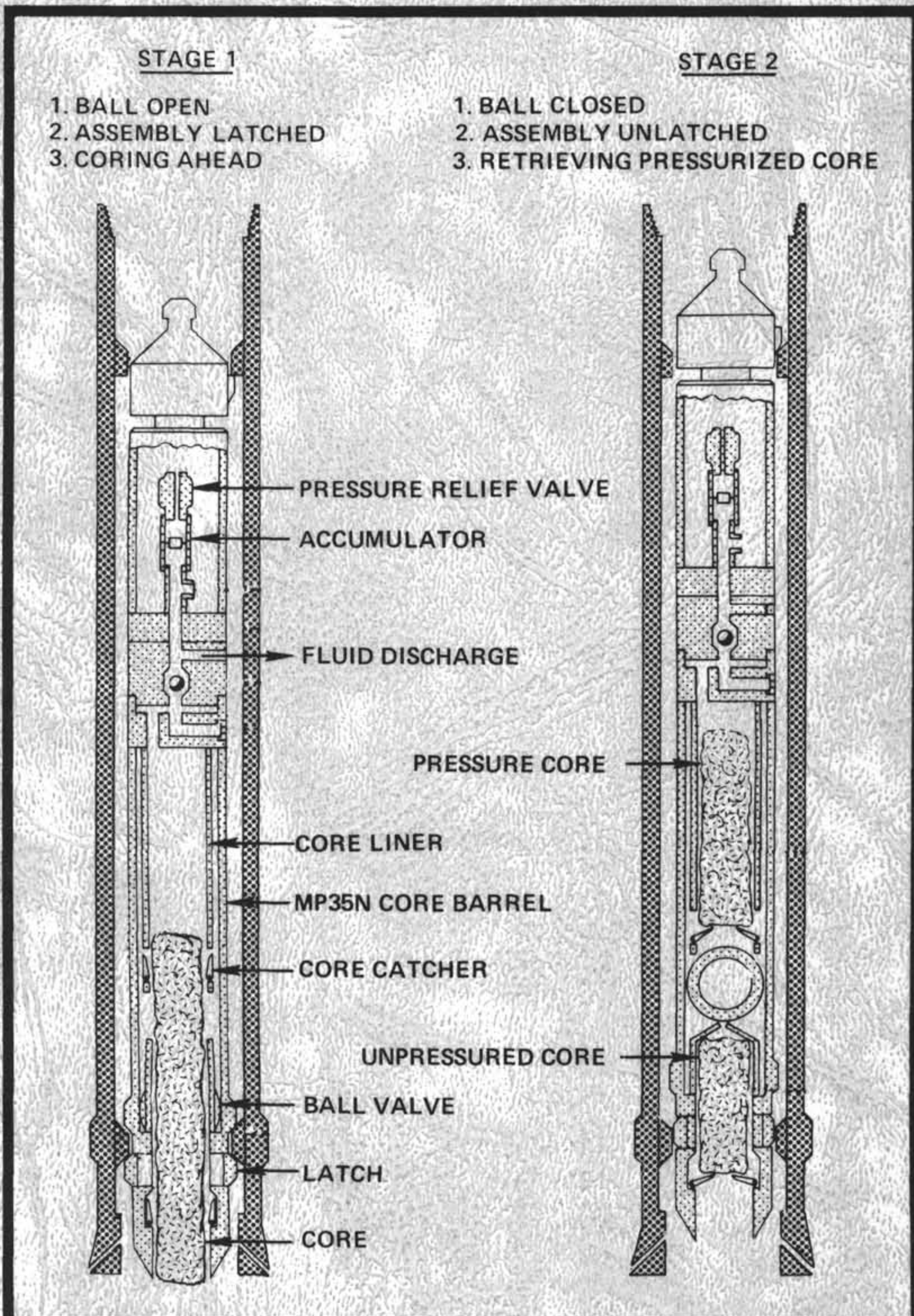
DEEP SEA DRILLING PROJECT
DEVELOPMENT ENGINEERING
TECHNICAL REPORT NO. 16

DESIGN AND OPERATION OF A WIRELINE PRESSURE CORE BARREL



SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA AT SAN DIEGO

CONTRACT NSF C-482
PRIME CONTRACTOR: THE REGENTS, UNIVERSITY OF CALIFORNIA

DISCLAIMER

THE COVER PICTURE

A simplified representation of the Pressure Core Barrel shows the two chief modes of operation. In Stage 1, the barrel is latched in and the ball valve is open while coring ahead. In Stage 2, inner sleeve has been mechanically shifted to separate the core, the ball and upper vent are closed, and the tool is unlatched. The mechanical actuation is accomplished by wireline pull.

TECHNICAL REPORT NO. 16

Prepared for
The National Science Foundation
National Ocean Sediment Coring Program
Under Contract C-482

by

The University of California, San Diego
Scripps Institution of Oceanography
Prime Contractor for the Project

March 1984

W.A. Nierenberg, Director
Scripps Institution of Oceanography

M.N.A.Peterson
Principal Investigator and
Project Manager
Deep Sea Drilling Project
Scripps Institution of Oceanography

FORWARD

Deep Sea Drilling Project

The Deep Sea Drilling Project (DSDP) began coring in August of 1968. Funding and direction was given by the National Science Foundation's (NSF) Ocean Sediment Coring Program. Their mandate was to increase man's knowledge of the earth's development through an ambitious ocean sediment coring program. The Prime Contract for the Project was executed in 1966 between NSF and the University of California (UC) Board of Regents. Scripps Institution of Oceanography, an integral part of the UC system, was to be responsible for management of the Project. Global Marine Inc. (GMI), through a subcontract with Scripps, was to provide the drilling vessel and crew.

Major oceanographic institutions of the United States were called upon to support the proposed drilling program by contributing to the planning of the scientific objectives. The resultant organization became known as "Joint Oceanographic Institutions for Deep Earth Sampling" (JOIDES). These institutions continue to provide scientific guidance for the drilling effort.

International Phase of Ocean Drilling

Prompted by the vast scientific and technical successes of the first seven years, the Project increased the scope of the coring program to include even deeper penetrations into the ocean floor. International interest in the Project was increasing. Several foreign scientific institutions, excited by past scientific results and confident of future successes, were interested in becoming members of JOIDES. These institutions were willing to contribute financially to the Project in exchange for a greater role in the scientific planning. In 1975, the "International Phase of Ocean Drilling", known as IPOD, was born. IPOD was an initial three-year Deep Crustal coring Program supported both scientifically and financially by the governments of France, Germany, Japan, England and Russia.

D/V Glomar Challenger

The GLOMAR CHALLENGER, with its unique coring procedures, has long been recognized as a major technical achievement in its own right. The 10,500 metric ton drillship utilizes an advanced onboard computer and dual bow and stern thrusters to dynamically position itself. The CHALLENGER has operated as far north as 76 degrees latitude; as far south as 77 degrees latitude and has the capability to maintain its station in 30-knot winds and 7-10 foot seas. Similar to conventional drillships, the vessel incorporates a 43 meter derrick amidship with a hookload capacity of 450 metric tons and can deploy a 7000 m drill string. The

CHALLENGER utilizes an automatic pipe racker capable of handling 7,300 meters of 5-inch S-135 drill pipe, and is equipped with a drill pipe heave compensation system.

Most coring operations are conducted in very deep water and all sites are carefully screened to ensure that there is no possibility of encountering gas or hydrocarbons. For these reasons no riser or blow prevention equipment is used. Circulation while coring is provided by two National 1600 mud pumps and consists of seawater without return circulation. Core barrels are retrieved by wireline utilizing a coring winch equipped with up to 7900 m of 6 x 16 wire rope. Well equipped shipboard scientific laboratories are utilized to conduct comprehensive core analyses.

ACKNOWLEDGEMENTS

The Wireline Pressure Core Barrel provides a means to recover unlithified core samples from the deep ocean at in situ (5,000 psi maxiumum) pressure. These core samples may be retrieved through the drill pipe without the need to trip the drill string as required by conventional pressure coring systems. This capability is invaluable to the study of gas hydrate occurrences in the marine environment as well as other geochemical studies.

The first Wireline Pressure Core Barrel (PCB-I) was developed by Mr. M. A. Storms and Mr. B. W. Adams, DSDP Project Engineers. Hydril, Lynes and Page Oil Tools offered major assistance by fabricating some of the specialized components.

Development of the PCB-II (second version) was continued by Mr. Storms with the assistance of Larry Russell and Associates who designed the ball valve (lower closure) mechanism. Mr. D. H. Cameron was instrumental in supervising the fabrication and both shore based testing and sea trials of the tool.

Final modifications of the tool, resulting in the current PCB-III version were accomplished by Mr. Cameron, who also compiled and edited Technical Report No. 16.

Special thanks is given to Mr. S. T. Serocki, Chief Development Engineer, who provided the overall direction and general engineering supervision of the work.

M.N.A . Peterson
Principal Investigator
and Project Manager
IPOD/DSDP/SIO

CONTENTS

DESIGN AND OPERATION OF A WIRELINE PRESSURE CORE BARREL

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This Deep Sea Drilling Project Technical Report No. 16 discusses the design and operation of the Pressure Core Barrel Mod III (PCB-III), and the development leading to this third version of a tool with a history dating back to 1973. The chief reason for its development was to recover methane gas hydrates--compounds which exist only within a narrow range of temperature and pressure. Its most important features include the ability to recover 6.8 meters of core at pressures of up to 5000 psi, and its compatibility with the standard DSDP wireline coring system. Since the PCB-III is lowered and retrieved through the drillstring by wireline, it can be run instead of a standard rotary core barrel wherever desired in the hole. The pressurized core is trapped between a lower ball valve and an upper vent sub, both of which are mechanically closed after the core is cut. The core diameter is limited to 2-1/4", a restriction imposed by the maximum size orifice which could fit through the ball valve; in order to run the PCB-III, the drillstring must include a special PCB drill bit which cuts a 2-1/8" diameter core.

Sea Trials for the PCB-III occurred during DSDP Leg 76, Site 533, off the southeastern shore of the United States. It was successfully deployed four times in five attempts. Controlled degassing of the cores on deck indicated that they contained small amounts of gas hydrates.

INTRODUCTION

The remarkable success of the Deep Sea Drilling Project is evidenced by the voluminous samples and information acquired over the 16 years of its existence. The single achievement of successfully adapting a wireline coring system to recover continuous sediment and rock cores from the deep ocean without tripping the drill string has greatly enhanced the body of scientific knowledge in all areas of ocean studies.

As with any scientific endeavor, the attainment of initial objectives stimulated a host of new questions, and the need for more sophisticated sampling devices. A wireline operated pressure core barrel was developed by the Deep Sea Drilling Project (DSDP) to recover cores at existing formation pressure (up to 5000 psi) and thereby inhibit phase changes that accompany conventional core recovery.

Scientific justification came from four independent sources:

1. Seismic profiles of sediments in certain areas of the ocean floor have shown discordant reflecting horizons which could not be related to known or inferred stratigraphy of these areas. Cores from these reflectors have revealed no anamoly of density or lithology sufficient to explain their presence. It has been postulated that the reflectors consist of zones of interstitial gas hydrates which sublimate into methane gas and water before they can be observed in the cores. Figure 1 shows the temperature and pressure conditions necessary to produce solid methane hydrate from free methane gas and water. Confirmation of the presence of hydrates in deep sea sediments has profound implications for Deep Sea Drilling's future drilling programs near the continental margins and may have extremely valuable economic significance in the foreseeable future.

2. Organic geochemists have desired samples recovered at in situ pressure to test for air contamination in samples routinely taken under normal coring techniques.

3. The inorganic geochemists have also requested sampling under in situ pressure to monitor pressure sensitive chemical reactions between pore fluids and inorganic materials.

4. Gas samples from cores maintained at in situ pressure would be a major contribution for the development of techniques for assessing the presence of potentially dangerous gas pressures at depth.

This Technical Report discusses the design, operation, and field testing of the Wireline Pressure Core Barrel. Its six year developmental history produced two prototypes before the third and current version. The appendix includes several operational test reports and a paper by Larry Russell & Associates who, under contract to the DSDP, designed the PCB Ball Valve Assembly (BVA). Also included in the appendix, is a set of fabrication drawings and an assembly drawing.

DEVELOPMENTAL HISTORY

In 1972 the DSDP conducted an industry search to determine the state of the art in pressure coring devices. The only operational pressure core barrel commercially available with any degree of reliability was a conventional type built by Loomis Hydraulic Testing Company under an ESSO research patent. The tool was not wireline retrievable and was not adaptable to the DSDP coring system.

The DSDP required a wireline-retrievable pressure core barrel operated in the same manner as the DSDP wireline core barrel. The barrel, shown in Figure 2, is allowed to free fall down the drill pipe, which has a minimum I.D. of 4-1/8 inches. The barrel lands in the lower support bearing at an impact velocity of 10-14 ft/sec. The support bearing allows the barrel to remain nonrotating as the bit cores ahead. The core barrel latch, at the top of the assembly, prohibits upward motion of the core barrel during coring. The latch operates by latching under a restriction sleeve in the outer barrel assembly. On completing the coring operations, an Otis type "RS" retrieving tool is lowered on a wireline and latched onto the pulling neck, camming-in the latch dog and releasing the core barrel for retrieval to the surface.

After showing initial interest, Loomis decided against contracting with the DSDP to develop a wireline PCB. In August of 1973 a "Request for Proposal" for building a PCB was submitted to ten other companies. The most important specifications, in addition to compatibility with the DSDP coring system, were outlined as follows:

1. The main components should be adapted from existing oil industry equipment.

2. The lower pressure seal should be a mechanically or hydraulically operated ball valve capable of retaining 5000 psi.

3. The diameter of the core, limited by the I.D. of the ball valve, should be at least 1.5 inches (optimally 2.5 inches).

4. The barrel should be able to maintain structural integrity at 5000 psi with a 4:1 factor of safety.

All of the solicited companies eventually declined to accept the contract, since there appeared to be no commercial market for a wireline PCB.

PCB MOD I

From 1973 through 1975 the Deep Sea Drilling Project developed the first prototype wireline pressure core barrel (PCB I). Figure 3 shows a schematic of the PCB I, which was 32 feet long from the latch to the bottom landing shoulder and could recover approximately 7.5 meters of core. The Ball Valve Assembly (BVA), shown in Figure 4, was designed by Battelle Ocean Engineering and Research Co. Central to its operation was a 2.815 inch diameter Monel K-500 steel ball with a 1-1/2 inch diameter hole. The ball was manufactured by Page Oil Tools, a company that specialized in safety valves. The BVA was a spring loaded device which opened with the set-down weight of the tool, and reclosed when the barrel was retrieved. The 1-1/2 inch diameter hole through the ball valve required that the core be trimmed to 1-1/2 inches from the usual 2-7/16 inch gage core cut by the roller cone drill bit. This was accomplished by terminating the PCB with a sawtooth profile cutting shoe and a drive sleeve which engaged a jaw clutch type insert in the throat of the drill bit (Figure 5). Several standard 4-cone tungsten carbide drill bits were modified to include the drive insert. Rotation of the drill string caused the PCB to rotate, and forced the cutting shoe to trim the core down to 1-1/2 inches before entering the ball valve assembly.

The core barrel section comprised several five-foot long core barrels, made from 1/2" heavy wall allow steel tubing and connected with shorter subs which had provisions for safety relief valves. Hydril double shouldered type 15.5 lb/ft "CFJ-P" threads were used for all the pressure connections. An upper poppet-type vent sub and a pressure relief/ sampler sub were designed and built by Lynes, Inc. The tool was rather heavy and cumbersome to handle on deck, but the weight was needed for ball valve assembly actuation downhole.

The PCB-I was first field tested in May 1975 during DSDP Leg 42B in the Black Sea. It was run 11 times, three of which resulted in significant pressure recovery (1000-1300 psi; in-situ pressure was expected to be approximately 3000 psi). The failures were mainly due to mechanical actuation problems and to core jamming in the cutting shoe. The ball valve assembly caused most of the operational problems. The ball was designed to be cracked open slightly while running down the hole in order to prevent a pressure differential from building up which would hinder its opening upon landing. Unfortunately, the controlling mechanism had too short a stroke to withstand rig floor handling and the drop down the drill pipe; the ball usually prematurely tripped shut, and either didn't reopen, or opened against a high pressure differential which caused severe damage to the seal. Even when it activated properly, the BVA components were often damaged from the landing impact of the tool. It was also evident that the PCB-I had an unfavorable core diameter-to-length ratio. The frictional resistance of the core/barrel interface was apparently exceeding the bearing strength of the stiffer formations resulting in poor core recovery. Subsequent shore based tests showed that increasing the I.D. of the cutting shoe from 1-1/2 inches to 2 inches or better caused a substantial increase in core recovery (Appendix A). These observations were reinforced by continued low recovery with the PCB-I on Leg 44, and by a small diameter core recovery comparison test run on Leg 47. A list of the operational results of the PCB-I appears in Table I.

A complete design review of the PCB-I resulted in the decision to extensively redesign the tool rather than attempt to modify the existing one.

PCB MOD II

The design goals for the second generation PCB-II were identified as follows:

1. Redesign the BVA to decouple the ball actuation function from the barrel landing. The ball should be open and properly aligned prior to the drop. The ball should be tripped downhole after coring has been completed. The ball valve should have a minimum 2.0 inch I.D. The ball closing torque should be increased substantially, allowing the ball to shear through formations of up to 8 tons/ft^2 shear strength.

2. Redesign the vent sub assembly to simplify its operation, increase its reliability, and strengthen it against lateral loads (inherent with on-deck handling). Reduce the total barrel weight by replacing the thick wall alloy steel core barrels with one made from high strength thin walled corrosion resistant tubing.

4. Incorporate a pressure transducer in the upper section of the tool to allow immediate digital pressure measurement before the high pressure fluid is sampled.

5. The tool should be non-rotating as it receives the core in order to minimize core disturbance.

In April of 1977, a Houston based engineering consulting group, Larry Russell and Associates, Inc., was contracted to design an improved BVA. The Deep Sea Drilling Project concurrently redesigned the core barrel section and the Vent Sub Assembly. What emerged, in 1978, was a completely new PCB; it was lighter, more robust, and less complex than the previous version.

The PCB-II consisted of the new BVA, a special MP35N nickle-cobalt based steel core barrel, a pressure relief sub, a hydrostatically operated vent sub, and a sampling sub. The core diameter was increased to 2-1/4 inches (limited by the hole through the ball valve). A special 2-3/16 inch I.D. x 9-3/4 inch O.D. roller cone drill bit eliminated the need for a driven cutting shoe and allowed the PCB to remain non-rotating as the core was cut. The larger core diameter allowed the use of standard 2.6 inch I.D. x 0.1 inch wall butyrate core liners in the core barrel section.

The new BVA Latch (Figures 6,7), incorporated three spring loaded latch dogs which locked the PCB below the support bearing before coring. The ball closure mechanism (shown in Figures 8,9) was initially locked with the ball in the open position by a set of three shear pins. A single shear pin held together a telescoping section, and a set of four pins kept the latch dogs locked out under the support bearing. After coring, wireline pull was used to sequentially shear the pins and stroke a core-catching inner sleeve through the ball, rotate the ball closed, and shear loose from below the support bearing. The available wireline pulling force varied with the length of the line, since its own weight added to the total load. In a deep hole (6000 m), the maximum safe overpull was about 2500 pounds. The BVA latch was designed to release at 2000 pounds pull. The ball closing- torque allowed the ball to shear through formations of nearly eight $tons/ft^2$ shear strength.

The ball seat was critical to the operation of the tool because it had to be strong enough to retain 5000 psi, yet had to conform easily to the ball to seal against minimal pressure (since the pressure builds up slowly during tool retrieval). The selected design consisted of a Vespel* seal in a stainless steel body. The Vespel was machined to conform to the curvature of the ball.

The pressure relief sub had a dual purpose: It contained a Paine 0-10,000 psi pressure transducer which allowed external pressure monitoring when the PCB was on deck. It also contained a Circle Seal pressure relief valve adjusted to vent pressures in excess of 5000 psi.

The hydrostatic vent sub, located above the pressure relief sub, was held open during coring by hydrostatic downhole pressure acting against a spring sealed in an atmospheric chamber. During retrieval, as the external hydrostatic pressure decreased, the

*Vespel is a Trademark for a group of Polyamide and Aramide Resins fabricated by DuPont spring force acted against a piston to seal the vent and trap the pressurized core inside. The amount of pressure retention depended upon the spring force; several springs were available, dependent upon the expected hydrostatic pressure encountered.

The sampler sub contained a sample valve assembly which also functioned as a back-up safety relief valve. Four brass shear pins (rated at 10,000 psi) retained a valve stem which sealed the sample port from barrel pressure. If the 5000 psi pressure relief valve failed to vent, and the barrel pressure built up to 10,000 psi, the pins would shear to release all of the pressure and maintain a minimum ultimate safety factor of 2:1. To sample the pressurized fluid, a sample valve lock screw was tightened down against the head of the valve stem to take the pressure load off of the shear pins; then the shear pins were removed, and the screw was backed off slowly until the valve stem opened the sample port to the internal pressure.

The core barrel section was constructed from MP35N tubing (3-1/2" O.D. x 3" I.D.) with 3-1/2-9.2 lb/ft "F" Hydril threads. It was both stronger and much lighter than the thick wall tubing of the former PCB-I. The weight of the new tool was just over 400 pounds--approximately two thirds the weight of the PCB-I. The core recovery capacity of the PCB-II was initially only four meters, but later was nearly doubled (to 7.8 meters) with the addition of a second core barrel and a coupling.

Table II lists the operational results of the PCB-II. The first seagoing operational tests were conducted during Leg 62 in July 1978. It was run five times, three of which recovered substantial pressure. No hydrates were encountered. Subsequent test runs on Legs 64, 66, 67, 72, and 74 (see Appendi C) revealed an inherent unreliability in the actuation and sealing capability of the BVA. During this time, a mechanical vent sub was developed to replace the hydrostatic vent sub. The new vent sub depended on wireline pull to shear a pin and close the vent after the core was cut. The advantage gained was that the mechanical vent sub did not depend upon hydrostatic pressure; it could be mechanically closed at the bottom of the hole, and thereby retain the full downhole pressure.

By Leg 72, the ball seal was perfected; a chamfered metal seat with a teflon O-ring replaced the Vespel seal. The O-ring effected a low pressure seal. As the pressure increased, the teflon compressed into its groove allowing a metal-to-metal contact between the ball and the seat to provide the high-pressure seal. There was no simple solution to the mechanical actuation failures. The successful actuation of the BVA depended upon the correct sequence shearing of three sets of shear pins. On-deck handling and the drop down the drill pipe often resulted in premature shearing or weakening of the pins; one stage of pins, preferentially weakened relative to a "weaker" stage, would result in incorrect sequencing in the BVA actuation. The subsequent modification to the BVA and several improvements made in the upper section, resulted in the final (current MOD III) version of the PCB.

PCB MOD III

Description

A representation of the PCB-III in several operational modes is shown in Figure 10. It is 34 feet long and accepts 7.8 meters of core, 6 meters in the pressurized section above the ball valve, and 1.8 meters in the unpressurized section. The largest component is the 3-7/8" O.D. ball closure mechanism, which had to be spaced to operate above the 3-7/8" I.D. hydraulic bit release in the bottom hole assembly; this necessitated the long unpressurized core section between the ball and the lower core catcher.

The PCB-III is distinguished from its predecessor by improvements made in the BVA actuation mechanism and in the upper sampler assembly. The shear pins in the BVA were eliminated in favor of a combination of a collet sleeve, ball locks, and disc spring stack which ensure correct sequential actuation of the three BVA functions: stroking a sleeve through the open ball to clear it of core, rotating the ball closed, and releasing the lower latch to allow retrieval.

In the PCB-III, the pressure relief valve is located in the sampler assembly above the sampler sub, where it is isolated from the pressurized core by means of a 0.5 liter capacity floating piston accumulator. A temperature probe has been plumbed into the pressure relief sub so that the core temperature as well as pressure can be externally monitored when the tool is on deck. The accumulator serves a dual purpose of protecting the pressure relief valve from sediment clogging, and maintaining barrel pressure against possible leaks in the pressure chamber. When the upper chamber of the accumulator is charged with nitrogen to, say, 4000 psi, barrel pressure above 4000 psi will move the piston to increase the gas pressure accordingly. When the barrel pressure exceeds 5000 psi, the pressure relief valve will open to vent some of the nitrogen, thereby saving all of the sample fluid. Even a very small leak in the ball or vent sub seals will quickly reduce the barrel pressure since it mostly contains relatively incompressible sediment and water. In this case the gas in the accumulator will expand to support the barrel pressure against the leak. An alternate sampling assembly, which employed a sediment trap and a 20 μ filter in place of the accumulator to protect the pressure relief valve, was made available in the event the accumulator developed a problem.

The alterations to the sampler sub assembly necessitated the elimination of the back-up pressure relief feature possessed by the PCB-II. The sampler sub was therefore modified to include a 7000 psi Fike rupture disc unit. If the pressure relief valve failed to vent, the barrel pressure could increase to no more than 7000 psi, before the disc would burst. The structural integrity of the tool would be protected although all pressure would be lost.

Operation

A typical operating cycle is described as follows:

1. Suppose that the water depth at a site is 3800 m, and scientific objectives call for a pressurized core at 200 m subbottom. The standard wireline core barrel is used to continuously core to 200 m (using the PCB drill bit).

2. Expected bottom hole pressure is 5840 psi (4000 m x 1.46 psi/m), so the PCB accumulator is charged with nitrogen gas to 3000 psi in order to approximately centralize the piston in the accumulator cylinder when the barrel is at the bottom.

3. The PCB is go-deviled down the drill pipe to land on the support bearing and latch under the latch sleeve as does the standard core barrel. A second latch in the BVA locks in under the support bearing.

4. The PCB rides on the support bearing and remains non-rotating as the core is cut and enters the barrel through the open ball valve. The water above the core is exhausted through the open vent sub at the top of the barrel (Stage 1, Figure 10).

5. After the core is cut, a retrieving tool is run in on the wireline to lock onto the PCB and release the upper PCB latch. However, the lower latch is still effective. Increasing wireline pull against the lower latch dogs forces the BVA to scope apart against the restraint of the disc spring stack. After one half inch of relative movement, a collet sleeve releases to allow a core catching tube to scope through the ball and clear it of core. Three small locking balls, which restrained the ball valve rotating mechanism, can now fall into the space vacated by the tube; the ball rotates closed. In the vent sub, the restraining shear pin shears, and the vent is pulled closed (Stage 2, Figure 10). Finally, at several thousand pounds pull, the disc spring stack is compressed enough to allow the latch dogs to fall into detents and release the tool from under the support bearing (Stage 3, Figure 10).

6. During retrieval, the downhole pressure will remain sealed in the barrel while the hydrostatic pressure decreases. When the pressure differential across the pressure relief valve exceeds 5000 psi, the valve will

vent the excess pressure.

7. After it has returned to the surface, the drill pipe is disconnected at a joint to expose the PCB, which is still connected to the wireline. The protective cap is removed from the pressure transducer, and an immediate pressure measurement is taken while the PCB is still within the protective sheath of the drill pipe.

8. The PCB is then removed from the drill pipe and either layed down in an inclined horizontal ice bath, or in a vertical shuck containing ice water. The internal pressure and temperatures are monitored as the pressurized fluid and gas are withdrawn through the sampling assembly (Stage 4, Figure 10). If gas generating hydrates have been recovered, then the pressure will increase after it has been initially dropped through samplings.

10. Several hours are needed to redress the BVA; several BVA's are provided so that used ones can be redressed without holding up rig floor operations.

Sampling

Sampling procedures may vary according to the Scientific objectives of the operator. Normally there is a desire to stabilize the temperature of the barrel during sampling--hence the ice bath. The sample port is a 1/4 inch FPT "tee" fitting located between two valves in the sampling assembly. The valves may be closed to isolate the port and allow the installation of the sampling manifold.

The simplest sampling manifold is portrayed in Figure 10 (Stage 4). A more complicated one, used on Leg 76, is shown in Appendix D (Figure 2). In either case the configuration allows the pressurized gas and water from the PCB to be regulated into evacuated pressure cylinders, which are usually rated at 1800 psi and have capacities ranging from 75 ml to 300 ml. When the filled cylinder is disconnected from the manifold it may either be immediately analyzed on the shipboard gas chromatograph, or frozen for shipment to a shore based laboratory.

Only after the barrel is bled down to atmospheric pressure is the ball valve removed to allow access to the core. From that point the core is processed just as the standard DSDP rotary cores.

Leg 76 Sea Trials

The PCB III was tested in September of 1980 during Leg 76. The details are reported in Appendix C and in Table III. It was run five times on Site 533A. The water depth was 3194 meters. Four runs were successful in recovering pressure; the only failure was due to operator error when a plug was inadvertently left out of the sampling assembly. Evidence of gas hydrates was discovered in two of the cores. The BVA and the mechanical vent sub functioned flawlessly on all runs. On three of the four successful runs, the barrel retained pressure in excess of 4000 psi. The one run where relatively little pressure was retained (1500 psi) was the only one in which the alternate sampling assembly was used in place of the accumulator; here the pressure relief valve may have stuck open too long due to particle contamination from the sample fluid passing directly through the valve.

Appendix D contains a paper co-authored by Kvenvolden, Barnes, and Cameron which discusses the results of the analysis of the pressurized cores obtained during Leg 76.

Leg 84 Results

The PCB-III was deployed three times at Site 568 on the upper part of the Middle America Trench slope, in about 2000 meters of water. On an earlier site (Site 565), large quantities of gas hydrates were recovered in several cores without the benefit of the PCB, which could not be used because the bottom hole assembly did not include a PCB drill bit.

The major objective of Site 568 was to monitor the gas in the whole section in a study of the formation of gas hydrates. As shown in Table III, the first two PCB cores (cores Nos. 11 and 21) recovered relatively little core at in situ pressure; no gas hydrates were recovered. However, the next (standard) core, while not physically recovering gas hydrates, showed hydrocarbon gas concentrations which suggested evidence of decomposed hydrates. The PCB was used again for core 31, where it recovered 1.2 meters in the unpressurized section. No core was recovered above the ball valve, although it sealed properly and retained water at 2000 psi.

The distributional pattern of gas hydrates--which was pieced together later from all available evidence--showed that cores 11 and 21 were taken in a non-hydrate zone. Core 31 was taken in a zone containing hydrate dispersed in a fine grained sediment, but no pressurized core was recovered.

CONCLUSION

General

The DSDP Wireline Pressure Core Barrel Mod III (PCB-III) is the culmination of a long developmental program. It is capable of recovering deep ocean sediment at pressures of up to 5000 psi. Being wireline retrievable, it can be run as many times as desired, and at any depth in the hole. It has recovered hydrates on DSDP Leg 76, and is considered to be a fully operational tool. Though the development phase of the tool has officially ended with the PCB-III, it is recognized that relatively few operational runs have been made and that many more runs in various sediment types are needed to fully debug it.

Compatibility

The PCB-III was designed to be compatible with the standard DSDP rotary coring system. It must be run with a special 2-1/4" I.D. roller cone drill bit which requires that the entire hole be committed to recovering slightly smaller diameter cores, even though only one or two PCB cores may be desired. In soft formations, the smaller diameter cores may cause increased core disturbance, since they are retained in a standard 2.6" I.D. core liner and hence are more subject to wall erosion from excess water in the liner. However, in hard formations recovery may be improved, since there is less wall friction to inhibit core entry, and since the hard core is less affected by excess water.

Well logging can be done in a PCB hole when a Hydraulic Bit Release (HBR) is included in the Bottom Hole Assembly (BHA) of the drill string. The HBR enables the driller to release the bit in the hole to allow open hole logging before tripping the drill string. The minimum restriction through the HBR is 3-7/8". The PCB ball closure mechanism is also 3-7/8" diameter. To prevent interference, it was necessary to adjust the PCB spacing to position the ball closure mechanism above the HBR when the tool was landed. This required that a 1.8 meter long unpressurized core section be included between the ball and the lower core catcher. The unpressurized section was also unlinered. Fortunately, it could be disassembled into smaller components from which the core could be relatively easily removed. But one component, the meter-long Dog Retainer, required the aid of a hydraulic piston extruder to remove the core.

The Heat Flow Tool, a special wirelined instrument which is used to obtain bottom hole temperature measurements through the drill bit, terminates in a meter long probe which protrudes through the bit and into the sediment. Slimmer probes were fabricated so that the tool could be used with the small-hole PCB bit.

Two new important coring tools were developed after the PCB-III: The Hydraulic Piston Corer (HPC), and the Extended Core Barrel (XCB). Both of these tools require the use of a wide throat (3.8" I.D.) drill bit, and are not compatible with the PCB-III.

Problems

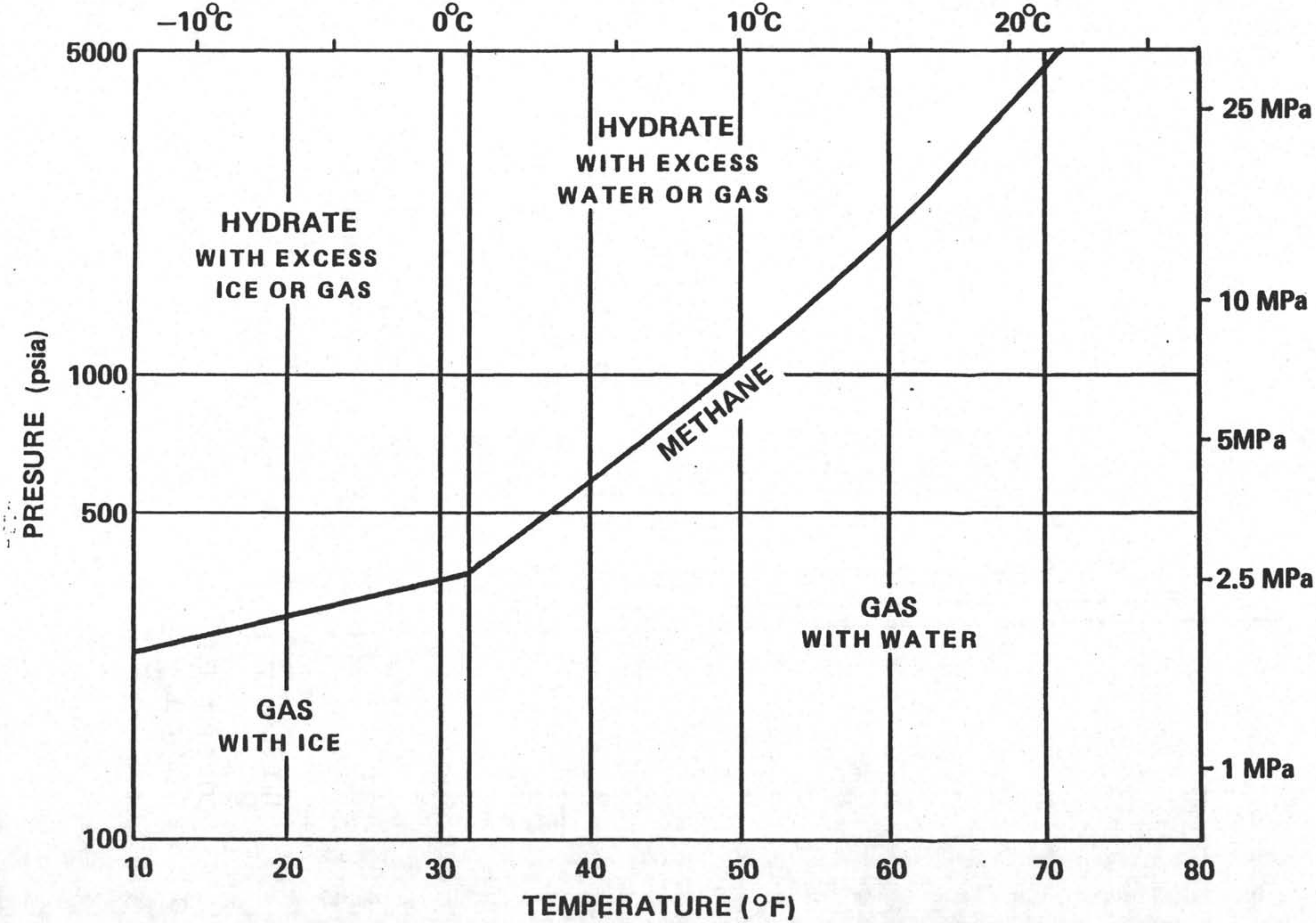
1. In six of the eight deployments of the PCB-III during Legs 76 and 84, no core was recovered in the 1.8 meter non-pressurized section below the ball valve. Though that section, being non-pressurized, was relatively unimportant, it still represented a significant percentage of the total potential recovery. In the PCB-III design, only one core catcher is located below the ball to retain the unpressurized core; in a standard core barrel two core catchers are used to retain the entire core. Too few runs have been made to warrant a redesign, but if that pattern continues, the bottom connection should be redesigned to incorporate two core catchers.

2. The low core recoveries in the three PCB-III cores taken during Leg 84 suggested that the mechanical vent sub may have been closing prematurely. It is the only mechanism in the PCB-III which still uses a shear pin. If it closed before coring, it would trap the water column above the incoming core, and would inhibit or completely halt further core entry into the barrel. The number of shear pins can (and should) be increased to two or even three to prevent premature failure of the pins.

3. Because of its complexity, several hours are required to clean and redress the PCB III, and it has a high potential for misassembly. However, it has functioned with a high degree of reliability thus far.

Recommendations For Future Improvements

The incompatibility between the PCB-III and the HPC/XCB systems is a major hindrance, since the newer systems are projected to shoulder the bulk of future ocean coring. The next step in the development of the PCB should be to adapt it for use with the wide throat HPC/XCB bits. The modification would require that a core trimmer (to reduce the core diameter from 3.8" to 2-1/4") be designed to either be run down on the wireline when needed, or--more likely--to become incorporated in the PCB cutting shoe, and engage to be driven at the bit. The major problem to be overcome is to decouple the trimmer from the core barrel section so that the barrel does not rotate with the bit.



