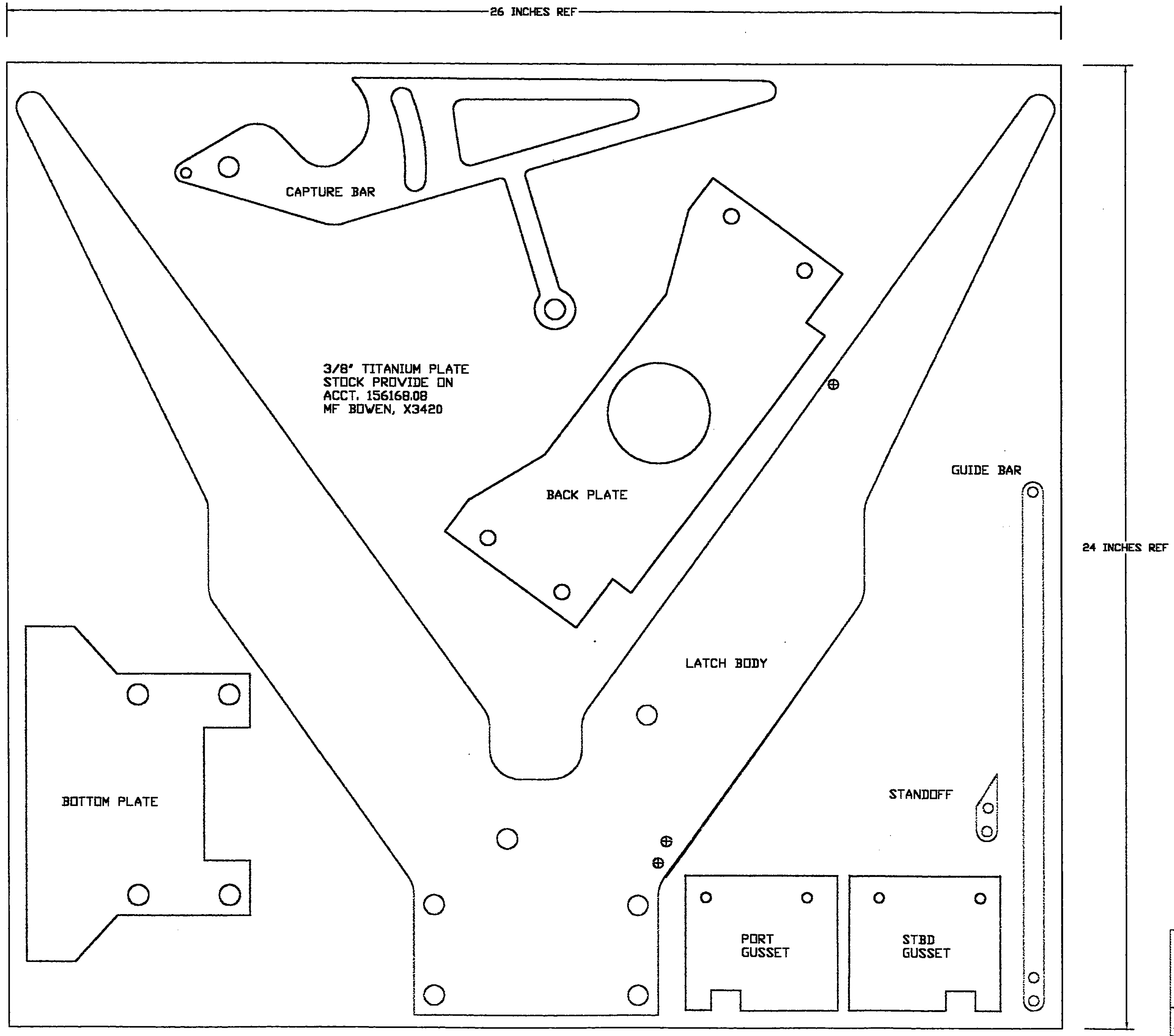

ODYSSEY AUV TITANIUM LATCH DRAWING PACKAGE

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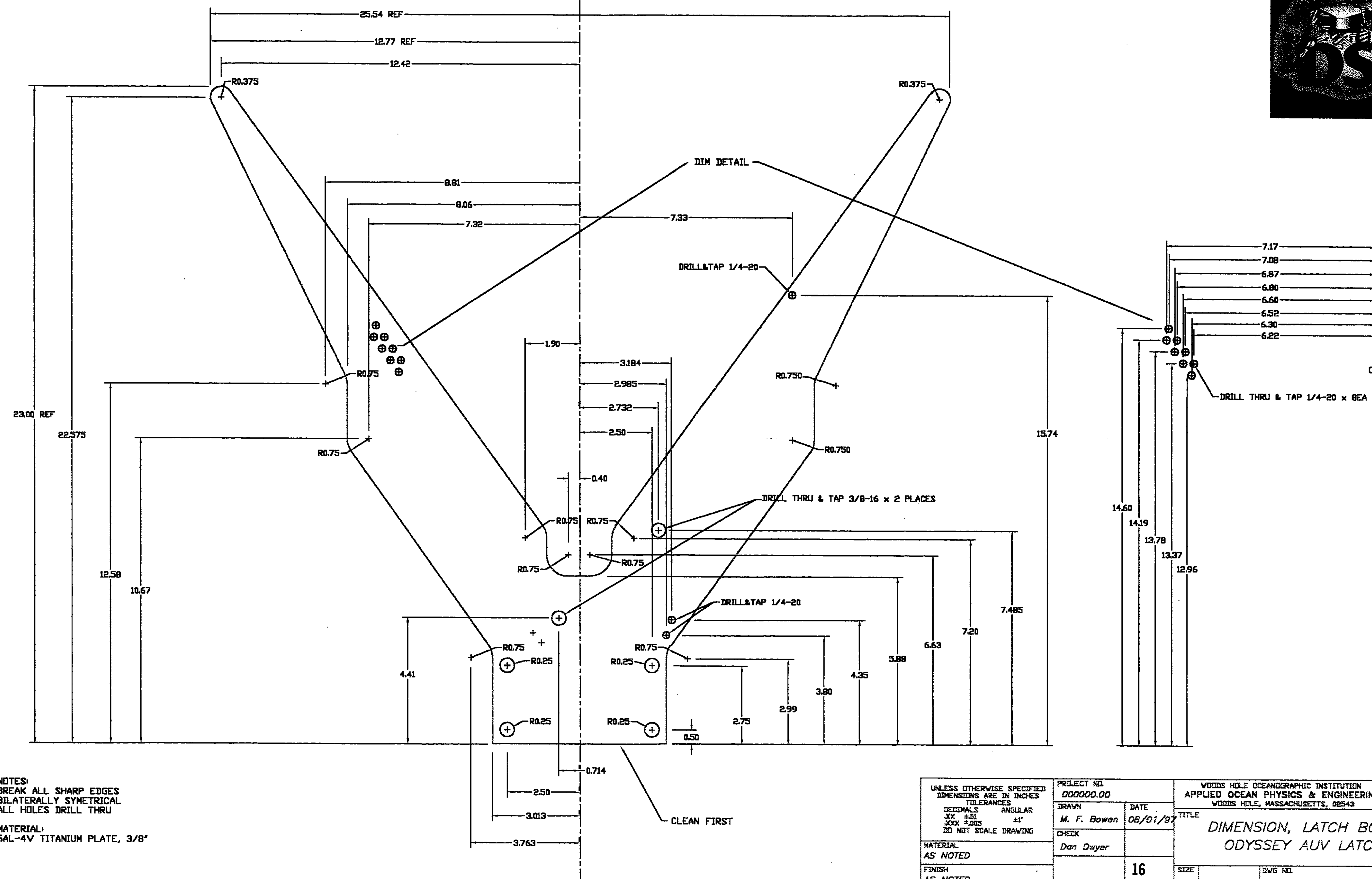

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NOTE: REVERSE SIDE SHOWN

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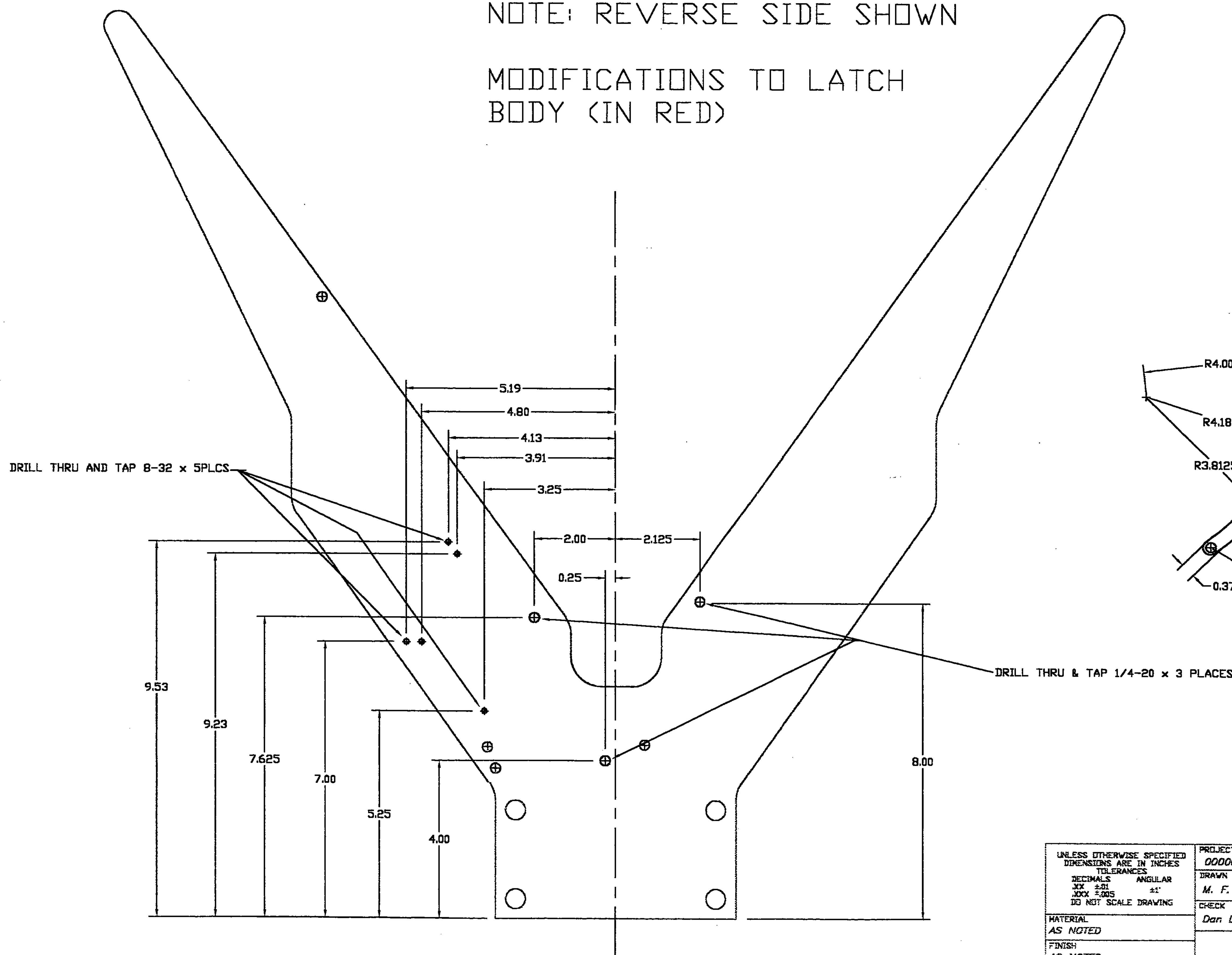