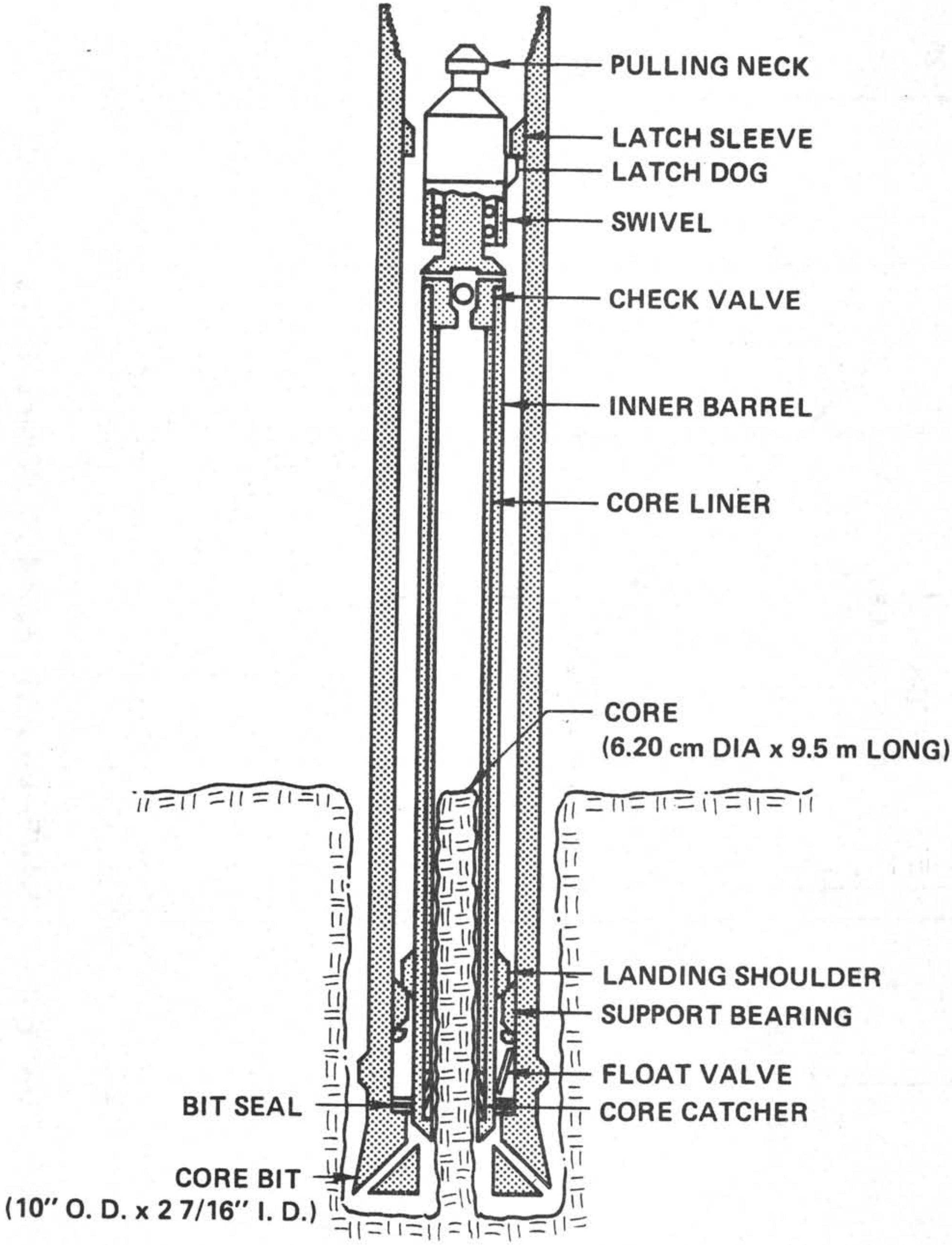
CONDITIONS FOR METHANE-HADRATE FORMATION (after Katz et al., 1959)

FIGURE 1

FIGURE 2

DEEP SEA DRILLING PROJECT

WIRELINE CORING SYSTEM



SCHEMATIC
DSDP WIRELINE PRESSURE CORE BARREL
PCB-I

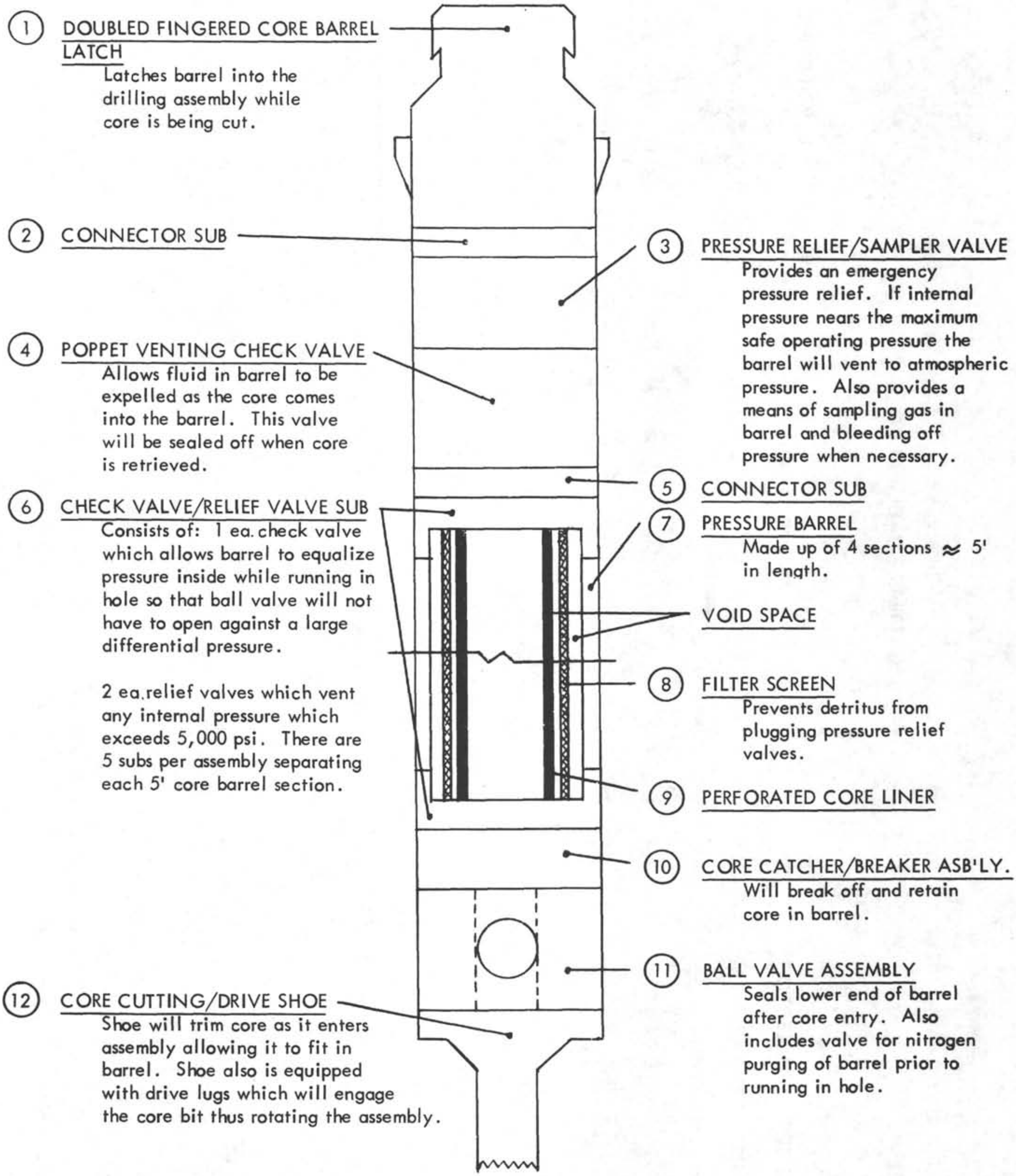


FIGURE 3

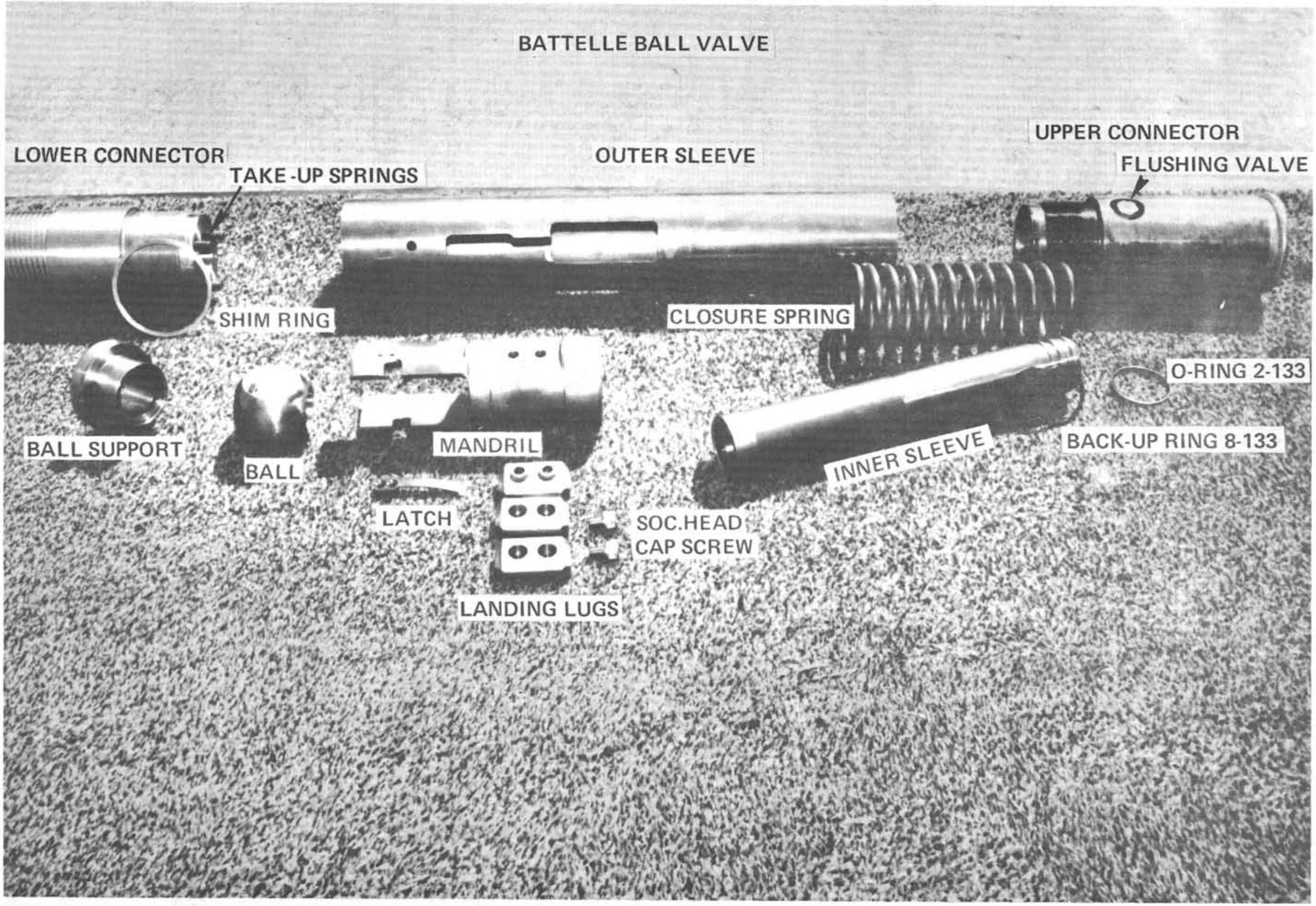


FIGURE 4
PCB-I
BALL VALVE SUB DISASSEMBLED

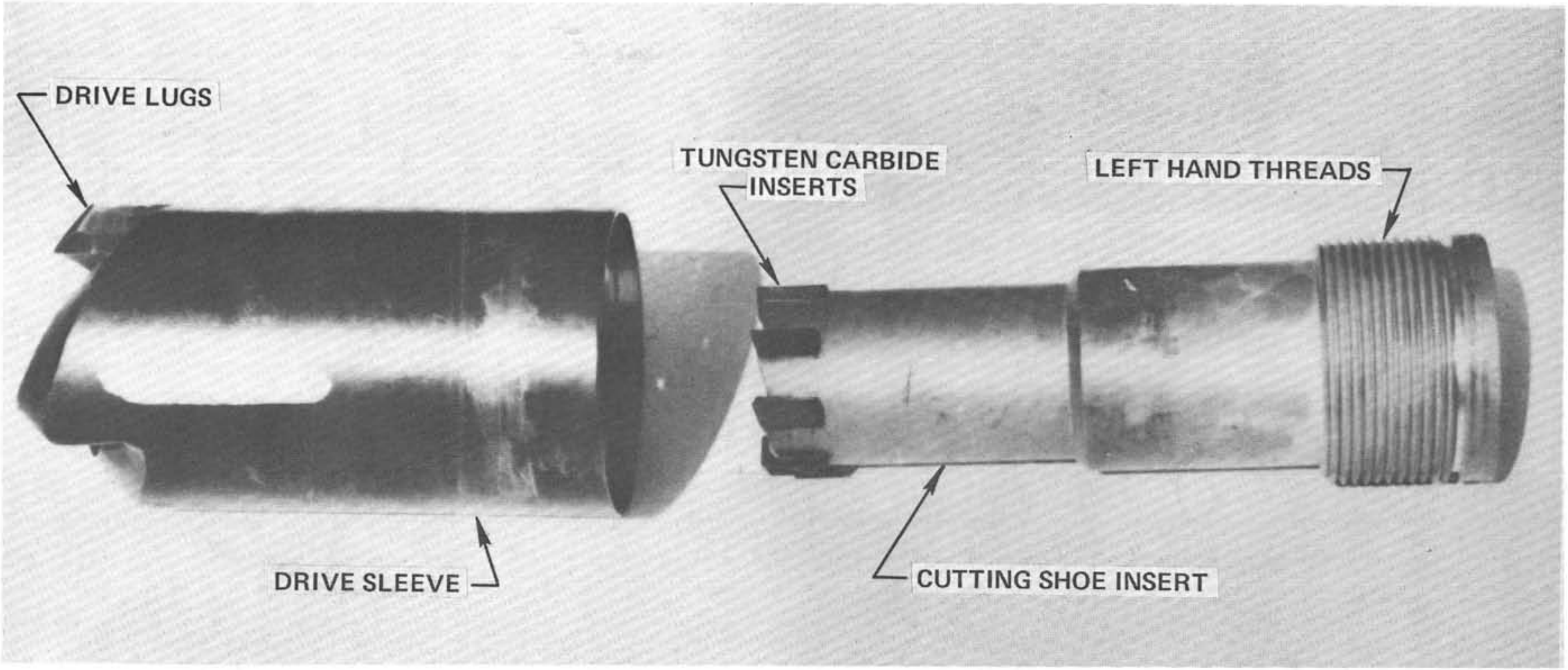


FIGURE 5
PCB-I
DRIVE / CUTTING SHOE

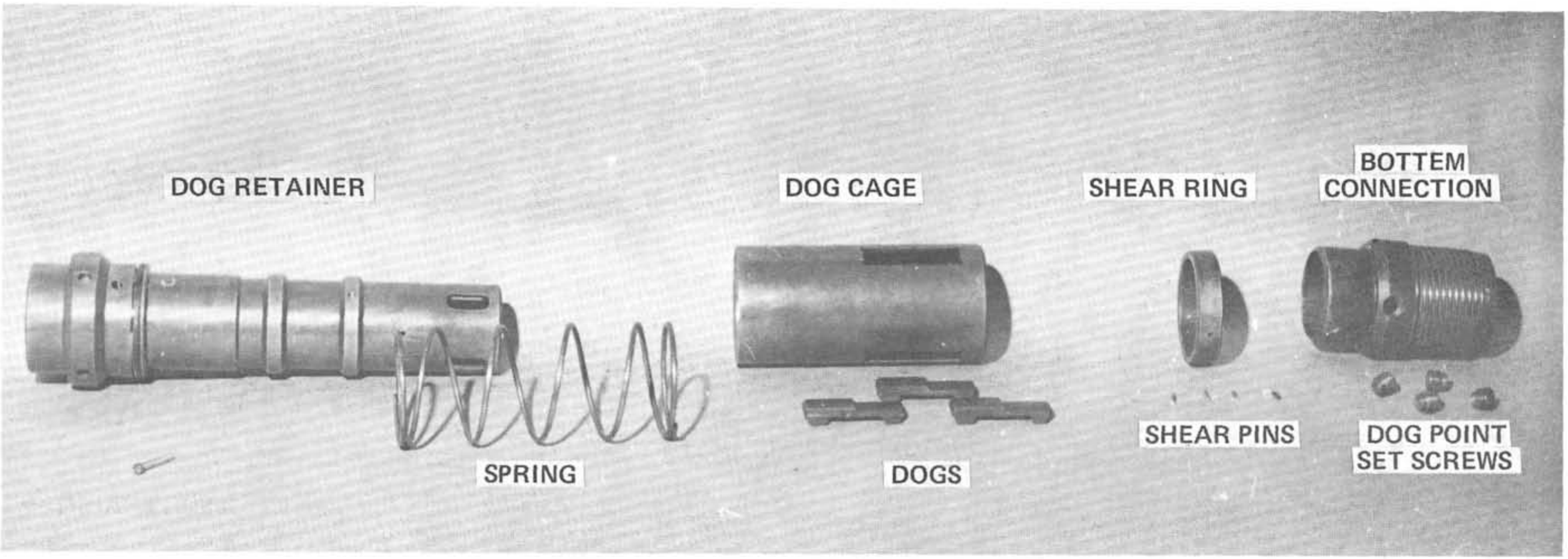


FIGURE 6
PCB-II
BALL VALVE ASSEMBLY LATCH DISASSEMBLED

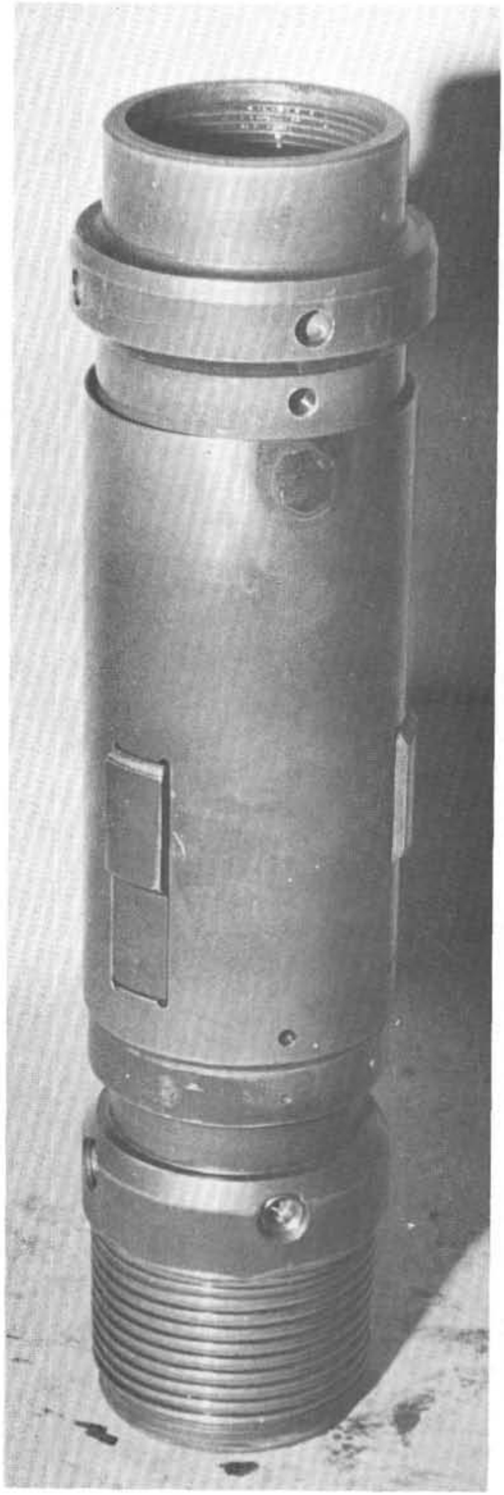


FIGURE 7
PCB-II
FULLY ASSEMBLED BVA LATCH

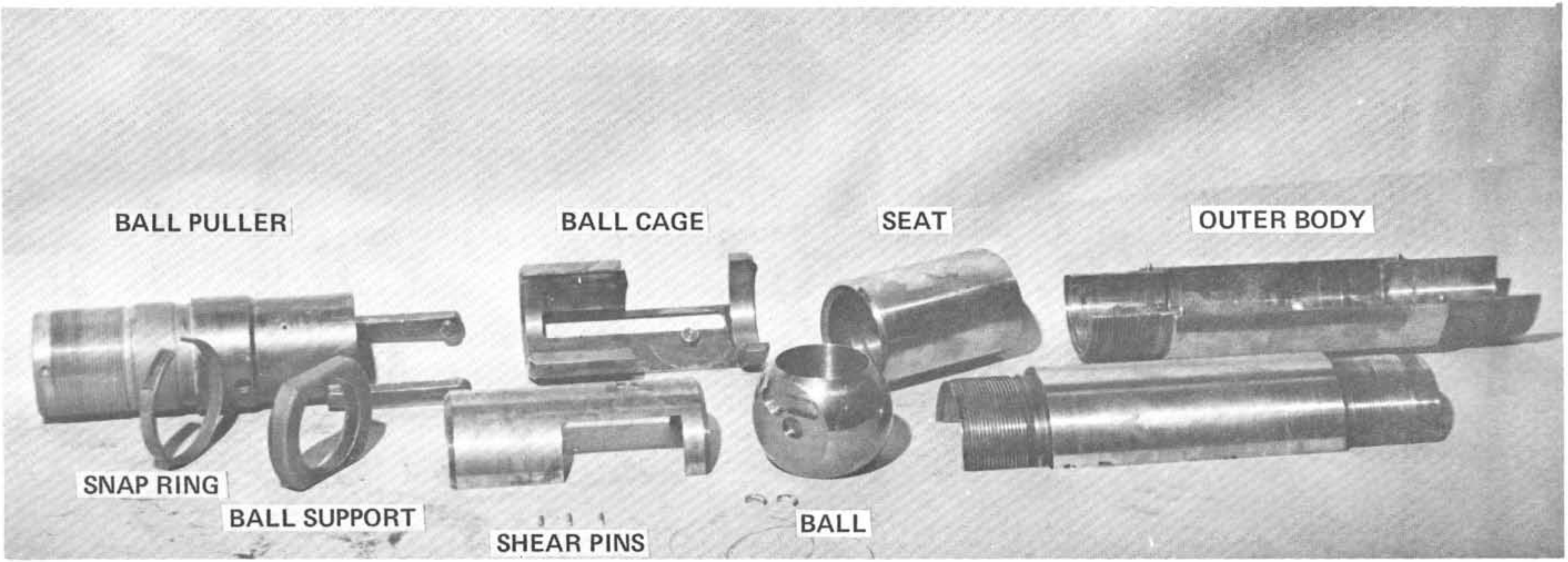


FIGURE 8
PCB-II
BALL CLOSURE ASSEMBLY DISASSEMBLED

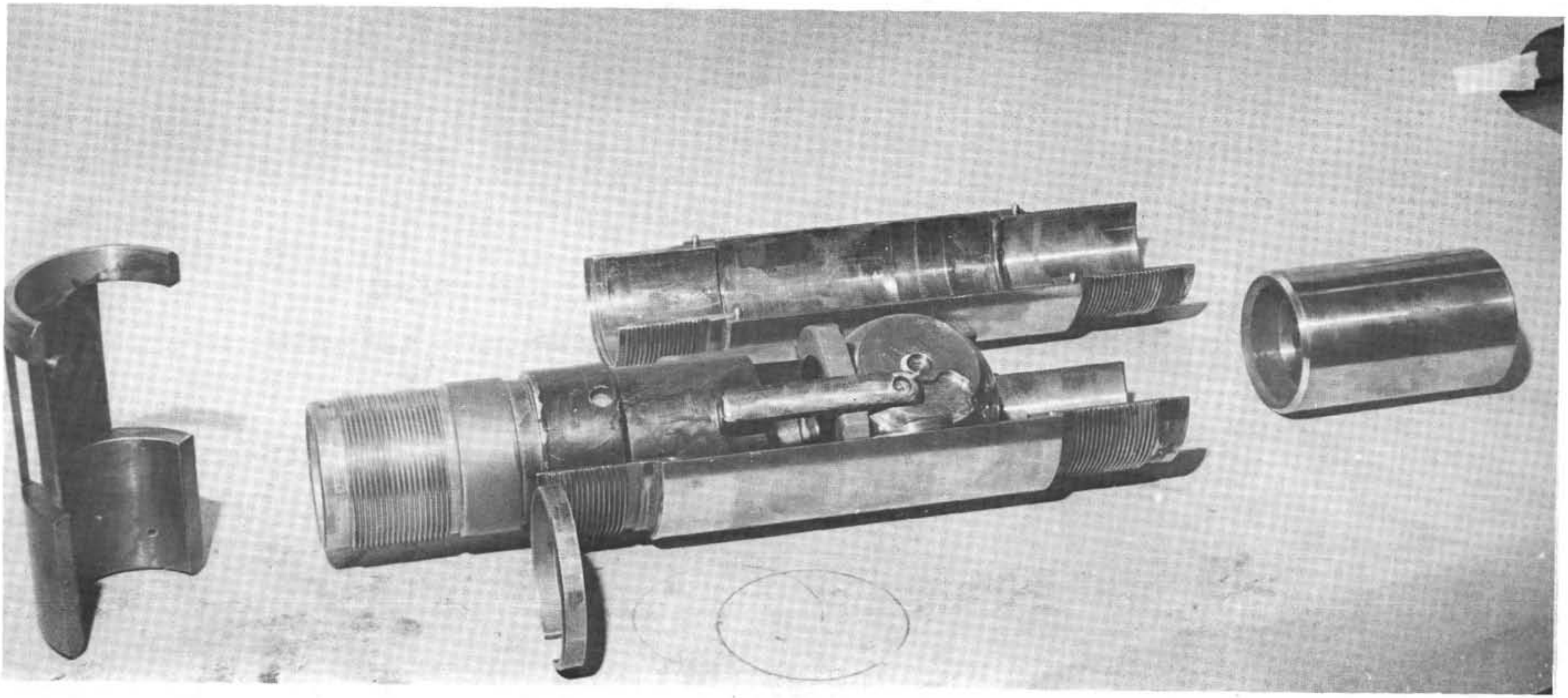


FIGURE 9
PCB-II
BALL CLOSURE ASSEMBLY PARTIALLY ASSEMBLED

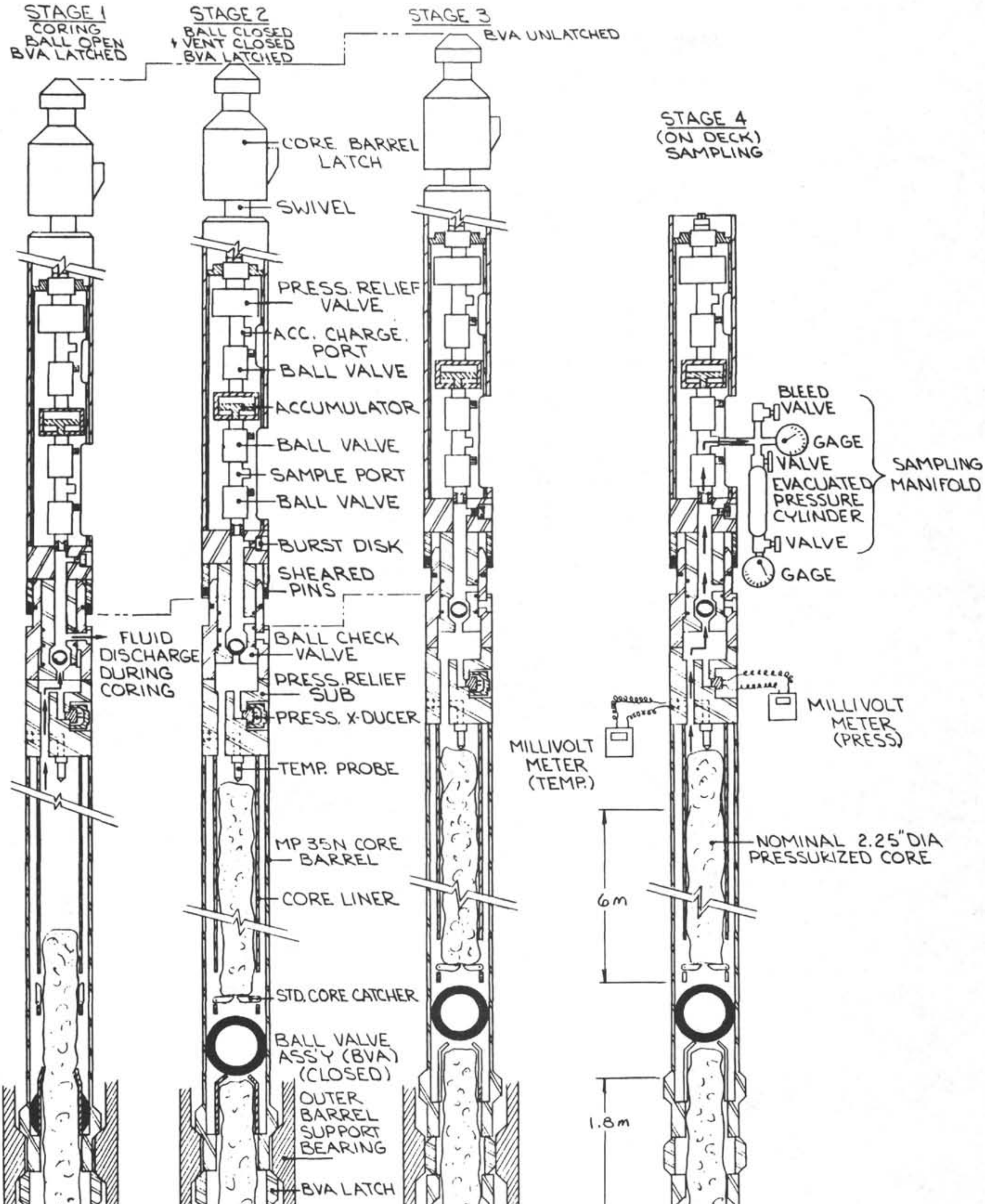


FIGURE 10
PCB-III OPERATION SEQUENCE

TABLE I

PCB-I OPERATIONAL RESULTS

Leg	Site	Core No.	Depth (m)	Cored (m)	Recovered (m)	Pressure (psi)	
42B	379	-	870	-	-	1000	Intial actuation test. Tool functioned well.
	379	1	2171	7	4	1300	Mudline punch core.
	379A	33	2472	7	0.5	0	Tool failed to latch-in. Check valve malfunction caused leak.
	379A	41	2550	2	0.5	0	Tool failed to latch-in. Check valve leaked again.
	379A	61	2729	4	0.2	0	Stiff clay jammed in cutting shoe. Ball jammed open. Seat Damaged.
	379B	2	2184	7	0	0	Ball jammed open.
	380	-	2120	7	8	0	Punch core--recored after test modified ball seal leaked.
	380	34	2428	4	0	0	Ball valve not completely shut.
	380A	28	2704	4	0.5	1000	Soupy core. Tool functioned well.
	380A	61	3008	8	0.2	0	Stiff clay jammed in cutting shoe. Ball jammed open. Damaged on impact.
	381	21	1940	5	0.2	0	Ball never fully opened and did not seal.
44	388	3	4976	7	0.2	0	Ball and seal damaged from impact. Clay jammed in cutting shoe.
44	388	7	5224	7	5.5	0	No apparent damage. Ball open; either stuck, or could not shear stiff clay.

TABLE II

PCB-II OPERATIONAL RESULTS

Leg	Site	Core No.	Depth (m)	Cored (m)	Recovered (m)	Pressure (psi)	
62	463		170	-	-	150	Initial actuation test. Tool functioned well.
	463	5	2570	4	3.2	Unknown	Tool functioned well. Pressure bled off on deck when valve stuck.
	463	23	2732	4	1.5	1700	Minor damage to tool. Some pressure lost when vent valve opened on deck.
	466	10	2756	4	0.2	0	Cored chert. Catcher sleeve deformed and jammed ball open.
	466	32	2956	4	0	0	Ball closed prematurely.
64	478	18	2072	4	0.2	3000	Vent sub closed prematurely. Sample gas was mostly trapped air.
	478	38	2240	4	0.2	0	No apparent malfunctions. Ball may have leaked.
66	486	-	400	4	-	-	No core attempted. Tool did not latch-in. Ball did not close.
	487	-	1040	4	-	-	No core attempted. Rust and pipe dope blocked circulation. Ball leaked.
	490	-	1780	4	0	0	Mudline punch core. Rust and pipe dope blocked circulation. Ball leaked.
	491	12	2971	4	0	0	Tool did not latch in. Ball did not close.
	491	23	3070	4	1.9	0	Ball closed prematurely.
72	515	3	4314	6.5	0	0	PCB jammed in BHA. Tripped drill pipe. Some minor damage.
	516C	1	1342	6.5	0	0	Ball closed prematurely. Catcher sleeve smashed against ball.
74	525A	2	2482	6	0.3	0	Ball worked well. Mechanical vent sub leaked.
	525A	4	2530	6	1.5	1200	Mechanical vent sub leaked. Pressure bled down on deck.
	525A	27	2824	6	0.1	0	Ball prematurely closed. Vent sub leaked.
	525A	33	2872	6	0	1500	Ball prematurely closed. Vent sub leaked on deck.

TABLE II

PCB-II OPERATIONAL RESULTS

Leg	Site	Core No.	Depth (m)	Cored (m)	Recovered (m)	Pressure (psi)	Comments
	527	10	4522	4.5	0	1000	Ball may have prematurely closed.
	527	21	4617	4.5	0.4	0	Ball open. Lower latch prematurely sheared.

TABLE III

PCB-III OPERATIONAL RESULTS

Leg	Site	Core No.	Depth (m)	Cored (m)	Recovered (m)	Pressure (psi)	Comments
76	533A	5	3336	2.8	6.4	4000	No core below ball valve.
	533A	14	3471	7.8	1.6	0	Plug left out of sampling assembly. No core above ball valve.
	533A	23	3516	7.8	6.1	4700	No core below ball valve.
	533A	26	3545	7.8	7.4	1500	No core below ball valve.
	533A	29	3575	7.8	6.2	4400	No core below ball valve.
84	568	11	2120	9.4	1.0	3000	No core below ball valve.
	568	21	2217	9.7	1.6	2900	No core below ball valve.
	568	31	2313	9.7	1.2	2000	No core above ball valve.

APPENDIX A

"SMALL DIAMETER CORING SHOES TEST RESULTS"

SMALL DIAMETER CORING SHOES

TEST RESULTS

I. CONCLUSIONS

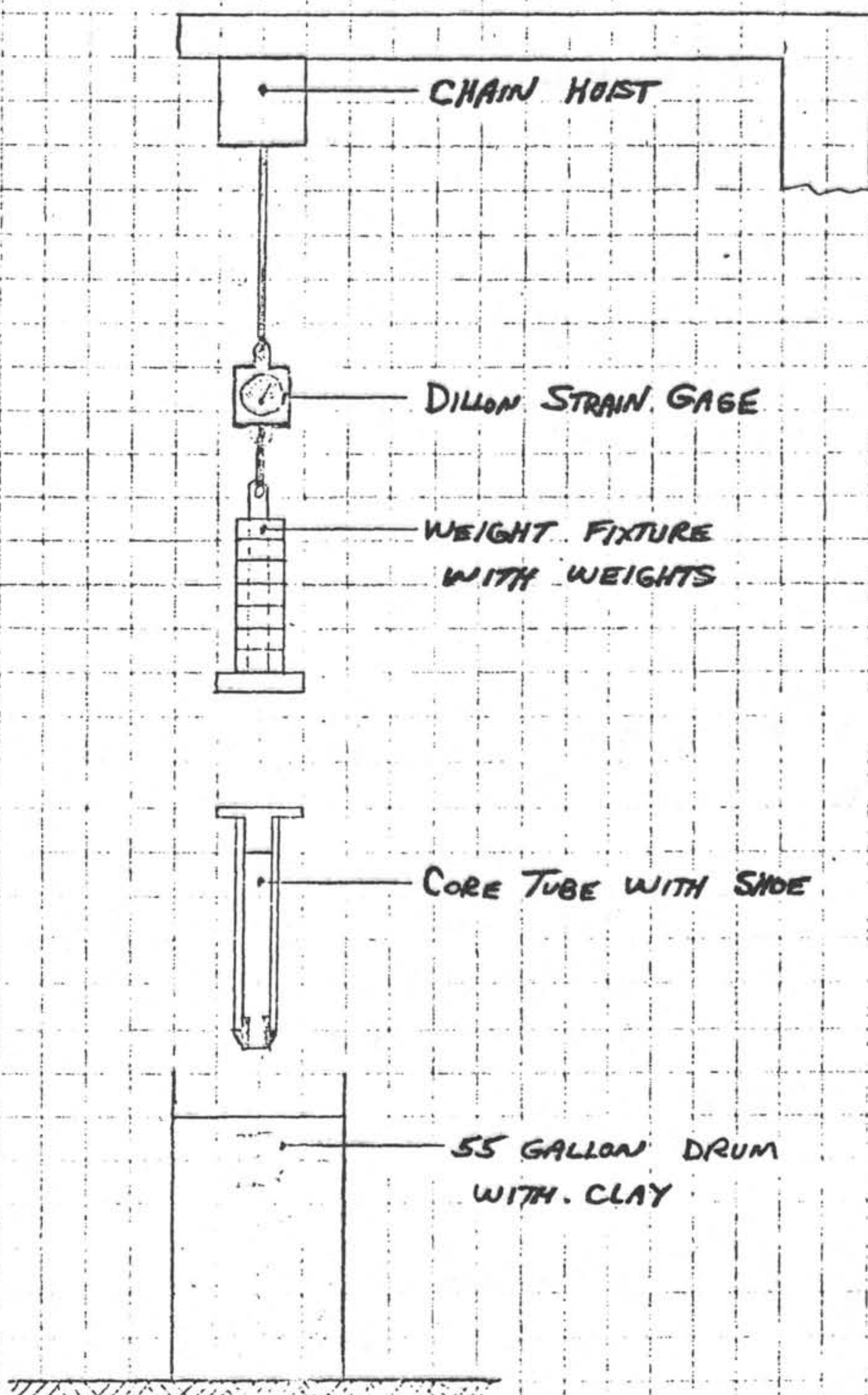
Increasing the inside diameter of the small diameter coring shoe from 1-1/2" to 2" or better will make a substantial difference in core recovery. A small amount of gage relief on the order of 0.1 to 0.125" is required. Increasing the gage relief beyond this point does not appear to improve recovery. Adhesion of the clay material to the inside of the core tube did not appear to be significant. With the use of proper coatings, it should be minimized. Work with varying the lead angle on the core shoe still needs to be done. It appears that a narrow angle and small wall thickness is optimum, however, this has not been tested as yet.

II OBJECTIVE

Past experience has demonstrated that clay sediments have plugged the 1-1/2" inside diameter Pressure Core Barrel cutting shoe. The objective of the laboratory testing was to determine if there existed a significant difference between cutting shoes with a 1-1/2" and 2" inside diameter. Also tested was the effect of varying degrees of inside "gage" relief. A third parameter, the effectiveness of various friction reducing coatings, and a fourth, the affect of changing lead angles, will be tested at a later date.

TEST PROCEDURE

A 55 gallon drum was filled with approximately 800 lbs of molding clay having a shear strength on the order of 5 tons per square foot (TSF). Various cutting shoe designs (Drwgs A-0430-00 thru A-0443-00) were then pushed into the clay utilizing a series of weights (30# increments) stacked on a special fixture and handled with a chain hoist (Fig. 1). Suspended between the chain hoist and the weight fixture was a Dillon strain gage which provided a measure of the required weight for penetration.



SMALL DIAMETER CORE SHOE
TEST ASSEMBLY

FIGURE 1

Four core shoe designs were tested (Table 1). In addition, two tests were run utilizing the core cylinders only without any core shoe attached. Since test No. 4 was the most successful it was rerun in an attempt to get repeatability of the data.

Test No. 7 was also run in a more controlled manner. The weights were applied directly to the fixture (and core tube) without using the chain hoist and strain gage. Just enough weight was applied to keep the tube penetrating. Weights and penetrations were carefully recorded.

RESULTS

As seen in the Summary of Results (Table 2), a slight increase in I.D. did seem to make a substantial difference in core recovery. Also recognized during the testing was the need for gage relief. It was apparent, however, that while some gage relief is mandatory, doubling the relief area made little difference in recovery.

TABLE 1

SHOE NO	O.D. (in)	I.D. (in)	LEAD ANGLE (Deg)	GAGES RELIEF (in/side)
1	1.9	1.0	30°	0.25
2	1.9	1.25	30°	0.125
3*	1.9	1.5	N/A	N/A
4	2.4	1.75	30°	0.125
5	2.4	1.5	30°	0.25
6*	2.4	1.9	N/A	N/A

* NOTE: Tests 3 & 6 were run with core cylinders only. No core shoe was put on.

TABLE 2

SUMMARY OF RESULTS

I.D. OF CORE SHOE (In.)	GAGE RELIEF (Per Side)	TEST NO.	LOAD ON SAMPLER (Lbs.)	PENET. (In.)	RECOVERY (In.)	RECOVERY (%)	ADHESION[1] FORCE (Lbs)	PULL OUT FORCE (Lbs.)	ANGLE SHEAR (TSF)
1.0	.25	1	50	15.0	1.25	8	25	340	5.5
1.25	.125	2	40	25.0	14.0	55	5	200	5.75
1.5	0	3	40-280	25.0	0	0	N/A	300	5.0
1.75	.125	4	80-330	21.0	16	76	Very Low	500	4.5
1.5	.25	5	60-330	29.0	18	62	Very Low	450	4.5
1.9	0	6	10-330	19.0	6[2]	32	N/A	450	5.0
1.75	.125	7	60-330	23.0	20	87	2-3	600	4.75

1 NOTE: Adhesion force was measured as amount of force required to start core moving out of tube.

2 Left in hole.

APPENDIX B

"DESIGN OF PRESSURE CORE BARREL CLOSURE MECHANISM FOR THE DEEP SEA DRILLING PROJECT"

DESIGN OF
PRESSURE CORE BARREL CLOSURE MECHANISM
FOR THE
DEEP SEA DRILLING PROJECT

by

Larry R. Russell

August 29, 1977

NOTE: REFERENCED DRAWINGS
NOT AVAILABLE FOR PRINTING

DESIGN OF PRESSURE CORE BARREL CLOSURE MECHANISM FOR THE DEEP SEA DRILLING PROJECT

CONTENTS

DESIGN OF PRESSURE CORE BARREL CLOSURE MECHANISM

By

Larry R. Russell
August 29, 1977

Abstract

This report describes the design of a closure device for the DSDP wireline pressure core barrel. The purpose and requirements of the device are given, and the reasons for selection of the final design are reviewed. The features of this design are described. Design layouts, fabrication specifications, and detail drawings are included, as well as information on servicing the tool. Design calculations are provided in an appendix.

Introduction

This device provides a readily operated means for retaining a significant fraction of sample in situ pressures during core recovery. In contrast to earlier successful pressure core barrel designs, this device operates with a wireline core barrel, so that more efficient operations are possible. The pressure barrel closure mechanism is strong enough to hold 5000 psi with a safety factor of 4, although the actual pressure retention capability is governed by the capacity of the seals. The amount of retained pressure is controlled by a DSDP designed vent valve.

The design objectives of the tool were to provide reliable operation, maximal OD cores, and maximum pressure retention capabilities. These objectives were subject to the design constraints given in the following section. This report reviews the work done on this project and describes the final design.

General Design Requirements

The following requirements were given for the tool or later emerged during the design process.

1. Compatability with existing DSDP hardware and/or designs.

2. Device to be limited to a closure mechanism only.

3. Maximum outer diameter 3-7/8 inch.

4. Maximal core size desired, with 2-1/4 to 2-1/2 inch barrel I.D. preferrable.

5. Device to be reliable, safe, and robust.

6. Pressure retention capability 1500 psi with a safety factor = 4.

7. Wireline pull available for actuation not to exceed about 1500 lb.

8. Device to operate when cores are soft to fairly stiff clays.

9. Actuation due to impact in the outer barrel is unsatisfactory.

10. Prevent open ball against differential pressure is to be avoided by running tool in open.

11. Corrosion resistance is mandatory.

12. Problems with thread galling in the device are to be avoided.

13. Ensurance of reliable retrieval is imperative.

14. Tool cost should be relatively low.

Design Selection

Five design concepts were prepared in the initial phase of the project; one concept was developed prior to the start of the job. All concepts are based on a ball valve which is run in the hole open and then is closed mechanically as a consequence of pulling the tool from the outer core barrel.

I felt that the availability of several reasonably straightforward mechanical actuation means made it unnecessary to investigate hydraulic actuators based on hydrostatic head acting against entrapped atmospheric pressure. This latter type of design appears much less likely to operate reliably than the final design; additionally, conceptual study funds were exhausted after development of six concepts. These concepts were shown to the DSDP in early June. Additionally, three well experienced consultants reviewed the concepts and submitted their opinions to the DSDP.

Four of the initial design concepts are dependent upon latching of the lower end of the tool underneath the inner barrel support bearing. The remaining two concepts were only latched by the standard latch employed on the upper end of the core barrel.

The initial concept (No. 1), developed before job initiation, is dependent upon the correct cycling of a cam-controlled actuator and the ability of the ball seal assembly to reliably cut the core and still seal. It is inadvisable to subject the ball to such conditions if there are other options. Therefore, work on the other concepts focused on protecting the ball by entrapping the core in a sleeve stroked through the ball, thus clearing the path of the ball. This engagement of the core by the sleeve is made possible by core catcher dogs or by various means of plastically deforming finger like segments of the sleeve inwardly when the sleeve is stoking through the ball. The final design choice uses lead buttons on the outside of the fingers which abut an inwardly slanted shoulder. In the event of core resistance preventing inward movement of the fingers and, hence, stroking of the sleeve, the lead buttons can be sheared loose so the tool can still operate.

Two other concepts (Nos. 4 & 5) are also dependent on the cam of Concept No. 1, but utilize the stoking sleeve for core withdrawal from the ball. One concept used a spring to stroke the sleeve, while the other used the wireline pull. The consultants all objected to the cam-based devices as being complex, subject to stoppages from entrapped trash, and having problems with an internal latch common to all three designs.

Concepts No. 3 and No. 6 are based on downwardly pulling core catcher dogs entrapped in recesses until the stroking of the inner sleeve is initiated by shearing of a pin by the wireline pull. In Concept No. 3, the sleeve is withdrawn through the ball. Concept No. 6 has sleeves above and below, but not through, the ball which stroke away from the ball far enough to virtually ensure core removal; this concept yielded the maximum core size (2--3/8 in. I.D.). The provision of slotted sleeves for the core catcher dogs on these two concepts significantly weakens them structurally. Concept No. 6 also required a sliding seal on the upper sleeve. This sliding seal appeared to offer potential problems outweighing the advantages of a 1/8-inch larger core than that available from Concept No. 3 or the final design.

The final design is based on Concept No. 2. This concept uses sequentially shearing sets of pins to stroke the core catching inner sleeve through the ball, rotate the ball closed, and to shear loose from below the support bearing. The tool bore is 2-1/4-inch I.D. All the consultants and I strongly preferred this concept because of its simplicity and reliability. The tool is based on proven designs in common use in the oilfield. Further improvements have been made since conceptual development, so that some previously questionable features of this concept have been rectified or eliminated.

Description of Design

The final design of the tool is visually described by the sequential layout drawings (Layouts No. 1-6) and the detail drawings included in this report. Supporting calculations are also given in an appendix. Reference to these drawings will indicate most clearly the tool operation.

A double shearable release arrangement on the lower latch of the inner core barrel assembly, shown in Layouts No. 1 and Nos. 4-6, has been added to enhance the reliability of the tool. The basic arrangement of this releasable latch has been successfully used for years in packers. Inclusion of the double shear feature permits opening a new volume for latch dog retraction in event that foreign material in the tool prevents release with single shear.

The shearable lead buttons shown will fall loose at a 600-pound pull if the core is too hard to permit inner catcher sleeve withdrawal with the buttons intact. Use of lead buttons is cheap and simple. The inner catcher sleeve might be reusable occasionally, but should be considered expendable; it is a low cost part. Provision of the split retainter nut for the inner sleeve simplifies its installation.

The core size appears to be the maximum obtainable in this design with the 3-7/8-inch O.D. tool. In order to have a reasonably wide seat surface in contact with the ball, given the expected errors in rotational positioning accuracy for the ball, it was necessary to use a split cage and split outer body for the ball. A sleeve for an outer body would have been a cheaper alternative, but would have provided a wall thickness of only about 0.067 inch in the thread root. Such a sleeve type design with 2-1/4-inch bore would be overly prone to catastrophic failure if subjected to [highly probable] large lateral loads during shipboard handling when pressurized. It is felt that the slightly higher cost of a split body (versus a sleeve body) is justified by the approximately 1/8-inch larger core obtainable.

The tool body thicknesses are sufficient for impacting on the support bearing and provide some reasonable level of bending strength. The tool largely is not highly stressed. For such components a 303 or 316 or 416 series stainless steel could be very satisfactory if the tool is reasonably maintained and the threads are suitably treated. For the more highly stressed parts, use of a 17-4PH stainless appears suitable. The 303 and 17-4PH stainless steels are reportedly less prone to thread galling than other alloys. Use of higher priced materials in the tool body parts does not appear necessary. Carpenter A-286 is recommended for the ball, and MP-35N for the ball camming pins. Hydril evidently has had good experience with this material selection for their balls and pins.

Most of the threaded connections in the tool are 12 pitch UNC, with diameters around 2-1/2 to 3-1/2 inches. These threads could be a significant problem area because of their frequent making and breaking during tool dressing. For this reason, treatment of the threaded parts with a process such as IMPREGLON 218 is recommended. The thread where the tool joins the DSDP inner core barrel assembly is a 3-3/8 inch Stub Acme, since it will probably be made up and broken in the rig floor area, rather than in a workroom.

The ball seal for the tool is either Vespel or Delrin in a metal body. This should seal easily because of its conformability, but still hold large pressures.

The dressing of the tool is somewhat involved because of the sleeves and split cage, but reference to the exploded view and instructions provided should make the task reasonably tractable.

Tool Maintenance

The tool has several parts and requires essentially total disassembly between uses, so that dressing it is somewhat involved. The primary things requiring particular attention are threads, upper seat and ball condition, and latch assembly condition. Cleanliness and liberal use of suitable lubricants, particularly on threads and the latch assembly. are necessary.

Tool handling, disassembly, and reassembly after a run follow the procedure below. Refer to Layouts Nos. 7 and 8 for part numbers and steps.

A. It is recommended that the operator slip an approximately 4-inch I.D. x 5-1/2 ft. long sleeve over the lower end of the tool so that the sleeves and the total tool are protected from lateral loads, since the tool is under pressure. Then handle the core barrel according to DSDP procedure.

B. Only after all pressure is completely released from the core barrel, separate this closure tool from the DSDP core barrel tube. Place this tool in a suitable cradle or on a workbench.

C. Remove and clean the DSDP lower termination and core catchers.

D. Remove the latch assembly (Sub-Assembly A in Layout No. 7) from the tool and disassemble it by removing Set Screws (30) and Shear Pin stubs (29) (by drilling and using a small screw extractor). Wash off, then inspect for damage. Replacing any damaged parts, lubricate threads and the latch components. Reassemble in the sequence indicated for Sub-Assembly A in Step 1 of Layout No. 7.

E. Remove the Retainer Sleeve (16), Shear Pin Stubs (27), and Extension Sleeve (15), wash, and inspect for damage. Roll the Extension Sleeve (15) on a flat surface to check it for straightness.

F. Remove the Outer Extension Body (14), the Inner Extension Body (18), the Split Retainer Nut (19), and pull the Catcher Sleeve (20) from the tool body. Wash the parts after removing any pieces of the core and inspect for damages. The Catcher Sleeve (20) should always be replaced if in doubtful shape after straightening and/or reinstallation of the lead Shear Buttons (25).

G. Remove the Retainer Ring (11) and Upper Connection (6), and then disassemble the remaining portions of the tool. Clean and inspect for damage, particularly on the Seats (4,5,8), Ball (1), Puller Pins (10), and Ball Cage Pins (2).

H. Lubricate all threads, sleeves, pins, etc. in the disassembled tool.

I. Referring to Step 2 of Layout No. 7, assemble the parts (1), (2), (4,5), (8), (9,10), (12), and (13) onto the Catcher Sleeve (20) from the lower end. This creates Sub-Assembly B. The Ball (1), Lower Seat (8), and Ball Puller Assembly (9,10) have to be positioned suitably before sliding over the Catcher Sleeve (20). Insert three new 1/8-inch x 1/2-inch long Shear Pins (33) in the holes in the Ball Cage (2) and Ball Puller (9).

J. Referring to Step 3 of Layout No. 7, assemble the parts (B), (3), (6), (7), (11), (26), (32), and (34) into Sub-Assembly C. First place the Outer Body (3) halves around Sub-Assembly B and hold things together with some screw type metal hose clamps (not over the threads). Be sure the Shear Pins (33) haven't fallen out. Screw on Retainer Ring (11) and install Set Screws. Insert the Spacer Sleeve (7) into the Seal Assembly (4,5) and put the Wavy Washer (32) and a new O-Ring (28) into the Top Connection (6). Screw the Top Connection (6) onto the Outer Body (3), install the Set Screws (26) on the connection, and then remove the hose clamps. Insert the DSDP Core Catchers and then the O-Ring (34) into the top end of the Top Connection (6). [Note that this last item can be deferred until reassembly with the Core Barrel.]

K. Insert the Split Retainer Nut (19) halves into the slots of the Catcher Sleeve (20) projecting out of Sub-Assembly C. screw the Inner Extension Body (18) onto the Split Retainer Nut (19). Then screw the Outer Extension Body (14) onto the end of the Snap Ring Retainer (13) projecting fro Sub-Assembly C; install

Set Screws (26). Slide the Extension Sleeve (15) about halfway into the annulus between the Outer (14) and Inner Extension Bodies (18). Screw the Retainer Sleeve (16) into the Outer Extension Body (14). Screw the Inner Extension Body (18) into the end of the Dog Retainer (17) projecting from Sub-Assembly A. Install Shear Pin (27) and Set Screw (26).

L. Check the bore to ensure openness. Reassemble with the Core Barrel.

Note that the tool should always be dressed prior to storage, with particular attention given to the O-Ring grooves and threads. Assembly torques need not be very high, since most connections hold no pressure and are secured with set screws.

Suggested Spare Parts

The Catcher Sleeve (20) and the Shear Buttons (25) should be considered as suitable for only one time use until experience indicates some reuse is possible. Accordingly, enough of the parts should be taken on any cruise so that the impossibility of reuse will not hamper operations. Estimate one Catcher Sleeve and five Shear Buttons are needed per use. The Extension Sleeve (15) is designed as a "weak link" in the tool in order to prevent severe bending stress during shipboard handling after recovery from overloading the already pressure-stressed Outer Body. Probably two Extension Sleeves per cruise will suffice, unless severe sea-state conditions are expected. Provide 1-1/2 to 2 Shear Pins (27), four Shear Pins (29), and five Shear Pins (33) per use. Provide one set of O-Rings (28) and (34) per use. Provide two sets of Set Screws (26) and two sets of Set Screws (30) per cruise. Provide one spare Sspring (31), three spare Dogs (24), and one spare Wavy Washer (32) per cruise. For a cruise , one or two spare Seats (4) should be included.

Inclusion of a Spare Ball (1) would appear to be optional, since the ball will be fairly hard and probably not ever highly stressed.

Specifications for DSDP Pressure Barrel Closure Mechanism

1. All parts of 17-4PH stainless steel should be heat treated to have a yield stress in excess of 150,000 psi.

2. All parts of SAE 660 brass should have an ultimate shear strength of 25,000 psi + 5000 psi.

3. The hardness of the ball surface should be Rockwell C50 or greater.

4. The ultimate tensile strength of the material for the Extension Sleeve (Part No. 15) should be in the range of 85,000 psi to 100,000 psi.

5. All threads are to be treated with Impreglon 218 or Gullite (Armaloy) or a similar process. If Impreglon is used, the non-threaded area should be masked off.

6. Dimensional specifications are given on the drawings.

7. Alternative materials may be substituted with the prior approval of the DSDP. Otherwise, the materials list is to be followed.

8. Alternate designs may be selected for Parts No. 6 and 16.

Commentary on Specifications

The specifications for this tool are intended to be somewhat flexible, given that the tool is a prototype and the majority of the parts are not ever at critical stress levels. However, if unusual conditions (such as HS service) are anticipated, in the future, then more specific choices of materials must be made.

The critical parts of the tool in terms of personnel safety (i.e., pressure retention) are the Top Connection (6), the Outer Body (3), the Ball Puller (9), the Ball Cage (2), the Lower Seat (8), and the Retainer Ring (11). These should all be made of a stainless steel with good seawater corrosion resistance, yield strength equal to or exceeding 150 ksi, and high toughness. Use of 17-4PH stainless is recommended. Another part, the Extension Sleeve (15), is intended to be a "weak link" which will fail before excessive bending from lateral loads builds up failure level stresses in the pressure retaining structure. This part should be made of a relatively ductile stainless steel (down to 10F) with 80-100 ksi. Annealed 410 stainless steel would be a suitable choice.

The Ball (1) should be relatively hard to prevent scoring; Carpenter A-286 steel is specified for the ball. The Lower Seat (8), which doesn't hold pressure, should be softer in order to avoid damage to the ball. MP35N steel is specified for the Puller Pins (10).

The other steel portions of the tool could be 17-4PH, 416, 316, or 303 stainless, depending on price and availability. Use of 416 and 17-4PH stainless likely is advisable in view of anticipated thread galling problems.

The brass Shear Pins (27), (29), and (33) should have an ultimate shear strength of 25 ksi + 5 ksi. SAE 660 Brass appears suitable. The Seat (94) should be either Vespel SP-1 or Delrin A/F. The Spring (31) is suggested as 17-7PH stainless steel, but the spring manufacturer's recommendations for this service (Max. Shear Stress 97 ksi, seawater, low cycles but shock loads) should probably be followed.

In order to prolong thread life, all threads should be treated with some suitable process. Since use of either Impreglon 218 or Armaloy (Gullite) would evidently enhance the thread life, these are specified as options. The threads in the body of the tool are about 2-1/2 to 3-1/2 inch - 12 UNC; use of a coarse, rounded API thread form may be more desirable if the fabricator can conveniently machine it.

The fabrication tolerances in general are fairly loose; as-built drawings should be made to indicate the final sizes in case replacement parts are required.

APPENDIX

DESIGN CALCULATIONS

Sizing of Lead Buttons for Core Catchers:

Very likely the strength of the lead used for the buttons will depend quite a bit on the alloy and fabrication technique.

From Machinery's Handbook, 20th Edit, p 453, $\sigma_{ult} = 2.2^{ksi}$ to 4.9^{ksi}

From Marks' Handbook, 5th Edition, pp 616 & 617, $\sigma_{ult} = 2.75^{ksi}$ to 8^{ksi} for Antimonial Lead & about half that for Chemical Lead.

Estimate that $\tau_{ult} \approx 2/3 \times \sigma_{ult}$, & Assume $\sigma_{ult} \approx 2.2^{ksi}$ for Cast Lead.

Then, with 4 Lead Pieces to Shear &, say, 600^{lb} of pull available,

$$A_{req'd} = \frac{F_{pull}}{4 \cdot \tau_{ult}} = \frac{600^{lb}}{4(1330\ lb/in^2)} = 0.1128\ in^2$$

$$d_{req'd} = \sqrt{\frac{4 \cdot A_{req'd}}{\pi}} = 0.379\ inch.$$

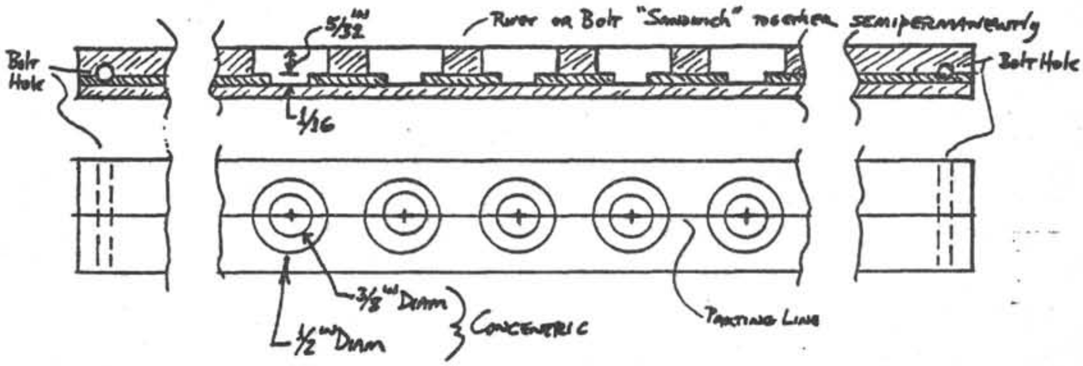
... Look @ Bearing in the hole:

$$t \geq \frac{F_{pull}}{4 \cdot \sigma_{ult} \cdot d_{req'd}} = 0.0495\ inch$$ ... OK ... $t = 0.0625^{in}$ on Sleeve

Can stake the Lead Buttons to hold them in ... can readily dress them with a File.

Button Fabrication ~~ 2 Options: (A) Machine

(B) Cast ~ like in early bullet molds



Spring Selection:

Need a Linear Helical Spring to Work in a Space where

$$D_{MIN} = 2\tfrac{49}{64}^{in} = 2.7656^{in}$$

$$D_{MAX} = 3\tfrac{15}{64}^{in} = 3.2343^{in}$$

$$\Delta D_{iam}/2 = 0.234^{inch}.$$

... Should try a wire spring with Wire Diameter < 0.2".

Look @ US. Steel Wire Gauge #6 Wire with $d = 0.1920^{in}$.
Say Mean Diameter $= D = 2.992^{inch}$.

$$C = \frac{D}{d} = \left(\frac{2.992^{in}}{0.1920^{in}}\right) = 15.58$$
$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} = 1.0909$$

Say $\tau_{MAX} = 75^{KSI}$ ... Then $F_{MAX} = \frac{\tau_{MAX}\cdot \pi d^2}{8K\cdot C} = 0.0639^{K}$ ... pretty low.

Go to a Stainless 17-7 PH ... $\tau_{MAX} = 97^{KSI}$, & $F_{MAX} = 82.6^{lb}$.
OK.

While Active in the Tool, the Length of the Spring varies from 2.25^{inch} Long to $(3.688^{inch} + 0.688^{in}) = 4.375^{inch}$.

Say want $F \approx 50^{lb}$ when $l = 4.375^{in}$
$F \approx 82^{lb}$ when $l = 2.250^{in}$.

Then $k = \frac{\Delta F}{\Delta l} = \left(\frac{32^{lb}}{2.125^{in}}\right) = 15.06^{lb/in}$

... Thus the Free Length $= (4.375^{in}) + \left(\frac{50^{lb}}{k}\right)$

$= (4.375^{in}) + (3.32^{in})$
$= 7.70^{inch}$ ... $\delta = 5.45^{in}$.

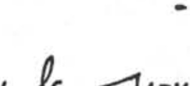
Now $\tilde{y}$, the deflection/coil, is

$$\tilde{y} = \frac{8\cdot F\cdot D^3}{d^4\cdot G} = \frac{8(0.082^{K})(2.992^{in})^3}{(0.1920^{in})^4(10500^{KSI})} = 1.231^{inch}/coil.$$

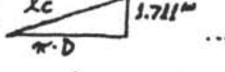
$$n = \frac{\delta}{\tilde{y}} = \left(\frac{5.45^{in}\ Defl}{1.231^{in}/Coil}\right) = 4.43\ Coils.$$

Say have 4.5 Coils w/ Plain Ground Ends.

... Pitch $= 1.711^{inch}/Coil = p$.

Initial 

... $l_c \doteq \sqrt{(\pi D)^2 + p^2} = 9.554^{inch}$

Loaded 

$D_F = \frac{1}{\pi}\sqrt{l_c^2 - (0.500^{in})^2} = 3.037^{inch}$
$D_{OUT} = D_F + d = 3.229^{inch}$ ✓ OK, but Barely.

Spring Selection, Cont.:

Spring Specifications:

1) Material is 17-7 PH Stainless Steel

2) Wire is U.S. SWG. #6 Gauge = 0.1920 in Diam

3. 4.5 Coils, Plain Ground Ends

4. Unloaded Length 7.70 inch, so Pitch = 1.711 inch/coil

5. Unloaded OD = 3.172 inch
Unloaded ID = 2.788 inch
Unloaded Mean Diam = 2.980 inch

6. Needs to Slip over a 2.766 inch Rod;
Needs to Fit inside a 3.234 inch Cylinder.

7. Maximum Load ≈ 82 lb and Maximum Compression of 5.45 inch. (Ie., Loaded Length = 2.25 inch.)

DSDP Pressure Barrel Closure | Larry R. Russell | Aug. 29, 1977 | 4/

Forces on Pinned Assemblies when Shear Pins Fail:

① Primary Shear Pin - 660 Brass, 1/4 inch OD.

Estimate $\tau_{ULT} \approx 25{,}000^{psi}$ ... based on Machinery's Hdbk, 20th Edit, p 2233: $\sigma_{ULT} = 30^{ksi}$.

$A_{1\text{-}PIN} = \frac{\pi}{4} \cdot d^2 = (\frac{\pi}{4})(0.25^{inch}) = 0.0491 \, in^2$

$F_{ULT_{1\text{-}PIN}} \approx 1.227^K$ ~ too High

~ Unless this Brass is much Weaker than indicated, should go to 1/8 inch Pins.

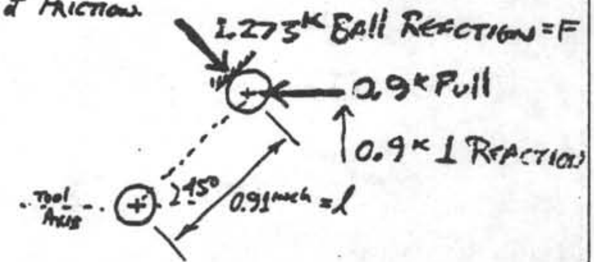
☆ Use 1/8 inch SAE 660 Brass Shear Pins worth ≈ 320^{lb} Ultimate Shear/Pin.

... Thus, 3 Pins gives about 960^{lb} Required to Rotate the Ball. Assume only 0.9^K Available because of Friction.

Moment Arm on Ball:

$M = [(0.9^K)(\sqrt{2})] \cdot (0.91^{inch})$

$= 1.158^{K\text{-}inch}$.



Now, if there was some core in the ball at closing, then

$M = 2 \cdot \tau \cdot \frac{\pi}{4} \cdot (d^2) \cdot x$ — dist. from ball ctr to mouth of bore ≈ 2.716 in

$\tau = \frac{(1.158^{k\text{-}in})}{(\frac{\pi}{2})(2.25 \, in)^2 (1.358 \, in)} = 0.107^{K/in^2} \doteq 7.72 \, ^{ton}/_{ft^2}$ ... fairly stiff.

Shear-out Force ≈ 1280^{lb} ... within Capability of Unit.

Burst Strength of Top Connection:

The Weak Point is the O-Ring Groove... Wall can be down to 0.212 inch.

$d_o \geq 3.859^{in}$
$d_i \leq 3.375^{in}$

Axial Stress: $\frac{\pi}{4}(d_o^2 - d_i^2) \cdot \sigma_{AX} = P \cdot \frac{\pi}{4} \cdot d_i^2$

$$\sigma_{AX} = P \cdot \left[3.25 \right] \text{ ... Tension.}$$

Hoop Stress: $2 \cdot \sigma_{HOOP} \cdot t = P \cdot d_i$

$$\sigma_{HOOP} = P \cdot \left[6.97 \right] \text{ ... Tension}$$

Assume that Yield of Material = Failure, and say if $\sigma_{HOOP} = \sigma_Y$, then have Yielded.

Thus $P_{MAX\ ALLOW} = \frac{\sigma_Y}{(SF=4)(6.97)}$.

To get Barrel Burst Capacity of ~~5000~~ 4500 psi, need: (IE, $P_{MAX\ ALLOW} = 5^{KSI}$)

$$\sigma_Y \geq (6.97)(4)(5^{KSI}) = 139.4^{KSI}.$$

✱ Call for 17-4 PH Stainless Top Connection Heat Treated (Precipitation Hardened) to Min Yield of $\sigma_Y = 150^{KSI}$.

Force on Seal of Valve: ... Say "Piston" (IE, Seal Assembly) has ID of Seal $= d_i = 2.380^{in}$
" " " OD " " $= d_o = 2.766^{in}$.

Neglect Wavy Washer Preload. d_s = Seal OD $\approx 2.656^{in}$.

$$P_{SEAL} \cdot \left(\frac{\pi}{4}\right)(d_s^2 - d_i^2) = P \cdot \left(\frac{\pi}{4}\right)(d_o^2 - d_i^2)$$

$$P_{SEAL} = 1.43 \cdot P \text{ ...}$$

General Strength Checks on Tool:

When Tool is Scoped out, the Weakest Points in Bending are the Extension Sleeve (Item #15) and the Ball Puller (Item #9). Check:

Extension Sleeve: $d_{o_{min}} = 3\,7/64^{in} = 3.109^{in}$, $d_{i_{max}} = 2\,61/64^{in} = 2.953^{in}$ } Pessimistically assuming worst situation on tolerances.

$$S = \frac{\left(\frac{\pi}{64}\right)(d_o^4 - d_i^4)}{(d_o/2)} = 0.550\ in^3.$$

Say $\sigma_Y = 35^{ksi}$ ... Then

Get Failure (... i.e., a bent part) for an Applied Moment of $\sigma_Y \cdot S = 19.2^{k\text{-}in}$.

Length of Tool below Top of Extension Sleeve is

$l \approx 33.25^{inch}$, so a $\perp$ Load of $577^{lb} = \frac{\sigma_Y \cdot S}{l}$

Can initiate Bending. For Full Plastic Behavior,

$Z = \left(\frac{d_o^3 - d_i^3}{6}\right) = 0.718\ in^3$ & $M_p = Z \cdot \sigma_Y = 25.1^{k\text{-}in}$,

$\Rightarrow \perp$ Load $\approx 750^{lb}$ will completely fold up the Extension Sleeve.

This is not too unlikely a load on a floating Vessel.

$\Rightarrow$ Go to a Material with $\sigma_{ULT} \approx 100^{ksi}$ & Good Toughness & Ductility @ 10°F.

Ball Puller: $d_{o_{min}} = 2\,45/64^{in} = 2.703^{in}$ ... under Snap Ring

$d_{i_{max}} = 2\,27/64^{in} = 2.422^{in}$ ... under Snap Ring.

$S = 0.690\ in^3$
$Z = \left(\frac{d_o^3 - d_i^3}{6}\right) = 0.924\ in^3$
Moment Arm $l \approx 47^{inch}$ when Scoped Out.

For Design Safety, say Design Ball Puller Strength (Elastic) to be at a higher limit for Same Load as is Extension Sleeve.

$$P_\perp = \left[\frac{\sigma_{ULT} \cdot Z}{l}\right]_{\substack{EXTENSION\\SLEEVE}} \leq \left[\frac{\sigma_Y \cdot S}{l}\right]_{\substack{BALL\\PULLER}}.$$

Thus $\sigma_{Y_{BALL\ PULLER}} \geq (100^{ksi})\left(\frac{47^{inch}}{33.25^{inch}}\right)\left(\frac{0.718\ in^3}{0.690\ in^3}\right) = 147^{ksi}$.

Say Ball Puller Yield Stress $\geq 150^{ksi}$ to 160^{ksi}. Require Good Toughness & Ductility @ 10°F.

<u>Load in Ball Cage:</u> Outer Body Must Support all of Load Applied to Ball ... Transferred in by Case.

$$d' = 2.766''$$

On Split ~~Cage~~ Outer Body, $d_o \geq 3.859''$
$d_i \leq 3.635''$

$$\sigma_{AX} \cdot \frac{\pi}{4}(d_o^2 - d_i^2) = P \cdot \frac{\pi}{4}(d'^2)$$

$$\sigma_{AX} = P \cdot [4.56].$$

... Require, for $P_{DESIGN} = 20^{ksi}$, $\sigma_Y \geq 91.2^{ksi}$.

Again, Use 17-4 PH treated to a Minimum 150^{ksi} Yield.

Likewise for the Retainer Ring.

Ball Cage Carries Bearing Load from Lower Seat ...

Thickness of Ball Cage Wall is $\geq 0.411^{inch} = t$ ... About 59.5° of Arc on each side of each piece carries load ...

Thus $\tilde{\sigma} \cdot 4 \cdot t \cdot \bar{d} \cdot \theta_{RAD} = P \left(\frac{\pi}{4}\right) \cdot (d'^2)$

$$\tilde{\sigma} = \frac{P \cdot \left(\frac{\pi}{4}\right)(2.766_{in})^2}{4(0.411_{in})(3.208^{in})(1.038_{RAD})} = 1.096 \cdot P \approx 22^{ksi}$$ ... Mean Stress Around Contact w/ Lower Seat.

Look @ Contact with the Outer Body: $A \geq 1.039_{in^2}$ (Assuming only Sections in Line with the Ball's Bearing Area carry Load.

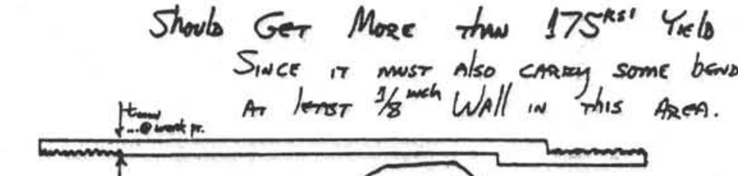
$$\sigma_{BEAR} = \frac{P \cdot \frac{\pi}{4} \cdot d'^2}{A} = 5.78 \cdot P \approx 116^{ksi}.$$ So Use 17-4 PH Here, too.

Look @ Sleeve-Type Outer Body: $t_{MIN} \geq 0.0670^{inch}$ at Internal Thread Root

So Thread Root Area $= 0.799\,in^2 \ldots = A_{TR}$

$$\sigma_{AX} = \frac{\pi \cdot P}{4 \cdot A_{TR}} \cdot (d')^2 = \frac{\pi \cdot (20^{ksi})}{4(0.799_{in^2})}(2.766_{in})^2 = 150^{ksi}.$$

Should Get More than 175^{ksi} Yield to trust this arrangement, Since it must also carry some bending load. Really must have at least $\frac{1}{8}^{inch}$ Wall in this Area.



APPENDIX C

SHIPBOARD OPERATIONAL RESULTS, LEGS 62-76

September 11, 1978

WIRELINE PRESSURE CORE BARREL (MOD.II) TEST

ABSTRACT

During Leg 62 the new pressure core barrel was tested five times on two different sites. None of the sites were deeper than 3000 meters and on all of them a great deal of chert was encountered. Still, three of the tests were successful. The one weak point in the ball valve assembly is the catcher sleeve which caused the failure of test no. 4 and was also damaged in test no. 3. More testing should be done in a greater variety of sediments than those encountered on Leg 62.

Donald H. Cameron

Donald H. Cameron

WIRELINE PRESSURE CORE BARREL (MOD. II) TESTS

LEG 62

INTRODUCTION

The pressure core barrel mod. II (PCB) is the second prototype pressure core barrel tested aboard the Glomar Challenger. It is designed to be used with a special small hole-diameter (2 1/4") drill bit, but otherwise no special procedures or equipment are needed to drill and retrieve a core. It is capable of recovering 4 meters of core, 3 meters pressurized and 1 meter unpressurized. The pressure sealing device is a ball valve assembly (BVA) which is locked open while runnung down the pipe and during coring. If the tool malfunctions (ball does not close, or closes but does not seal) it will still retrieve a full but unpressurized 4 meters of core.

The tool consists of the BVA, two sets of core catchers (one set on either side of the BVA), a special MP35N steel inner core barrel, a pressure relief sub, a hydraulic vent sub, and a sampling sub. The entire assembly is 32 feet long and is connected to the upper half of a regular inner core barrel. The lower section of the BVA latches under the roller bearing in the bit sub. The PCB is mechanically activated after coring by pulling with the wireline against the lower latch and shearing three stages of pins that allow the tool to telescope and finally release from the roller bearing.

Shearing the first stage (1 pin) allows a long,tubular, thin-walled metal catcher sleeve (which is initially positioned through the open ball) to travel clear of the ball. The sleeve is equipped with four narrow "fingers" which are merely slots cut in its wall, each having a lead button pressed onto its outer end. As the tool scopes and the ball is drawn up past the sleeve, the diameter narrows and the buttoned fingers are forced inward in order to grip the core, break it at the upper core catcher, and draw it clear of the ball.

Increasing pulling force from the wireline will then shear the 3 pins of the second stage which scopes to pivot the ball closed against its seal. The 4 pins of the third stage then shear to release the lower latch and allow retrieval.

The pressure relief sub was designed to monitor barrel pressure with the aid of a pressure transducer. The correct transducer was unavailable at the time of testing so the transducer port was sealed and the sub served merely as a crossover sub.

The vent sub is located above the pressure relief/crossover sub. Its purpose is to vent the PCB while coring, then close to mantain the pressure as the tool is retrieved. A spring keeps the vent valve closed at low pressure. Bottom hole pressure compresses the spring, forcing the valve stem to remain open during coring. As the tool is retrieved and the ambient pressure decreases, the valve reseals. The amount of pressure retained in the barrel depends on the strength of the spring. A mechanical venting assembly has been developed which allows full bottom hole pressure retention, but it was not available for these tests.

The sampler sub contains a sampling valve assembly which is also a safety relief valve. Four brass shear pins (good to 10,000 psi) retain a valve stem which seals a sample port against barrel pressure. If the barrel encounters a pressure differential of greater than 10,000 psi the pins will shear to release all the pressure. When the tool returns to deck a sampling manifold with pressure guage is screwed into the sample port. Then the sample valve lock screw is tightened down against the head of the valve stem which takes the load off the shear pins. The pins are removed and the lock screw is slowly backed off until the valve stem is clear of the sample port and the manifold pressurizes to barrel pressure.

TEST RUN DETAILS

The PCB was scheduled for at least 10 runs during Leg 62. Only 5 runs were completed due to the following reasons:

1) Last minute rearrangements shortened the available drilling time. Several sites in the Gulf of Alaska were eliminated. Of the four sites drilled, two sites, 463 and 466, were made available for PCB testing.
2) Chert. High chert recovery on all sites precluded more frequent testing.
3) The length of time between successive test runs was necessarily long (5 - 6 hours if no problems developed) since the tool has to be completely disassembled for redressing. With only one operator this allowed a maximum of two runs per day.
4) Incompatibility of the smaller size PCB drill bit with the heat flow probe. The heat probe does not fit through the hole in the PCB bit. The chief scientists desired heat flow measurements on Sites 464 and 465 and were therefore unwilling to commit these holes to the PCB bit. On the last site the heat flow probe was modified to fit through the small bit, but it has not yet been tested.

TEST RUN No. 1 SITE 463 TWO STANDS HANGING PIPE (170 m.)

Results

Recovered a water sample at 150 psi.

Observations

As a first test the PCB was dropped through 170 m. of hanging drill pipe. It did not drop freely and after 14 minutes it had to be pumped down to latch. Mild steel shear pins were used on all stages of the BVA. It took a wireline pull of 5500 lbs. (with virtually no hanging weight) to shear the four last stage pins. The BVA actuated perfectly. The barrel retained 150 psi. Two lead buttons were lost from the catcher sleeve.

Comments

The vent valve had remained closed at the near-surface pressure encountered during the test which prevented circulation through the PCB and was partly responsible for the slow freefall rate of the PCB. The PCB is also larger in diameter than a regular core barrel and makes a tighter fit in the pipe.

The mild steel shear pins were too strong. Maximum shear strength for the last stage should be 2000 lbs. Aluminum shear pins will be used on all subsequent runs.

<u>TEST RUN No. 2</u> SITE 463 CORE 5 WATER DEPTH 2532 m. CORE DEPTH 2731 m.

<u>Results</u>

Recovered 3.2 meters of soft nanno ooze under pressure. Brass safety shear pin stuck, disallowing sampling.

<u>Observations</u>

The PCB was pumped down the pipe at 50 strokes/min. (SPM) and at a circulation pressure of 300 lbs. It took 10 minutes to latch. The bit was then punched 4 meters into soft nanno ooze at a rate of 2 meters/min. The first retrieval attempt was unsuccessful. The overshot shear pin broke with less than 3500 lbs. total weight on the line. Hanging weight was 3200 lbs., so it is assumed that the PCB was not the cause of the problem. The second attempt was successful. The tool unlatched at 1800 lbs. over line weight. During retrieval a momentary 1000 lb. increase in weight was noticed each time the tool passed a pipe joint.

Once again on deck, preparations were made for sampling. It was discovered that one of the four brass safety shear pins could not be removed to release the sampler valve stem. It was sawed off, then drilled out as much as possible. The valve stem lock screw was then backed off with the ideas that if there was pressure in the barrel it would shear off the remaining stub of the pin, but there was still no evidence of pressure. Upon breaking down the tool it was discovered that it <u>was</u> pressurized. All pressure bled from the broken connection.

All o-rings were intact. The sampler sub o-rings were replaced for the next run. The catcher sleeve functioned properly: all fingers were bent inward.

One lead button was missing. The closed ball was free of core. The unpressurized section below the ball was full of core, and the pressurized section was nearly full. The latch dogs were slightly flared and had to be filed down.

Comments

Batting 1000. So far there have only been minor problems.

TEST RUN No. 3 SITE 463 CORE 23 CORE DEPTH 2732 m.

Results

Recovered 1.5 meters of alternating soft and hard chalk ooze and some chert fragments at 1700 psi.

Observations

The PCB was pumped down the pipe at 50 SPM/300 lbs. It took 10 minutes to latch. Penetration rate was 1.3 meters/min. Drill bit was rotated at 30 RPM. The tool was returned to deck and appeared to have functioned properly, except that 2 of the 4 brass safety shear pins were stuck. They were finally sheared with the aid of a slide hammer after attempts to drill them out proved unsuccessful. During attempts to shear these pins the sampler sub was tapped with a hammer whereupon the vent sub momentarily released pressure, then resealed.

Pressure at the sampling guage (preloaded with water at 100 psi) was 1700 psi. Vent sub spring # 3 was used (measured average pressure retention for this spring was 1729 psi). Two stainless steel evacuated cylinders were filled. While filling the second one the vent valve cracked open again; this time it remained open and released all the remaining pressure.

Disassembled the tool and found;

1) The ball had to cut through the core in order to close. A piece of sticky chalk/ooze was inside the ball. No chert was in this piece, but some small fragments were discovered in the upper end of recovered section.
2) No core was recovered in the unpressurized section below the ball.
3) Three fingers of the catcher sleeve were badly mauled (turned inside out). All of the buttons were missing. The sleeve was able to pass through the ball but had failed to clear it of core.

4) The Vespel seat was partly extruded from the seat body.

5) The two lower o-rings and one backup ring on the vent valve stem were broken. A piece of one was found in the manifold.

6) Sampler sub o-rings were good. The shear pin groove in the head of the sampler valve stem was scored in several places from attempts to drill out the shear pins.

7) Two latch dogs were slightly bent and were replaced.

8) A small dimple was noticed in the slot on one side of the ball. The ball was checked to ensure that it still worked smoothly.

Comments

Subsequent bench testing showed that tightening down on the safety valve lock screw will deform the brass shear pins to an extent that they cannot be withdrawn. To remedy this problem the shear pin groove was widened by 1/64" on each side. Scoring caused by drilling out the pins was smoothed as much as possible.

Vent sub and sampler sub o-rings will be changed every run from now on.

Since no core was found in the catcher sleeve, the probable cause the the finger deformation was that cherty ooze, passing up the sleeve during coring, bent the fingers before the closure mechanism was ever activated. The fingers, though initially flush with the I.D. of the sleeve, may have been depressed slightly when the sleeve was inserted into the seat body (due to the irregular sizes of the lead buttons.