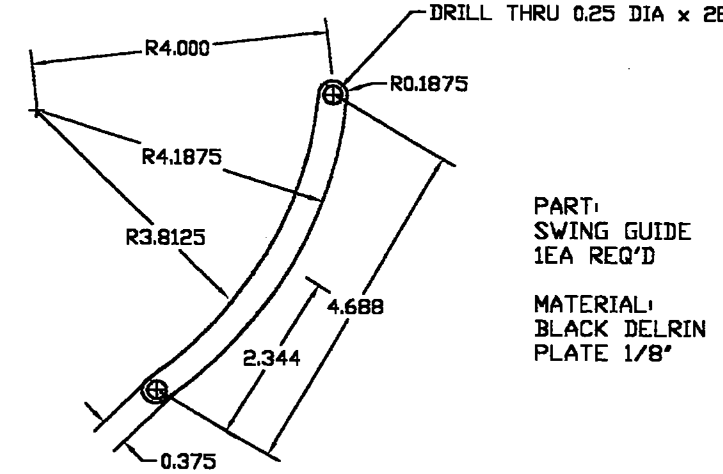

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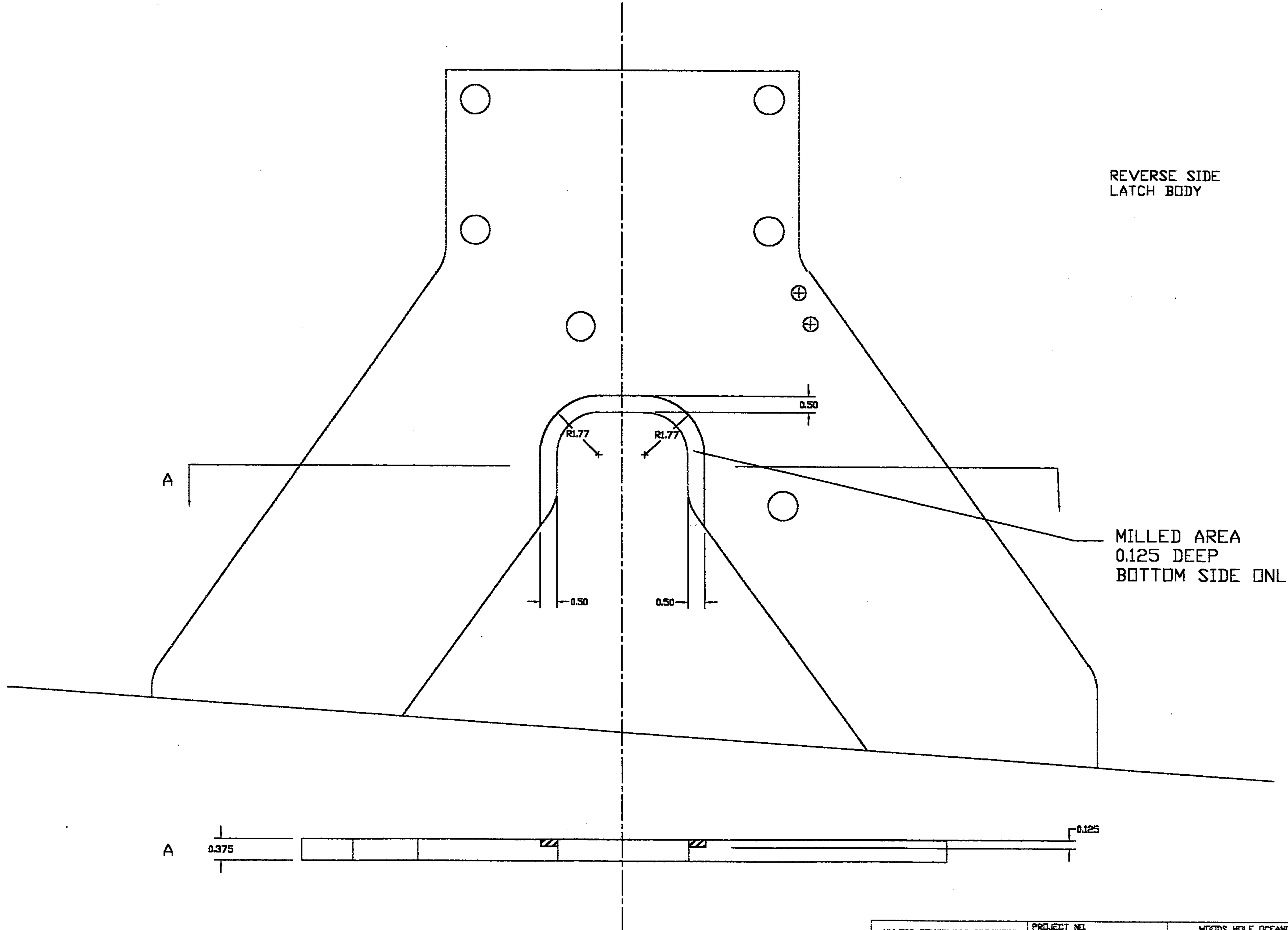

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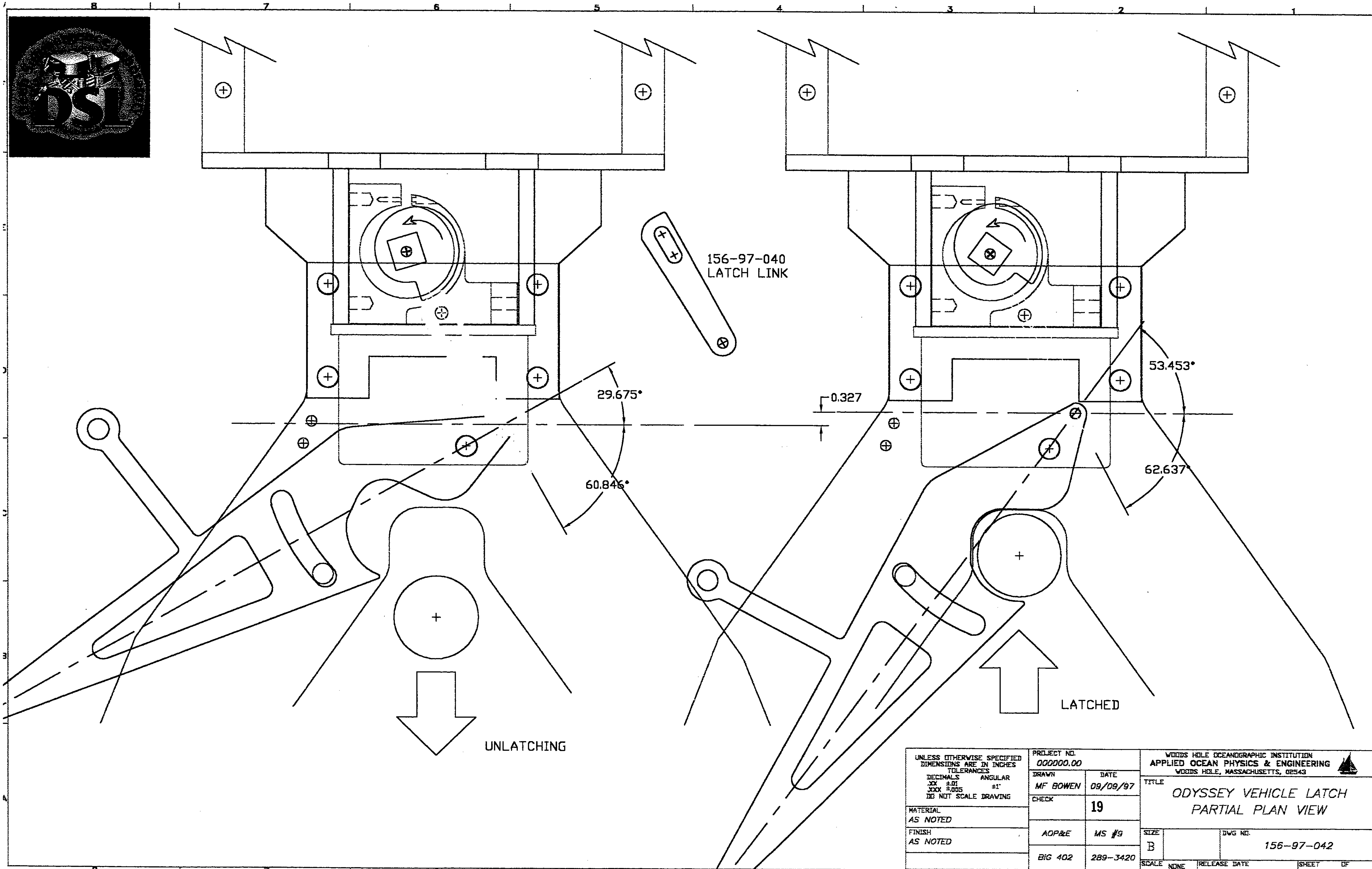

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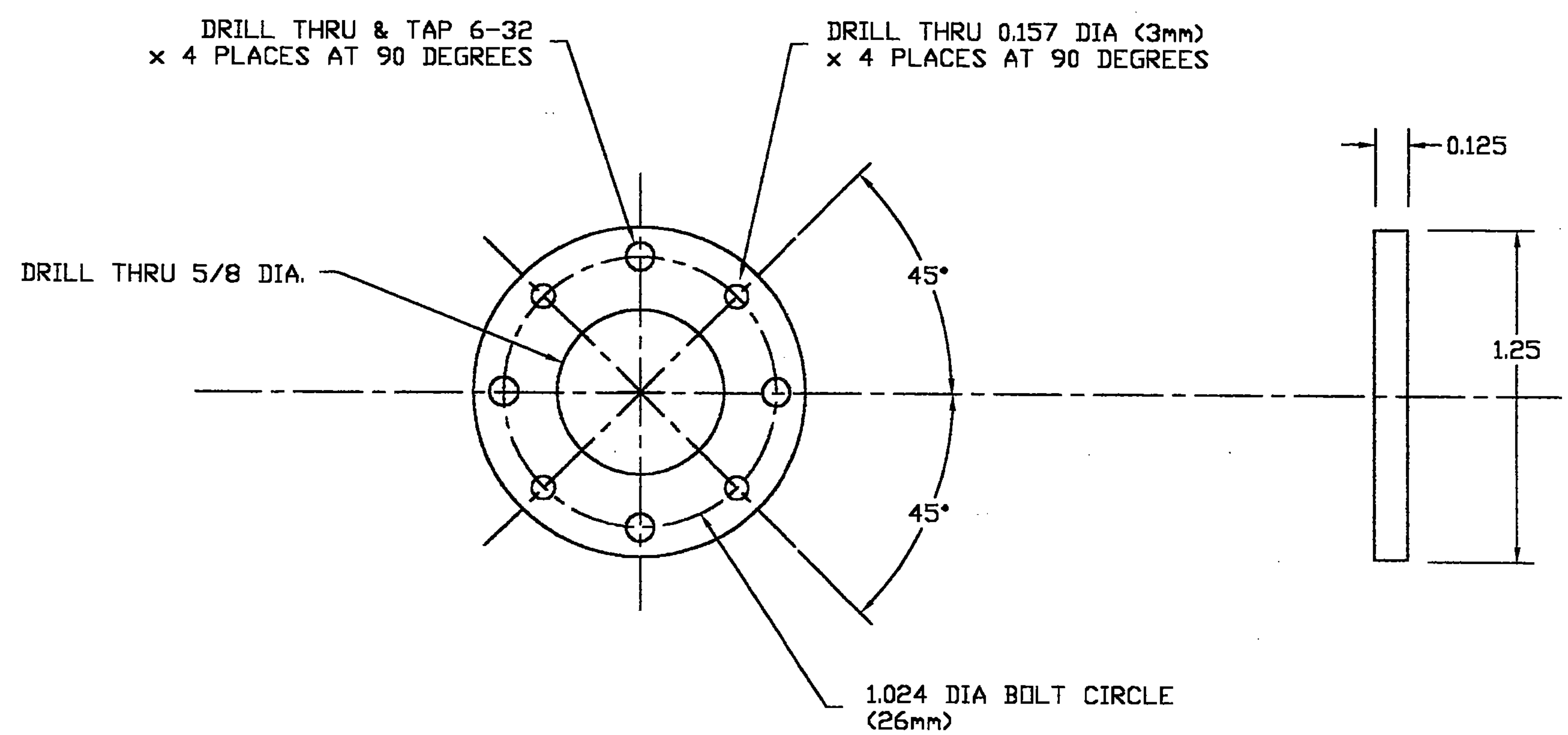

NOTES:
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(508) 289-3420 WHOI
(508) 457-2132 FAX