The gas samples obtained were run on the Carle gas chromatograph. They produced high ehtylene and ethane peaks. This caused some consternation until it was discovered that the sample cylinders were contaminated with some type of solvent. Two of the unused gas cylinders also smelled of solvent.

TEST RUN No. 4 SITE 466 CORE 10 WATER DEPTH 2672 m. CORE DEPTH 2756 m.

Results

Recovered 0.2 meter of chert chips. No pressure.

Observations

After nine good cores graduating from soupy chalk ooze to firm, sticky chalk, core 10, the first PCB attempt this site, hit a chert layer. It was pumped down at 60 SPM/450 lbs. Penetration rate was 2 meters/minute with the bit rotating at 45 RPM.

The tool was not scoped when returned to deck. The first and third stage pins had sheared but the second stage pins were unstressed and the ball was open. Some large pieces of chert were found in the core catcher, and cherty sand was scattered throughout the tool.

Disassembled the tool and found:

1) The fingers of the catcher sleeve were again badly deformed, so much so that they had hung up on the seat body, preventing the sleeve from moving. When the closure was activated the first stage sheared but could not scope because of the jammed catcher sleeve. The sleeve had carried the load until the third stage sheared, bypassing the second stage.
2) The retainer sleeve could barely be unscrewed from the outer extention body. Both pieces were taken to the machinist for cleaning-up. He discovered the outer extention body was slightly out of round. The threads were recut to fit the retainer sleeve.
3) Ball puller pins had come loose and were reset with Locktite.
4) Vent sub o-rings were intact.

Comments

Since the catcher sleeve fingers were definitely flush with the I.D. of the sleeve this time, a possible reason for their deformation is that cherty sand, while passing up inside the barrel during coring, intruded the space behind the fingers and bent them inward and upward before closure. The sleeve had barely moved from its original position, yet the fingers were reversed.

The deformation of the outer extention body is an enigma. Deformation during make-up is unlikely since all threads have set screw locks making it unnecessary to use high tightening torques on connections. Neither could it have been caused by bottom hole pressure since the PCB did not seal and therefore experienced no pressure differential.

TEST RUN No. 5   SITE 466   CORE 32   CORE DEPTH 2956 m.

Results

No pressure. No recovery.

Observations

Earlier cores had encountered several chert layers, but cores 29 and 30 each contained over one meter of dark limestone and chalk with little evidence of chert. So the PCB was set up to run for core 32 (there is routinely a delay of one core between the decision to run the PCB and the action, in order to mantain a smooth work flow on the rig floor).

When core 31 arrived on deck it was set aside while the PCB was dropped, then it was opened to find nothing but chert and limestone fragments in the core catcher.

The PCB core was cut at a rate of 0.6 meters/minute. The drill bit rotated at 60 RPM. Upon retrieval the second stage was scoped but the first stage was closed. It appeared that at some point the tool had scoped properly, but was then jammed closed. The catcher sleeve was smashed into the bottom of the closed ball and had jammed in the lower seat. It had compressed approx. 2 inches. The position of the sleeve fingers showed they had functioned properly. Some gritty material was found on and above the ball. The ball had closed but there was no pressure. One small fragment of mudstone was found in the lower catcher. All o-rings were intact.

The drill bit was plugged after retrieval of the PCB. It was cleared, but the next core was also a no-recovery core. Core 34 recovered a good section of limestone and chalk with a chert nodule at the top.

Comments

Once scoped, the first stage of the PCB does not lock open as does the second stage. Therefore if the scoped tool were to be dropped on its lower end, the first stage will re-close until the catcher sleeve comes in contact with the closed ball. If the jolt is hard enough the thin-walled sleeve will crumple against the ball. This appears to be exactly what happened during test no. 5. How or when it happened is unknown at this point. Either the PCB was dropped back to the bit after it was latched onto by the wireline overshot during retrieval, or it had scoped prematurely on the way down and had jammed closed when it landed. Most of the evidence points to a case for the latter:

1) The wireline overshot appeared to have latched easily on the first attempt. The seas were calm during recovery.

2) No core was recovered and the tool was unpressurized though the ball was closed. The gritty material found on and above the ball may have been in the water column at whatever point the ball closed.

3) The catcher sleeve fingers were not abnormally deformed. Previous encounters with chert had badly deformed the fingers, indicating that this time core may have never passed through the catcher sleeve.

On the other hand, while it might be possible to prematurely shear the single first stage pin, it is hard to envision a situation where the three pins of the second stage would shear before the PCB had latched (patricularly since the resistance form the water head as the tool was pumped down the pipe should have kept it from scoping.

CONCLUSION

PCB Evaluation

As it turned out, Leg 62 may not have been the most appropriate leg on which to test the PCB. The sites origionally planned in the Gulf of Alaska would have been ideal for testing (red clays, turbidites, and deeper holes), but these were eliminated due to time considerations. The abundant chert encountered in all the holes drilled provided unfair test conditions, since the PCB was never designed nor intended for operating in chert. Still it has proved itself capable of retrieving a pressurized core in non-cherty oozes at depths of about 3000 meters.

The only weak point in the ball valve assembly is the catcher sleeve (and that may only be a problem in chert). The sleeve fingers are too easily deformed. Perhaps a heavy grease packed in the space behind the fingers would prevent core material from intruding there and prematurely bending them, but a design change to eliminate the space or to provide a stiffer sleeve would be more appropriate.

Effects of Small Diameter Bit

The 2 1/4" diameter bit did not inhibit the recovery of regular cores. Though the softer surface cores may have been slightly more disturbed along the walls, they filled the diameter of the regular sized liner. On the harder cores the diameter was slightly smaller. On Site 463 the bit lasted for 86 hours of drilling time, much longer than expected, especially since much of the coring was in chert.

The major drawback is its incompatibility with the re-entry tool and the heat probe. On Leg 62 the conflict of interest between the PCB and the heat probe resulted in the small diameter bit being used on only two of the four holes drilled.

LEG 64

PRESSURE CORE BARREL

The Pressure Core Barrel (PCB) was run twice on Site 478 in the Guaymas Basin. Water depth was 1913 meters.

Run #1

The new mechanical vent sub was used. Sub-bottom depth was 159.5 meters. The coring rate was 1 meter/ minute. 3000 psi was recovered along with 18 cm of diatomaceous ooze above the ball valve seal. No core was recovered below the ball. Gas analysis showed the sample to be mostly compressed air. It is suspected that the vent sub shifted closed during insertion of the PCB into the drill pipe.

Run #2

Sub-bottom depth was 326.5 meters. The hydrostatic vent sub was used this time with spring #3. Coring rate was very slow at 0.17 meters/minute (the previous core had no recovery, just some loose sand in the catcher). Recovered 21 cm of sandstone below the ball seal. No pressure was retained. An autopsy was performed and revealed that there were no apparent malfunctions or damaged parts. All of the O-rings were in good shape and there was no sandy material (as first suspected) around the ball or seat. The entire tool was very clean except for the sandstone in the lower section.

Comments

It would have been desirable to test the mechanical vent sub a second time, but the scientists were interested in maximizing the chances for pressure recovery.

The modified seat body and a new short-fingered catcher sleeve were used on both runs. They performed flawlessly. It was a simple matter to bend the fingers back into shape with a pair of pliers. The soldered lead buttons are also a marked improvement.

Only one of the six catcher sleeves was able to fit within the split lock nut. The slots on the other five need to be enlarged.

The small diameter pressure core barrel bit used on Site 478 achieved excellent core recovery. It penetrated nearly 130 meters of basalt, recovering sometimes over 2 meters of unbroken sections.

The modified small diameter heat probe tool was used twice at this site.

Don Cameron

LEG 66

PRESSURE CORE BARREL REPORT

The PCB was used five times this leg. None of the runs were completely successful in capturing a core at in situ bottom pressure due to a series of relatively minor problems. It's my opinion that, with further testing and refinement, the tool could become a functional part of our coring capability.

I have summarized the salient features of the Leg 66 testing in the accompanying tables, but there are several general aspects of PCB operations that merit more in depth discussion here.

1. The pressure core barrel, in its present state of development, requires a substantial amount of technician time. I spent an average of fourteen hours on each run between: prep. time, running the tool, sampling, rebuilding and analyzing the results. After all the problems have been ironed out, I still expect it will require the full time attention of one technician for any extensive PCB coring program.

2. We learned that the PCB shouldn't be used until the drill string has been cleared of pipe dope and rust scale. Due to the large diameter of the ball valve assembly, the PCB tends to collect any available pipe dope from the wall of the drill string and deposit it as an effective plug when the tool latches-in. We experienced a loss of circulation due to this problem on two of our five runs and I'd suggest not using the PCB until at least four regular core barrel trips have been made.

3. We attempted unsuccessfully to determine the feasibility of using a normal bit to cut a core for the PCB in soft sediments. If it works, this could extend the tools usefulness by enabling the taking of a pressurized core in some particularly interesting formation without changing to the special bit. Unfortunately, none of the regular bit runs provided much information. On two of the regular bit runs we lost circulation and on the third the tool never latched-in properly. Hopefully, future testing will resolve this question.

4. There is some question whether the PCB was properly latched in on any of the test runs. The latch sleeve in the bottom hole assembly has an I.D. of 3 15/16"; and, the ball valve assembly measures 3 14/16". Considering the close tolerance in this area, its not hard to imagine the protruding lip of the latch sleeve catching the PCB latch mechanisms dogs on the wireline trip up and producing partial or even complete shearing when the tool was't properly latched at the onset. The results of tests #1 and 4 seem to support this idea and a latch-in problem may have contributed to the low recovery in run # 5. I think we should try painting the top surfaces of the latch mechanism dogs as a diagnostic device on the next few runs. If a latch-in problem is indicated, I suspect the close fit at the latch sleeve was jamming the tool momentarily and reducing the latch-in velocity considerably. A likely solution may simply be to pump it down harder.

5. Lastly and most frustrating was the failure to hold pressure even when the tool operated normally otherwise. Before and immediately after run # 5, I deck-tested both the top and bottom subs to 2000 psi and found no evidence of leaking; but, somehow the core came up with no pressure and no water. The hydril threads seem at once the most probable and least likely suspect. Most probable because they are all that's left, yet least likely because they are so simple and straightforward.

Bill Meyer

Leg, Hole, Run	Depth (feet)	Pump Down	Bottom Characteristics	Circulation During	Over Pull (lbs)		Mech. Vent style	B.V.A. (# pins)	Extension Sleeves	Latch Assy	Core Recovery (meters)	Pressure Recovery		Observations	Conclusions
66 486 #1	1200	free fall	water	Not pumped	800	|	Closed	Open (2)	Not scoped (1)	Not scoped (2)	Θ	Θ		1. Catchersleeve - Valve seat missmatch; short fingers w/ the high relief seat. Extension sleeves easily scoped by hand on Deck, so jamming unlikely. 2. Regular Bit used	Tool was not pumped down due to the short distance run. Probably it never seated properly and a partial shearing resulted from contact with the latch sleeve or OCB lip on the wireline trip up.
66 487 #2	3411	.10	firm clay	No	4900		Closed	Closed (3)	Scoped (1)	Scoped (4)	water	Θ		1. PCB first thing down string 2. Pipe dope and rust scale prominent throughout tool. 3. Wavy washer not installed.	PCB large diameter collected all excess pipe dope and rust scale and stopped circulation by packing the narrow opening between the PCB and OCB. This packing effectively jammed the tool and prevented the full sandline tension from being applied to the latch mechanism. The lack of pressure was probably due to the missing wavy washer.

Leg. Hole. Run	Depth (Feet)	Pump Down (…	Bottom Characteristics	Circulation During…	Over Pull (Lbs)		Mech. Vent sub	BVA (# pins sheared…	Extension Sleeves (…	Latch Assy (# Pins …	Core Recovery (meters…	Pressure Recovery (psi…	
66 789 #3	5352	10	Firm muddy Clay	No	1200	¦	Closed	Closed	Scoped	Scoped	θ	θ	
66 791 #4	8916	10	Soft Spongy Mud	Yes	1200		Closed	Open	Not Scoped	Scoped	θ	θ	

Run #3

Observations	Conclusions
1. Pipe dope found throughout tool. 2. Core punched rather than drilled. 3. BVA deck tested after run and found to leak badly at ball valve seal.	Loss of circulation as in run # 2. Lack of core due to jamming on punch in. No water or pressure because of leaky ball valve seat.

Run #4

Observations	Conclusions
1. No pipe dope. 2. Catcher sleeve-valve seat mis-match again. 3. Mud traces above ball. 4. No latch in pressure kick during pump down. With increased pressure however the tool appeared seated. (1100 psi @ 60 spm)	Probably PCB never latched properly in the bit and was partially activated on the way up as in Run #2

Leg, Hole, Run #	Depth (Feet)	Pump Down (S.P.M.)	Bottom Characteristics	Circulation During Coring	Over Pull (lbs)		Mech. Vent Sub	B.V.A. (# pins sheared)	Extension Sleeves (pins)	Latch Assy (# Pins)	Core Recovery (meters)	Pressure Recovery (psi)	
66 491 #5	8631	15	Spongy mud	yes	⊖		Closed	Closed	Sheared	Sheared	1.9 No water	~10 psi	

Observations	Conclusions
1. Disassembly showed normal functioning	As in run #4 its likely that the tool never latched in and the core recovered was the result of the tool "riding" the incoming core and gathering some from its own weight. The tool may have been activated by jamming during the drilling process against the OCB lip
2. No pressure kick on latch in.	
3. Upper and lower subs tested separately to 2000 psi + little or no leaking found.	

SITE 491 * PHYSICAL PROPERTIES SUMMARY TABLE H-4

CORE	SEC	INT. (cm)	SUB DEPTH (m)	VELOCITY (km/sec) PARA	VELOCITY (km/sec) PERP	2-MIN GRAPE WET BULK DENSITY (g/cm³) PARA	2-MIN GRAPE WET BULK DENSITY (g/cm³) NORM	2-MIN GRAPE POR (%)	CONT GRAPE WET BULK DENSITY (g/cm³)	CONT GRAPE POR (%)	ROCK CHUNK %H₂O	ROCK CHUNK POR (%)	ROCK CHUNK WET BULK DENSITY (g/cm³)	SHEAR STRENGTH (g/cm²)	LITHOLOGY	COMMENTS
8	1	109-112	68.10								22.6			1245.68	Olive green clayey silt	
8	2	132-135	69.85								30.2					
8	4	106-109	72.56								24.5					
8	5	136-139	74.36													
8	6	128-131	75.80								36.4	48.7	1.84			
9	1	139-142	77.90								21.7				Greenish clayey silt with	
9	2	113-116	79.15								27.5				indistinct sand and silt	
9	3	99-102	80.50								27.0	49.3	1.82		"	
9	5	48-51	83.00								24.6				"	
9	7	10-13	85.60								28.0	52.8	1.80		"	
10	5	79-82	92.80								24.5				Greenish clayey silt "	Zone of ice fracture
10	6	69-72	94.20								23.9					

SITE 491 PHYSICAL PROPERTIES SUMMARY TABLE H-5

CORE	SEC	INT. (cm)	SUB DEPTH (m)	VELOCITY (km/sec) PARA	VELOCITY (km/sec) PERP	2-MIN GRAPE WET BULK DENSITY/g/cm³ PARA	2-MIN GRAPE WET BULK DENSITY/g/cm³ NORM	2-MIN GRAPE POR (%)	CONT. GRAPE WET BULK DENSITY (g/cm³)	CONT. GRAPE POR (%)	ROCK CHUNK %H₂O	ROCK CHUNK POR (%)	ROCK CHUNK WET BULK DENSITY (g/cm³)	SHEAR STRENGTH (g/cm²)	LITHOLOGY	COMMENTS
11	2	117-120	98.20								24.5				Green clayey silt	High gas content
11	3	77-80	100.80								27.8	50.5	1.81			
14	3	59-62	118.10								26.3				Green clayey silt	Abundant gas expansion
14	6	55-58	122.55								21.6					features
15	1	98-101	125.0								25.7	47.3	1.84		Green clayey silt	Dripping laminae;
15	4	99-102	129.5				1.939	45.44			22.1					frozen gas gel.
15	5	98-101	131.0								21.7					
15	7	21-23	133.21								26.5	48.3	1.84			
16	1	119-122	134.70								26.7				Green clayey silt	Notable change
16	4	72-75	138.75								25.1	46.6	1.86		"	in texture very stiff
16	6	68-71	141.70								16.7				Green clay	clays in section 6
16	6	108-111	142.10								19.72	38.9	1.97		"	
16	5	88-91	140.4								22.6					
16	4	108-111	139.10								21.7					

SITE 491 PHYSICAL PROPERTIES SUMMARY TABLE N°1

CORE	SEC	INT. (cm)	SUB DEPTH (m)	VELOCITY (km/sec) PARA	VELOCITY (km/sec) PERP	2-MIN GRAPE WET BULK DENSITY (g/cm³) PARA	2-MIN GRAPE WET BULK DENSITY (g/cm³) NORM	2-MIN GRAPE POR (%)	CONT GRAPE WET BULK DENSITY (g/cm³)	CONT GRAPE POR (%)	ROCK CHUNK %H₂O	ROCK CHUNK POR (%)	ROCK CHUNK WET BULK DENSITY (g/cm³)	SHEAR STRENGTH (g/cm²)	LITHOLOGY	COMMENTS
21	3	101-104	185.01								18.6				Green clayey silt	Indicating of possible
21	3	134-137	185.35								20.9	44.1	1.97			overturned bed -3-115.
21	4	7-10	185.60													
22	4	03-07	195.05								25.9	49.5	1.91		Gray silty clay	Sand [illegible]
22	4	145-147	196.45								18.9					
23	2	39-41	200.90								21.0 18.8	45.9	1.95		Gray silty clay	PCB sample
25	1	143-146	210.95								20.2				Green silty clay	" Drilling Biscuits
25	2	31-34	211.33								22.8	43.5	1.91		"	
25	3	48-51	213.0								22.8				"	
25	5	31-34	215.31								23.1	44.0	1.91		"	
25	6	31-34	217.82				2.01	41.30			22.5					
26	2	109-112	221.60				2.05	39.1			23.1	43.9	1.97		Green silty clay	" Drilling biscuits".
26	3	127-131	223.20								20.5				"	high angle shear
26	5	108-111	226.10								20.3				"	fracture by drilling
26	6	137-140	227.90								22.4	46.0	1.92		"	

LEG 72 PCB REPORT

Abstract

The Pressure Core Barrel was unsuccessfully tested twice downhole and once on deck. During the first test it was discovered that the PCB was incompatible with both the modified HPC head sub and the hydraulic bit release - both assemblies having inner diameter restrictions of 3 7/8" which is the same as the outer diameter of the PCB. Therefore use of the PCB was limited to the one remaining rotary-cored site. On the second and last downhole test, the PCB failed due to premature shearing of the aluminum pins which held it together. This diagnosis is supported by the results of the one deck test in which the first stage, second stage, and vent sub pins sheared after dropping the tool about 12 inches through air.

The shear strength of brass pins vs. aluminum was measured using a hydraulic press. The brass pins appear to be stronger by about 200 lbs/pin. Three of the four PCB units have been rebuilt using brass shear pins. The fourth has not been rebuilt due to lack of spare pivot pins which were sheared on the last test.

TEST #1 Site 515 Water Depth: 4265 m. Core Depth: 49 m.
BVA used: "A".
Included in drill string: Standard bit, hydraulic bit release sub, modified HPC head sub.
Results: No pressure, no recovery. PCB stuck in pipe. Drill string had to be tripped.

Immediately prior to the first test it was discovered that the inner bore through the core guide of each of the five PCB bits aboard was too narrow. These were later machined out to the proper bore, but for the first test a standard bit had to be used.

The overall plan for the site was to spot core through the first 150-200 meters - during which time two PCB tests were to be run - then continuously core to bit destruction, then drop the bit, pull up to the mudline, set the HPC collet in the modified head sub, and finally piston core the upper section of the hole. After a mudline core and a second standard core, the PCB was dropped down the pipe. It was pumped down at 35 SPM for 20 minutes. After 35 minutes, when the PCB appeared to reach bottom, all circulation through the drill string was lost.

A 6.5 m. core was cut. During retrieval attempts the PCB was repeatedly able to travel only about 10 meters up from the bit before it jammed in the pipe. After several attempts of pulling up to 13000 lbs. (8500 lbs. overpull) with no success, the drill string was tripped.

On deck it was discovered that the 3 7/8" O.D. Ball Valve Assembly could not pass up through the modified HPC head sub, though it had passed through on the way down. Specification drawings were checked to find that both the modified HPC head sub and the hydraulic bit release have 3 7/8" inner diameters which make them incompatable with the PCB.

The post-run inspection of the PCB revealed the following:

1. The Ball was closed and undamaged.
2. The face of the Seat was marred by several shallow depressions, but the Teflon O-ring was intact.
3. The Vent Sub was closed, and the Latch Assembly Shear Pins had sheared.
4. The Catcher Sleeve was destroyed - smashed against the Ball.
5. The two halves of the Outer Body were bowed slightly apart. One of the halves suffered a shallow gouge (3/8" long by 3/16" wide) at the point of maximum deformation along its outer circumference. The Outer Body regained its shape when the Catcher Sleeve obstruction was removed.
6. One Puller Pin was deformed and had to be replaced.
7. The burst disk in the Pressure Relief Valve had burst. There were no spares aboard for this part, but one was fabricated out of .003" stainless steel shim stock. It was tested on deck to 4700 psi.

All of the damage can be attributed to the rough treatment the tool recieved during the retrieval attempts, where it was repeatedly subjected to compressive loads after it had scoped out. The damages were not serious and the tool is still operational.

<u>TEST #2</u> Site 516 - Drop Test - 12" through air.
BVA used: "D".
Results: First stage, second stage, and Vent Sub pins sheared, apparently from impact.

This was not originally meant to be a test. In order to check the

PCB spacing a fully assembled PCB including swivel and latch (but minus the four shear pins in the BVA Latch) was picked up and dropped about 12" into the lower bottom hole assembly which was hung off below the rig floor prior to running in the hole. When the PCB was stabbed into the pipe, the Catcher Sub was knocked against the pipe, causing the first stage pin to shear. But the fingers on the Catcher Sleeve held it in place and prevented the first stage from scoping out, so it was decided to continue lowering the tool. The PCB was lowered as far as possible, then dropped. When it was picked up and layed on deck it was discovered that the second stage and Vent Sub pins had sheared.

The post-test inspection revealed:

1. The Ball was partially closed, crimping the Catcher Sleeve which had not drawn clear. The Ball was also dented on its leading edge. (It was filed smooth again).
2. The Outer Body was bowed apart slightly by the mangled Catcher Sleeve inside. It regained its shape when the Catcher Sleeve was removed.
3. The Vent Sub Shear Pin had sheared and the Vent Sub was closed.

TEST #3 Site 516C Water Depth: 1251 m. Core Depth: 14 m.
BVA used: "B".
Included in the drill string: PCB bit, standard bit sub, standard head sub.
Results: No pressure, no recovery.

The PCB was carefully stabbed in the pipe to ensure that the first stage pin remained intact. It was pumped down at 35 SPM. The pump was.

turned off before it reached the bottom 11 minutes later, with the bit still above the mudline. There was no loss of circulation when it latched in.

The weather was deteriorating rapidly, and it was necessary to wait 20 minutes before spudding in due to an excursion from the beacon. The bit was washed down 14.1 meters before punching the 6.5 meter core. No trouble was encountered in retrieving the PCB, but once on deck it was evident that it had again been damaged. Sea conditions required pulling the pipe without running the second scheduled PCB test.

The post-run inspection revealed:

1. The Ball was closed and undamaged, but the 2 Pivot Pins through the Ball Cage were sheared off.
2. The Catcher Sleeve was destroyed, having smashed against the closed Ball.
3. The Vent Sub was closed, and the BVA Latch appeared to have functioned properly.
4. On one of the halves of the Outer Body, the notched lip which engages the Snap Ring was deformed. It was filed back into shape.
5. The Outer Body was again bowed apart by the crumpled Catcher Sleeve inside. Again the deformity was not permanent.
6. A small section was missing from the Teflon O-ring in the Seat.
7. No traces of mud were found either above or below the Ball. However, sand was found packed in the Double Box Sub and between the Extension Sleeve and the Outer Extension Body (where it had reclosed).

It appears that all of the damage was caused by the tool slamming closed after prematurely scoping open before it landed. Shear loads of aluminum vs.

brass shear pins were later measured using a hydraulic press. The loads to shear 4 pins were 1800 lbs. and 2600 lbs. respectively. Three pins sheared at 1500 lbs. and 2000 lbs. respectively. Using the stronger brass might prevent future premature failure of the shear pins.

Don Cameron

LEG 74

PRESSURE CORE BARREL

The pressure core barrel shows every promise of functioning successfully and reliably if one or two modifications are made. As it stands now, I would not hesitate to predict continued satisfactory operation if these modifications can be successfully designed and implemented.

NOTE: Unless otherwise stated, the PCB was built as follows and go-deviled downhole. Vent sub was built with 3 x 0.187 threaded brass shear pins. The pressure relief valve, filter, and sediment trap were not installed; a cap plug was installed in their place. The first stage of shear on the BVA was built with only one 3/16" dia. x 3/16" HH brass shear pin. The second stage (ball cage and puller ass'y) was built with 3 x 3/16" dia. x 1/2" HH brass pins. The third stage (dog latch) was built using 4 HH brass pins 3/16" dia.x 5/8".

The BVA was assembled with the ball closed prior to every run and pressure tested to 3000 psi to ensure proper sealing at ball seat. The vent ass'y was also taken apart and cleaned of foreign objects and /or sediment after each run. O-rings and poly paks were replaced as needed and the vent was also rebuilt closed and pressure tested to 3000 psi prior to each usage.

RUN #1

Only on the first run did we wireline the PCB downhole. We used a gentle five strokes/min. to pump the tool down. When the tool was latched into the support, we slacked off six meters on the wireline, left the overshot connected and as the sed. was still very soft, cored 6 meters without bit rotation. An overpull of approximately 3500# exclusive of wireline and tool weight was needed to shear the dog latch and release the tool. The total pull, including weight of wireline, etc., was approx. 7000# at a depth of 2488.6 meters.

Results: Tool was pulled from pipe, the vent sub lock installed, and laid down on sawhorses on the deck. The body extension had backed off somewhat. The pressure transducer indicated no pressure within and this was confirmed by the pressure gages on the sampling manifold when installed,and the sampler valve stem opened. Core was found to the height of 30 cm above the lower core catcher. On breakdown, no sign of core was found above the closed ball, and the various ports and passages in the vent ass'y were relatively clean, aside from some muddy water residue. All parts of the tool had scoped properly, although not necessairly in order. the snap ring, newly added to prevent the catcher sleeve from scoping back on the ball, was expanded over its support and essentially non-functional. The vent sub rod was found to have backed off the sampler sub along with the extension body.

Analysis: The most likely explaination for the above results is premature ball closure. Prehaps the heave of the ship or the motion of the drill pipe during wireline descent caused the one pin in the first stage to shear, stressing the shear pins in the second stage making them more susceptible to the heave on the wireline, or perhaps shearing them outright. If the vent sub also closed prematurely, it would explain lack of pressure in the core barrel. A better explaination would be that since the vent sub rod had backed off from the sampler sub, despite the roll pin lock, pressure could easily have escaped through this passage. It is interesting to note that if the vent sub rod is backed off, The body extension must also be backed off in order to install the vent sub lock. Conversely, if the vent sub lock cannot be installed, then either the body extension, vent sub rod, or both have backed off, or less likely but possible, the vent has not closed all the way. That the ball closed prematurely is also the best explanation for the location and amount of core recovery. If the ball was closed when coring began, then only a small amount could be forced up into the dog retainer before back pressure refused the admission of any more, and of course, no trace of core should be found above the ball in this situation.

Modifications: We decided that go-deviling would lessen the likelyhood of premature ball closure by removing the stresses produced by the heave of the wireline . Because of the erratic behavior of shear pins in the latch when we drop-tested it on the beach, we had some apprehension as to the effects go-deviling would have on that particular stage of shearing. We also made sure the vent sub rod was made up tight, the roll pin installed, and that the body extension was also torqued strongly.

RUN #2

On the second run, we pumped the PCB downhole at 25-30 spm for 10 min. and then allowed it to freefall for 15 min. The wireline depth was 2530.0m. A 6 m. core was rotary drilled and the tool unlatched at a combined pulling force of approx. 6000#. The weight of the wireline and tool was about 3900# so the dog latch sheared with about 2100# of overpull. When pipe was broken and the vent ass'y exposed, there was noticable bubbling around the threaded shear pins, body extension threads, and the base of the body extension. I was unable to insert the vent sub lock until the body extension was backed off 1/2 to 1 full turn. The tool was laid down on horses on the rig floor, pressure was checked via transducer, and a pressure of 1200 psi was revealed. This rapidly dropped to zero in the course of about one min. The sampler ass'y was operated and revealed a short burst of pressure when opened. All stages had sheared and scoped properly; however, the snap ring on the split retainer nut had again expanded beyond functional size. When the tool was broken down, there was a very small amount of core (about 5 cm) in the lower core catchers, but we found about 1-1/2 m. of soupy core above the closed ball.

The empty liner above the core was both collapsed and split. Silty and grainy mud was evident throughout the vent ass'y, including the pressure relief sub and sampler ports, and several of the sampler rod O-rings were damaged. The vent sub rod was again not sufficiently secured by the roll pin and had backed off somewhat.

Analysis: The results of this run indicated that the PCB did essentially what it was supposed to do. There was core above the ball, the ball closed properly, and finally the dog latch released. That the latch was weakened by go-devil landing was evident from the lowered shear strength of the pins, yet they appeared to retain enough strength to properly activate the tool. The liner collapse could be attributable to a slight but very forceful compression if it had been cut slightly too long. That no pressure sample was recovered is surely because the roll pin once again failed to lock the vent rod and its face seal O-ring tightly enough to the sampler sub body to prevent premature pressure bleed-off which we observed around the body extension.

NOTES: Care was taken to make up the sampler sub as tightly as possible to the vent sub rod. A new snap ring was installed onto the split retainer nut. O-rings and back-ups were changed out on the sampler rod- a bitch of a job I might add, without the proper tool- and the face seal O-ring on the vent sub rod pin was found damaged and replaced.

Run #3

PCB was pumped downhole at about 30 spm for 10 min. and allowed to free-fall for 15 min. The bit was rotated and 6 m. were cored. A pulling force of approx. 5000# (an overpull of about1500#) was needed to shear the third stage at a wireline depth of 2824.5 m..

Results: The pressure transducer was exposed and connected while the tool was still vertical. No pressure registered on the box. No pressure was confirmed when the tool was laid down and the sampler mechanism operated. Once again the vent sub rod had backed off the sampler body. The BVA was removed from the MP-35 barrel to reveal a collapsed liner and no core evident above the ball. A very small amount of core was trapped in the lower core catchers. All parts had scoped properly although the order of shearing was questionable. Again the snap ring designed to prevent reverse scoping of the catcher sleeve had expanded beyond a functional size. Before further breakdown the tool was reassembled on deck as it had been when it came out of the pipe. The vent sub rod was made up tight and pressure induced into the system via the sampler port to 3000 psi. There was no loss of pressure. When broken down, there was very little evidence of mud in the sampler, pressure relief, or vent subs.

Analysis: It is more than likely that this is a typical example of premature ball closure. This could be due to pin weakening or shearing during set down on the hang-off plate. The 1500# overpull needed to unlatch the tool indicates a substantial weakening of the pins in the third stage during landing. Again no pressure was due to the inability of the roll pin to lock the threads on the vent sub rod.

Run #4

Number four was again pumped down the hole at a rate of 25-30 spm for 10 min. and allowed to free fall for 15 min. The shear force necessary unlatch the tool was about 5000#, including an approx. 3700# combined wireline and tool weight at a depth of 2872.0 m..

Results: Upon retrieval, once again was unable to install vent sub lock easily. Bubbling and audible pressure release around the body extension indicated that the vent sub rod had backed off. The pressure transducer was connected to hanging tool and initially showed a pressure of 1500 psi dwindling down to zero in about 1.5 min.. All parts of the tool had scoped although the snap ring on the split retainer nut again overexpanded. Upon breakdown, a small amount (about 3 cm.) of core was found in the lower core catchers. No core was above the closed ball and the upper 2/3 of the liner was collapsed. Most of the vent ass'y was fairly clean, although quite a bit of sediment built up in the sampler sub end cap, and some in the check valve around the seat. The teflon ring in the ball seat was quite gritty and embedded with sediment particles.

Analysis: Once again I'm forced to attribute unsuccessful operation to two recurring problems: premature ball closure, and the inability of the roll pin to maintain integrity of the face seal O-ring on the vent sub rod pin. Ball closure is almost certainly due to pre-stressing of pins during hangoff or drop through air to water line. A single pin in the first shear plane is most likely insufficient , and force applied to the second stage by shearing of the first stage on the hangoff plate might well be enough to seriously weaken or shear the pins holding the ball open. A set screw lock must be added to the vent sub rod pin/sampler sub to insure that seal remains pressure tight. The roll pin is definately inadequate to lock these threads securely. Would welcome explaination for continued liner failure!

Modifications and proceedural changes made as a result of the first 4 runs.

1. In anticipation of a shallow site, an extra shear pin hole was added to the second and third stages to beef up the shear strength of the ball cage and latch. We felt we could use extra pulling force as the wireline weight would be much lighter in shallow water.

2. We decided to definitely run 2 pins in the first stage; something I should have done from the start.

3. We decided to leave the ass'y lock screw and the ass'y lock bolt as well as the vent sub lock in place until the PCB is picked up and stabbed in

the pipe. The pins will be removed and the plugs installed as the tool is lowered into the pipe.

4. A hole will be drilled through the bottom of the vent sub rod to accomodate a roll pin. Based on a suggestion from the Beach, this arrangement is designed to prevent the check valve ball from locking closed during coring.

5. Because of pin failure in the face spanner tool, it was redesigned to provide more torqueing force. The vent sub rod was also modified to accomodate the new design.

6. A set screw hole, 5/16"-16 was drilled and tapped into the sampler sub and a detent drilled into the vent sub rod pin threads to lock this connection securely.

7. Pumps were to be circulated to get maximum water level in pipe, prior to go-deviling tool.

8. Pay particular attention to gentleness when setting tool down on hang off plate.

Run #5

The new improved PCB was set down with great care and gentleness on the hangoff plate. It was pumped downhole at 25 spm for 20 min and allowed to freefall with pumps cutoff for 17 min.. As we were pressed for time, we combined tests and included the DBMI in place of one of the MP-35 core barrels and therefore cored a total of only 4.5 m.. The tool was built with 4 pins in the second stage in an effort to correct our problem with premature ball closure. Two pins were installed in the first stage and only four pins in the third stage because the greater water depth created a greater wireline weight and 5 pins would have put us very close to maximum pull allowed us by the limits of our overshot. The water depth here was 4437 m., requiring a wireline and tool weight of approx. 6600#. Two shear forces were noted when the tool was retrieved. One at about 7500# (900# overpull), and the second, much more pronounced at about 10000# (3400# overpull). The vent sub lock was again difficult to install as the body extension had backed off slightly.

Results: The pressure transducer yielded a pressure of 1000# while the tool was hanging in the pipe, just after retrieval. The pressure held steady for about 3 min., after which we laid the tool down on horses on the rig floor and reconnected the pressure transducer. It read 1100 psi when the sampler manifold was connected. When the sampler port was opened, a pressure of 800 psi registered on the gage, corresponding exactly to the reading derived from the transducer. A 500 ml evacuated cylinder was placed in line on the manifold and the tool was emptied of pressure by the one cylinder. The tool was scoped properly with the ever-present exception of the recalcitrant snap ring mentioned previously ad nauseum. No core was in evidence throughout the barrel except for sediment deposits in evidence in various nooks and crannys in the vent ass'y. The core liner was shattered, and a piece of liner was found in the ball seat of the check valve, preventing the ball from seating.

Analysis: To recreate a sequence of events to explain these results, I had to tax my analytical abilities. Picture, if you will, the two pins (run for the first time) in the first stage holding securely as the tool was set down gently on the hangoff plate, and holding again as the tool was dropped through a shortened interval of air to penetrate the surface of the water with a somewhat lessened momentum. Think then of the shear pins in the ball cage, for the first time relatively unstressed, and 4 of them having the same strength as those in the dog latch. Now the tool lands and the pins in the latch are weakened. The core is cut and the tool is retrieved. Perhaps the 7500# shear is the vent or the first stage shearing, the 10,000# release is definitely the dog latch yielding; but what of the previously unstressed pins in the ball cage?

Surely the 10,000# pull severely stressed but probably did not completely shear them. As the tool is pulled out of the hole, these pins still hold, preventing the ball from closing and allowing whatever core is present to be washed out of the barrel and back down into the briny depths. And would there be core anyway? If the check valve was held open while coring by the piece of liner, then maybe the core was washed away by the pumps even as it was entering the barrel. The cores on either side of PCB run #5 were rather soft and soupy and recovery was low. So here we have the barrel being lifted, the ball held open by 4 weakened yet tenacious brass pins, when suddenly a large swell causes the ship to heave upward--a force transmitted through the wireline to the PCB and causing the last bit of brass in the ball cage shear pins to give, thus closing the ball and sealing the pressure at that level within. Granting that no pressure was lost after ball closure, that level would correspond to approximately 700 m. of water depth. The new set screw devised to lock the vent sub rod to the sampler sub worked fine. It seems that a second pin in the first stage, and careful handling of the tool during hangoff may obviate the need to beef up the second stage. We are making progress!

Run #6

Two pins were built int the first stage.The extra pin deemed unnecessary, the ball cage was run with 3 pins, while we continued to use four pins in the latch. Special care was given to hanging the tool off in the pipe and all the assembly locks and pins were replaced or removed as the tool was lowered. The PCB was pumped downhole for 18 min. at 25 - 30 spm and allowed to freefall with pumps cut for 22 min.. Again only one MP-35 barrel was used and the DBMI pressure case was used for spacing. A 4.4 m. core was cut and when we went to pull the tool up, ther was no perceptible shear force necessary to unlatch the damn thing. The wireline weight with the tool at 4617 m. was approximately 5500# and the load indicator on the rig floor never went over 6000#.

Results: When we got the tool up and attached the pressure transducer, no pressure was detected. The vent had closed however, and the vent sub lock was easy to install. As we raised the PCB out of the hole, it was gradually revealed that neither stage one nor stage two had sheared. The ball was still open. Sigh! There was approximately 10 cm. of core in the lower core catcher along with 30 cm above the open ball, trapped by the upper catcher. The vent ass'y was suitably silty. When the check valve retainer nut was removed, the valve seat was found cocked. The nut had been made up tight, but apparantly the threads were botched and it was unable to run up and lock the seat in properly.

Analysis: The tool obviously landed in such a way that the pins in the dog latch retainer were sheared on impact. This could be most easily explained if it had landed in such a way that the single finger latch at the top of the tool did not immediately engage the lip of the latch sleeve. Admittedly only a fairly small arc of tolerance would allow for this to have happened. If the tool could bounce while the dog latch was engaged, it could shear the pins quite readily as we proved in several drop tests at the hydraulics lab. Since the latch pins were sheared, there was nothing to pull against to release the first and second stages, and it is quite a testimony to their strength, or lack of distortion when landing that they did not shear throughout the round trip. The soupiness of the core previous to PCB #6 and the poorly seated check valve would contribute to the small amount of core recovered. The liner, which was cut 1/4" shorter for this run did not split or shatter.

Run #7

The tool was built with 2 pins in the first stage, 3 pins in the second stage, and 4 pins in the third. A double finger latch was used. The PCB was used in conjunction with the DBMI so only one MP-35 core barrel was run and 4.5 meters cored. It was gently lowered into the pipe onto the hangoff plate. The assembly pins were removed and plugs installed as they became accessible while it was being lowered. The tool was go-deviled down-hole for 22 minutes without pumping. The wireline weight at 1117 meters was about 1300# and the tool weight including core was estimated at 600#. The force necessary to release the tool was about 4600# or an overpull of about 2700#.

Results: Tool was brought up to rig floor and the transducer affixed showing no pressure in barrel. The vent lock was easily installed. As the barrel was raised from the hole, it became evident that neither the first or second stage pins had sheared. A flapper-type catcher was run in the bottom connector core catcher. As usual the sampler manifold was connected and verified the transducer reading. The vent assy was removed to reveal a full liner. The BVA was then removed and the core was removed. The vent assy was immediately redressed for the 8th test and found to be full of soupy sediment. The sampler rod had one broken O-ring which was replaced. No backing off of the vent sub rod or body extension was detected. The ✓ valve was impacted with sediment and difficult to clean but evidently it functioned properly. The sampler sub cap was also packed with sediment.

It was difficult to tell whether the first stage pins had not sheared or if they had sheared and then jammed back in place, but it is probable they didn't shear as a considerable amount of force was necessary to break off the dog retainer from the inner extension body and it is hard to believe the snap ring could be re-installed if it had been previously expanded. The pins in the ball cage showed signs of stress.