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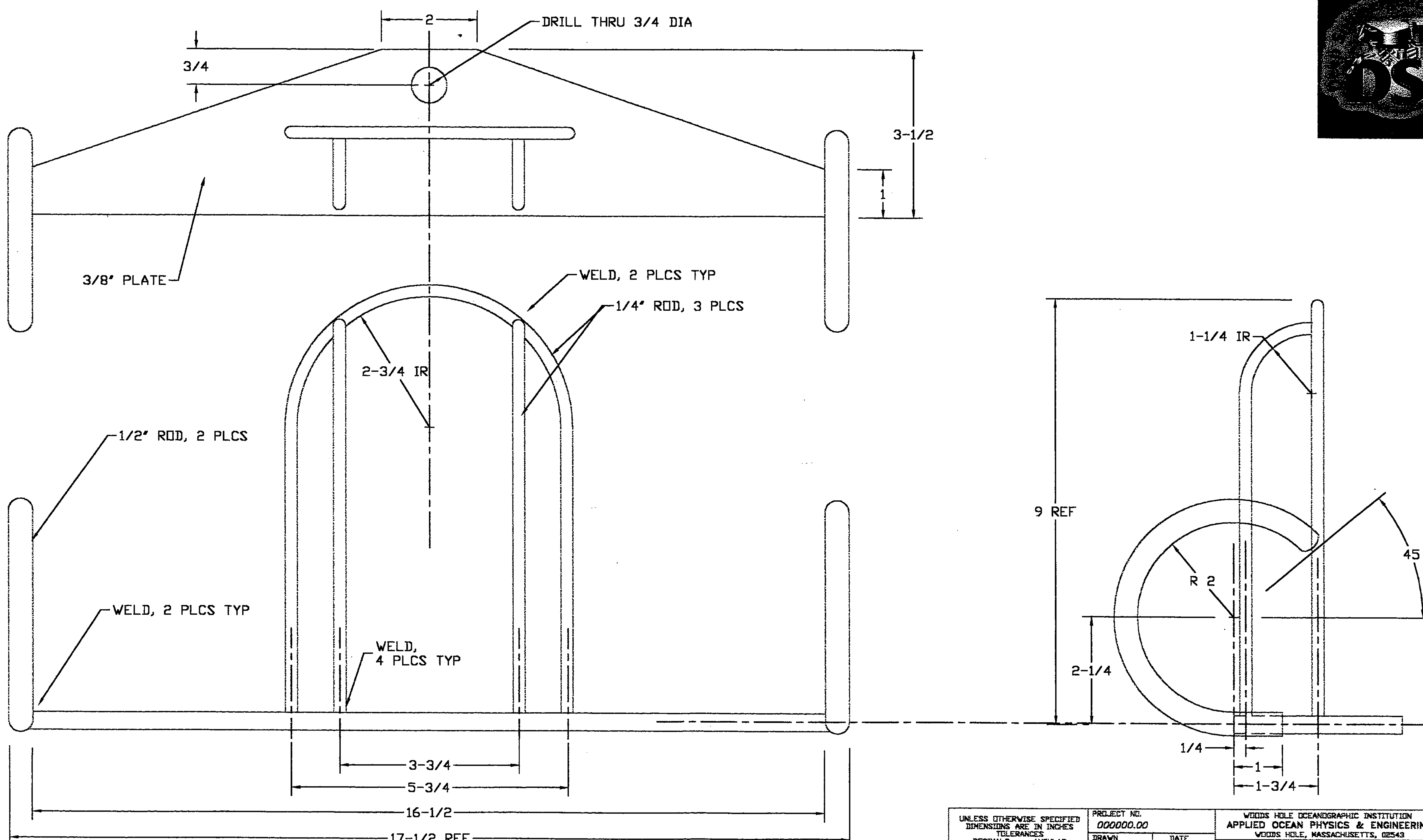

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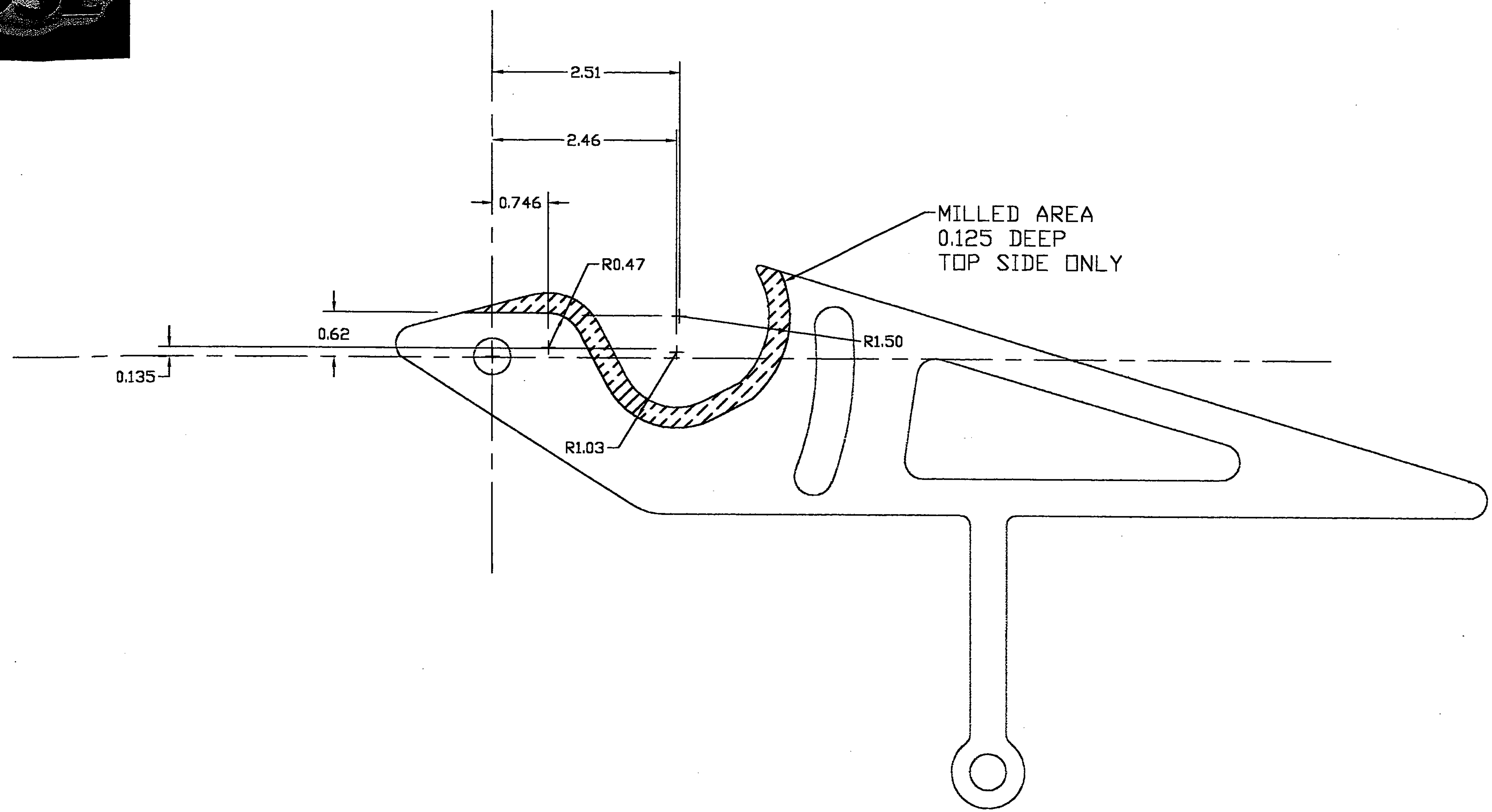
PROJECT NO.
000000.00

DRAWN	DATE
MF BOWEN	12/18/97
CHECK	21
AOP&E	MS #9
BIG 402	289-3420

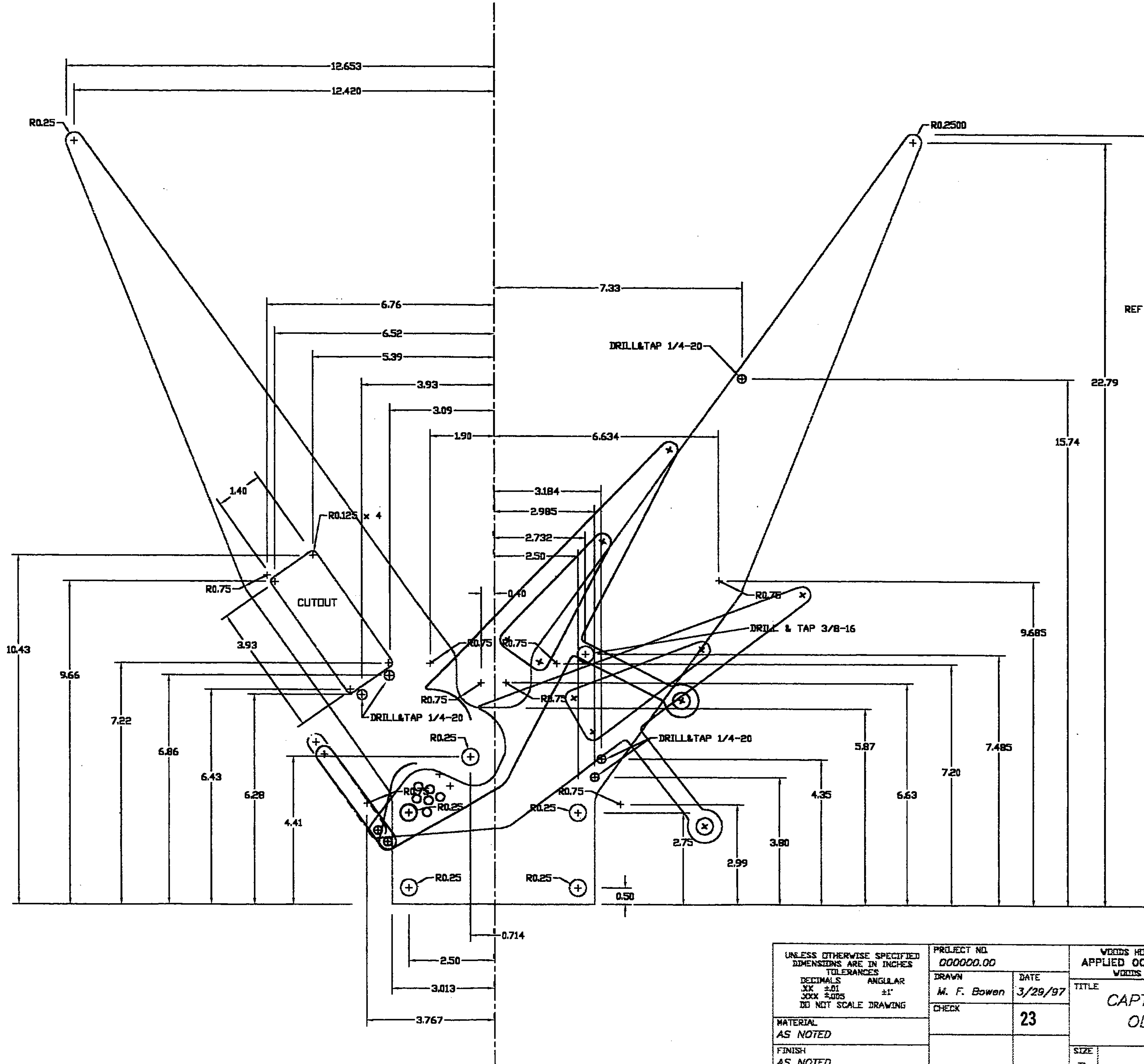
WOODS HOLE OCEANOGRAPHIC INSTITUTION
APPLIED OCEAN PHYSICS & ENGINEERING
WOODS HOLE, MASSACHUSETTS, 02543