Analysis: Again the blame seems to lie with the third stage pins. They appear to be stressed unpredictably when the tool lands and their remaining strength determines if the other stages will shear or not. The core was taken without rotation and packed very firmly in the core barrel, but there did not seem to be much core in the ball or below until about 30 cm from the bottom of the lower core catcher. Don't quite understand why the first stage at least did not shear, however, as 2700# of pull should be sufficient to shear two pins unless something else was cocked or jammed. Who said seven was a lucky number?

Modifications: Decided to beef up dog latch with fifth shear pin. I am convinced that the third stage shearing problem is all that prevents successful runs of the PCB.

Run #8

The tool was built in the same manner as in as in Run #7 with the exception that 5 pins were run in the dog latch. At this shallow water depth, there is more leeway with pulling force required for shear pins. The tool was again run in conjunction with DBMI. It was go-deviled 22 minutes sans pumps. A 4.5 meter rotary core was taken. The wireline weight was 1500# with an estimated tool weight of 600# in a total depth of 1283.5 meters. The wireline was retrieved slowly and three planes of shear were thought to be observed at 3500#, 5000#, and 5500#.

Results: Barrel was retrieved from pipe and hung on tugger while transducer was attached. A reading of 1200 psi was detected. The tool was then removed from pipe and laid down on horses on rig floor. All stages had scoped and sheared properly. Even the recalcitrant snap ring on the split retainer nut was in place and functioning. The sampler manifold was affixed to the port but it was very difficult to remove the shear pins holding the sampler rod in place. Finally, two of the pins were removed, but the third had to be sheared using the slide hammer. After shearing the pressure dropped to about 500 psi, both on the transducer and the manifold gage. The pressure was released in a short jet of water and air. The vent assy was removed, revealing another full core! The BVA was then removed and the core liner extruded. The perfect end to a perfect run!

Analysis: As anticipated, the key to successful operation was in the third stage. This time there was enough strength with the extra shear pin to hold the barrel down until the other stages had sheared. The three stages of shear observed on the wireline weight indicator probably correspond to those in the tool. The first stage required 1400# overpull, the second 2900#, and the third 3400#. This indicates that again the third stage was weakened but the extra pin provided the necessary strength to hold. The drastic press. reduction observed when the sampler was opened indicated that very little gas was in the sampler and that the opening into the manifold allowed it to expand sufficiently to drop press. as it did.

CONCLUSIONS

It is obvious that more work is necessary to ensure continuous, reliable operation of the PCB. Progress was made to guarantee a pressure seal in the vent assy, but the sequential shearing of the stages needs to be made more predictable. I am convinced that if we can solve the problem of premature shearing of the third stage, we will have a functional and reliable tool. The problem with adding a fifth or sixth shear pin to achieve the needed strength is that, as often as these pins weaken on landing, we cannot consistently count on their doing so. In shallow water with low wireline weight, our margin of wireline overpull can accommodate the extra shear strength necessitated by a fifth or sixth pin, even if no weakening occurs during landing. In deep water, however, our overpull can be drastically curtailed by excessive wireline weight, and the extra force needed to shear five or six intact pins can preclude their use. Therefore, I believe we should look to modifying the third stage in some manner to make the releasing force constant.

The second snap ring installed over the split retainer nut to prevent the catcher sleeve from scoping back on the ball functioned properly only once in eight tries. We should reassess the value of this ring and decide whether we can make it work properly or eliminate it entirely. The majority of problems left to be solved to ensure complete satisfaction with the PCB, with the exception of consistency in the third stage, are minor and with a little more work, we're going to have another winner! Perhaps a greater number of pins of smaller diameter or using some sort of spring release could be the answer.

Another problem that bears looking into is sampler rod release. In all of the tests, any time there had been significant pressure trapped in the barrel, the shear pins that hold it down have been distorted and varying degrees of difficulty were encountered in their removal. Perhaps the pin holes could be slotted to facilitate easier removal after the locking nut has been tightened down prior to sampling.

The set screw replacing the roll pin used to lock the vent sub rod to the sampler is working fine, with no complications encountered after its installation. The double finger latch used on runs #7 and #8 would preclude the chance of the PCB being able to bounce if it happened to land in the particular orientation suggested in test #6. We should consider whether this possibility warrants continued use of the double finger latch.

The diminished diameter of core cut by the PCB bit also causes problems when it is intruded into the standard size liner. All cores cut with this bit are soupier, messier, and less desirable. This, in turn, arouses the ire of those scientists indifferent to pressure barrel coring and in some cases turns their impartiality to irate antagonism. Maybe we could get a smaller diameter liner to run with the PCB, thus improving both the quality of recovered core and the relationship between the sedimentologists and the engineering department!

Another problem I encountered during the last two PCB runs was in retrieving core from the dog latch retainer. If it is full of stiff sediment, it is quite difficult to retrieve and bears little resemblance to the rest of the core.

Two pins in the first stage and three pins in the second stage seem entirely adequate in holding their assemblies in place until the time comes to shear. In fact, I would be curious to see what would result from running softer shear pins with less strength in both these stages if the opportunity presented itself. The first four tests I think proved that one-half hard brass shear pin is not strong enough to hold the first stage and when it went, the 3 pins in the ball were overstressed and had to shear also. But bear in mind that we were not paying particular attention to gentleness in hanging off the tool prior to go-deviling; a time when the first two stages are most vulnerable to stress. Perhaps with the gentler techniques currently in use, annealed brass or aluminum pins in the first and second stages would be adequate and would require less overpull to shear, thereby giving more latitude for weakening of the pins in the dog latch.

T. W . Witte
19 jul 1980

LEG 76 PRESSURE CORE BARREL REPORT

Introduction

The Mod II Pressure Core Barrel has been tested on several cruises beginning with Leg 62. During that time a dependable ball valve seal and upper vent seal evolved, and most of the bugs were worked out of the system. The remaining problems were narrowed to two:

1) The successful operation of the PCB depended upon three sets of shear pins in the Ball Valve Assembly acting in correct sequence. The pins were unreliable; they would often shear prematurely as the tool descended the pipe.

2) The pressure relief valve - a safety feature designed to maintain the core barrel at no more than 5000 psi by venting the excess pressure - was incorrectly deployed within the pressure chamber. It would open at pressure far less than 5000 psi.

The modifications incorporated in the Mod III version PCB used on Leg 76 included the elimination of the shear pins in favor of a combination of a collet, ball locks, and a stack of spring washers in the respective first, second and third stages of activation in the Ball Valve Assembly. The pressure relief valve was relocated to a position outside the pressure chamber. Two alternate sampling assemblies were made available. The primary assembly incorporated a floating piston accumulator (with a 1/2 liter capacity) isolating the pressure relief valve from the pressurized core. (When the accumulator is initially charged with nitrogen to, say, 4000 psi, a barrel pressure exceeding 4000 psi will cause the piston to move and further compress the nitrogen. When the barrel pressure exceeds 5000 psi, the pressure relief valve opens and vents only nitrogen, thereby saving all of the sample gas and protecting the pressure relief valve from possibly clogging with sediment). An alternate sampling assembly incorporated a sediment trap and a 20 micron filter instead of an accumulator.

The Mod III PCB can recover 7.87 meters of core, 5.94 meters in the pressurized section and 1.93 meters in the unpressurized section.

Description of Runs

The Mod III Pressure Core Barrel was run five times on Leg 76, Site 533A. The water depth was 3194 meters. The sea conditions were moderate; roll and pitch ranged between 3 and 4. The heave compensator was used in the passive mode. The sediments recovered were gassey clayey muds becoming quite stiff at the bottom of the hole. Four of the runs were successful in recovering pressurized core, two of which contained evidence of gas hydrates.

PCB # 1 was the fourth tool to be run down the drill string. It latched in without problem, but circulation was lost as soon as coring commenced. (Normally water is pumped at a low rate of flow around the core barrel during coring to lubricate the hole). Past experience has shown that the PCB - which is wider in diameter than a regular core barrel - sometimes jams in a "new" drill string that has not yet been reamed of rust and pipe dope. Also it was discovered that the 3-13/16 in. diameter landing shoulder on the PCB rests inside the 3-7/8 in. diameter liner of the hydraulic bit release. This minimal clearance could have aided in plugging off the circulation. (Flutes were cut in the landing shoulder for subsequent runs, and no further circulation problems were encountered).

It was decided to cut a 2.5 meter "dry" core. 8500 pounds pull was needed to unlatch the barrel. This was 4500 pounds over the 4000 pound line weight. Previous tests on the "C" spring pack configuration (See Table 1) had indicated a 3000 pound pull necessary to release the PCB. It was thought that the loss of circulation and the high unlatching load were both caused by rust jamming the tool in the pipe, and it was hoped that fluting the landing shoulder would solve both problems. However, on all subsequent runs - while circulation was restored - the unlatching loads continued to be high, even after a weaker spring pack was tried (See Table 1).

TABLE 1

PCB#	CORE#	TOTAL DEPTH(M)	CORED(M)	RECOVERY(M) PRESSURIZED	UNPRESSURIZED	PRESSURE(PSI)	SAMPLING* ASSY	SPRING** PACK	WIRE LINE TO PUL UNLATCH(OVERPUL IN LBS.
1	3	3336.0	2.5	6.40	0	4000	A	C	9000 (5000)
2	14	3431.0	7.8	0	1.56	0	A	C	8500 (4500)
3	23	3516.5	7.8	6.13	0	4700	A	D	9500 (5500)
4	26	3545.0	7.8	7.45	0	1500	B	D	9000 (5000)
5	29	3575.2	7.8	6.20	0	4400	A	D	10000 (6000)

*A = Primary Assembly   B = Alternate Assembly

**C = Series parallel stack of 44 spring washers (2 up, 2 down) x 11

D = Series parallel stack of 42 spring washers (2 up, 2 down, 1 up, 1 down) x 7

PCB # 2 operated well mechanically except for the high release load. No pressure or core was recovered above the ball valve due to a combination of (what is politely called) "operator error" and a faulty core liner. A plug was left out of the sampling assembly, thus no pressure was retained. Also the core liner was returned totally shattered. It was a spliced liner. Though the actual splice was not used in the barrel, the liner was used down hole before and may have become brittle. (Fracture problems with spliced liners were later noticed on regular cones during core splitting).

Ironically PCB # 2 was the only one to recover core in the unpressurized section below the ball valve. The recurring failure to recover unpressurized core may have been due to the single lower core catcher allowing the fine-grained clays and muds to wash through. It may also be correlated to the high pulls needed to unlatch the tool.

PCB's # 3, 4, and 5 all recovered full pressurized core and no unpressurized core. PCB # 4, the only run in which the alternate sampling assembly (without the accumulator) was used, recovered only 1500 psi. It was not leaking on deck, so it was assumed that the pressure relief valve temporarily jammed (possibly due to passing muddy water).

On each of the successful PCB runs, a plug of core was trapped in the ball, indicating that the catcher sleeve did not clear the ball of core. Runs in more lithified sediments will have to be made to fully test the clearing action of the catcher sleeve.

Sampling

A rather elaborate sampling procedure was employed at the request of the Geochemists. After returning to deck, the unpressurized section was immediately removed. Then the PCB was craned to the deck outside the Electonics Van and placed in a long box filled with ice. Pressure and temperature were continually monitored while gas samples were intermittently withdrawn over a period of several hours. Then it was moved to a warmer bath where the sampling procedure continued.

A temperature sampling port was devised by plugging off the inside of an unused port in the pressure relief sub, filling the bore with heat sync compound, and plugging off the outside with a pipe plug before running downhole. One of the geochemists had a digital thermometer with a probe which was inserted into the hole after removal of the outside plug during sampling. The sampling manifold included a filter, regulator and several sample cylinders on a branch plumbed to allow selective filling of the cylinders (See photo). During the sampling of PCB # 1, thick soupy mud clogged the filter, so this was removed for subsequent samplings. However, all of the other PCB barrels discharged relatively clean water and gas with no clogging problems.

The temperature of the PCB was easily controllable with the ice bath. The initial deck temperature was usually 15°C-20°C and began dropping as soon as it was placed in the bath.

Assembly and Operation

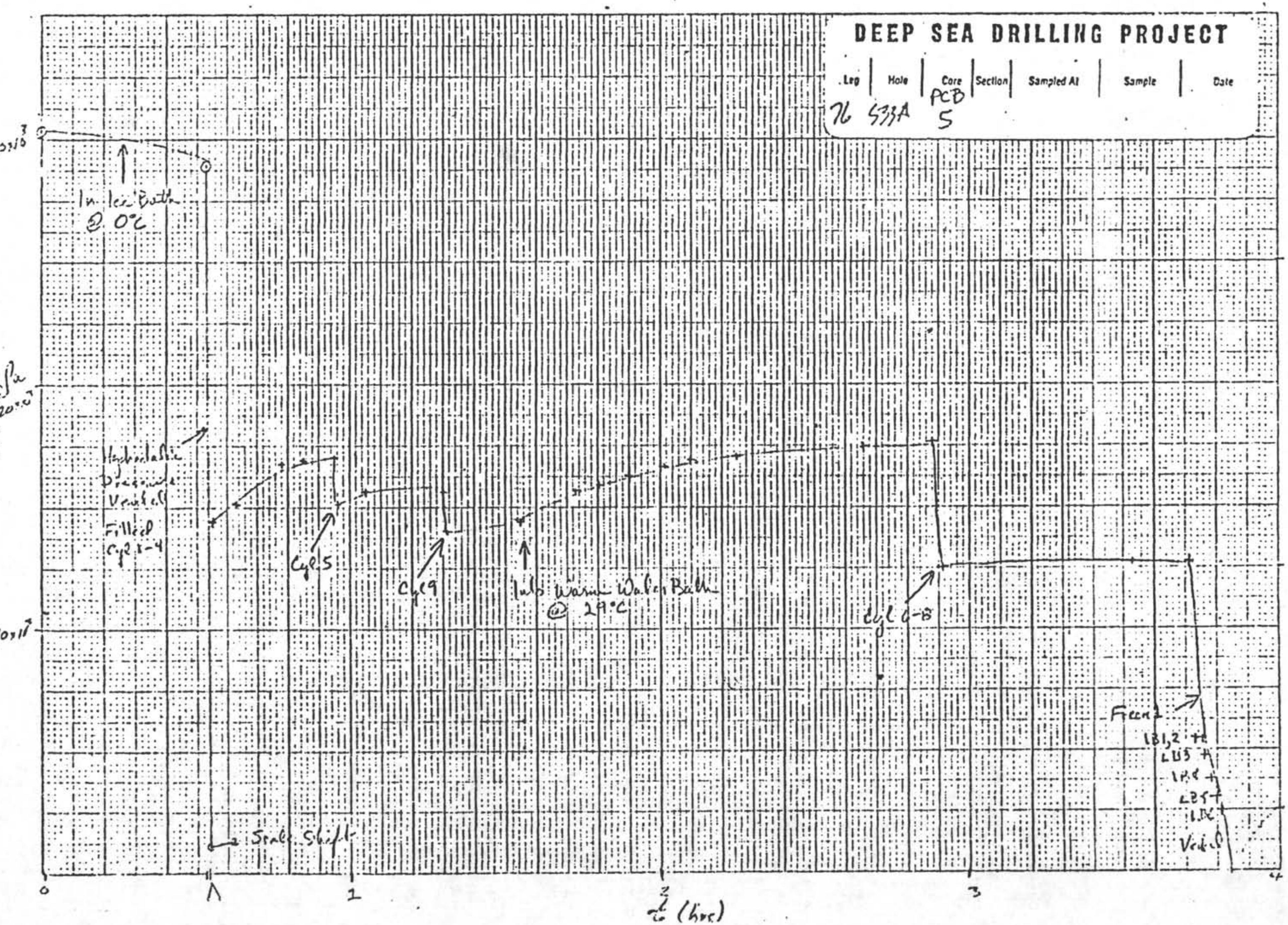
Lack of working space is an ever present problem with the PCB. On this cruise it was compounded by the necessity that it remain unopened for several hours as other cores continued coming on deck. The following procedure was adopted to minimize conflicts with regular coring.

The Ball Valve Assembly and Upper Assembly (from the pressure relief sub to the three foot spacer sub) were assembled as complete subunits in the PCB work area outside the Electronics Van. These were moved by elevator to the Core Lab deck and made up to either end of the MP-35 core barrel which hung on a rack on the starboard rail.

When the time neared to run it, the PCB was moved to saw horses on the rig floor. The swivel and latch were made up to the upper end, and all connections needing high torque were tightened by the roughnecks. The spring washer stack was greased with either pipe dope or silicone grease to protect it from clogging with rust or sediment.

When the previous core barrel returned to deck, it was laid down on the center ramp. The PCB was then picked up and stabbed into the pipe. The vent sub lock bolt was removed, then the PCB was hung off to remove the tugger line. It was go-deviled down the pipe while pumping 30 strokes per minute. This was cut back to 20 SPM after 15 minutes. It took 45 minutes to latch in as compared to 20 minutes for a regular core barrel. After latching in, the core was cut while pumping at 10 SPM.

Usually two distinct loads were observed when unlatching the PCB. One at 6500 pounds and the other at 8500-10000 pounds. Once back on deck, the vent sub lock bolt was installed, and an immediate pressure reading was taken from the transducer in the pressure relief sub before laying the PCB down on the rig floor. The unpressurized section, swivel and latch were removed, and the PCB was craned down to the ice bath on the next lower deck. After the gas sampling procedure, it was again hoisted to the cat walk to remove the core.


DEEP SEA DRILLING PROJECT
Leg
Hole
Core
Section
Sampled At
Sample
Date
76
533A
PCB
5
In Ice Bath
@ 0°C
Filled
Cyl 5
Cyl 9
@ 29°C
Scale Shift
kPa
10x10³
20x10³
0
1
2
3
4
t (hrs)

APPENDIX D

"PRESSURE CORE BARREL: APPLICATION TO THE STUDY OF GAS HYDRATES DEEP SEA DRILLING PROJECT SITE 533, LEG 76"

Reprinted from Sheridan, R. E., Gradstein, F. M., et al., 1983
Initial Reports of the Deep Sea Drilling Project, Volume LXXVI, Washington (U.S. Government Printing Office)

7. PRESSURE CORE BARREL: APPLICATION TO THE STUDY OF GAS HYDRATES, DEEP SEA DRILLING PROJECT SITE 533, LEG 76[1]

Keith A. Kvenvolden, Pacific-Arctic Branch of Marine Geology, U.S. Geological Survey, Menlo Park, California
Leo A. Barnard, Department of Oceanography, Texas A&M University, College Station, Texas
and
Donald H. Cameron, Deep Sea Drilling Project, Scripps Institute of Oceanography, La Jolla, California

ABSTRACT

A pressure core barrel (PCB), developed by the Deep Sea Drilling Project, was used successfully to recover, at *in situ* pressure, sediments of the Blake Outer Ridge, offshore the southeastern United States. The PCB is a unique, wire-line tool, 10.4 m long, capable of recovering 5.8 m of core (5.8 cm in diameter), maintained at or below *in situ* pressures of 34.4 million Pascals (MPa), and 1.8 m of unpressurized core (5.8 cm in diameter). All excess internal pressure above the operating pressure of 34.4 MPa is automatically vented off as the barrel is retrieved.

The PCB was deployed five times at DSDP Site 533 where geophysical evidence suggests the presence of gas hydrates in the upper 600 m of sediment. Three cores were obtained holding average *in situ* pressures of 30 MPa. Two other cores did not maintain *in situ* pressures. Three of the five cores were intermittently degassed at varying intervals of time, and portions of the vented gas were collected for analysis. Pressure decline followed paths indicative of gas hydrates and/or dissolved gas. The released gas was dominantly methane (usually greater than 90%), along with higher molecular-weight hydrocarbon gases and carbon dioxide. During degassing the ratio of methane to ethane did not vary significantly. On the other hand, concentrations of higher molecular-weight hydrocarbon gases increased, as did carbon dioxide concentrations. The results from the PCB experiments provide tentative but equivocal evidence for the presence of gas hydrates at Site 533. The amount of gas hydrate indicated is small. Nevertheless, this work represents the first successful study of marine gas hydrates utilizing the PCB.

INTRODUCTION

The Deep Sea Drilling Project (DSDP) has been a leader in the development of new, sophisticated technology for deep ocean drilling (Larson et al., 1980). Among the Project's important technological advances is a unique, wire-line, retrievable pressure core barrel (PCB) capable of recovering sediment cores at original formation pressures. In such cores, pressure-related changes that accompany conventional core recovery are inhibited or prevented; the core is maintained essentially as it was at depth.

The PCB is especially useful for the study of gas hydrates in oceanic sediments. Gas hydrates are naturally occurring, crystalline solids composed of a three-dimensional framework of water molecules that is initiated and stabilized by included molecules of gas, mainly methane in marine sediments. Appropriate conditions of high pressures and moderate temperatures are found in deep oceanic sediments where natural gas (methane), in excess of the amount soluble in water, will interact with water to form gas hydrates. Kvenvolden and McMenamin (1980) and Kvenvolden and Barnard (in press) have reviewed the known and inferred occurrences of gas hydrates in oceanic sediments and have shown that gas hydrates are likely to be common in continental margin sediments throughout the world. Gas hydrates decompose upon decrease of pressure and increase in temperature. The PCB provides an appropriate device to recover at nearly *in situ* conditions sediment containing gas hydrate. Within the PCB a recovered gas hydrate can be decomposed under controlled conditions and samples of gas obtained for analysis. The observed pressure changes and compositional analyses can be used to verify that gas hydrates have been cored and to determine the sources of the gas.

HISTORY OF DEVELOPMENT OF THE PCB

Although the need for a PCB was recognized early on at DSDP, the development of a successful coring system took several years. An early version of the PCB was deployed at Site 185 on Leg 19 in the southeastern Bering Sea. Unfortunately this PCB jammed, shearing the pin in the sand-line recovery mechanism, which made it necessary to abandon the hole (Creager, Scholl, et al., 1973). A modified PCB (Mod. I) was tested eleven times during Leg 42B in the Black Sea with varying degrees of success (Ross, Neprochnov, and Supko, 1978): at Site 379 this PCB was used six times to recover sediment, but no pressures are given (Ross, Neprochnov, et al., 1978a). Four tests with this PCB were made at Site 380; in one of these tests gas compositions were measured, but this tool failed on subsequent tests (Ross, Neprochnov, et al., 1978b). The PCB was given its eleventh test at Site 381, but no results are reported (Ross, Neprochnov, et al., 1978c). As a result of the PCB testing on Leg 42B several modifications were recommended, and two attempts were made to test the PCB at Site 388 of Leg 44 on the western Atlantic continental margin, (Benson, Sheridan, et al., 1978). Both tests were unsuccessful due

[1] Sheridan, R. E., Gradstein, F. M., et al., *Init. Repts. DSDP*, 76: Washington (U.S. Govt. Printing Office).

to the failure of the ball assembly to close and maintain pressure.

On the basis of the preceding tests the PCB was extensively modified, and a second version (Mod. II) was tested on Legs 62, 64, 66, 72 and 74 in both the Pacific and Atlantic Oceans. Only results from Leg 62 are currently available (Thiede et al., 1981). On this leg the PCB was deployed five times at two different sites. On three of the tests the PCB maintained some pressure. Two cores were recovered, but the occurrence of chert limited the degree of success of PCB coring on this leg. During the series of tests on Legs 62, 64, 66, 72, and 74 a dependable ball-valve seal and an upper exhaust-vent seal evolved.

One problem that remained to be solved was the sporadic, premature tripping of the ball closure, vent, and release mechanisms. Ultimately the problem was traced to shear pins, which should have sheared during increasing pull on the wire line, thereby triggering the ball closure, vent, and release mechanisms in three separate steps. The shear pins, however, became weakened during the trip down the pipe and, upon impact with the bit, sheared prematurely, causing the release of the tool before closure of the ball valve.

The last version (Mod. III) of the PCB (Fig. 1) incorporates, instead of shear pins, a system combining a collet, ball locks, and a stack of disk springs. The pressure relief valve is located outside the pressure chamber. Two alternate sampling assemblies are available for use. The primary assembly incorporates a floating piston accumulator (500 cm^3 capacity) in-line between the pressure chamber—containing the pressurized core—and the pressure relief valve. The other sampling assembly uses a sediment trap and a 20-micron filter instead of an accumulator.

Now the Mod. III PCB (Fig. 1) consists of a high-pressure, wire-line core barrel terminating in a ball-valve assembly with a 5.8-cm-diameter orifice at the lower end and a sampling mechanism, exhaust vent, and pressure relief valve at the upper end. The PCB is dropped down the drill string to latch in at the drill bit. After the core is cut by rotary coring, a retrieving tool is lowered down the pipe by wire line to latch onto the PCB. The force of the wire-line pull against the latched-in PCB activates a series of mechanisms that shift close the ball valve and the exhaust vent and finally unlatch the tool. As the PCB is retrieved, the pressure relief valve maintains internal pressure at no more than 34.4 million Pascals (MPa) (5000 psi) by venting nitrogen from the precharged floating piston accumulator, if the primary assembly is used, or by releasing excess pressure through the sediment trap and filter if the alternate assembly is in place. When the floating piston accumulator is used (Fig. 1) and is initially charged with nitrogen to about 27.5 MPa (4000 psi), a barrel pressure exceeding 27.5 MPa will cause the piston to compress the nitrogen. When the pressure in the sampling chamber of the PCB exceeds 34.4 MPa, the pressure relief valve opens and vents only nitrogen, thereby saving the gas in the sediment sample and protecting the pressure relief valve from possible clogging with sediment.

When the PCB reaches the deck, the pressure and temperature of the core can be monitored, and pressurized gas and fluids can be withdrawn under controlled conditions. The unique, wire-line retrieval system allows several pressurized cores to be collected while coring progressively in the same drill hole. This procedure contrasts with more conventional pressure-coring systems used by the petroleum industry that require a complete round trip with the drill string for recovery of each core.

SPECIFICATIONS FOR MOD. III PCB

A detailed diagram of the Mod. III PCB with the floating piston accumulator (Fig. 1) illustrates both the latched configuration used during coring and the unlatched configuration used during core retrieval. Operating specifications and general information on this PCB are as follows:

Operating Pressure. A pressure relief valve maintains the system at or below 34.4 MPa (5000 psi) independent of the hydrostatic pressure encountered.

Safety. Internal-burst (yield) strength of the system is 137 MPa (20,000 psi). The factor of safety is 4:1 at the 34.4 MPa operating pressure. A burst disk will rupture at 48 to 55 MPa (7000–8000 psi) in case the pressure relief valve fails.

Core Diameter. Nominal diameter is 5.78 instead of the 6.43-cm diameter of the standard DSDP rotary coring system. A special core bit is used at a hole in the pressure coring program. The standard, unpressurized, wire-line coring utilizes the same bit at the hole and recovers cores of the smaller diameter. The volume of sediment cored with the smaller bit is about 19% less than the volume of sediment cored with the standard bit. A reentry scanning sonar tool has been designed to protrude through the smaller bit. Thus pressurized core recovery, unpressurized rotary core recovery, and reentry with scanning sonar tool are all compatible. Pressurized core recovery is not compatible, however, with hydraulic piston coring.

Core Length. Approximately 1.8 m of unpressurized core and approximately 5.8 m of pressurized core can be recovered.

Core Liner. The PCB utilizes the same butyrate core liner as the standard DSDP coring system. The 1.8 m of unpressurized core is not recovered in a liner.

Barrel Length. The total length of the PCB is the same as the standard DSDP wire-line coring assembly of 10.4 m (34 ft., 0.10 in.).

Sampling. A sampling port (0.25 NPT, National Pipe Thread) is provided in the sampling assembly near the upper end of the PCB to permit sampling of gases and fluids after the tool has reached the deck. Pressure and temperature can be measured immediately without opening the pressurized core barrel. Pressure is monitored through a pressure transducer, and temperature is monitored through a blind port filled with a heat sink compound into which a temperature probe is inserted.

Water Depth. The PCB can operate safely in a 6100-m (20,000-ft.) water depth. All excess internal pressure above operating pressure (34.4 MPa) is automatically

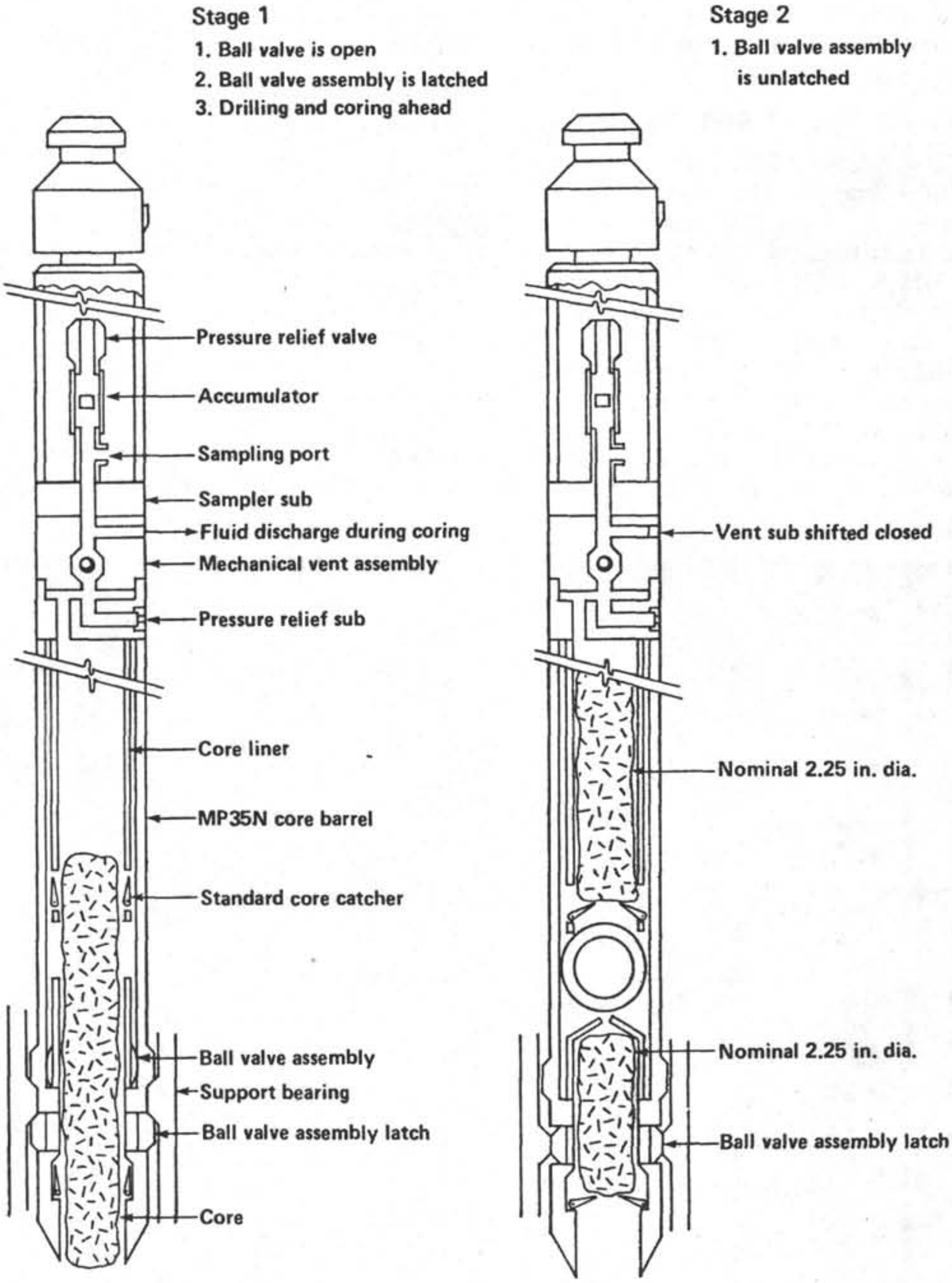


Figure 1. Mod. III pressure core barrel. (Stage 1 shows the configuration of the PCB during drilling and coring with the ball valve open and the ball valve assembly latched to the drill pipe. Stage 2 shows the configuration of the PCB during core recovery. The ball valve and vent sub have closed, sealing the pressurized core in the pressure chamber. The unpressurized core is held in place at the lower end of the tool by a core catcher. The PCB has been unlatched from the drill pipe.)

vented off as the barrel is retrieved. Thus at water depths greater than 3050 m (10,000 ft.) excess pressure is vented.

Operating Time. Operating time for the PCB is comparable to that of the standard DSDP wire-line rotary coring system. However, the ball-valve assembly must be totally redressed after each run, and this operation requires 2 to 5 hr. Thus the frequency with which the PCB can be deployed is limited by the number of available ball-valve assemblies. Handling time on deck is a function of the required scientific program.

Theory of Operation. Unlike the standard core barrel, the PCB latches in under the support bearing located just above the rotary drill bit. After the core is drilled, a wire-line is sent down to retrieve the tool. A pressure seal is effected by rotating the ball valve at the lower end and shifting closed the exhaust vent in the upper end of the core barrel. Each of these mechanisms is activated by a wire-line pull of somewhat less force than is required to unlatch the tool from the support bearing. The resistance of the latch can be adjusted by altering the configuration of the stack of disk springs. The force needed to unlatch the PCB ranges from 2000 to 6000 lb. over the wire-line weight.

PCB DEPLOYMENT AT SITE 533

The Mod. III PCB was deployed five times at Site 533 in 3184 m of water at sediment depths between 152 and 399 m (Table 1). Three cores (PCB-1, PCB-3, and PCB-5) were recovered at approximately *in situ* pressures between 27.5 and 32.3 MPa. PCB-4 had only 10.3 MPa pressure due possibly to a temporarily jammed pressure relief valve. PCB-2 had no pressure because of a missing plug. This PCB contained no sediment core in the upper chamber (Fig. 1), and was the only PCB to recover unpressurized core in the lower chamber (Fig. 1). The pressurized sediment cores were intermittently degassed at varying intervals of time, and portions of the gas were collected for analysis by venting the gas through a transfer manifold and high-pressure regulator into steel sampling cylinders (Fig. 2).

PCB-1

At Site 533 the first 167.5 m of sediment (Hole 533) was cored with the hydraulic piston corer (HPC), another DSDP technological innovation (Larson et al., 1980). The first PCB was not deployed at this point because the PCB and HPC do not have compatible bottom-hole assemblies. Instead, the drill pipe was pulled. A standard rotary coring assembly, through which PCB coring could be accomplished, was installed, and the drill pipe was lowered to commence Hole 533A. At 152.0 m, PCB-1 was deployed to recover Core 3 from this hole.

PCB-1 latched in properly, but circulation was lost as soon as coring commenced. Normally during the coring

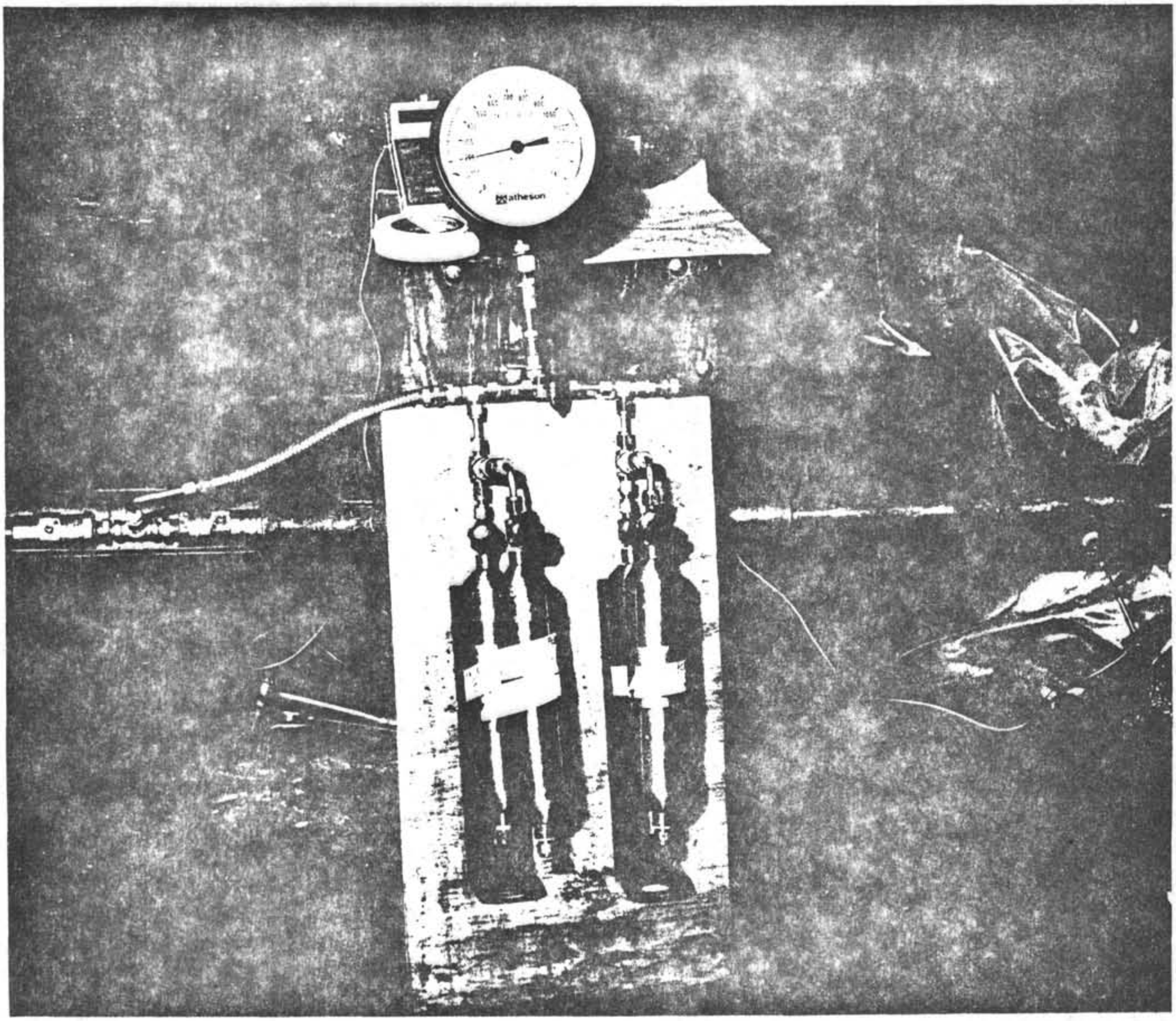


Figure 2. Gas transfer manifold showing pressure gauge and valves for controlling gas flow into evacuated cylinders. (A pressure transducer measures the internal pressure of the PCB and a digital thermometer measures the temperature of the PCB through an unused port filled with a heat sink compound that permits insertion of a temperature probe.)

operation water is circulated at a low flow rate around the core barrel to lubricate the bit and remove cuttings. Without water circulation a 2.5-m dry core was cut. To unlatch the barrel 8500-lb. pull was required. This pull was 4500 lb. over the line weight of 4000 lb. (Table 1). Previous tests on the "C" spring-pack configuration, defined in Table 1, had indicated that the PCB should release with a pull of 3000 lb. The loss of circulation and the high unlatching loads were attributed to rust jamming the tool in the drill pipe. Although circulation was restored by cutting flutes in the land shoulder of the coring assembly, the unlatching loads continued to be high on subsequent runs even though a weaker spring-pack configuration "D" was used (Table 1).

After recovery on deck, the pressure within PCB-1 was measured at 27.5 MPa. The tool was immersed in a bath at 25.7°C and was degassed over a period of 3 hr. (Fig. 3). During degassing soupy mud clogged the filters of the transfer manifold (Fig. 2). No gas samples were collected for analysis, but the degassing was monitored (Fig. 3) after the filters were bypassed. The pressure was reduced to atmospheric three times. After the first two pressure reductions, the pressure recovered to about 2 MPa after the valve was closed.

Although 2.5 m of sediment were cored (152.0–154.5 m), 6.4 m of material were recovered. This material consisted of a slurry of drilling fluids, cuttings, and a very disrupted sediment core. Much of the material had a frothy appearance, suggesting rapid degassing and the possible presence of gas hydrates.

PCB-2

PCB-2 was deployed to core the interval from 247.0 to 254.8 m (Hole 533A, Core 14). The decision to use the PCB at this interval was based on the observation of gas hydrate-containing sediment in Core 13, described by Kvenvolden and Barnard (this volume). PCB-2 operated well mechanically except for the high load required for unlatching (Table 1). Although this PCB functioned properly, it failed to maintain *in situ* pressure because of a missing plug and a faulty core liner. A plug had been inadvertently left out of the sampling assembly, and the core liner returned totally shattered. This liner had been used previously downhole and may have become brittle. Also the liner had been spliced, although the splice was not used inside the pressure chamber of the barrel. PCB-2 was the only PCB to recover core (1.6 m) in the unpressurized section of the barrel below the ball valve (Fig. 1). The recurring failure to recover unpressurized core in this section of the barrel may have been caused by the single lower core catcher allowing the fine-grained hemipelagic sediment to wash through. The failure may also be correlated with the high loads necessary to unlatch the PCB. Examination of the recovered 1.6 m of unpressurized core showed no frothing or other evidence attributable to the presence of gas hydrates.