TITLE
STEEL RECOVERY STAPLE
ODYSSEY AUV OPERATIONS

SIZE B
DWG NO. RECOVERY3.DWG
SCALE NONE
RELEASE DATE
SHEET OF



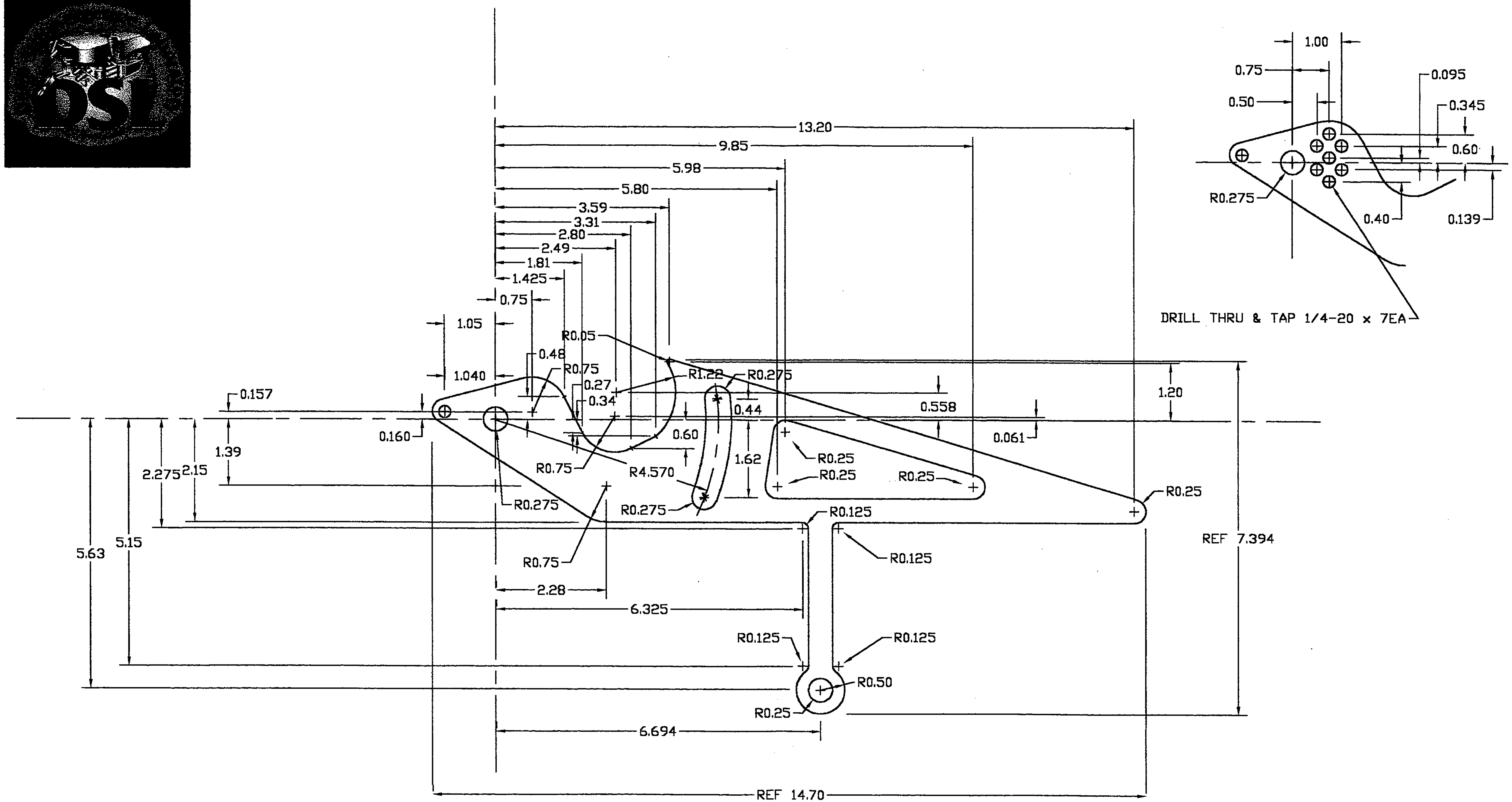
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN M. F. Bowen	DATE 3/29/97	TITLE MILL MOD, LATCH CAPTURE BAR ODYSSEY AUV LATCH
MATERIAL AS NOTED	CHECK	22	
FINISH AS NOTED			SIZE B latch5cb · DWG NO. 156-97-007
			SCALE NONE · RELEASE DATE · SHEET · OF



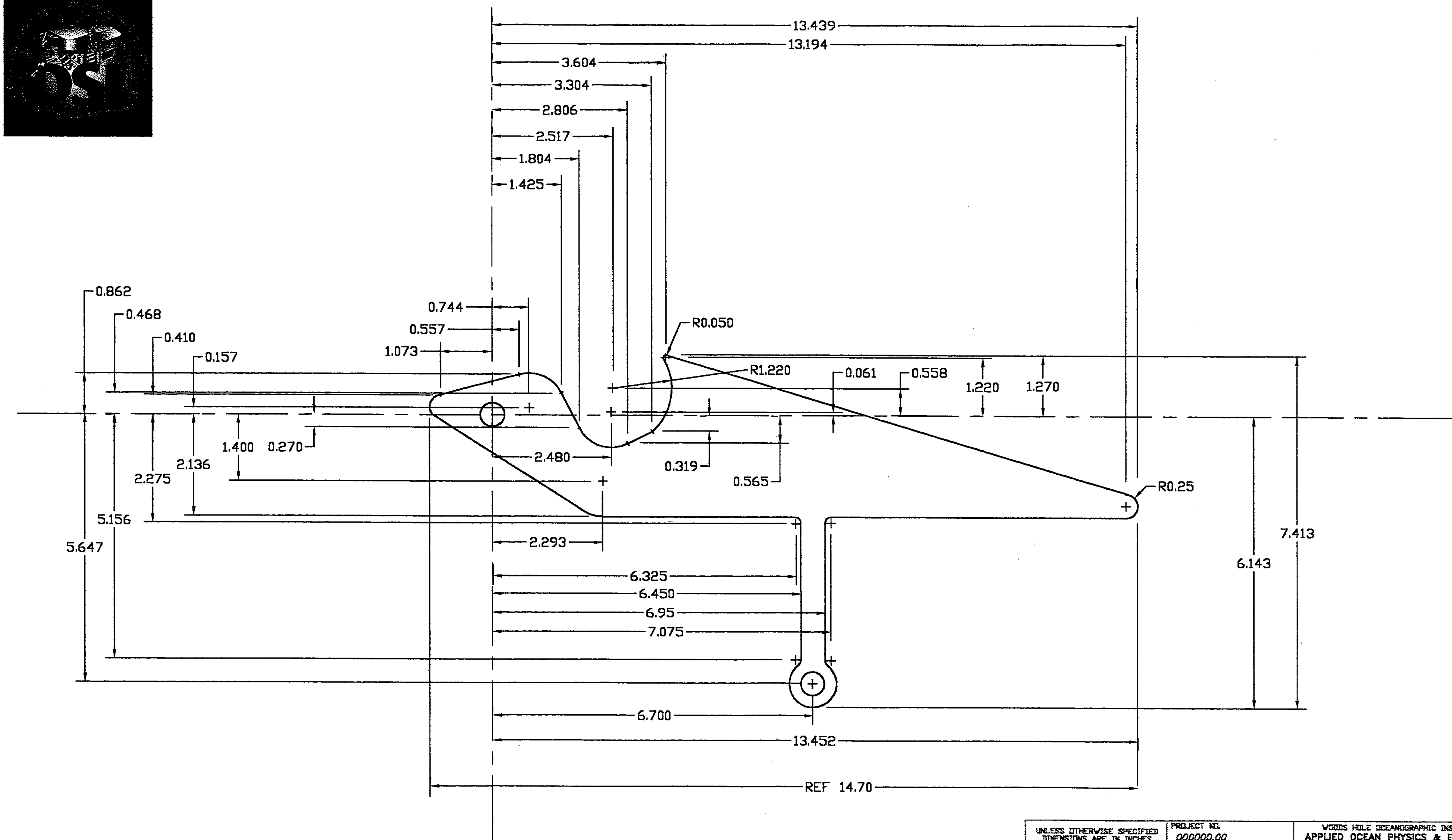
NOTES:
BREAK ALL SHARP EDGES
BILATERALLY SYMETRICAL
ALL HOLES DRILL THRU

MATERIAL:
6AL-4V TITANIUM PLATE, 3/8"

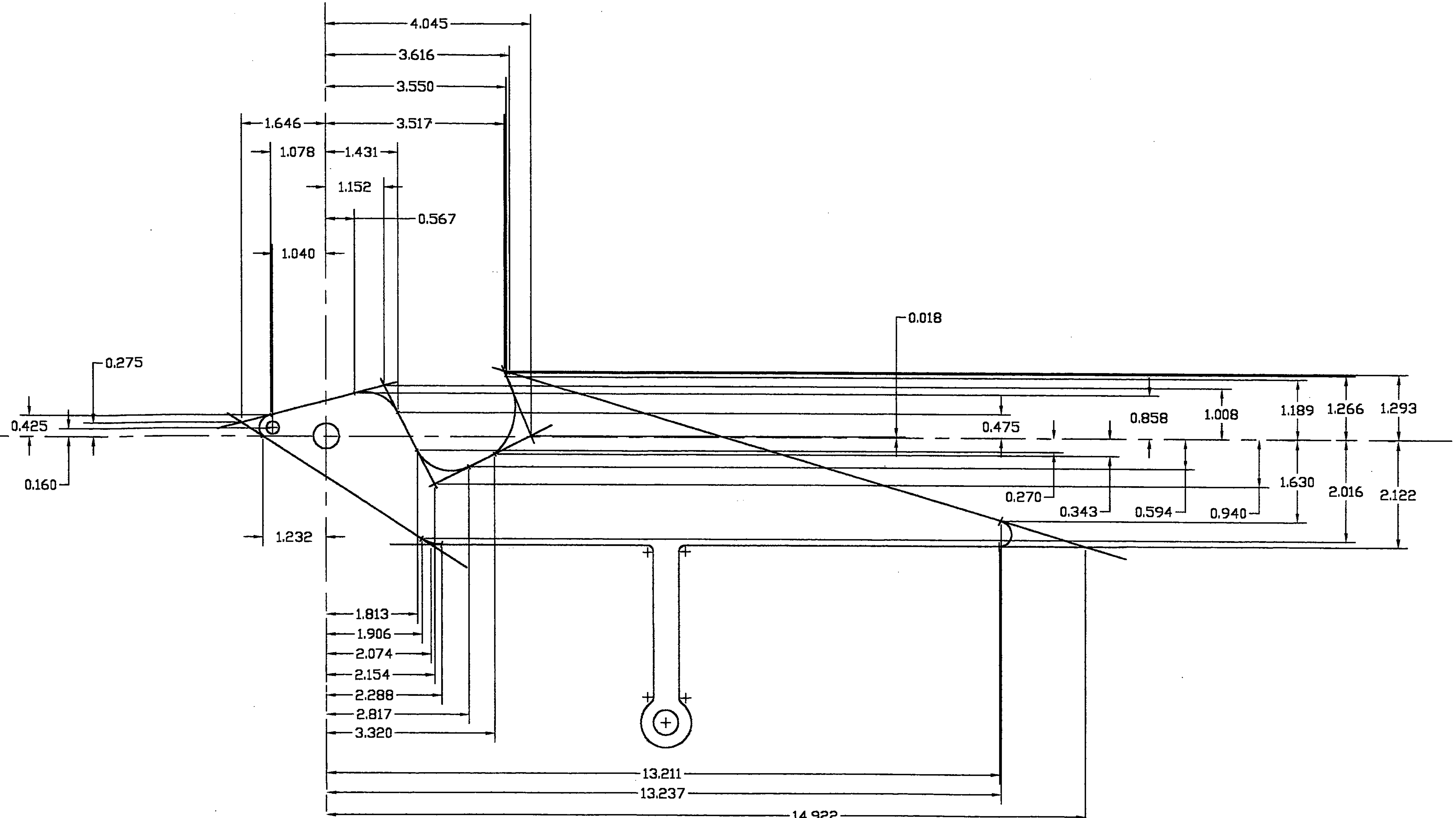
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN M. F. Bowen	DATE 3/29/97	TITLE CAPTURE BAR DIMENSION ODYSSEY AUV LATCH
MATERIAL AS NOTED	CHECK	23	
FINISH AS NOTED			SIZE B — DWG NO. 156-97-016
			SCALE NONE — RELEASE DATE — SHEET — OF