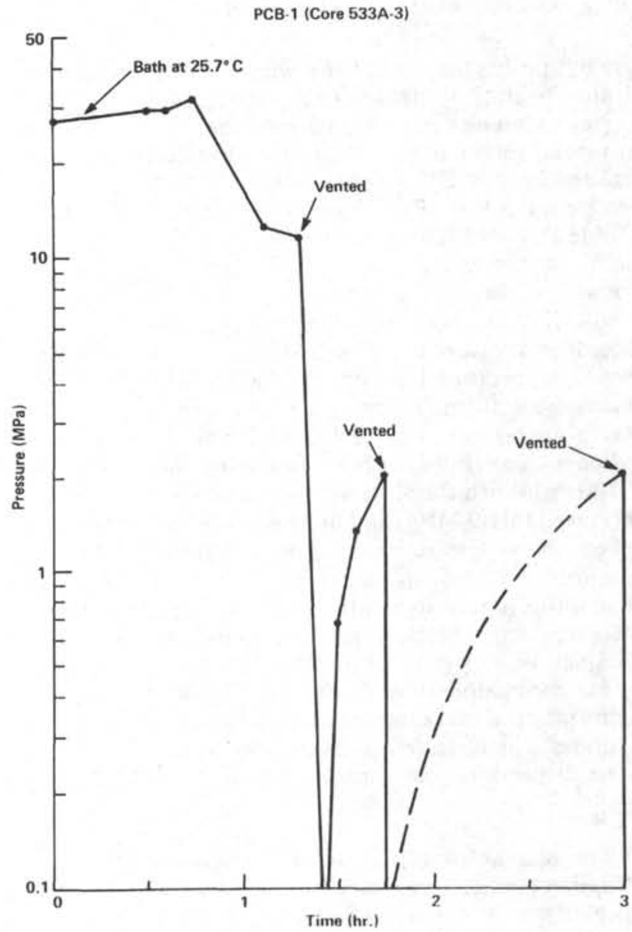


Figure 3. Pressure changes that took place during degassing of PCB-1. (Pressure scale is logarithmic in MPa [million Pascals] and time is in hours. Points where pressures were recorded are indicated with dots. The PCB was placed in a bath at 25.7°C after it was recovered on deck.)

PCB-3

Sediment in cores recovered by conventional rotary coring beneath the interval cored by PCB-2 (Core 14) was semiconsolidated, with disruption and gaps due to

Table 1. Pressure core barrel sampling in Hole 533A.

PCB no.	Core no.	Sediment depth interval cored (m)	Recovery Pressurized (m)	Recovery Unpressurized (m)	Pressure (MPa)	Sampling assembly[a]	Spring pack[b]	Wire line load to unlatch in lb (overpull, lb.)
1	3	152.0–154.5	6:4	0	27.5	A	C	8500 (4500)
2	14	247.0–254.8	0	1.6	0	A	C	9000 (5000)
3	23	332.5–340.3	6.1	0	32.3	A	D	9500 (5500)
4	26	361.0–368.8	6.1	0	10.3	B	D	9000 (5000)
5	29	392.2–399.0	6.2	0	30.2	A	D	10,000 (6000)

[a] A = Primary assembly with floating piston accumulator; B = alternate assembly with traps and filter.
[b] C = Series parallel stack of 44 spring washers; D = series parallel stack of 42 spring washers.

gas but no frothing or other evidence indicating gas hydrates. In spite of the lack of direct evidence for gas hydrates a plan was evolved to deploy the PCB three times at regular intervals until the target total depth of 399 m was reached. PCB-3 cored the interval 332.5 to 340.3 m, recovering 6.1 m of Core 23 at a pressure of 32.3 MPa (Table 1). This PCB was immediately immersed in an ice bath at 0°C and degassed through the transfer manifold for about 3 hr.; gas samples were collected in 15 evacuated cylinders (Fig. 4). Filling the first 4 cylinders reduced the pressure to about 2 MPa. After the valve was closed the pressure built up to 3.3 MPa, and 4 more cylinders were filled, reducing the pressure to 2.3 MPa. Again the pressure rose slightly to 2.5 MPa, and 4 more cylinders were filled with gas, reducing the pressure to 1.7 MPa. When the valve was again closed the pressure increased to 1.9 MPa, and after a single gas sample was taken, the system was vented to atmospheric pressure. The tool remained in the ice bath for 2 hr., at which time it was moved to a bath at 27.7°C. After a pressure increase of 0.2 MPa, two more cylinders were filled. Samples of gas from 6 of the 15 cylinders were analyzed by gas chromatography aboard ship (Table 2). When the sediment core was examined no direct evidence for gas hydrates was observed, although the sediment showed some disruptions and gaps due to gas.

PCB-4

The interval from 361.0 to 368.8 m was cored by PCB-4, and 6.1 m of Core 26 were recovered at 10.3 MPa (Table 1). PCB-4 was the only PCB that did not use the floating piston accumulator, but rather used the sediment trap and filter in the pressure relief valve of the sampling assembly. This pressure relief valve may have jammed because of muddy water passing through the filter, thus causing a partial loss of pressure in the sample chamber. PCB-4 was degassed into one cylinder, immediately vented to atmospheric pressure, opened, and inspected for the presence of gas hydrates. None was found. Collected gases were analyzed by gas chromatography aboard ship (Table 2).

PCB-5

The last core to be taken at Hole 533A was with PCB-5. Coring the interval 392.2 to 399.0 m produced 6.2 m of Core 29 at 30.2 MPa (Table 1). As in the case of PCB-3, PCB-5 was immersed in an ice bath and degassed for 1.5 hr., at which time the tool was moved to a seawater bath at 26.7°C. The temperature of this bath increased slowly over the next 2 hr. to 28.8°C (Fig. 5). A total of 16 evacuated cylinders were filled during the course of the degassing. The first 4 cylinders were filled and the pressure reduced to atmospheric. After the valve was closed, pressure increased to 1.4 MPa. When the next

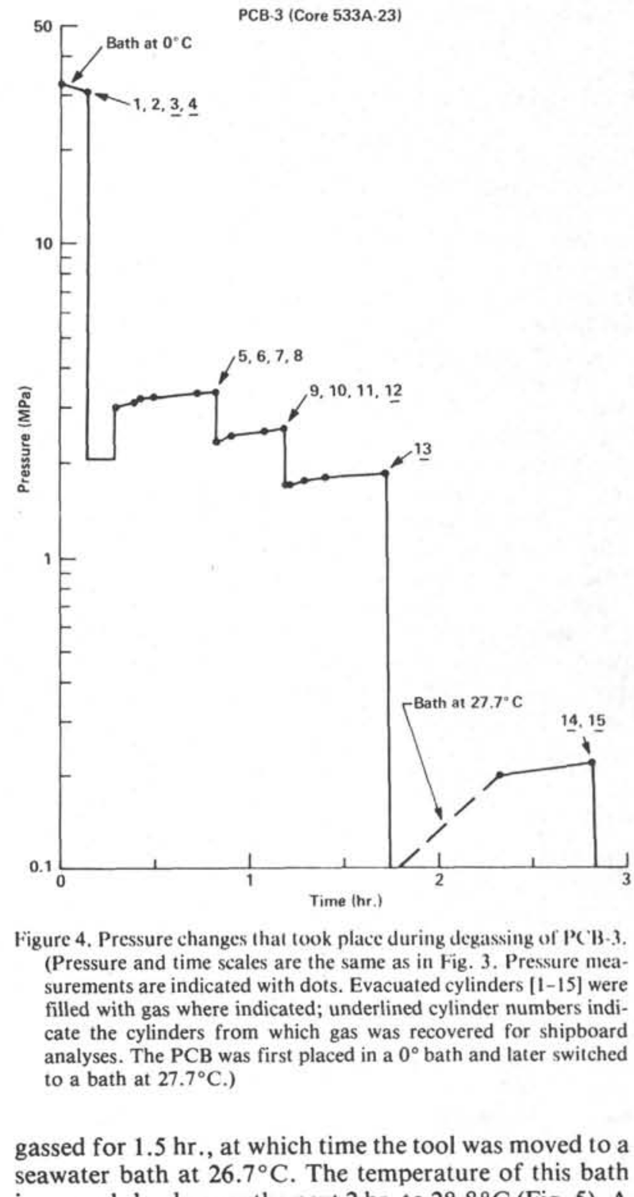


Figure 4. Pressure changes that took place during degassing of PCB-3. (Pressure and time scales are the same as in Fig. 3. Pressure measurements are indicated with dots. Evacuated cylinders [1–15] were filled with gas where indicated; underlined cylinder numbers indicate the cylinders from which gas was recovered for shipboard analyses. The PCB was first placed in a 0° bath and later switched to a bath at 27.7°C.)

Table 2. Composition of gases recovered from pressure core barrels at Site 533.

PCB no.	Core no.	Cylinder no.	Interval (m)	C_1 (%)	C_2 (ppm)	C_3 (ppm)	i-C_4 (ppm)	n-C_4 (ppm)	i-C_5 (ppm)	n-C_5 (ppm)	CO_2 (%)	C_1/C_2
3	23	3, 4	332.5–340.3	76	102	4.2	1.8	0.5	0.8	0.6	1.5	7500
3	23	12	332.5–340.3	96	171	5.8	1.9	0.7	1.2	0.5	0.9	5600
3	23	13	332.5–340.3	95	143	5.7	1.5	0.5	0.8	1.1	0.4	6600
3	23	14	332.5–340.3	90	179	5.7	3.0	0.7	1.6	0.3	5.0	5000
3	23	15	332.5–340.3	90	181	8.5	4.5	0.0	0.5	0.2	4.7	5000
4	26	6	361.0–368.8	7.0	13	0.7	0.2	0.2	0.2	0.1	0.04	5400
5	29	3	392.2–399.0	94	234	6.1	1.5	0.6	0.3	0.2	0.2	4000
5	29	9	392.2–399.0	97	242	8.0	1.6	0.7	0.5	0.3	0.5	4000
5	29	FR	392.2–399.0	96	237	11.9	2.5	1.5	1.3	0.6	1.8	4100
5	29	LB-1	392.2–399.0	97	237	12.5	4.0	1.6	1.7	0.8	0.3	4100
5	29	LB-3	392.2–399.0	94	230	15.8	4.5	2.0	2.2	1.5	1.9	4100
5	29	LB-6	392.2–399.0	94	223	18.5	5.5	2.4	2.7	1.3	2.4	4200

Note: Letter designation of cylinders indicates the type of container used. FR is a container that previously held freon. LB indicates containers that previously were gas lecture bottles.

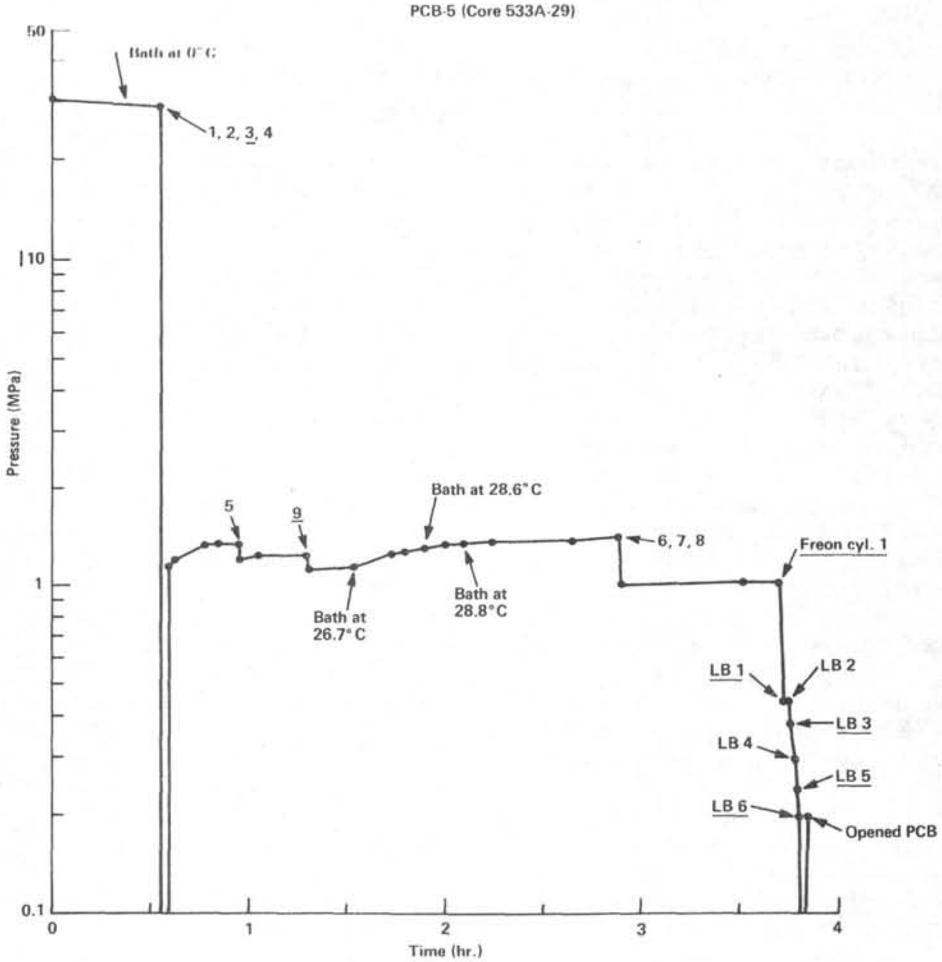


Figure 5. Pressure changes that took place during degassing of PCB-5. (Caption for Fig. 4 applies, except that the second bath was at 26.7°C and changed temperatures to 28.8°C. The LB designation indicates sample cylinders that previously were gas lecture bottles.)

two cylinders were filled, the pressure decreased slightly but rose again after the valve was closed. Pressure rose from 1.2 to 1.4 MPa when the tool was moved from the ice bath and immersed in the seawater bath for 2 hr. After 3 cylinders were filled, pressure dropped from 1.4 to about 1.0 MPa, where the pressure remained constant until a large evacuated container, previously containing freon, was filled to about 0.035 MPa. Six cylinders were then filled as the pressure decreased from 0.4 to 0.2 MPa. After the tool was vented to atmospheric pressure and closed, the pressure returned to 0.2 MPa. Of the 16 cylinders filled with gas, the contents of 6 of these were analyzed by gas chromatography aboard ship (Table 2). Examination of the recovered sediment core showed evidence of gas but no unequivocal evidence of gas hydrates.

INTERPRETATION OF PRESSURE CURVES

Hunt (1979, pp. 160–161) discusses a means of identifying gas hydrates in the subsurface by use of a pressure core barrel. The internal pressure is measured as gas is vented from the barrel. If only free gas is present, the pressure will decline approximately as shown in Figure 6.

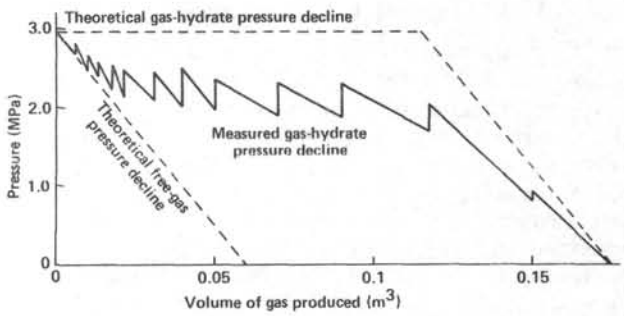


Figure 6. Graph showing expected pressure decline curves for free gas and gas hydrates. (When a gas hydrate is present the pressure should follow a sawtooth curve as gas is intermittently vented from the PCB. Redrawn after Hunt [1979, p. 161].)

If gas hydrate is present and the gas is released at the same rate at which free gas is formed by gas-hydrate decomposition, there will be no change in pressure until the gas hydrate is completely decomposed, at which time normal pressure decline will occur (Fig. 6). With intermittent release of gas a sawtooth curve results, as shown in Figure 6. Release of small amounts of gas causes the pressure to drop. When the valve is closed the pressure will increase toward the theoretical gas-hydrate pressure as decomposition of the gas hydrate takes place. This increase in pressure each time the valve is closed confirms the presence of gas hydrates.

Figures 3, 4, and 5 show the pressure changes that took place during the degassing of PCB-1, PCB-3, and PCB-5. Because we could not measure the volumes of gas released, these figures differ from Figure 6 in that pressure is measured against time rather than against volume of gas produced. All of the pressure curves from the three PCBs showed "sawtooth" characteristics suggesting that gas hydrates were present, but inefficient transfer of gas coming out of solution in sediment confined in the core liner could also have produced similar results. Nevertheless, the fact that pressure returned twice to about 2 MPa after PCB-1 was vented to the atmosphere (Fig. 3) suggests that gas hydrates were present in this sample. Pressure changes on venting PCB-3 did not return to previous values (Fig. 4), suggesting that most of the gas came from solution and little was in the form of decomposing gas hydrates. PCB-5 showed pressure changes (Fig. 5) during the first 2 hr. that almost returned to previous values after venting, but the results do not unequivocally signal the presence of gas hydrates.

The results from the PCB experiments provide tentative evidence for the presence of gas hydrates at Site 533. The amount of gas hydrate indicated is very small, and this conclusion agrees with the visual evidence obtained when the sediment in the PCB cores was examined. Only PCB-1 had frothy, very disrupted sediment that strongly suggested gas hydrates had been present. The sediments in PCB-3, PCB-4, and PCB-5 contained gaps and some disruptions but no obvious evidence of gas hydrates.

ANALYSES OF GASES FROM PCBS

Preliminary analyses of gases vented from PCB-3, PCB-4, and PCB-5 were obtained on board ship using instrumentation described in the Site 533 report (Sheridan, Gradstein, et al., this volume). The points on the pressure release curves (Figs. 4 and 5) of PCB-3 and PCB-5 where cylinders were filled is indicated by the cylinder number; gases were analyzed aboard ship from those cylinders with underlined identification numbers. The results are shown in Table 2. More detailed chemical, as well as isotopic, studies were carried out on shore, and this work is described by Brooks et al. (this volume).

The most abundant hydrocarbon gas vented from the PCBs is methane (C_1), which ranged from 76 to 96% of the gas mixtures recovered from PCB-3 and from 94 to 97% in gas mixtures from PCB-5. Gas collected in the one cylinder from PCB-4 had only 7% C_1, and this result indicates that gas was lost during the sampling procedure and the cylinder contaminated with air. Ethane (C_2) is the most abundant of the higher molecular-weight hydrocarbon gases. C_2 is consistently more abundant in samples from PCB-5 than in samples from PCB-3. Ratios of C_1/C_2 did not vary significantly during degassing. This constant ratio is particularly evident during the degassing of PCB-5. The average C_1/C_2 ratios for PCB-3, PCB-4 (one number), and PCB-5 are 6000, 5400, and 4100, respectively. These ratios compare favorably with the average C_1/C_2 ratios of 9000, 3800, and 4100, respectively, from gas pockets in sediments from nearby sediment intervals (Sheridan, Gradstein, et al., this volume). These results contrast with observations made on DSDP Leg 42B in the Black Sea (Ross, Neprochrov, et al., 1978b). At Site 380 a PCB retained pressure, and the C_1/C_2 ratio of released gas was about 18,000, whereas gas recovered from unpressurized cores from nearby sediment intervals had C_1/C_2 ratios of about 2000. The difference observed at Site 380 in the measured C_1/C_2 ratios is probably an artifact of the sampling procedure.

Other hydrocarbon gases recovered from PCB-3, PCB-4, and PCB-5 (Table 2) are propane (C_3), i-butane (i-C_4), *n*-butane (*n*-C_4), i-pentane (i-C_5), and *n*-pentane (*n*-C_5). The concentrations of these gases generally increase during degassing by factors of about 2 to 4. This increase in the abundance of these gases during degassing is expected, because these lower-volatility substances would preferentially be retarded during the degassing of the PCB. Why the C_2 concentration did not increase and the C_1/C_2 ratios decrease during degassing is not known. Besides the hydrocarbons C_3 through C_5, CO_2 also tends to increase in abundance during the degassing procedure. For PCB-3, CO_2 ranges from 0.4 to 4.7%, and for PCB-5 it ranges from 0.2 to 2.4%.

These preliminary, shipboard analyses of gases recovered from these PCBs indicate that gas composition of sediments can be obtained with a minimum amount of air contamination. Our results do not provide unique insights into the gas composition of gas hydrates, because, as discussed earlier, PCB-3, PCB-4, and PCB-5 apparently did not contain sediments with large amounts of gas hydrates. In fact, evidence for gas hydrates in these sediments was minimal.

CONCLUSIONS

The successful deployment of the Mod. III PCB at Site 533 means that this tool is no longer an experimental development, but rather an operational achievement that joins other DSDP technological advances. Sediments of the Blake Outer Ridge were recovered at *in situ* pressures. Studies of the pressure changes taking place during intermittent degassing of these sediments provided tentative but equivocal evidence for gas hydrates at Site 533. The composition of gases released during the degassing procedures was mainly C_1 accompanied by CO_2 and low amounts of C_2 through C_5 hydrocarbons. Because the amount of gas hydrates in PCB-3, PCB-4, and PCB-5 was probably small, the gas composition measured does not likely reflect the gas content of gas hydrates but rather the general composition of gases disbursed throughout these sediments.

ACKNOWLEDGMENTS

We thank T. L. Vallier and M. Storms for their critical reviews of this paper.

REFERENCES

Benson, W. E., Sheridan, R. E., and Shipboard Scientific Party, 1978. Site 388: lower continental rise hills. *In* Benson, W. E., Sheridan,

R. E., et al., *Init. Repts. DSDP*, 44: Washington (U.S. Govt. Printing Office), 23–67.
Creager, J. S., Scholl, D. W., and Shipboard Scientific Party, 1973. Site 185. *In* Creager, J. S., Scholl, D. W., et al., *Init. Repts. DSDP*, 19: Washington (U.S. Govt. Printing Office), 169–216.
Hunt, J. M., 1979. *Petroleum Geochemistry and Geology:* San Francisco (W. H. Freeman).
Kvenvolden, K. A., and Barnard, L. A., in press. Hydrates of natural gas in continental margins. *Proceedings of Hedberg Conference:* Tulsa (Am. Assoc. Pet. Geol.).
Kvenvolden, K. A., and McMenamin, M. A., 1980. Hydrates of natural gas: a review of their geologic occurrence. *U.S. Geol. Surv. Circ.*, 825:1–11.
Larson, V. F., Robson, V. B., and Foss, G. N., 1980. Deep ocean coring—recent operational experiences of The Deep Sea Drilling Project. *55th Ann. Fall Tech. Conf. and Exhibition, Soc. Pet. Eng. AIME*, SPE 9409:1–9.
Ross, D. A., Neprochrov, Y. P., and Shipboard Scientific Party, 1978a. Site 379. *In* Ross, D. A., Neprochnov, Y. P. et al., *Init. Repts. DSDP*, 42, Pt. 2: Washington (U.S. Govt. Printing Office), 29–118.
_______, 1978b. Site 380. *In* Ross, D. A., Neprochnov, Y. P., et al., *Init. Repts. DSDP*, 42, Pt. 2: Washington (U.S. Govt. Printing Office), 119–291.
_______, 1978c. Site 381. *In* Ross, D. A., Neprochnov, Y. P., et al., *Init. Repts. DSDP*, 42: Pt. 2: Washington (U.S. Govt. Printing Office), 293–355.
Ross, D. A., Neprochnov, Y. P., and Supko, P. R., 1978. Introduction and explanatory notes, Leg 42B, Deep Sea Drilling Project. *In* Ross, D. A., Neprochnov, Y. P., et al., *Init. Repts. DSDP*, 42, Pt. 2: Washington (U.S. Govt. Printing Office), 3–15.
Thiede, J., Vallier, T. L., and Adelseck, C. G., 1981. Deep Sea Drilling Project Leg 62, North Central Pacific Ocean: introduction cruise narrative, principal results, and explanatory notes. *In* Thiede, J., Vallier, T. L. et al., *Init. Repts. DSDP*, 62: Washington (U.S. Govt. Printing Office), 5–31.

Date of Initial Receipt: March 29, 1982

APPENDIX E

PRESSURE CORE BARREL
PARTS LIST AND ASSEMBLY DRAWINGS

PRESSURE CORE BARREL
PARTS LIST

FEB-1984

DWG	P/N	DESCRIPTION	SYS/RQD
R	OP4500	MOD III PRESSURE CORE BARREL	PCB/1
C	OP4503	SAMPLER SUB BODY	PCB/1
B	OP4508	LONG SAMPLER ASSEMBLY	PCB/1
B	OP4509	SHORT SAMPLER ASSEMBLY	PCB/1
R	OP4512	MECHANICAL VENT/PRESSURE RELIEF SUB	PCB/1
C	OP4513	MECHANICAL VENT SUB ROD	PCB/1
N	OP4515	WRENCH,SPANNER (PROC474A)	PCB/2
B	OP4516	MECHANICAL VENT SUB BODY EXTENSION	PCB/1
C	OP4518	MECHANICAL VENT SUB BODY	PCB/1
B	OP4523	PRESSURE RELIEF SUB ASSEMBLY	PCB/1
C	OP4524	PRESSURE RELIEF SUB	PCB/1
N	OP4525	PRESSURE TRANSDUCER (PAINE, 10000 PSI)	PCB/1
B	OP4526	PRESSURE CAP	PCB/1
N	OP4528	PRESSURE RELIEF VALVE (CIRCLE SEAL)	PCB/1
N	OP4529	FILTER (MICROPOROUS)	PCB/1
B	OP4530	SEDIMENT TRAP ASSEMBLY	PCB/1
B	OP4531	SEDIMENT TRAP BODY	PCB/1
A	OP4532	END CAP,SEDIMENT TRAP	PCB/1
A	OP4533	SPACER, SEDIMENT TRAP	PCB/4
A	OP4534	BAFFLE, SEDIMENT TRAP	PCB/3
B	OP4536	MP35 CORE BARREL	PCB/2
B	OP4537	PRESSURE BARREL COUPLING	PCB/1
B	OP4538	DOUBLE HYDRIL PIN CONNECTOR	PCB/N
R	OP4541	TOP CONNECTOR (BVA)	PCB/1
B	OP4544	TEST CAP, HYDRIL 3-1/2, 9.2 LB/FT, FJ	PCB/N
A	OP4545	PULLER PIN (BVA)	PCB/2
B	OP4546	BALL (BVA)	PCB/1
B	OP4547	BALL SUPPORT (BVA)	PCB/1
B	OP4548	BALL CAGE (BVA)	PCB/1
R	OP4549	OUTER BODY (BVA)	PCB/1
B	OP4550	CATCHER SLEEVE (BVA)	PCB/1
A	OP4551	SNAP RING (BVA)	PCB/2
B	OP4552	RETAINER RING (BVA)	PCB/1
C	OP4553	BALL PULLER (BVA)	PCB/1
B	OP4554	SNAP RING RETAINER (BVA)	PCB/1
B	OP4555	SPLIT RETAINER NUT (BVA)	PCB/1
B	OP4556	INNER EXTENSION BODY (BVA)	PCB/1
B	OP4558	OUTER EXTENSION BODY (BVA)	PCB/1
A	OP4560	COMPRESSION SPRING (BVA)	PCB/1
A	OP4561	WAVY WASHER TYPE B (BVA)	PCB/2
R	OP4562	DOG RETAINER (BVA)	PCB/1
B	OP4563	DOGS (BVA)	PCB/3
R	OP4564	DOG CAGE (BVA)	PCB/1
B	OP4565	TEST PLUG, SAMPLER SUB	PCB/N

PRESSURE CORE BARREL
PARTS LIST

FEB-1984

DWG	P/N	DESCRIPTION	SYS/RQD
B	OP4566	BOTTOM CONNECTION (BVA)	PCB/1
R	OP4567	BALL VALVE ASSEMBLY (BVA)	PCB/1
A	OP4568	SPACER RING	PCB/1
B	OP4574	TEST PLUG, PRESSURE RELIEF SUB	PCB/N
B	OP4576	DIGITAL PRESSURE METER	PCB/1
A	OP4581	VENT SUB LOCK	PCB/N
B	OP4582	FACE SPANNER - VENT SUB ASSEMBLY TOOL	PCB/N
A	OP4583	ASSEMBLY LOCK SCREW	PCB/N
B	OP4584	ASSEMBLY LOCK BOLT	PCB/N
B	OP4585	POLYPAK INSTALLATION TOOL	PCB/N
B	OP4587	SEAT (BVA)	PCB/1
B	OP4588	DOUBLE BOX SUB	PCB/1
A	OP4589	SHEAR PIN	PCB/2
A	OP4590	PIVOT PINS (BVA)	PCB/2
B	OP4600	8-FINGER CORE CATCHER ASSEMBLY (PCB)	PCB/1-2
B	OP4601	8-FINGER SLOTTED CYLINDER (PCB)	PCB/N
A	OP4602	FLANGED RING (8,10 FINGER PCB CC)	PCB/N
A	OP4603	8-FINGER LARGE DOG FLAP (PCB CC)	PCB/N
A	OP4604	8-FINGER SMALL DOG FLAP (PCB CC)	PCB/N
A	OP4605	8-FINGER HINGE PIN (PCB CC)	PCB/N
A	OP4606	SLEEVE (8,10 FINGER PCB CC)	PCB/N
B	OP4607	10-FINGER CORE CATCHER ASSEMBLY (PCB CC)	PCB/1-2
B	OP4608	10-FINGER SLOTTED CYLINDER (PCB CC)	PCB/N
A	OP4609	HINGE PIN 10-FINGER (PCB CC)	PCB/N
A	OP4610	10 FINGER DOG (PCB CC)	PCB/N
B	OP4611	INTERNAL TEMP PROBE ASSY	PCB/1
B	OP4612	PRESSURE RELIEF SUB MOD (DRAWING ONLY)	PCB/N
B	OP4613	BODY-INTERNAL TEMP PROBE	PCB/1
A	OP4614	TIP-INTERNAL TEMP PROBE	PCB/1
A	OP4615	SEAL PLUG	PCB/1
A	OP4616	CYLINDER GUIDE (SAMPLING ASSEMBLY)	PCB/1
B	OP4617	2 1/4 CORE CATCHER SUB	PCB/1
A	OP4618	SPACER (CORE CATCHER ASSEMBLY)	PCB/1
B	OP4620	COLLET SLEEVE (BVA)	PCB/1
A	OP4621	DOG CAGE CAP (BVA)	PCB/1
A	OP4622	SPRING RING (BVA)	PCB/1
B	OP4623	SEDIMENT TRAP SEAL	PCB/1
N	OP4627	HOLD DOWN (FIKE RUPUTURE UNIT)	PCB/1
N	OP4628	RING (FIKE RUPTURE UNIT)	PCB/1
N	OP4629	BURST DISC (FIKE RUPTURE UNIT)	PCB/1
N	OP4630	BALL VALVE (HOKE #7223 F8Y)	PCB/3
N	OP4633	PORT ADAPTER (HASKELL #26250-3)	PCB/2

PRESSURE CORE BARREL
PARTS LIST

FEB-1984

DWG	P/N	DESCRIPTION	SYS/RQD
N	OP4634	ACCUMULATOR (HASKELL #15811-2SS)	PCB/1
C	OP4638	TEST PLUG, HYDRIL THREADS	PCB/N
A	OP4639	DISC SPRING	PCB/38-44
N	OD2037	O-RING (TEF) SEAT (BVA)	PCB/1
N	OD2121	O-RING (N70) SEDIMENT TRAP	PCB/1
N	OD2127	O-RING (N70) PRESSURE CAP	PCB/1
N	OD2210	O-RING (N70) VENT SUB ROD	PCB/1
N	OD2232	O-RING (N70) VENT SUB BODY	PCB/1
N	OD2337	O-RING (N70) BVA TOP CONNECTOR	PCB/1
N	OD3512	POLYPAK(MOL) #18701375/MECH.VENT ASBLY	PCB/3
N	OD8121	PARBAC (N90) SEDIMENT TRAP	PCB/1
N	OD8232	PARBAC (N90) MECH VENT SUB BODY	PCB/1
N	OD8337	PARBAC (N90) BVA TOP CONNECTOR	PCB/2
N	OD6050	SET SCREW,SOCKET 10/32X1/4 SED.TRAP	PCB/1
N	OD6775	SET SCREW,SOCKET 3/8-16X3/8 PR.REL.SUB	PCB/1
N	OD6775	SET SCREW,SOCKET 3/8-16X3/8 OUTER BODY	PCB/1
N	OD6775	SET SCREW,SOCKET 3/8-16X3/8 OUT.EXT.BODY	PCB/1
N	OD6775	SET SCREW,SOCKET 3/8-16X3/8 DOG RETAINER	PCB/1
N	OD6775	SET SCREW,SOCKET 3/8-16X3/8 BODY EXT.	PCB/1
N	OD6795	SET SCREW,SOCKET 3/8-16X1/4 TOP CONN.	PCB/1
N	OD6795	SET SCREW,SOCKET 3/8-16X1/4 RET.RING	PCB/1
N	OD6795	SET SCREW,SOCKET 3/8-16X1/4 SN RING RET.	PCB/1
N	OD6815	SET SCREW,SOCKET 5/16-16X3/4 /SMP.SUB BD	PCB/1
N	OD7110	ROLL PIN 1/8 X 2 1/4 /VENT SUB BODY	PCB/1
N	OD7184	SNAP RING(SPIRALOX)/BVA TOP CONNECTOR	PCB/1
N	OD7220	BALL BEARING, 5/16 BVA BALL PULLER	PCB/3
N	OD7260	TEE, 1/4 NPT,HP/SAMPLER ASSEMBLY	PCB/2
N	OD7261	PLUG, 1/4 NPT,HP/SAMPLER ASSEMBLY	PCB/4
N	OD7262	HEX NIPPLE, 1/4 NPT,HP/SAMPLER ASSEMBLY	PCB/1
A	OD7263	NIPPLE,5" 1/4 NPT,HP/SAMPLER ASSEMBLY	PCB/1
N	OD7280	NIPPLE,REDUCING 1/2X1/4NPT,HP/SMP.ASBLY	PCB/5
N	OC1001	CORE BIT 9 5/8 X 2 1/8 (PCB)	PCB/1
N	OC1002	CORE BIT 9-7/8" X 2-1/8" F94CK	PCB/1
R	OC1018	BODY/GUIDE ASSEMBLY(PCB)	PCB/1
D	OP3010	LATCH ASSEMBLY (INNER BARREL)	PCB/1
B	OP3100	INNER BARREL SWIVEL ASSEMBLY	PCB/1
N	OP3107	15/16 CHECK BALL AND SEAT	PCB/1
B	OP3108	VALVE SEAT RETAINER	PCB/1
B	OP3220	36" INNER BARREL SUB	PCB/1
A	OP3400	DSDP STANDARD CORE LINER	PCB/1
A	OP3410	SUPPORT SLEEVE	PCB/1

NO.	DWG. NO.	PART NO.	DESCRIPTION	REQ'D
1	B-OP4546	OP4546	BALL	1
2	B-OP4548	OP4548	BALL CAGE	1
3	R-OP4549	OP4549	OUTER BODY	1
4	B-OP4587	OP4587	SEAT	1
5	A-OP4568	OP4568	SPACER RING	2
6	R-OP4541	OP4541	TOP CONNECTOR	1
7	B-OP4600 &07	OP4600 &4607	8 or 10 FINGER PCB CORE CATCHER	2
8	B-OP4547	OP4547	BALL SUPPORT	1
9	C-OP4553	OP4553	BALL PULLER	1
10	A-OP4545	OP4545	PULLER PINS	
11	B-OP4552	OP4552	RETAINER RING	1
12	A-OP4551	OP4551	SNAP RING	1
13	B-OP4554	OP4554	SNAP RING RETAINER	1
14	B-OP4558	OP4558	OUTER EXTENSION BODY	1
15	A-OP4622	OP4622	SPRING RING	1
16	B-OP4620	OP4620	COLLET SLEEVE	1
17	B-OP4562	OP4562	DOG RETAINER	1
18	B-OP4556	OP4556	INNER EXTENSION BODY	1
19	B-OP4555	OP4555	SPLIT RETAINER NUT	1
20	B-OP4550	OP4550	CATCHER SLEEVE	1
21	B-OP4566	OP4566	BOTTOM CONNECTION	1
22	B-OP4621	OP4621	DOG CAGE CAP	1
23	B-OP4564	OP4564	DOG CAGE	1
24	B-OP4563	OP4563	DOGS	3
25				
26	—	OP4595	3/8-16 x 1/4 SET SC	3
27	—	OP4571	1/8 DIA x 2 1/4 ROLL PIN	1
28	—	OP4591+92	O-RING #2-337, PARBAK #8-337	1-2
29	A-OP4616	OP4616	CYLINDER GUIDE	1
30	A-OP4639	OP4639	DISK SPRING	38-44
31	A-OP4560	OP4560	SPRING, COMPRESSION	1
32	A-OP4561	OP4561	WAVY WASHER	1
33	B-OP4526	OP4526	PRESSURE CAP	1
34	—	OP4543	SPIROLOX RETAINER RING	1
35	—	OP4593	3/8-16 x .37 LG. SET SCREWS (NYLOC)	5
36	B-OP4617	OP4617	CORE CATCHER SUB (2 1/4")	1
37	A-OP4618	OP4618	SPACER-CORE CATCHER	1
37A	A-OP4570	OP4570	5" NIPPLE	1
38	C-OP4524	OP4524	PRESS RELIEF SUB	1
39	B-OP4536	OP4536	CORE BARREL (MP35N)	2
40				
41	—	OP4630	BALL VALVE-HOKE #7223F6Y	3
42	B-OP3108	OP3108	VALVE SEAT RETAINER	1
43	—	OP3107	BALL/SEAT (HARBISON-FISCHER)	1
44	B-OP4537	OP4537	PRESS BARREL COUPLING	1
45	C-OP4518	OP4518	VENT SUB BODY	1
46	—	OP4519	POLY PAK 18701375	3
47	C-OP4513	OP4513	VENT SUB ROD	1
48	—	OP4636	5/16 BALL BEARING	3
49	B-OP4516	OP4516	BODY EXTENSION	1
50	C-OP4503	OP4503	SAMPLER SUB BODY	1
51	—	OP4631	1/2 x 1/4 REDC NIPPLE, CAJON 1/2x1/4-8RN-4	5
52	—	OP4632	1/4 NPT TEE - CAJON 1/4-4-T	2
53				
54	—	OP4579	5/16-18 x 3/4 NYLOC SOC HD SET SC	1
55				
56	—	OP4633	1/4 x 3/8 SUPER PRESSURE PORT ADAPTER	2
57	A-OP3410	OP3410	SUPPORT SLEEVE	1
58	A-OP3400	OP3400	CORE LINER	1
59	B-OP4588	OP4588	DOUBLE BOX SUB	1
60	A-OP4569	OP4569	OUTER EXTENSION BODY PLUG	1
61	B-OP3100	OP3100	SWIVEL ASSY	1
62	D-OP3010	OP3010	LATCH ASSY	1
63				
64	—	OP4634	ACCUMULATOR-HASKEL #15811-2	1
65	B-OP4588	OP4588	DOUBLE BOX SUB	1
66	—	OP4525	PRESS X-DUCER, PAINE CO. #21035-550-01	1
67	—	OP4527	PARKER O-RING 2-127	1
68	—	OP4627	HOLD DOWN FIKE UNIT 1/2-100 SM	1
69	—	OP4628	RING " " " " "	1
70	—	OP4629	BURST DISK " " " " "	1
71	A-OP4589	OP4589	SHEAR PIN (THREADED BRASS)	3
72	—	OP4514	1/4 NPT HEX NIPPLE-CAJON 1/4-4-HN	1
73	—	OP4517	PARKER O-RING #2-037 TEFLON	1
74	—	OP4597	PARKER O-RING #2-210 (BUNA N)	1
75	—	OP4504	PARKER O-RING #2-232	1
76	—	OP4505	PARBAK #8-232	1
77	B-OP3220	OP3220	36" INNER BBL SUB	
78	—	OP4525	PRESS RELIEF VALVE-CIRCLE SEAL #RV205T1-4PP-6500	1
—				
80	B-OP4611	OP4611	INTERNAL TEMP PROBE ASS'Y	1
81	A-OP4590	OP4590	PIVOT PINS	2

REVISIONS

NO.	DESCRIPTION	DATE
1	UP DATED PER DETAIL REV	[illegible]
2	"	[illegible]
3	"	[illegible]
4	"	[illegible]
5	"	[illegible]
6	[illegible]	[illegible]
7	WAS OD 6067 / R-0688	[illegible]
8	[illegible]	[illegible]