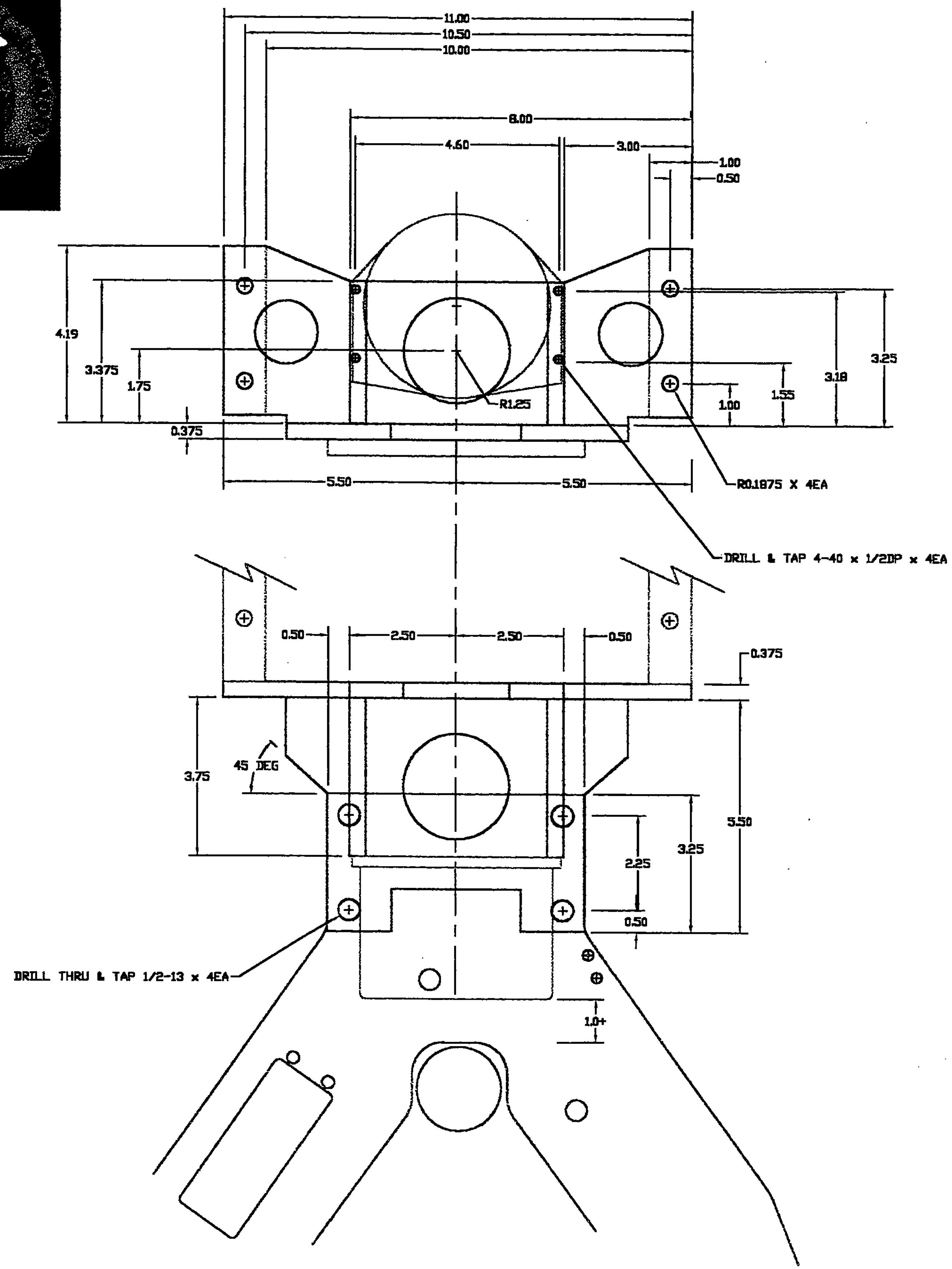
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00	WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
MATERIAL AS NOTED	DRAWN M. F. Bowen — DATE 08/01/97	TITLE CAPTURE BAR ODYSSEY AUV LATCH
FINISH AS NOTED	CHECK — 24	SIZE B — latch5 — DWG NO. 156-97-029
		SCALE NONE — RELEASE DATE — SHEET — OF

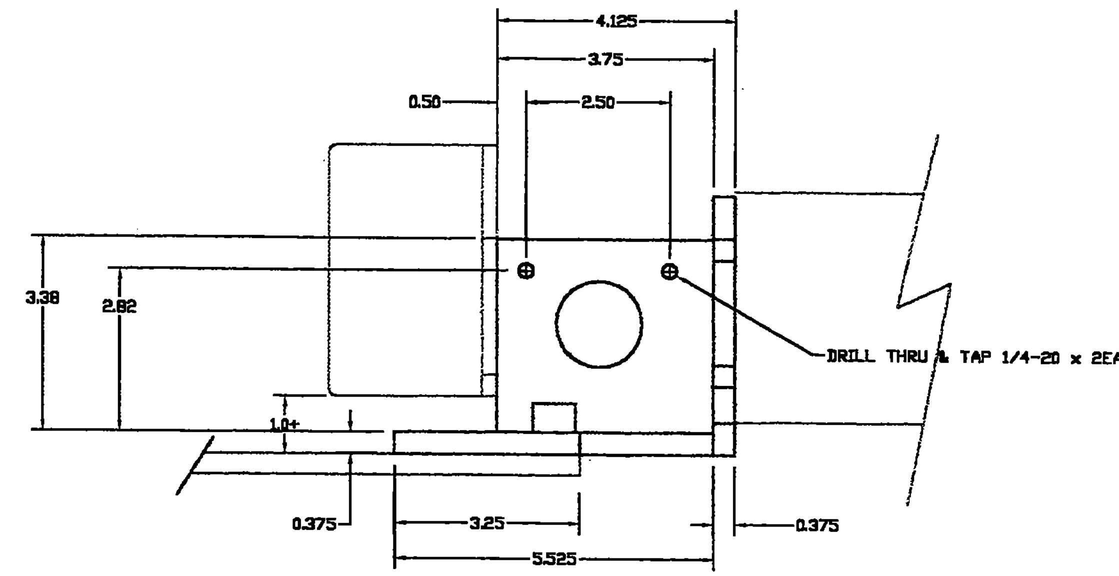


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00	WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN M. F. Bowen / DATE 07/31/97	TITLE CAPTURE BAR & LINK ODYSSEY AUV LATCH
MATERIAL AS NOTED	CHECK / 25	
FINISH AS NOTED		SIZE B / latch5 / DWG NO. 156-97-030
		SCALE NONE / RELEASE DATE / SHEET / OF



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
MATERIAL AS NOTED	DRAWN M. F. Bowen	DATE 6/25/97	TITLE CAPTURE BAR, BY CONRADS ODYSSEY AUV LATCH
FINISH AS NOTED	CHECK	26	SIZE B DWG NO. 156-97-022
			SCALE NONE RELEASE DATE SHEET OF

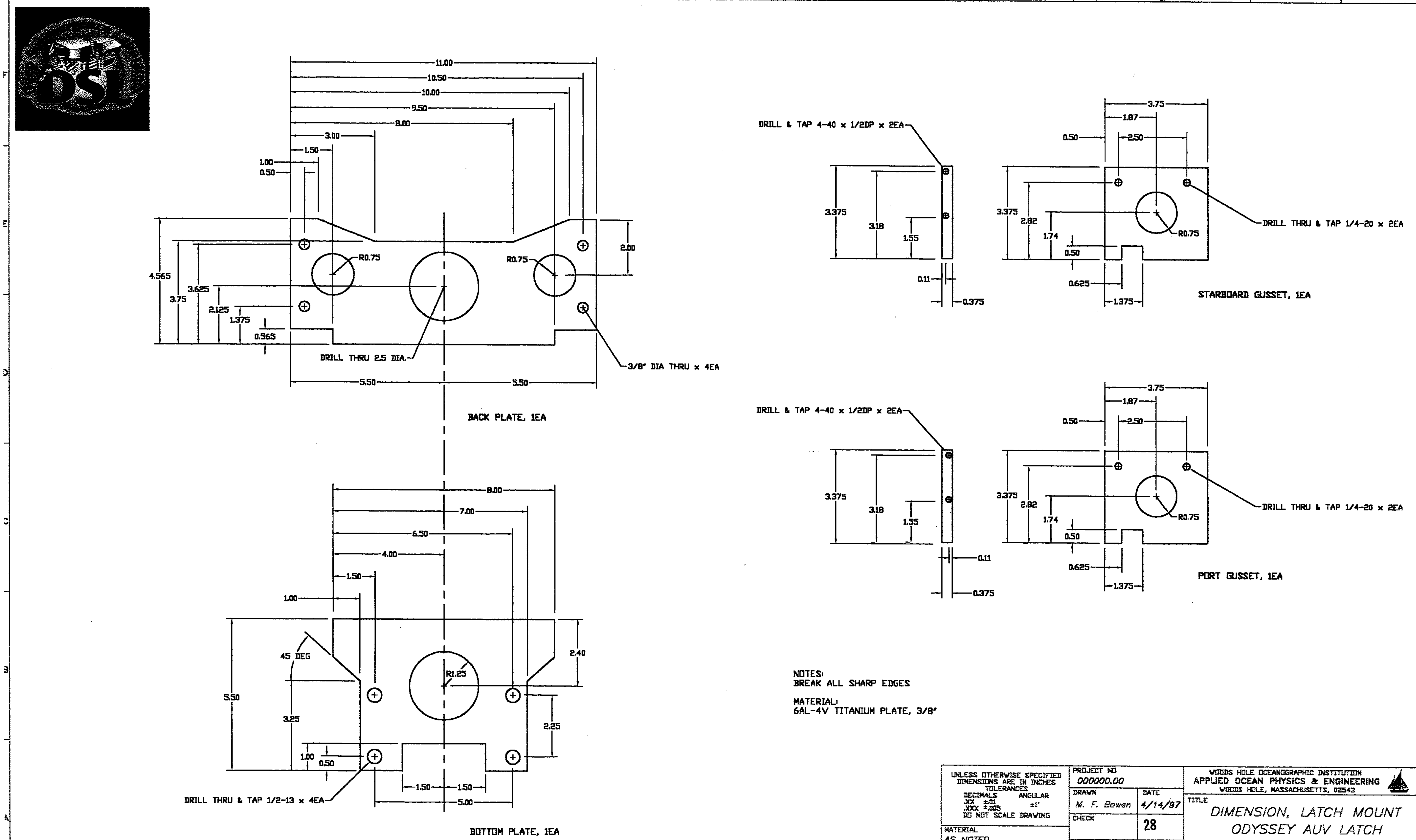




NOTES:
BREAK ALL SHARP EDGES

MATERIAL:
6AL-4V TITANIUM PLATE, 3/8"

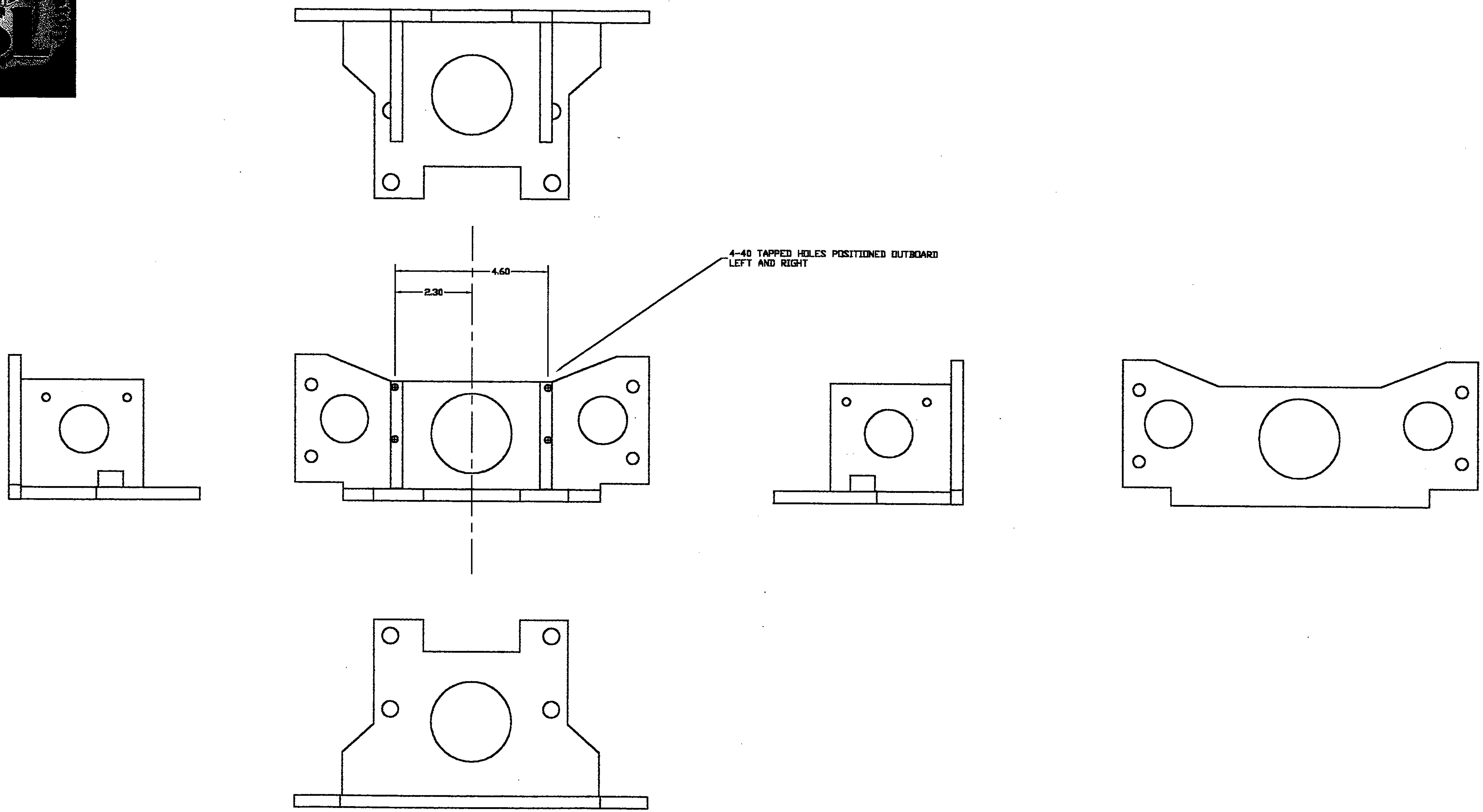
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN M. F. Bowen	DATE 3/29/97	TITLE MOUNT ASSY, LATCH & USBL ODYSSEY AUV LATCH
MATERIAL AS NOTED	CHECK	27	
FINISH AS NOTED			SIZE B mount1 DWG NO. 156-97-0001
			SCALE NONE RELEASE DATE SHEET OF



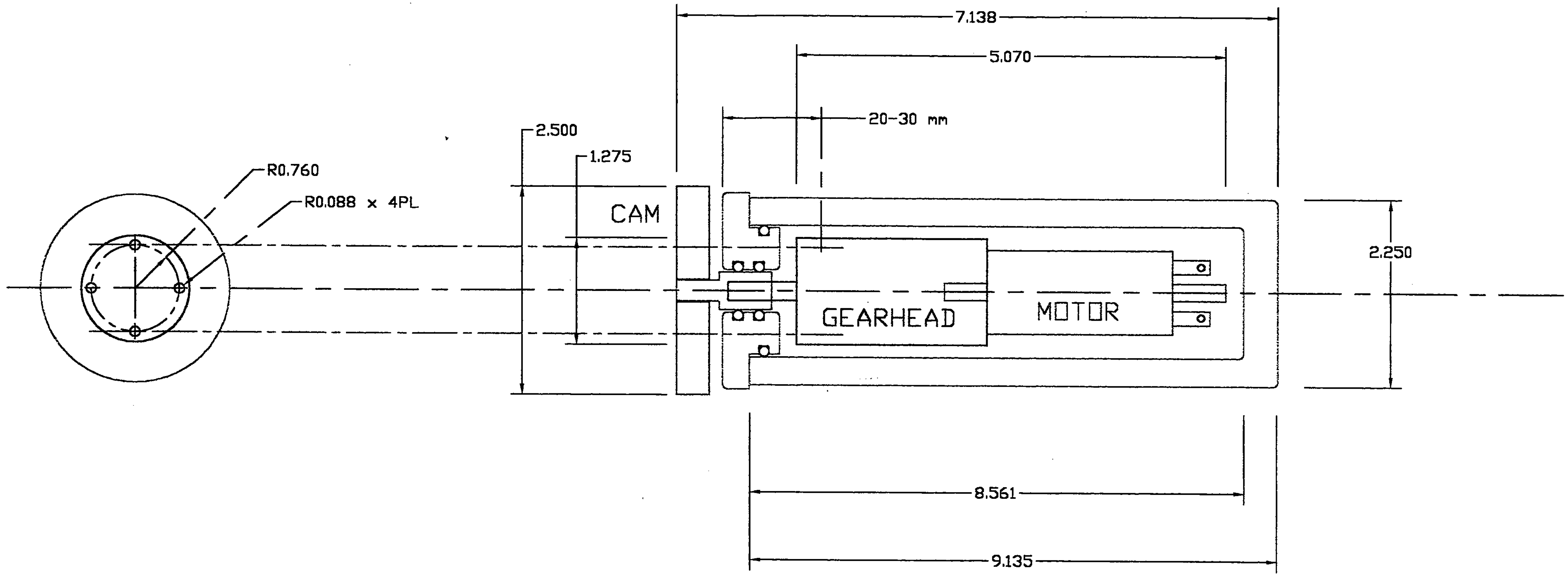
NOTES:
BREAK ALL SHARP EDGES

MATERIAL:
6AL-4V TITANIUM PLATE, 3/8"

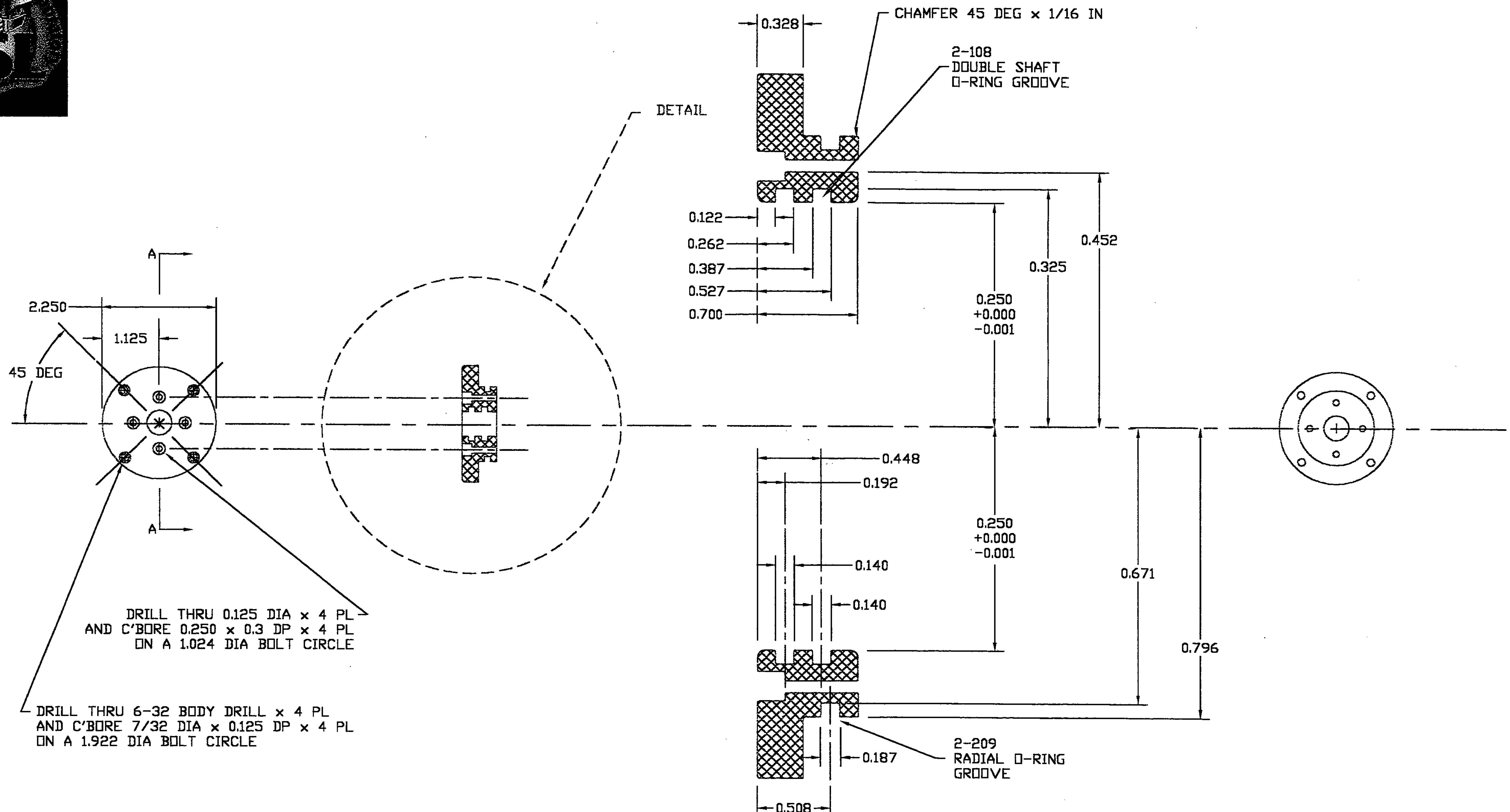
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN M. F. Bowen	DATE 4/14/97	TITLE DIMENSION, LATCH MOUNT ODYSSEY AUV LATCH
MATERIAL AS NOTED	CHECK	28	
FINISH AS NOTED			SIZE B mountalm · DWG NO. 156-97-008
			SCALE NONE · RELEASE DATE · SHEET · OF



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS ANGULAR .XX ±.01 ±1° .XXX ±.005 DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN M. F. Bowen	DATE 4/15/97	TITLE MOUNT WELDMENT ODYSSEY AUV LATCH
MATERIAL AS NOTED	CHECK	29	
FINISH AS NOTED			SIZE B weldmoun DWG NO. 156-97-009
			SCALE NONE RELEASE DATE SHEET OF

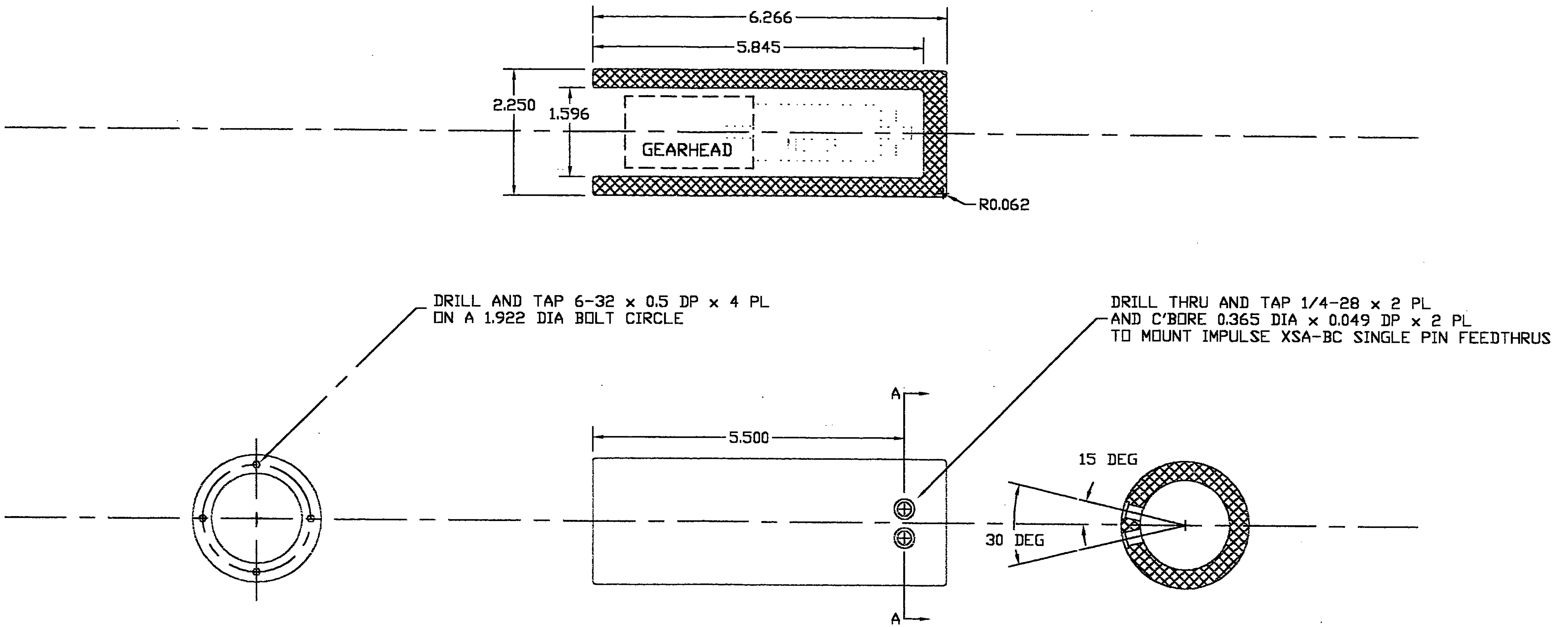


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 07/30/97	TITLE ODYSSEY LATCH CAM MOTOR HOUSING OUTLINE
MATERIAL AS NOTED	CHECK	30	
FINISH AS NOTED	AOP&E	MS #13	SIZE B / DWG NO. 156-97-024
	BIG G-3	289-3420	SCALE NONE / RELEASE DATE / SHEET OF