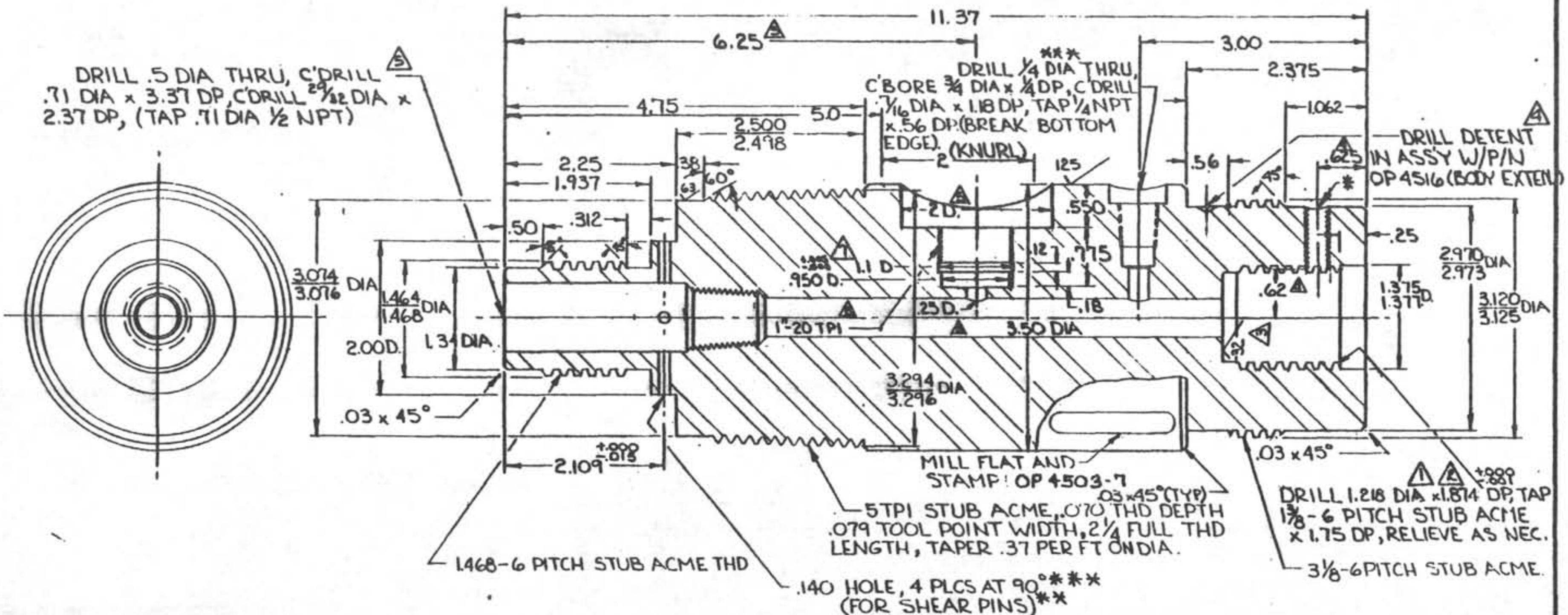
TOLERANCES UNLESS NOTED

DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA, SAN DIEGO
LA JOLLA, CALIFORNIA 92093

TITLE: MOD III PRESS. CORE BBL ASS'Y ~ TYPE B ~

DRAWN BY: K.T. | SIZE DWG. NO.: R-OP4500 | PART NO.: OP4500 | REV: 8

REVISIONS					
NO	DESCRIPTION	DATE	BY	CH	APR
1	1½-4 STUB ACME WAS ⅜ PIPE PLUG	APR 3 78	RK		
2	1⅜-6 STUB ACME WAS 1½-4 STUB ACME	MAY 25 78	RK		
3	ADDED	6-11-79	RK		
4	DELETE O-RING 2-232, ADD DETENT, "3 REQ'D" NOTE ADDED ADD ⅛ DIA HOLE	1-15-80	RK		
5	ADD: 2D, .25D, 1"-20 TPI, 6.25 / .90 D WAS ⅜-9 NC TAP, ½ NPT WAS .550	8-22-80	RK		
6	5/16-18 HOLE WAS ⅛ DIA ACROSS THD	9-12-80	RK		
7	ADD. .950 D x .18, 1.1 D x .12	9-24-80	RK		



* DRILL F (.257 DIA) THRU + TAP 5/16-18

** SHEAR PINS TO BE ⅛ DIA x 7/8 LONG, BRASS. (3 REQ'D • 7500 PSI SHEAR

*** OMIT FROM NEW PARTS FABRICATION, (NOT FUNCTIONAL IN NEW DESIGN)

TOLERANCE
.X = ± .1
.XX = ± .01
.XXX = ± .001
ANGLE ± 1°

MAT'L:
17-4 PH H1150 SERIES STAINLESS ST.
Rc 35 'C'

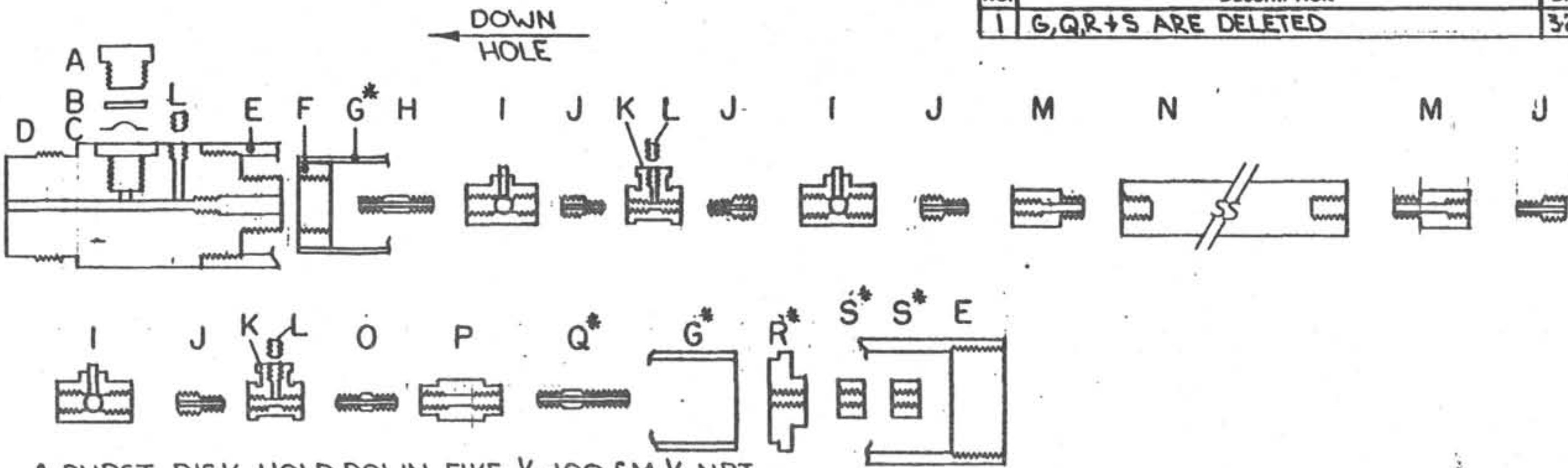
UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.

SCALE: FULL
DATE: 19 OCT 76
APPROVED BY:
DRAWN BY: RK

SAMPLER SUB BODY

PART NO. OP4503-7
C-OP4503-7

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	G,Q,R+S ARE DELETED	3-24-82	RK		



A BURST DISK HOLD DOWN-FIKE ½ 100 SM ¼ NPT
B BURST DISK RING- " " " " "
C BURST DISK- " " " " "
D SAMPLER SUB - DSDP P/N OP4503
E DOUBLE BOX SUB-DSDP P/N OP 4588
F CYLINDER GUIDE - DSDP P/N OP 4616
*G LONG CYLINDER - DSDP P/N OP 4615
H 5" NIPPLE - DSDP P/N OP4570
I HOKE BALL VALVE - P/N 7223 F8Y
J ½ x ¼ REDUCING NIPPLE-CAJON ½ x ¼-8RN-4
K ¼ NPT "TEE"-CAJON ¼-4-T
L ¼ NPT PIPE PLUG
M ¼ x ⅜ SUPER PRESSURE PORT ADAPTER
N ACCUMULATOR-HASKLINE MODEL 15811-2
O ¼NPT HEX NIPPLE-CAJON ¼-4-HN
P PRESSURE RELIEF VALVE-CIRCLE SEAL RV 205T1-4PP-6500
*Q CONNECTOR- DSDP P/N OP4614
*R CYLINDER PLUG-DSDP P/N OP4613
*S NUT-DSDP P/N OP4612

*DELETED

DO NOT SCALE
CONCENTRICITY ALL DIAMETERS: TIR .003

TOLERANCES UNLESS NOTED
FRACTIONS ± 1/64
DECIMALS ± .005
ANGLES ± 1/2°
CORNERS 1/64 x 45° or 1/64 R
FINISH 125 ✓

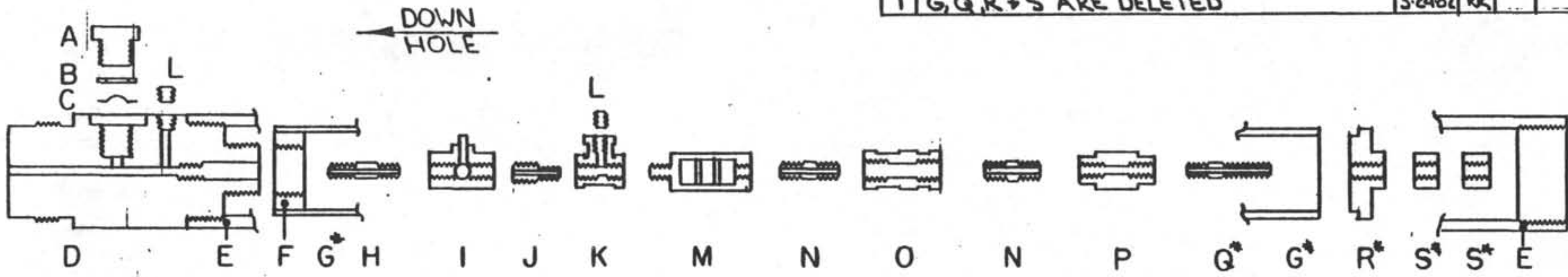
DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA, SAN DIEGO
LA JOLLA, CALIFORNIA 92093

TITLE LONG SAMPLER ASSY (WITH ACCUMULATOR) ~PCB III

SURFACE TREATMENT	MATERIAL	DATE	BY	CHECKED	APPROVED
—0—	—0—	9-10-80	RK		

HEAT TREATMENT	SCALE	REQ'D/ASS'Y	PART NO.	DWG. NO. (REV.)
—0—	—0—	—0—	OP4508-1	B-OP4508-1

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	G, Q, R + S ARE DELETED	3-24-82	RK		

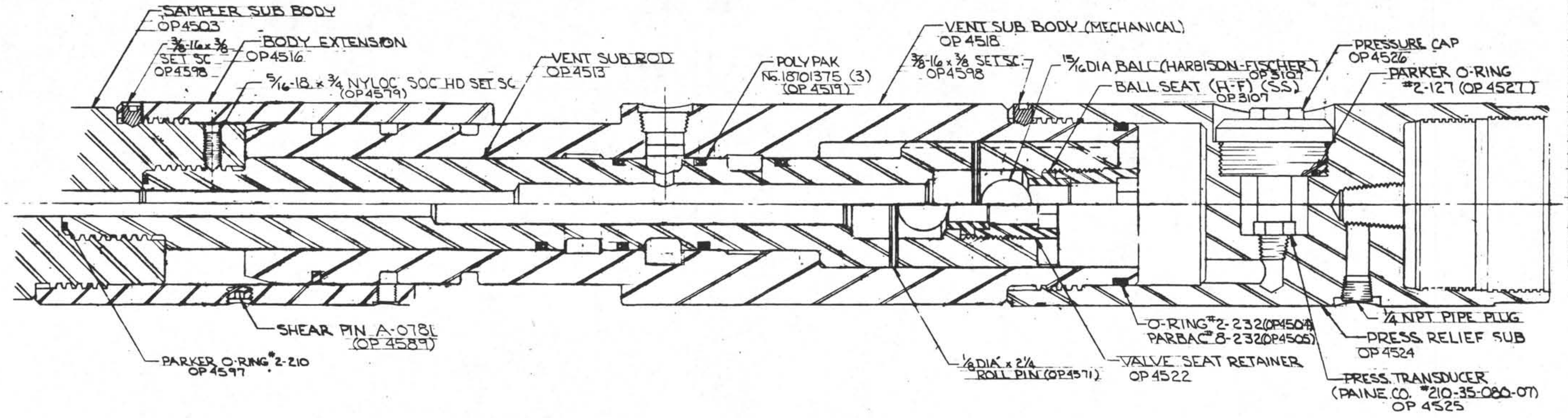


A BURST DISK HOLD DOWN - FIKE ½ 100 SM ¼ NPT
B BURST DISK RING " " " " "
C BURST DISK " " " " "
D SAMPLER SUB - DSDP P/N OP 4503
E DOUBLE BOX SUB - DSDP P/N OP4588
F CYLINDER GUIDE - DSDP P/N OP 4616
*G SHORT CYLINDER - DSDP P/N OP 4619
H 5" NIPPLE - DSDP P/N 4570
I HOKE BALL VALVE - P/N 7223F8Y
J ½ x ¼ REDUCING NIPPLE - CAJON ½ x ¼-8RN-4
K ¼ NPT "TEE" - CAJON ¼-4-T
L ¼ NPT PIPE PLUG
M SEDIMENT TRAP - DSDP P/N OP 4530
N ¼ NPT HEX NIPPLE - CAJON ¼-4-HN
O FILTER - WINTEC MODEL 4423
P PRESSURE RELIEF VALVE - CIRCLE SEAL RV 205T1-4PP-6500
*Q CONNECTOR - DSDP P/N OP4614
*R CYLINDER PLUG - DSDP P/N OP 4613
*S NUT - DSDP P/N OP 4612

- * DELETED ⚠1

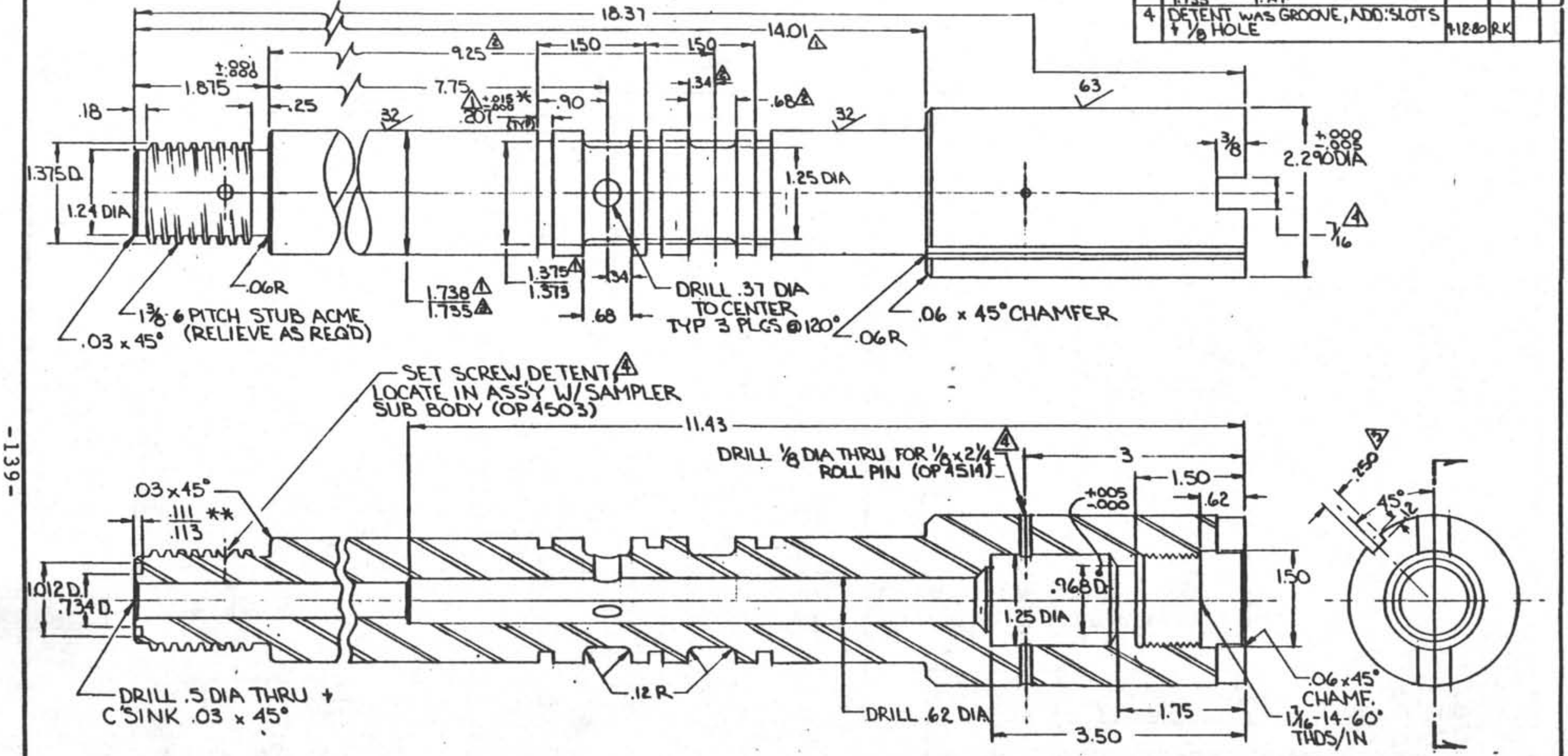
DO NOT SCALE — CONCENTRICITY ALL DIAMETERS: TIR .003

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125 ✓	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE SHORT SAMPLER ASS'Y (NO ACCUMULATOR) PCB III				
SURFACE TREATMENT —	MATERIAL —	DATE 9.9.80	BY RK	CHECKED	APPROVED
HEAT TREATMENT —	SCALE NO	REQ'D/ASS'Y —	PART NO. OP4509-1	DWG. NO. B-OP4509-1	(REV.) 1



NO.	DWG. NO.	PART NO.	DESCRIPTION	REQ'D
	C-OP4503	OP4503	SAMPLER SUB BODY	1
	B-OP4516	OP4516	BODY EXTENSION	1
	———	OP4571	1/8 DIA x 2 1/4 ROLL PIN	1
	C-OP4513	OP4513	VENT SUB ROD	1
	C-OP4518	OP4518	VENT SUB BODY	1
	B-OP4526	OP4526	PRESSURE CAP	1
	C-OP4524	OP4524	PRESSURE RELIEF SUB	1
	B-OP4522	OP4522	VALVE SEAT RETAINER	1
	A-OP4589	OP4589	SHEAR PIN	1
		OP4504	O-RING (2-232)	1
		OP4505	PARBAC (8-232)	1
		OP4519	POLYPAK (18701375)	3
		OP4598	3/8-16 x 3/8 SET SC.	2
		OP4527	O-RING (2-127)	1
		OP4597	" " 2-210	1
		OP4579	5/16-18 x 3/4 NYLOC SOC HD SET SC	1
		OP3107	BALL-HARBISON-FISCHER, 15/16	1
		OP3107	BALL SEAT-(H-F)	1
		OP4525	PRES. X-DUCER - PAINE CO. (#210-35-080-07)	1
		OP4569	1/4 NPT PIPE PLUG	1

REVISIONS					
No.	DESCRIPTION	DATE	BY	CH	AP
1	.201 was .280/.275, 1.749/1.747 was 1.747/1.746, 1.575/1.573 was 1.380/1.378, POLYPAK was O-RING 2-324 + PARBAC 8-324	2.15.79	RK		
2	ADD. GROOVE	2.25.79	RK		
3	14.01 was 14.00, ADD. SLOT 1.738/1.735 was 1.749/1.747, ADD .065R GROOVE	1.16.80	RK		
4	DETENT was GROOVE, ADD: SLOTS + 1/8 HOLE	1.12.80	RK		



*FOR POLYPAK No. 18701375 (3 REQ'D)

**FOR PARKER O-RING #2-210 (1 REQ'D)

MAT'L: 17-4 PH SS H 1025
R_c 38 165 KSI

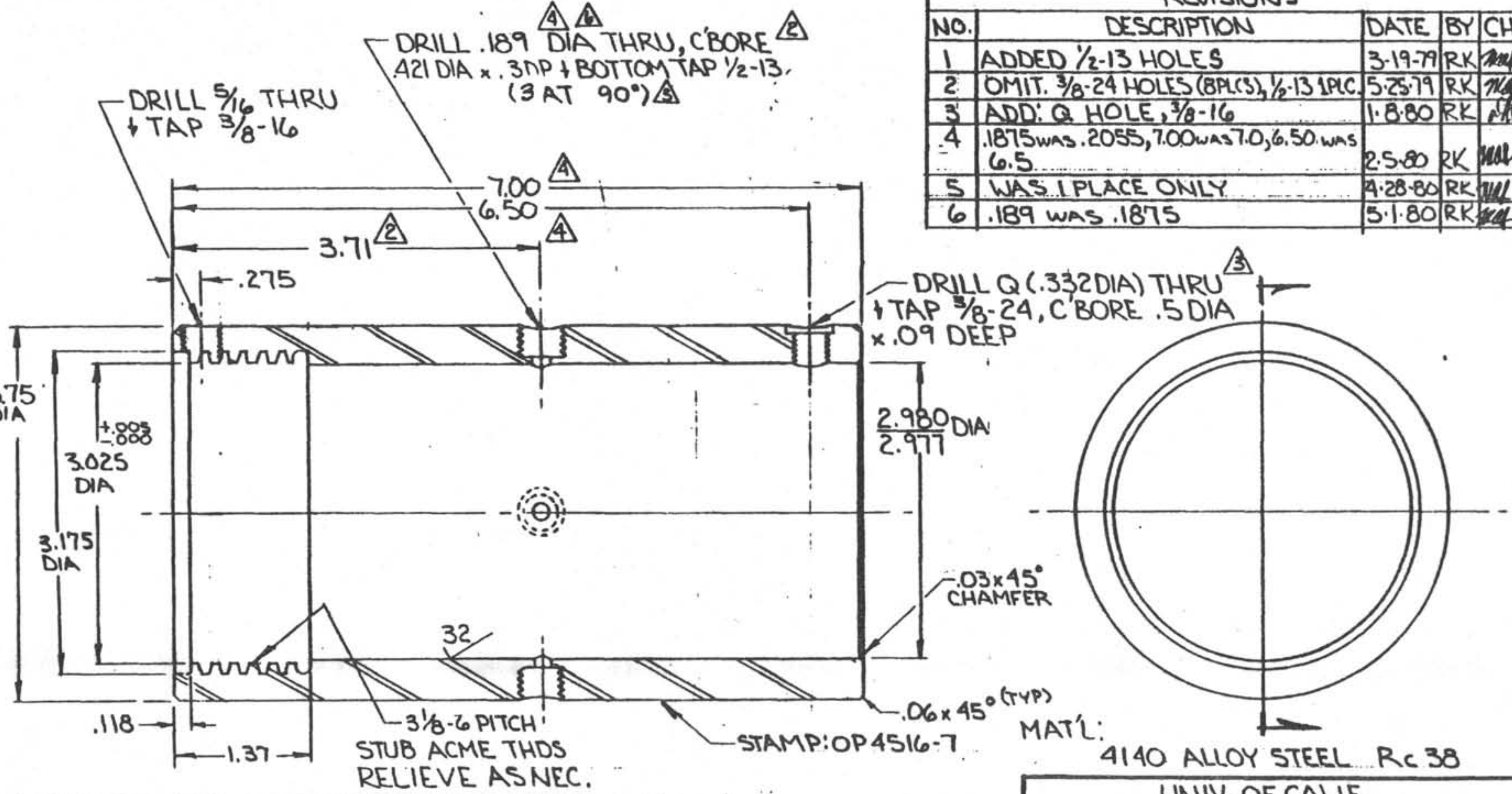
NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

TOLERANCES
UNLESS OTHERWISE SPECIFIED
X = ±.1
.XX = ±.01
.XXX = ±.001
ANGLES ± 30'

DO NOT SCALE

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: FULL	APPROVED BY: [signature] 5/1?	DRAWN BY: RK
DATE: APR 3 '78		REVISED: [signature]
VENT SUB ROD - (MECHANICAL) PCB II-III		
PART NO. OP4513-4		DRAWING NUMBER: OP4513-4

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH	AP
1	ADDED ½-13 HOLES	3-19-79	RK	[illegible]	3-20
2	OMIT. 3/8-24 HOLES (8PL(S)), ½-13 1PLC.	5-25-79	RK	[illegible]	[illegible]
3	ADD: Q HOLE, 3/8-16	1-8-80	RK	[illegible]	1-8
4	.1875 WAS .2055, 7.00 WAS 7.0, 6.50 WAS 6.5	2-5-80	RK	[illegible]	[illegible]
5	WAS 1 PLACE ONLY	4-28-80	RK	[illegible]	[illegible]
6	.189 WAS .1875	5-1-80	RK	[illegible]	[illegible]

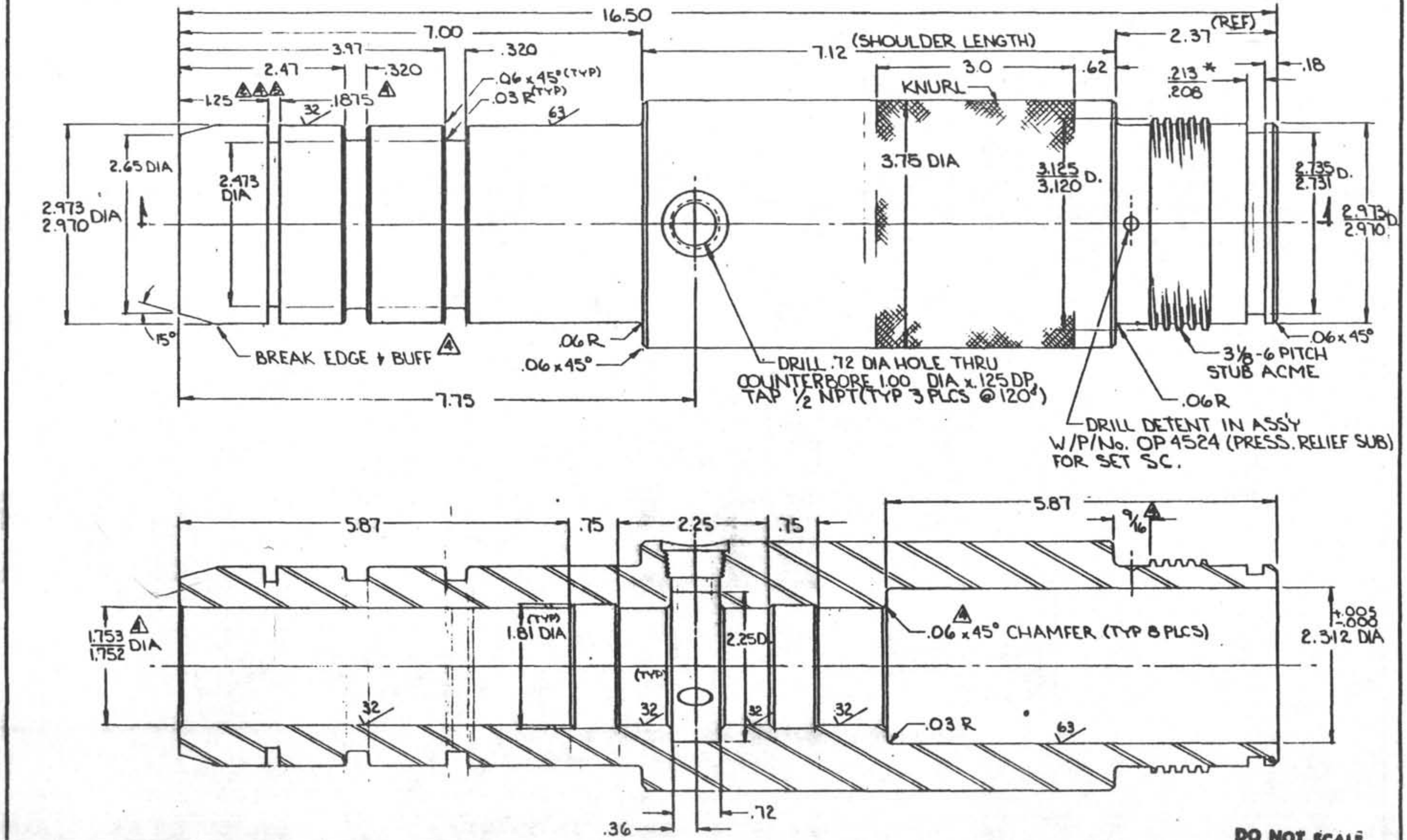


MAT'L: 4140 ALLOY STEEL Rc 38

REVISIONS - CONT					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
7	MAT'L WAS 17-4 PH H1075	8-4-80	RK	[illegible]	[illegible]

TOLERANCES UNLESS OTHERWISE SPECIFIED
.X = ±.1
.XX = ±.01
.XXX = ±.001
ANGLES ±30'

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: FULL	APPROVED BY: [signature]	DRAWN BY RK
DATE: APR 4 78		REVISED
BODY EXTENSION (MECHANICAL) PCB II-III		
PART NO. OP 4516-7		DRAWING NUMBER B-OP4516-7



DO NOT SCALE

*FOR PARKER O-RING, #2-232
" " PARBAK 8-232

MAT'L:
17-4 PH SS H 1025
165 KSI YIELD Rc 38

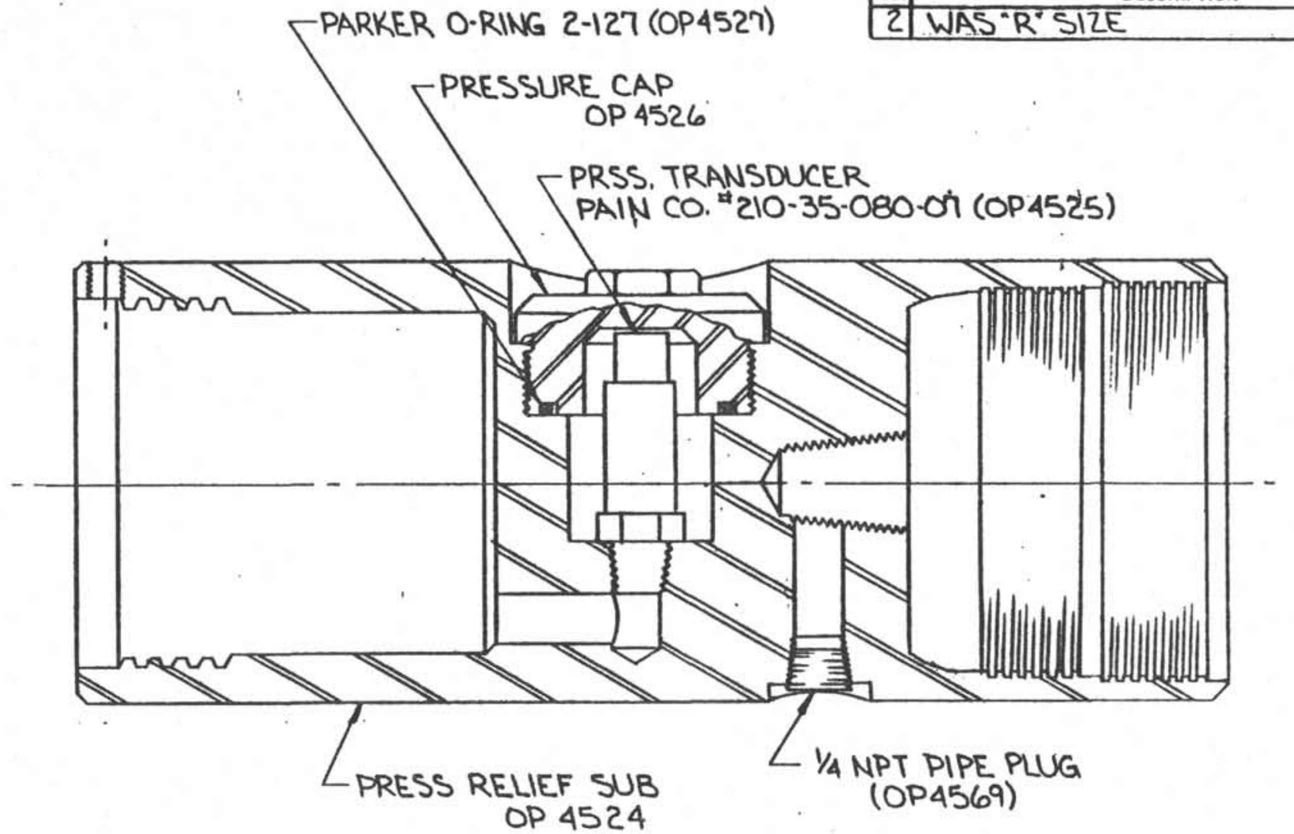
No	DESCRIPTION	DATE	BY	CH.	AP.
5	1.25 WAS 1.33	2-5-80	RK	[illegible]	[illegible]
4	ADD. DETENT, .320 WIDE SLOTS 1.753/1.752 WAS 1.752/1.750, ADD. BREAK NOTE; 9/16 1.33 WAS 1.24, .1875 WAS .2055, .06 WAS .03	1-15-80	RK	[illegible]	[illegible]
3	5.87 WAS 6, 2.25 WAS 2.00 OMIT .380 + .50 x 2.5 DIA GROOVES .72 WAS .43, 1.00 WAS .875, 1/2 WAS 1/4	5-25-79	RK	[illegible]	[illegible]
2	ADD. .2055 x 2.473 DIA SLOT	3-19-79	RK	[illegible]	[illegible]
1	ADD. .50 x 2.5 DIA GROOVE	2-15-79	RK	[illegible]	[illegible]

NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

TOLERANCES
UNLESS OTHERWISE SPECIFIED
.X = ±.1
.XX = ±.01
.XXX = ±.001
ANGLES ±30'

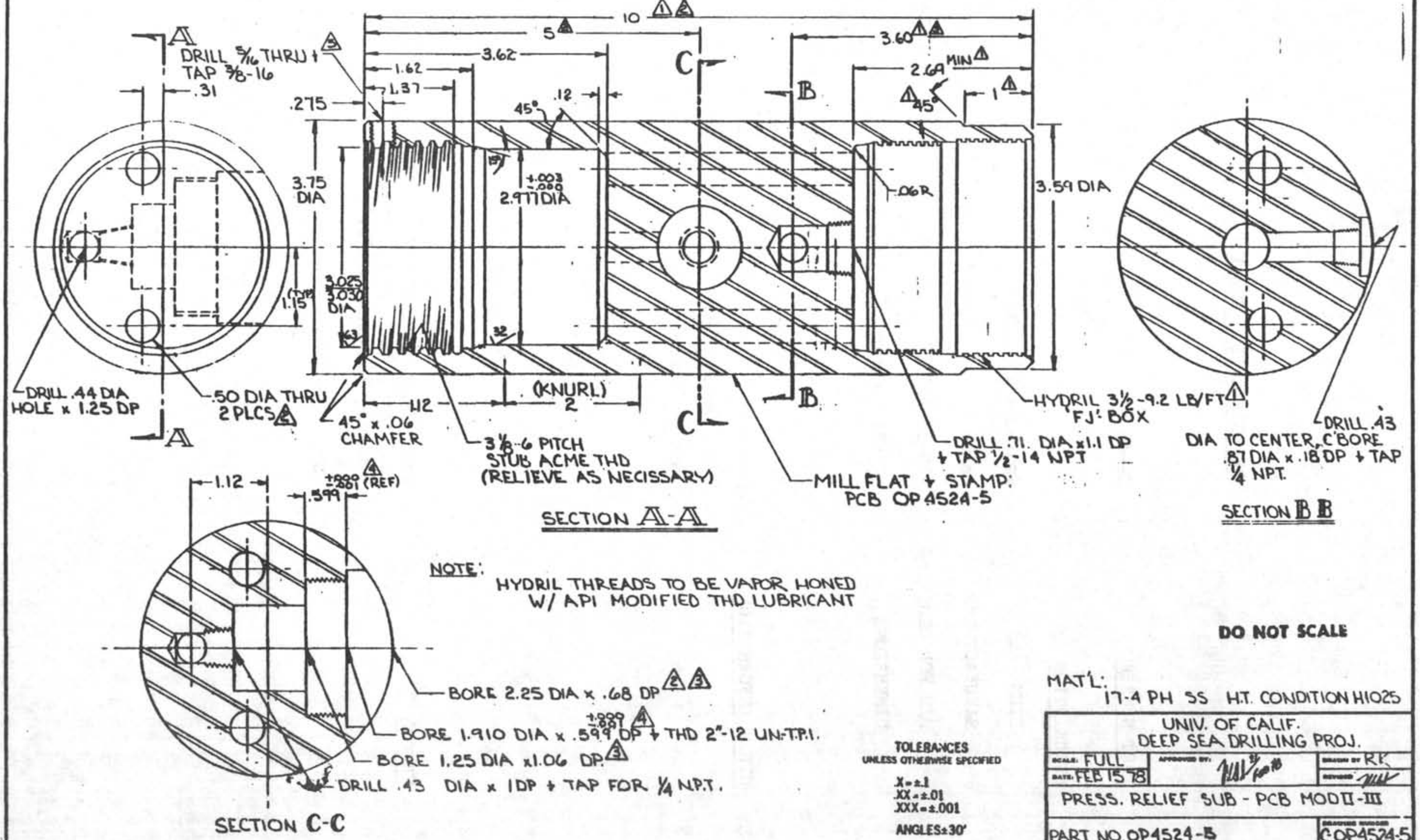
UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: FULL	APPROVED BY: [illegible] 5/14	DRAWN BY RK
DATE: APR 3 78		REVISED [illegible]
VENT SUB BODY (MECHANICAL) PCB II-III		
PART NO. OP 4518-5		DRAWING NUMBER 0OP4518-5

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
2	WAS "R" SIZE	9-17-80	RK		



TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE PRESSURE RELIEF SUB ASSY ~PCB~				
SURFACE TREATMENT —o—	MATERIAL —o—	DRAWN BY RK	DATE 9-17-80	CHECKED JAC	APPROVED
HEAT TREATMENT —o—	PART NO. OP4523-2	SIZE B	DWG. NO. OP4523-		REV. 2

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH	APR
1	2.69 WAS 2.25, 3½-9.2 LB/FT WAS FJ-40 THD, 3.59 DIA x 1" + 45° ADDED, 9.44 WAS 9.0 3.44 ADDED, THD. VAPOR HONED NOTE ADDED	3-7-78	RK		
2	5 WAS 4.68, 10 WAS 9.44, .50 DIA HOLES WERE ON ℄, TRANSDUCER HOLE RE-DESIGNED	3-16-78	RK		
3	BORE .68 DP WAS 1.06 DP, 1.06 DP WAS .70. 3.60 WAS 3.44	3-17-78	RK		
4	.599 +.000/-.001 WAS .600	3-21-78	RK		
5	ADDED 3/8-16 HOLE	1-16-80	RK		



NOTE: HYDRIL THREADS TO BE VAPOR HONED W/ API MODIFIED THD LUBRICANT

DO NOT SCALE

MAT'L: 17-4 PH SS H.T. CONDITION H1025

TOLERANCES UNLESS OTHERWISE SPECIFIED
X = ±.1
XX = ±.01
XXX = ±.001
ANGLES ±30'

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.