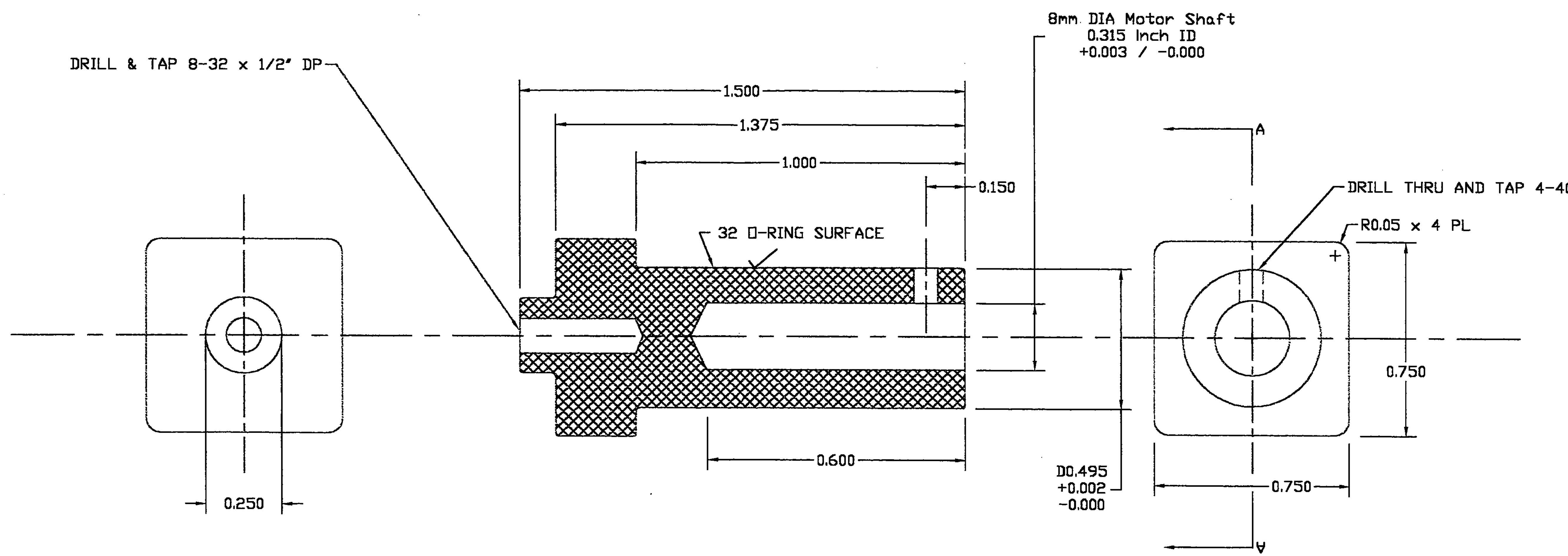
NOTES:
MATERIAL: 6061 T6 ALUM ROUND ROD
PLEASE BREAK ALL SHARP EDGES

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 08/06/97	TITLE ODYSSEY LATCH CAM ENDCAP
MATERIAL AS NOTED	CHECK	31	
FINISH AS NOTED	AOP&E	MS #13	SIZE B / DWG NO. 156-97-032
	BIG G-3	289-3420	SCALE NONE / RELEASE DATE / SHEET / OF



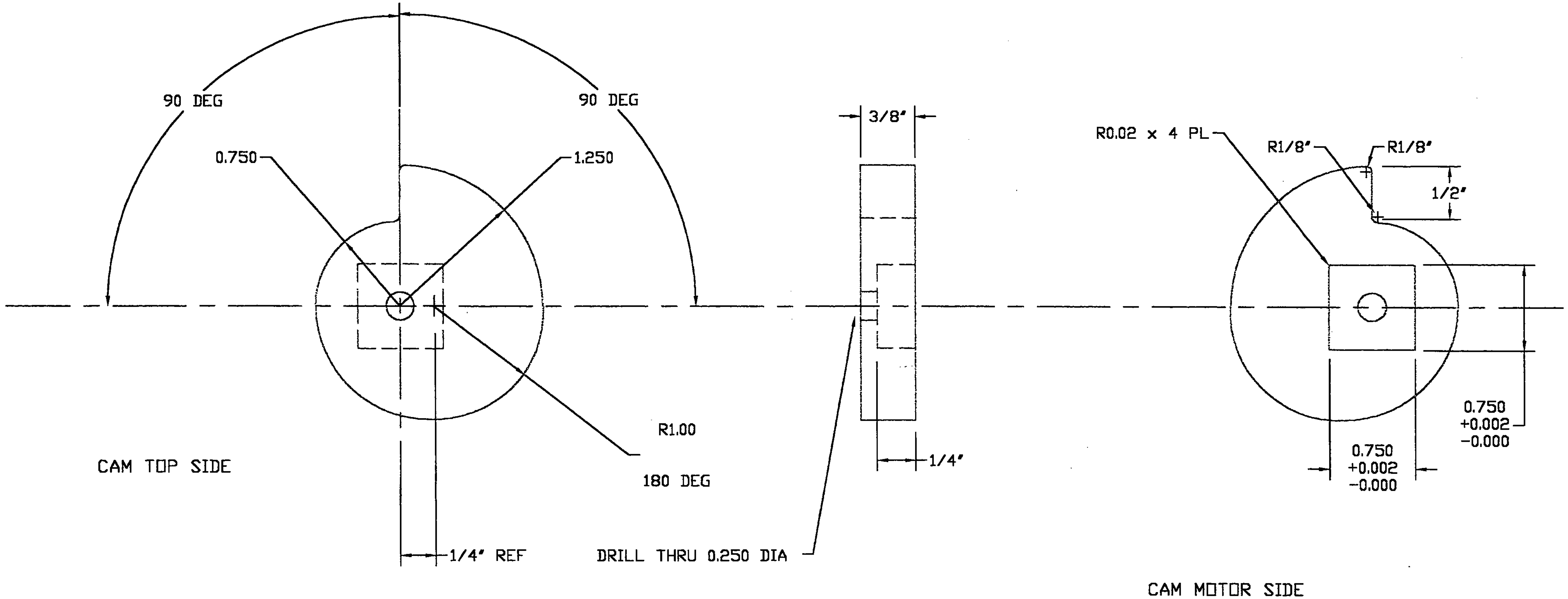
NOTES:
MATERIAL: 6061 T6 ALUM ROUND ROD
PLEASE BREAK ALL SHARP EDGES

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 08/06/97	TITLE ODYSSEY LATCH CAM MOTOR HOUSING DETAIL
MATERIAL AS NOTED	CHECK	32	
FINISH AS NOTED	AOP&E	MS #13	SIZE B — DWG NO. 156-97-033
	BIG G-3	289-3420	SCALE NONE — RELEASE DATE — SHEET — OF



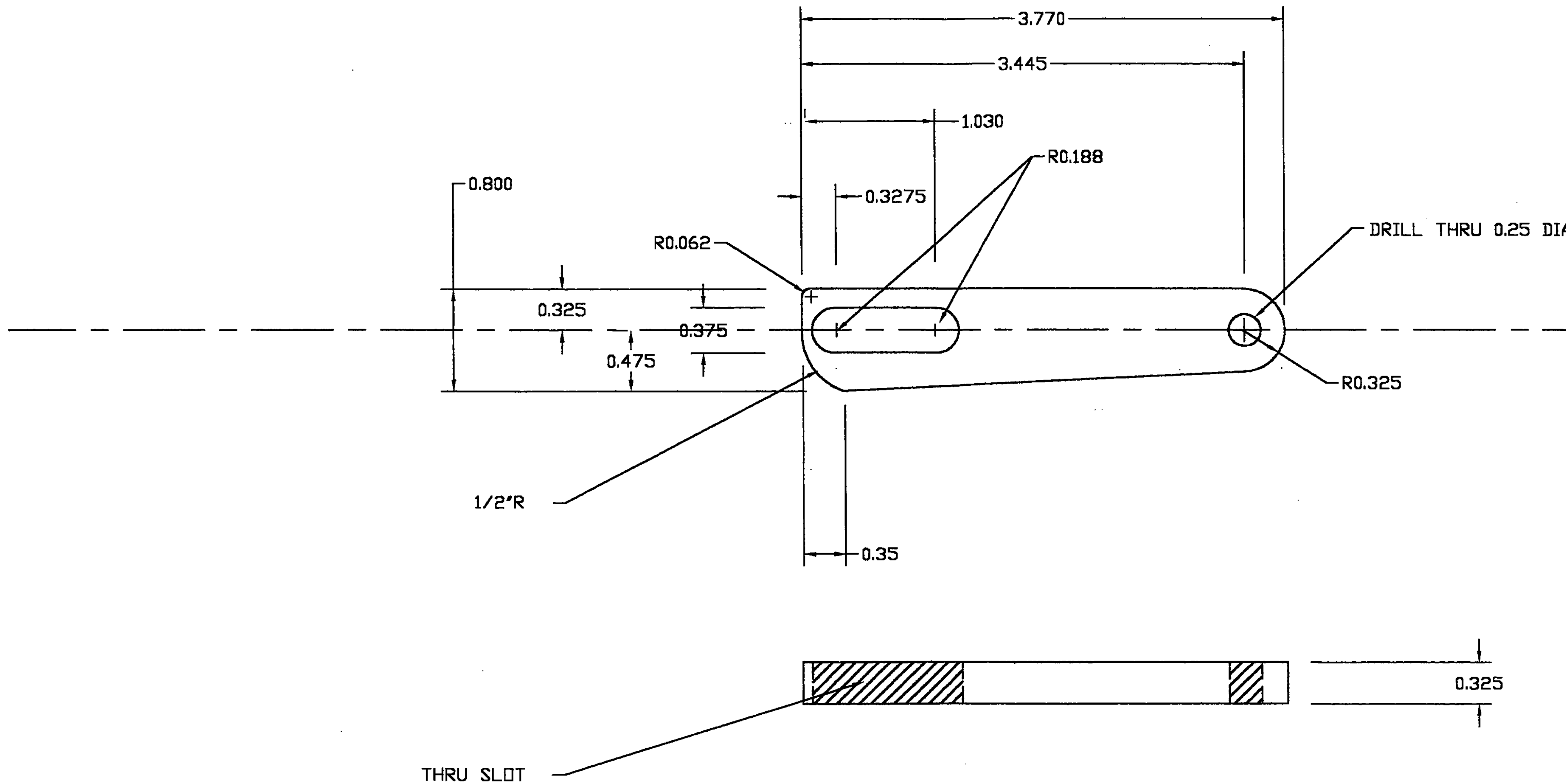
NOTES:
MATERIAL: 316 STAINLESS STEEL
PLEASE BREAK ALL SHARP EDGES

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 09/06/97	TITLE ODYSSEY LATCH CAM CAM SHAFT DETAIL
MATERIAL AS NOTED	CHECK	33	
FINISH AS NOTED	AOP&E	MS #13	SIZE B / DWG NO. 156-97-034
	BIG G-3	289-3420	SCALE NONE / RELEASE DATE / SHEET OF



NOTES:
MATERIAL: DELRIN
PLEASE MAKE ARC TRANSITIONS AS SMOOTH AS POSSIBLE

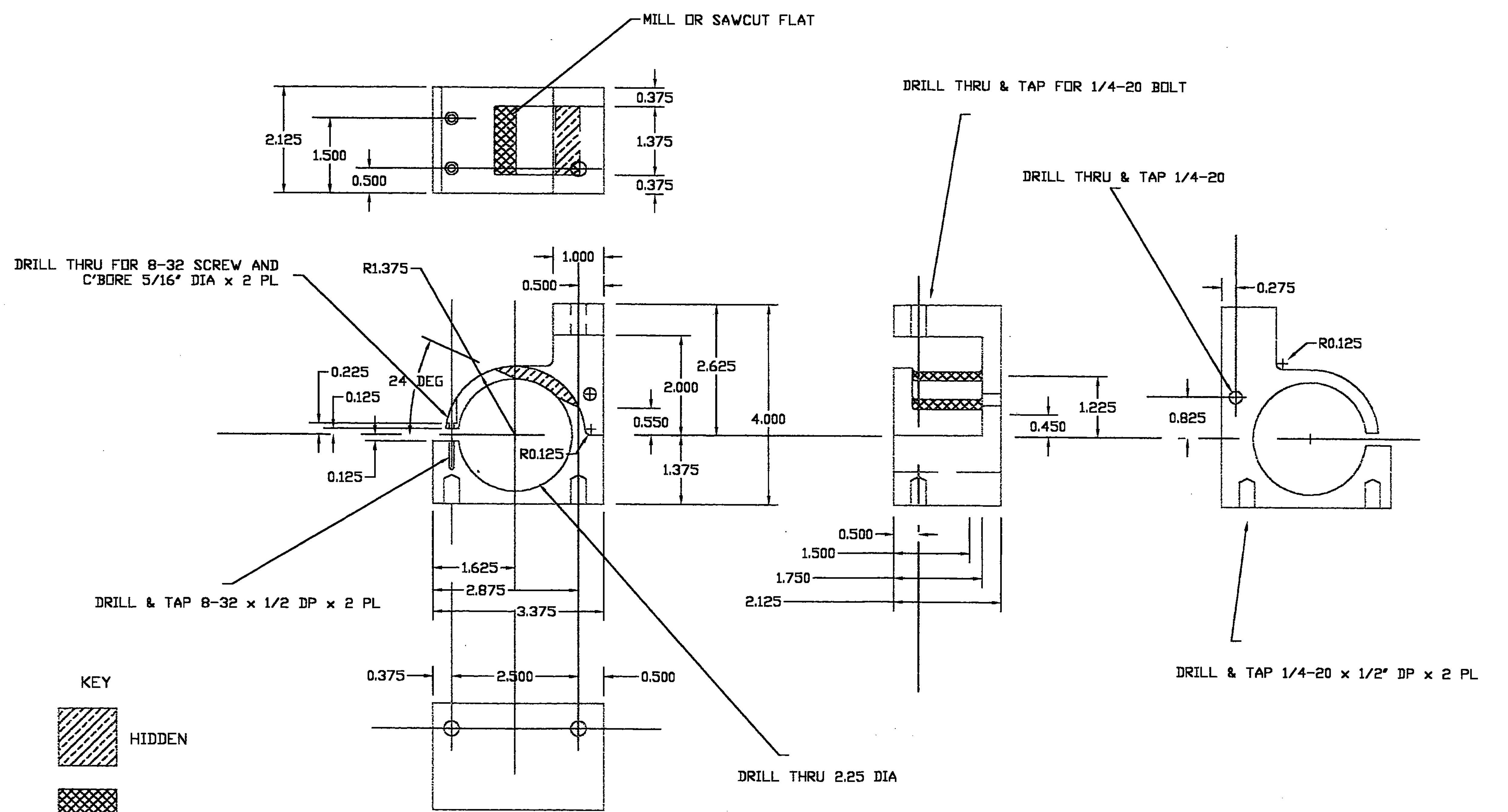
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 08/06/97	TITLE ODYSSEY LATCH CAM CAM DETAIL
MATERIAL AS NOTED	CHECK	34	
FINISH AS NOTED	AOP&E	MS #13	SIZE B — DWG NO. 156-97-035
	BIG G-3	289-3420	SCALE NONE — RELEASE DATE — SHEET — OF



NOTES:
MATERIAL IS GRADE 2 TITANIUM
PLEASE BREAK ALL SHARP EDGES
2EA REQUIRED
MARTIN BOWEN x3420
DWG# 15697040.DWG

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 156077.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 09/10/97	TITLE ODYSSEY LATCH CAM LATCH LINK
MATERIAL AS NOTED	CHECK	35	
FINISH AS NOTED	AOP&E	MS #9	SIZE B · DWG NO. 156-97-040
	BIG 402	289-3420	SCALE NONE · RELEASE DATE · SHEET · OF

MARTIN F. BOWEN
WHOI PHONE: 3420
ACCOUNT: ________
NO. REQUIRED: ____



NOTES:
BLACK OR WHITE DELRIN
PLEASE BREAK ALL SHARP EDGES

36

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1°
DO NOT SCALE DRAWING

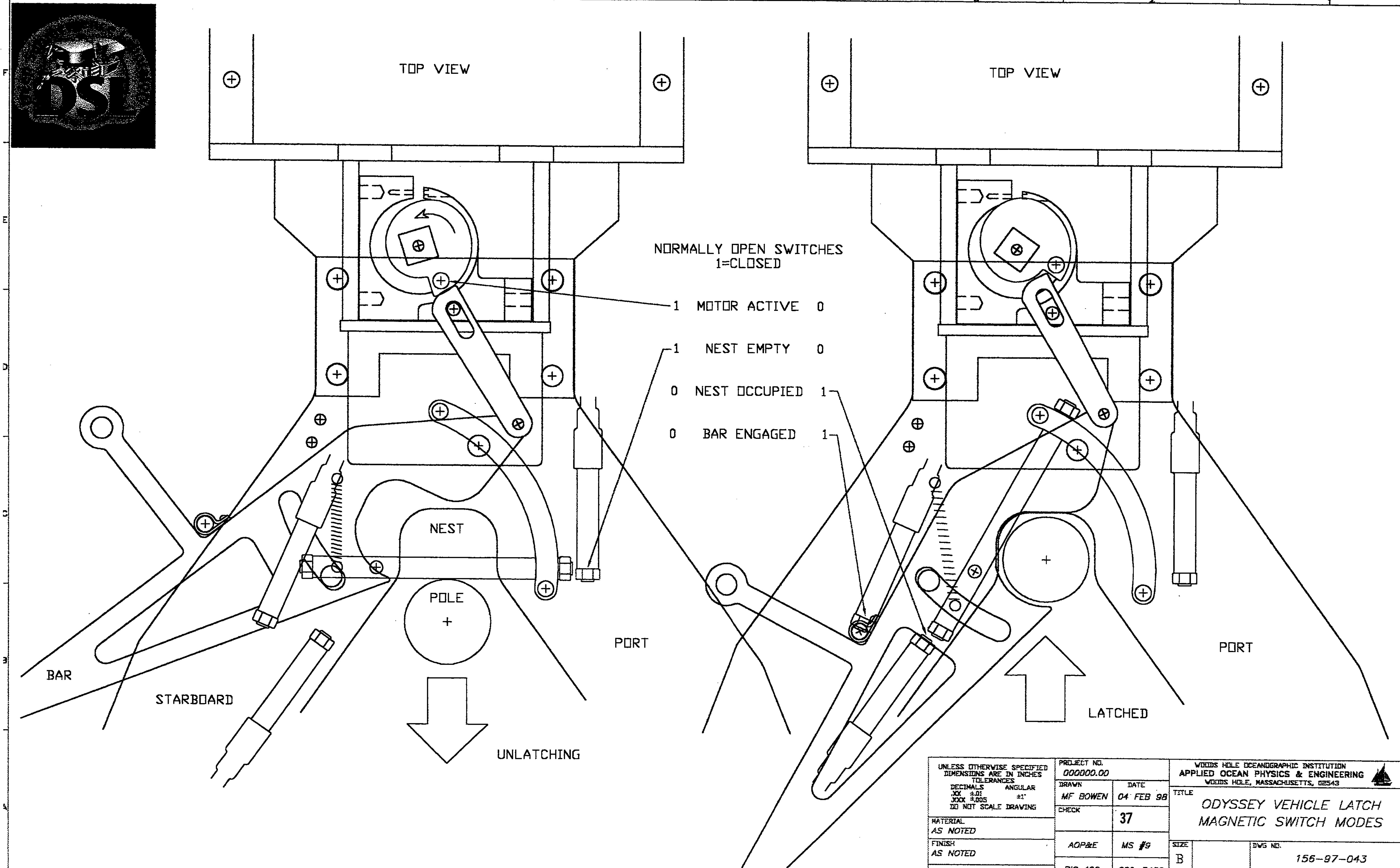
MATERIAL: AS NOTED
FINISH: AS NOTED

PROJECT NO. 156168.08
DRAWN: MF BOWEN — DATE: 7 FEB 98
CHECK: 17 x 22
AOP&E — MS #9
BIG 402 — 289-3420

WOODS HOLE OCEANOGRAPHIC INSTITUTION
APPLIED OCEAN PHYSICS & ENGINEERING
WOODS HOLE, MASSACHUSETTS, 02543

TITLE: MOTOR MOUNT ODYSSEY AUV LATCH

SIZE: C — DWG NO. 156-98-041
SCALE: NONE — RELEASE DATE — SHEET — OF



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 000000.00		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 04 FEB 98	TITLE ODYSSEY VEHICLE LATCH MAGNETIC SWITCH MODES
MATERIAL AS NOTED	CHECK	37	
FINISH AS NOTED	AOP&E	MS #9	SIZE B — DWG NO. 156-97-043
	BIG 402	289-3420	SCALE NONE — RELEASE DATE — SHEET OF

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REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-98-12	2.	3. Recipient's Accession No.

4. Title and Subtitle A Passive Capture Latch for ODYSSEY-Class AUVs	5. Report Date June 12, 1998 6.
7. Author(s) M. F. Bowen	8. Performing Organization Rept. No. WHOI-98-12
9. Performing Organization Name and Address Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543	10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) N000-14-95-1-1316 (G)
12. Sponsoring Organization Name and Address Office of Naval Research	13. Type of Report & Period Covered Technical Report 14.

15. Supplementary Notes

This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept., WHOI-98-12

16. Abstract (Limit: 200 words)

Under subcontract to the Massachusetts Institute of Techology's (MIT) Sea Grant Autonomous Ocean Sampling Network (AOSN) program, the Woods Hole Oceanographic Institution's Deep Submergence Laboratory (WHOI-DSL) produced a passive capture latch for ODYSSEY-class autonomous underwater vehicles (AUVs). The latch is an all-titanium, split tine device, shock-mounted to the bow of the AUV. When the AUV concludes a survey mission and returns to a moored, midwater docking station, the latch leads the AUV's approach and is the first device to collide with the station's vertical docking pole. Latching to the pole is an entirely passive event requiring only forward motion of the AUV. A positive capture indication generated by proximity switches mounted on the device initiates AUV power and data transfer servicing by the station. Unlatching action requires one revolution of a latch motor cam and a brief backing command to the AUV thruster. The possibility of system malfunction was considered in latch design. If for any reason the latched vehicle cannot perform normal unlatching behavior, or the station fails, the latch defaults by securing the AUV to the moored station indefinitely. Two WHOI AUV latches have been used successfully on three offshore engineering test cruises.

17. Document Analysis a. Descriptors

AUV
Latch
Docking

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Approved for public release; distribution unlimited.	UNCLASSIFIED	41
	20. Security Class (This Page)	22. Price

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