SCALE: FULL
DATE: FEB 15 78
DRAWN BY: RK

PRESS. RELIEF SUB - PCB MOD II-III

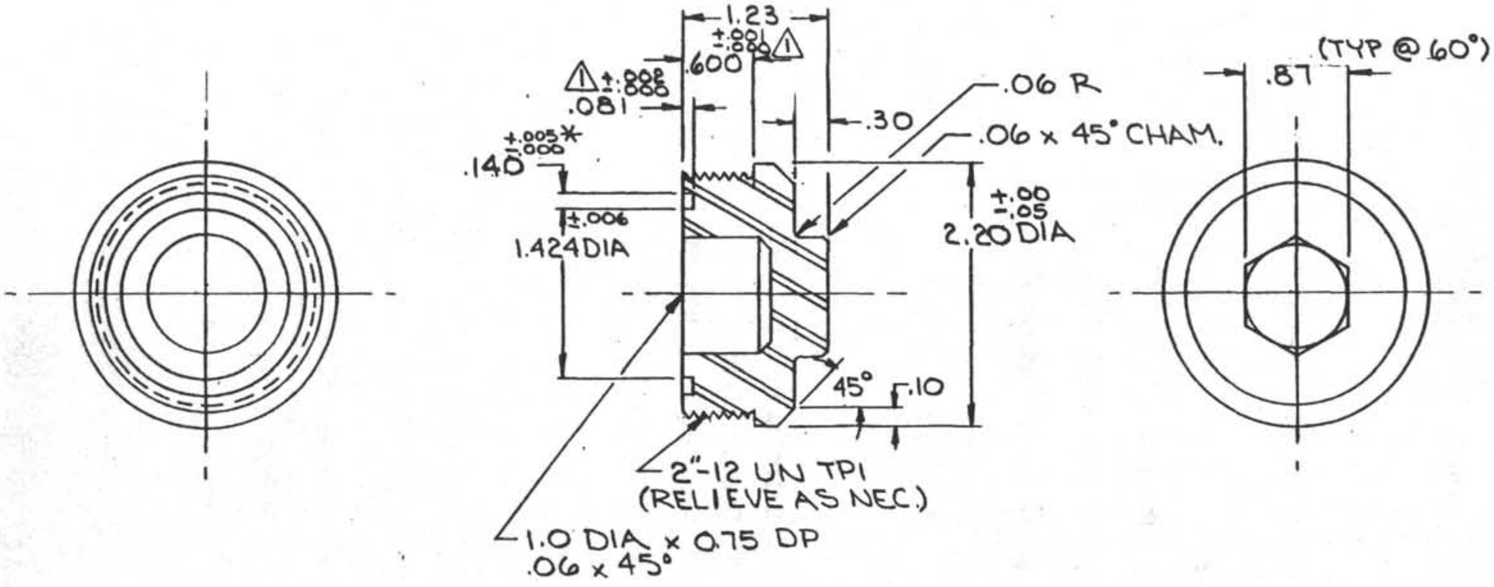
PART NO. OP4524-5

C OP4524-5

SPECIFICATION SHEET

PART NUMBER	:	OP-4525
DESCRIPTION	:	
ITEM	:	Pressure Transducer
MANUFACTURER	:	Paine
P/N FOR ORDERING	:	210-35-550-07
DIMENSIONS	:	¼" NPT Connection
OTHER INFORMATION	:	Electrical Connection Mates with P/N 247-99-100-1 (not included)
VENDOR	:	Paine Instruments 2401 South Bayview Street Seattle, Washington 98144 (800) 426-0366

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH	APR
1	ADDED .600 +.001/−.000 + .081 +.002/−.000	3.21.78	RK	[signature]	[signature]



* FOR PARKER O-RING #2-127

MAT'L:
17-4 S.S. H 1075

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: FULL	APPROVED BY: [signature] 3/17	DRAWN BY RK
DATE: 3.17.78		REVISED [signature]
PRESSURE CAP - P.C.B.		
PART NO. OP4526-1		DRAWING NUMBER B-OP4526-1

11227 PRINTED ON NO. 1000H CLEARPRINT

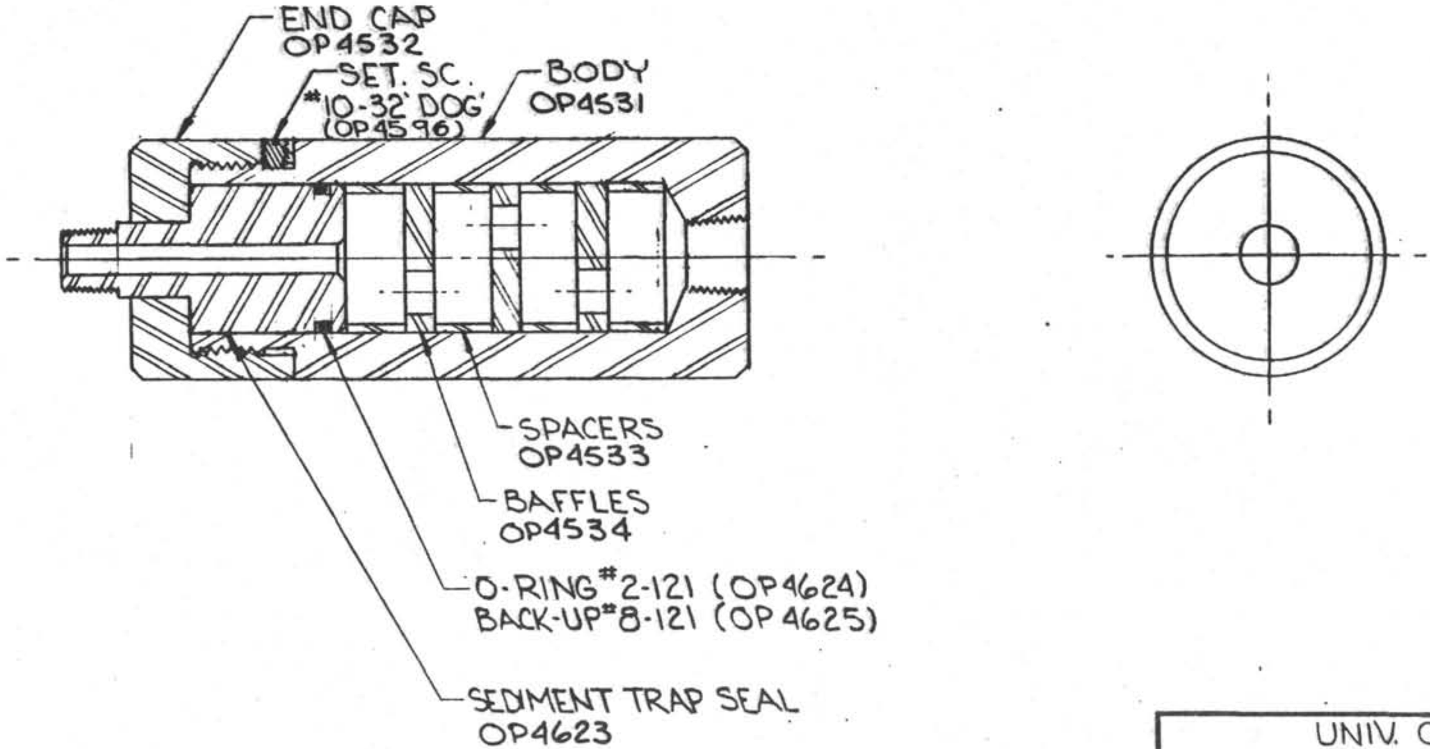
SPECIFICATION SHEET

PART NUMBER	:	OP-4528
DESCRIPTION	:	
ITEM	:	Pressure Relief Valve
MANUFACTURER	:	Circle Seal
P/N FOR ORDERING	:	RV 205TI-4PP-6500
DIMENSIONS	:	Length = 5.8" Diameter = 2.5"
OTHER INFORMATION	:	Inlet port is ¼ FPT Outlet port is ½ FPT Repair Kit: KIT RV 205TI-4PP-6500 Burst Disc: 6255-7500
VENDOR	:	Barbee Valve & Supply, Inc. 2116 Hancock Street San Diego, CA 92110 (619) 297-4213

SPECIFICATION SHEET

PART NUMBER	:	OP-4529
DESCRIPTION	:	
ITEM	:	Filter
MANUFACTURER	:	Microporous
P/N FOR ORDERING	:	4423G-20TL
DIMENSIONS	:	Length: 6" Diameter: 1.5" (across Hex Flats)
OTHER INFORMATION	:	¼" x ¼" FPT Ports Replacement Element #413G-20TL
VENDOR	:	Wintec 5523 West Imperial Highway Los Angeles, CA 90045 (213) 641-4300

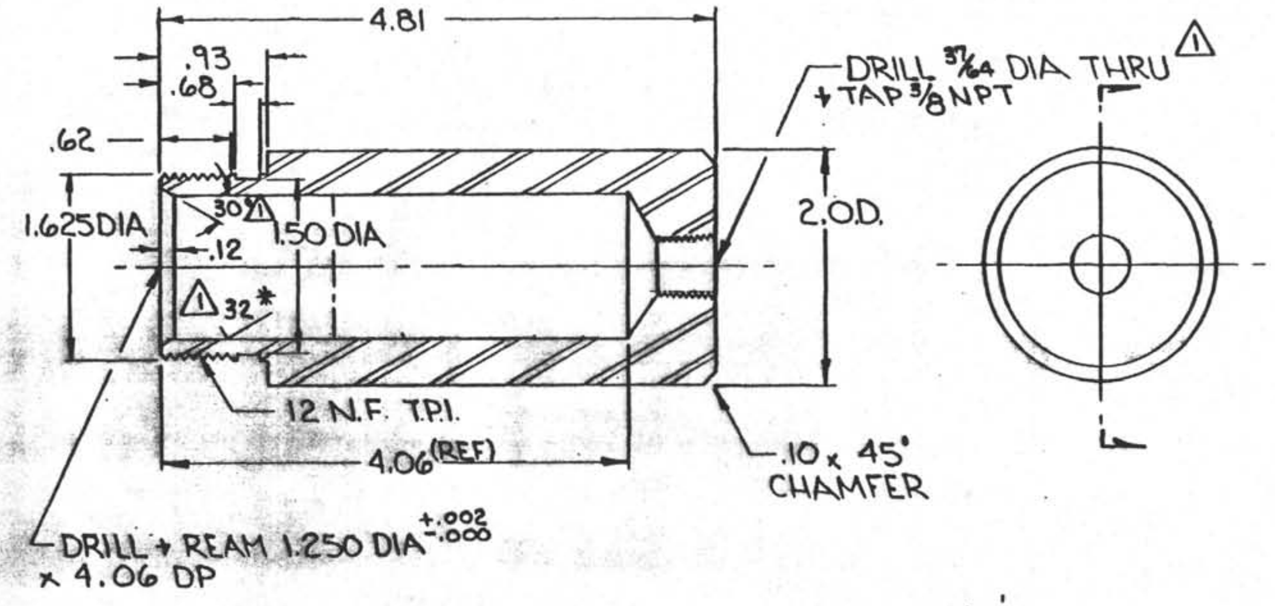
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	ADDED P/N's OP4623, 4624, 4625	8-18-80	RK		



UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.

SCALE: FULL	APPROVED BY:	DRAWN BY RK
DATE: 4-10-78		REVISED [illegible]
SEDIMENT TRAP ASS'Y - PCB		
ASS'Y NO. OP4530-1		DRAWING NUMBER B-OP4530-1

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	ADDED: 1/4 NPT, 32, 30° CHAM.	8-18-80	RK		



* 32 FINISH x 1.5 DP

DO NOT SCALE

MAT'L: 316 S.S.

TOLERANCES
UNLESS OTHERWISE SPECIFIED

.X = ±.1
.XX = ±.01
.XXX = ±.001
ANGLES ±30'

NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.

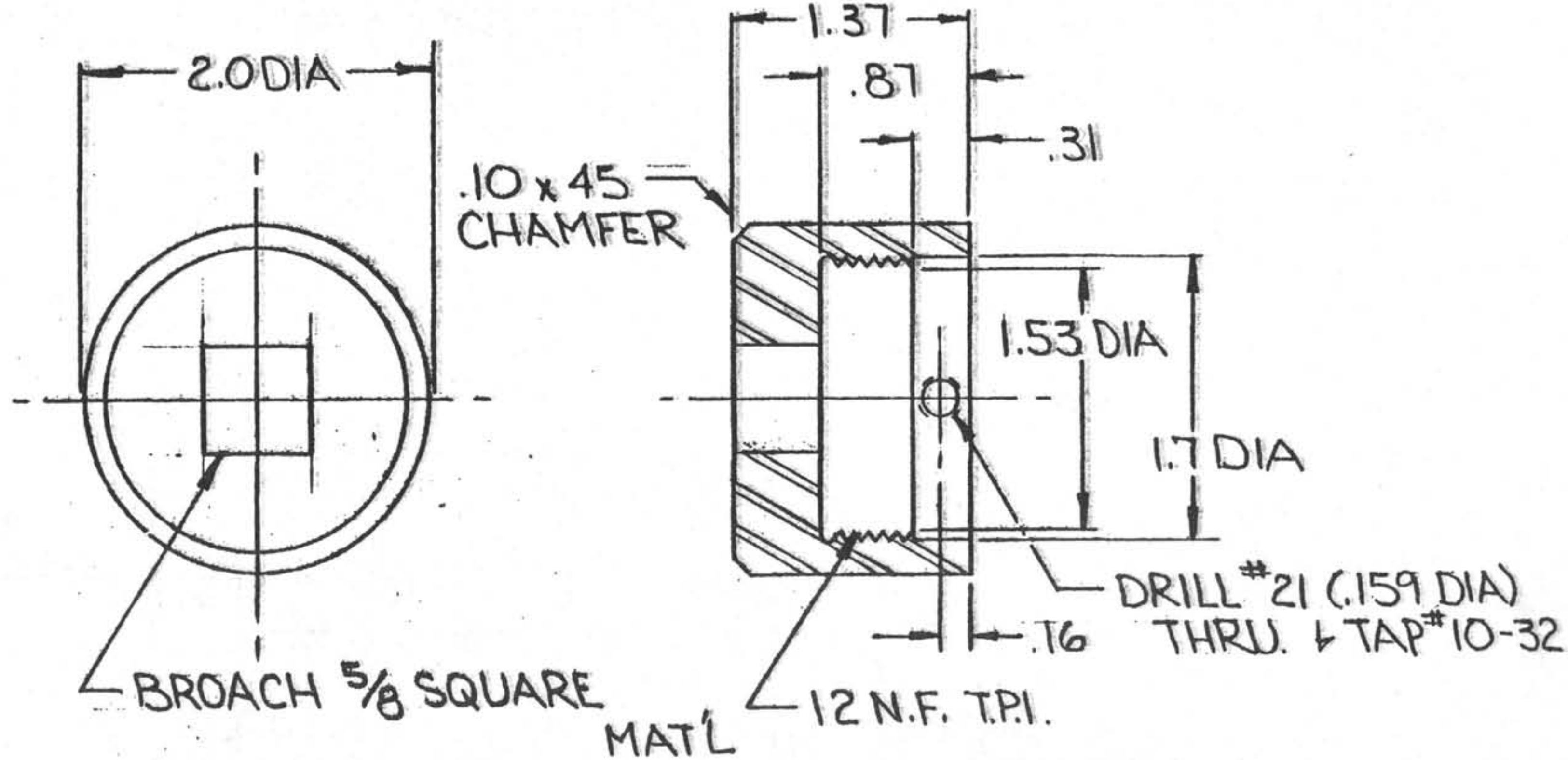
SCALE: FULL	APPROVED BY: [signature]	DRAWN BY RK
DATE: 4-10-78		REVISED [signature]

SEDIMENT TRAP BODY - PCB II

PART NO. OP4531-1 — DRAWING NUMBER B-OP4531-1

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	BROACH WAS 1/4 NPT	8.18.80	RK		

OP 4532



DO NOT SCALE

TOLERANCES
UNLESS OTHERWISE SPECIFIED

.X = ±.1
.XX = ±.01
.XXX = ±.001
ANGLES ±30'

NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

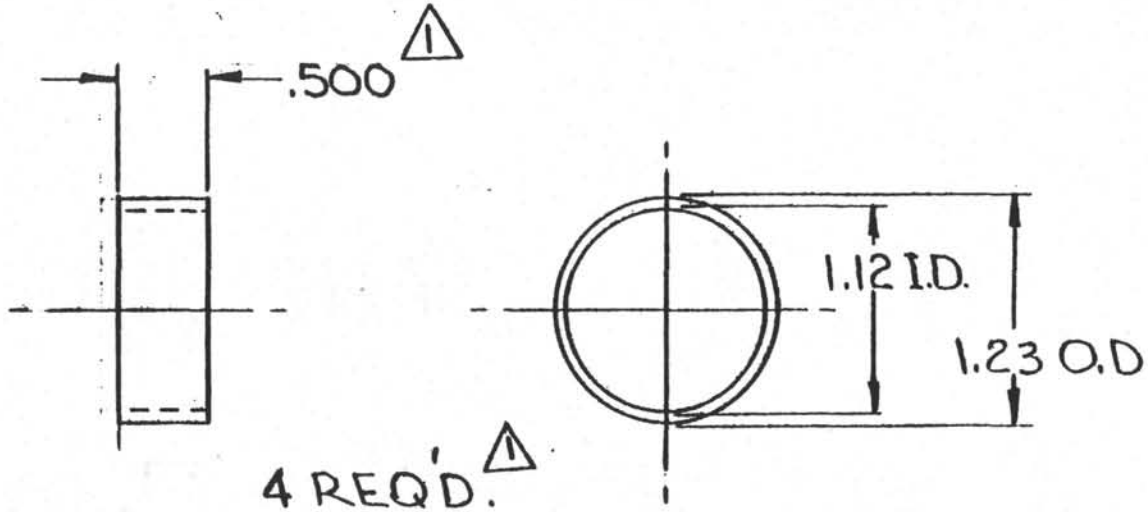
UNIV OF CALIF DEEP SEA DRILLING PROJ.		
SCALE: FULL	APPROVED BY:	DRAWN BY RK
DATE: 4-11-78		REVISED [signature]
END CAP, SEDIMENT TRAP - PCB II - III		
PART NO. OP 4532-1		DRAWING NUMBER A-OP4532-1

(14-0754)

8½ X 11 PRINTED ON NO. 1000H CLEARPRINT

OP4533

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	WAS 5 REQ'D, .500 WAS .600	8-18-80	RK		



MAT'L:
316 S.S.

UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.

SCALE: FULL	APPROVED BY:	DRAWN BY RK
DATE: 4-11-78		REVISED [signature]

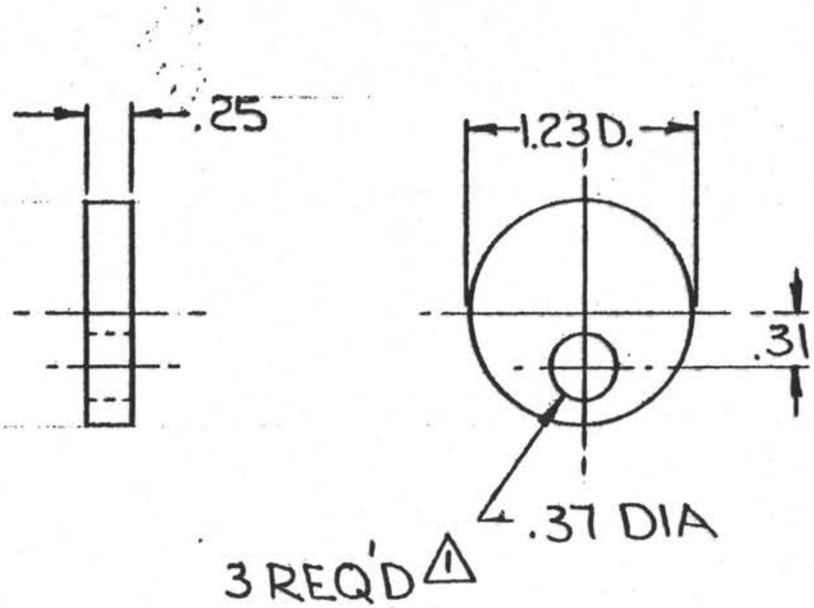
SPACER, SEDIMENT TRAP - PCB II-III

PART NO. OP4533-1	DRAWING NUMBER A-OP4533-1

8½ X 11 PRINTED ON NO. 1000H CLEARPRINT

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	WAS 4 REQ'D	8·18·80	RK		

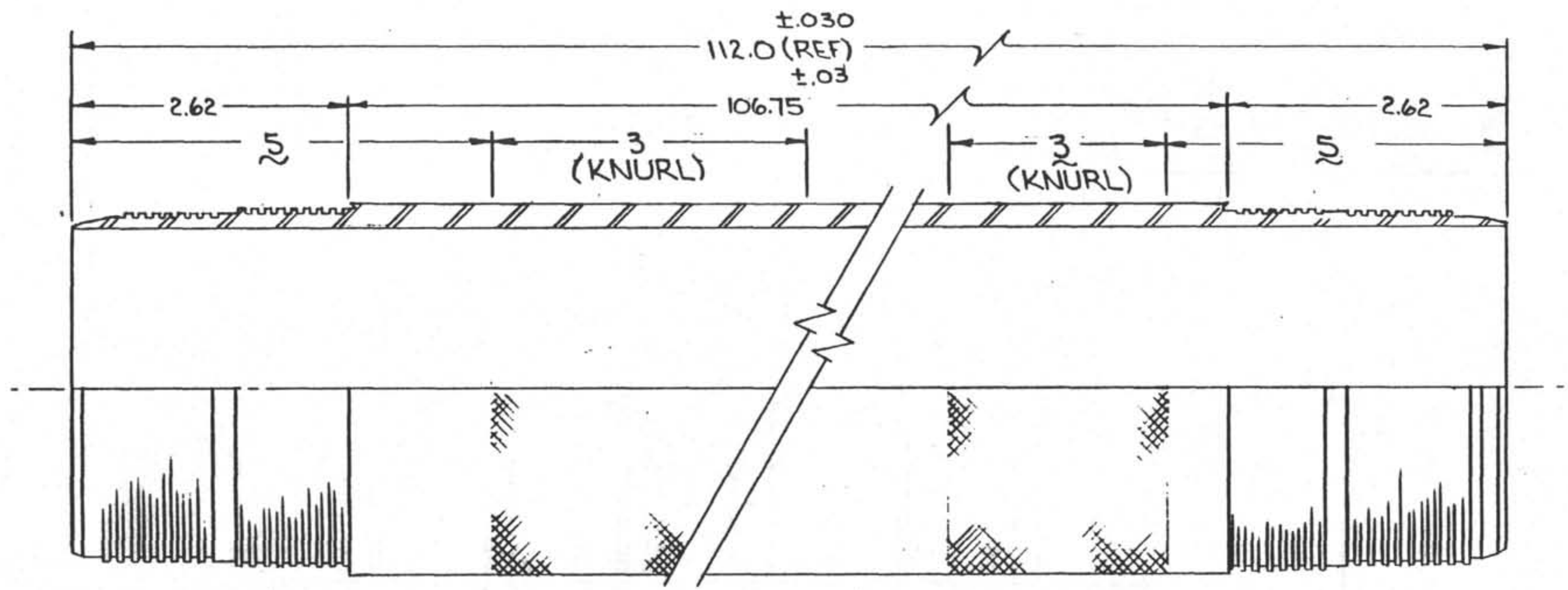
OP4534



MAT'L:
316 S.S.

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: FULL DATE: 4-11-78	APPROVED BY: [signature]	DRAWN BY RK REVISED [signature]
BAFFLE, SEDIMENT TRAP PCB II-III		
PART NO. OP 4534-1		DRAWING NUMBER A-OP4534-1

8½X11 PRINTED ON NO. 1000H CLEARPRINT



NOTE:
THREADS TO BE VAPOR HONED WITH API MODIFIED THD. LUBRICANT.

O.D. = 3.50
I.D. = 2.98
WALL = .25 NOMINAL
CONNECTIONS: HYDRIL 3½-9.2 LB/FT 'FJ' PINS

MAT'L:
MP 35 N TUBING, Rc 43, Y = 220 KSI

NO.	DESCRIPTION	DATE	BY	CH	APR
5	2.62 WAS 1.81, 106.75 WAS 108.0 3½-9.2 LB/FT THD WAS FJ-40	3.7.78	RK	[illegible]	[illegible]
4	WELDED UPSET TOOL JOINTS & HYDRIL 3½ SUPER "FJ" THD REMOVED	FEB 14 78	RK	[illegible]	[illegible]

REVISIONS

TOLERANCES
UNLESS OTHERWISE SPECIFIED
.X = ±.1
.XX = ±.01
.XXX = ±.001
ANGLES ±30'

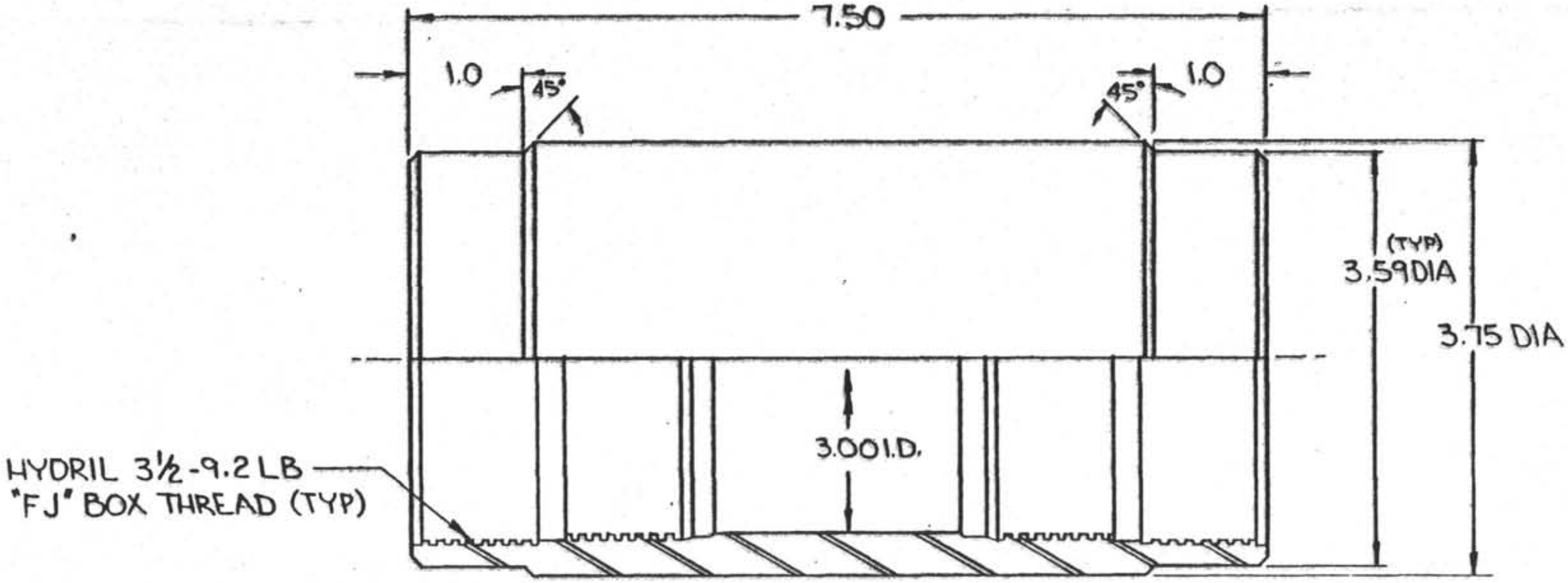
UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.

SCALE: FULL
DATE: FEB 14 '78
APPROVED BY: [illegible]
DRAWN BY: RK
REVISED: [illegible]

CORE BARREL - MP 35 (PCB MOD II-III)

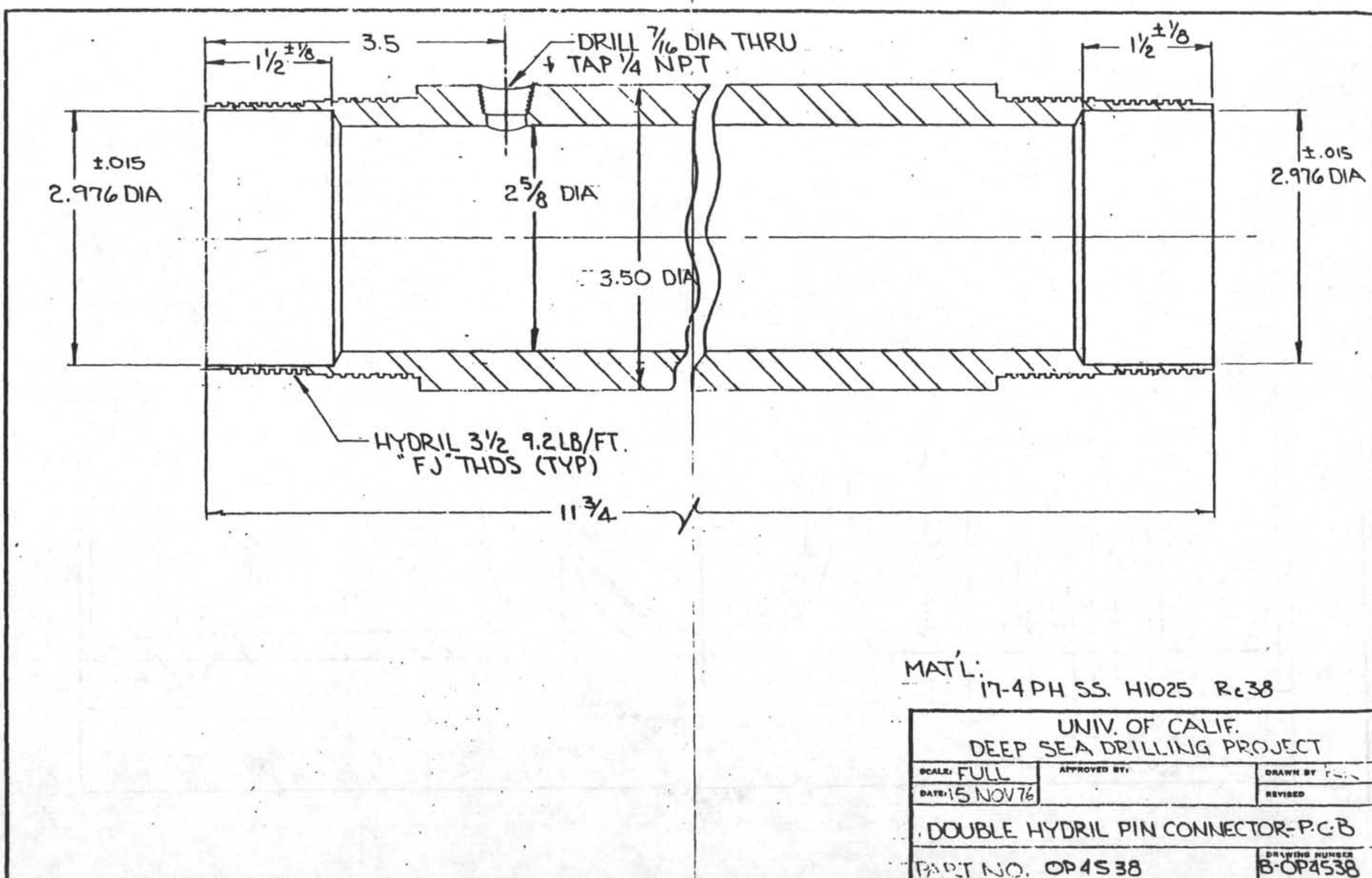
PART NO. OP 4536-5
DRAWING NUMBER: B-OP4536-5

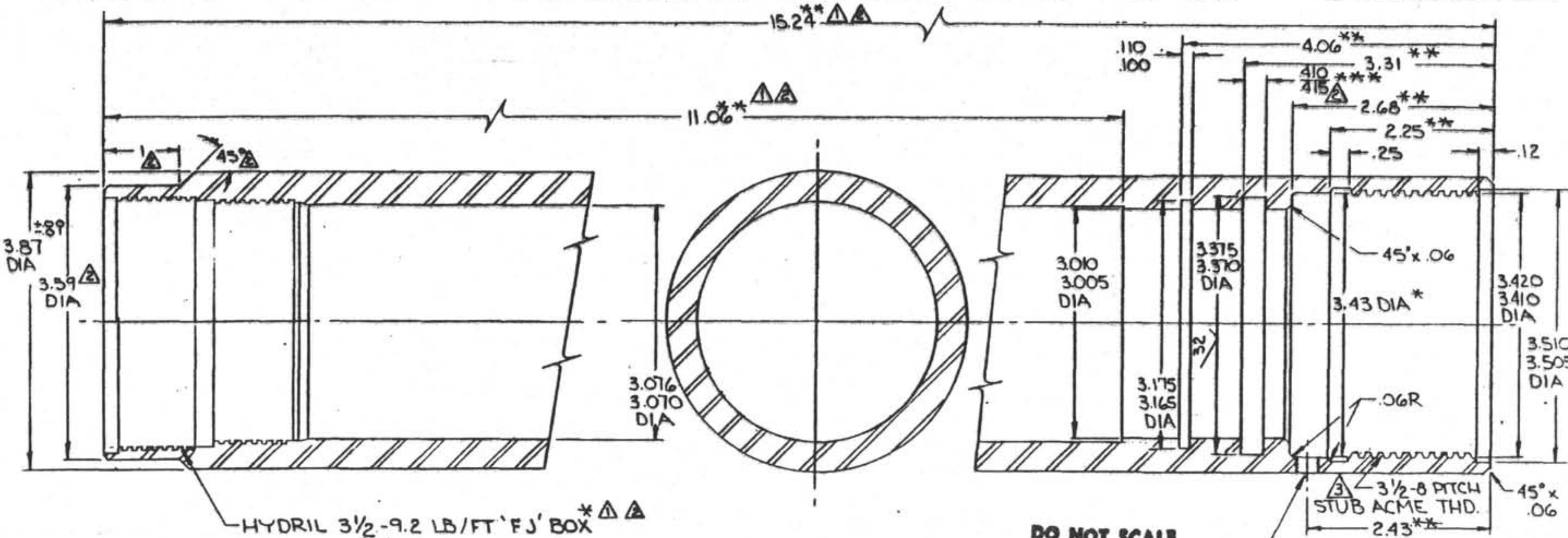
11817 PRINTED ON NO. 1000H CLEARPRINT



MAT'L: 17-4 PHSS H925

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: FULL DATE: 2·2·79	APPROVED BY: [signature]	DRAWN BY RK REVISED [signature]
PRESSURE BARREL COUPLING - PCB II-III		
PART No. OP4537		DRAWING NUMBER B-OP4537


3.5
1½ ±⅛
DRILL 7/16 DIA THRU
+ TAP ¼ NPT
1½ ±⅛
±.015
2.976 DIA
2⅝ DIA
3.50 DIA
±.015
2.976 DIA
HYDRIL 3½ 9.2 LB/FT.
"FJ" THDS (TYP)
11¾
MAT'L:
17-4 PH SS. H1025 Rc38
UNIV. OF CALIF.
DEEP SEA DRILLING PROJECT
SCALE: FULL
APPROVED BY:
DRAWN BY
DATE: 15 NOV 76
REVISED
DOUBLE HYDRIL PIN CONNECTOR-P.C.B
PART NO. OP4538
DRAWING NUMBER
B-OP4538



DO NOT SCALE

NOTES: TIN PLATE STUB ACME THREAD (ONLY) 5 AFTER ENSURING MAKE-UP W/P/N 14-0620-01..

* VAPOR HONED THREADS USE 2 API MODIFIED THD LUBRICANT.

** TOLERANCE .01 IN DIRECTION OF MACHINING.

*** FOR O-RING #2-337

DRILL + TAP 4 3/8-16 UNC AFTER 6 TORQUED W/14-0620-01 (DRILL SET SC 5 RECESSES IN P/N 14-0620-01)

MAT'L: 17-4 PH STAINLESS STEEL H 1075 CONDITION (Rc 34-38) 5

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH	APR
1	FJ-40 WAS 3½ CS, 14.43 was 15.43 10.25 WAS 11.25	FEB 14 78	RK	[illegible]	
2	1 x 3.59 + 45° ADDED, 3½-9.2 LB/FT WAS FJ-40 THD, 11.06 WAS 10.25, 15.24 WAS 14.43, VAPOR HONED NOTE ADDED, .12 was 2.8	3-6-78	RK	[illegible]	
3	3½-8 STUB ACME was 3½-10 ST. RD.	6-24-78	RK	[illegible]	
4	3/8-16 was 5/16-18			[illegible]	
5	KNURL OMITED, Rc WAS 36, TIN PL. + SET SC. NOTE ADDED.	2-8-79	RK	[illegible]	
6	3/8-16 was 2 PLCS, 14-0620 was 0623	12-13-79	RK	[illegible]	

NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

TOLERANCES UNLESS OTHERWISE SPECIFIED **
X = ±.1
.XX = ±.01
.XXX = ±.001
ANGLES ± 30'

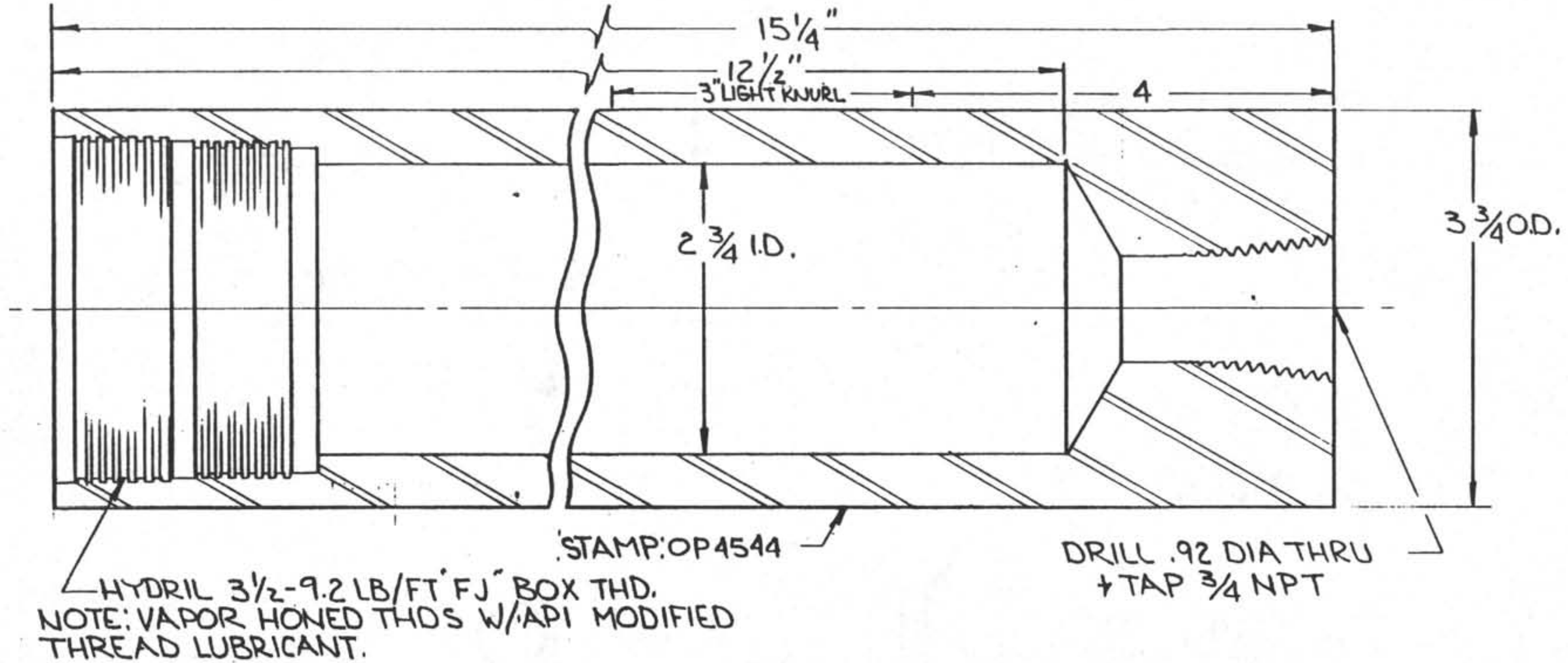
UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.

SCALE: FULL — APPROVED BY: [illegible] — DRAWN BY: RK
DATE: JAN 10 78 — REVISED

TOP CONNECTOR - P.C.B. BVA

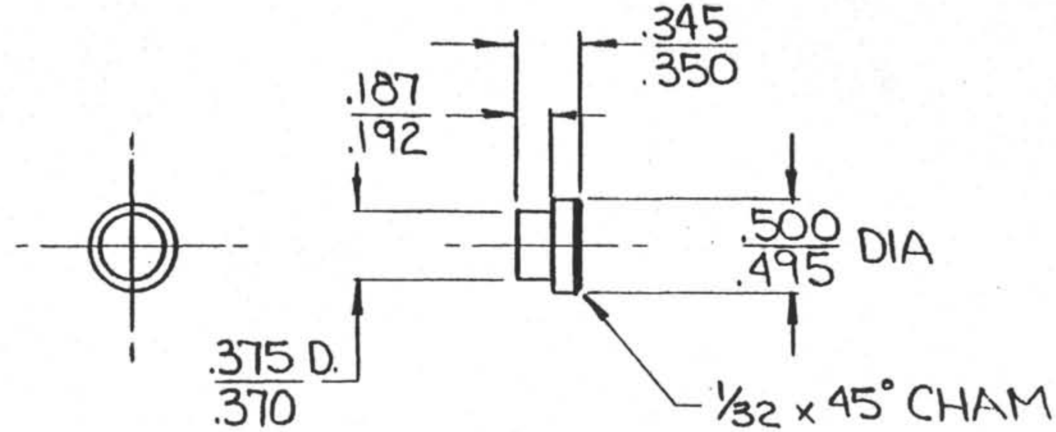
L.R. P/N 6 — PART NO. OP 4541-6 — DRAWING NUMBER OP4541-6

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE HYDRIL 3 1/2 9.2#/FT FJ TEST CAP ~ PCB II-III				
SURFACE TREATMENT	MATERIAL 17-4PH S.S.	DRAWN BY RK	DATE 1-23-80	CHECKED	APPROVED
HEAT TREATMENT H 1025	PART NO. OP4544	SIZE DWG. NO. B-OP4544			REV.

OP4545



NOTE:
LOCTITE (OR EQUIVALENT) PINS INTO BALL PULLER P/N OP4553

MAT'L: MP 35 N OR 15-5PH S.S. CONDITION H-1025

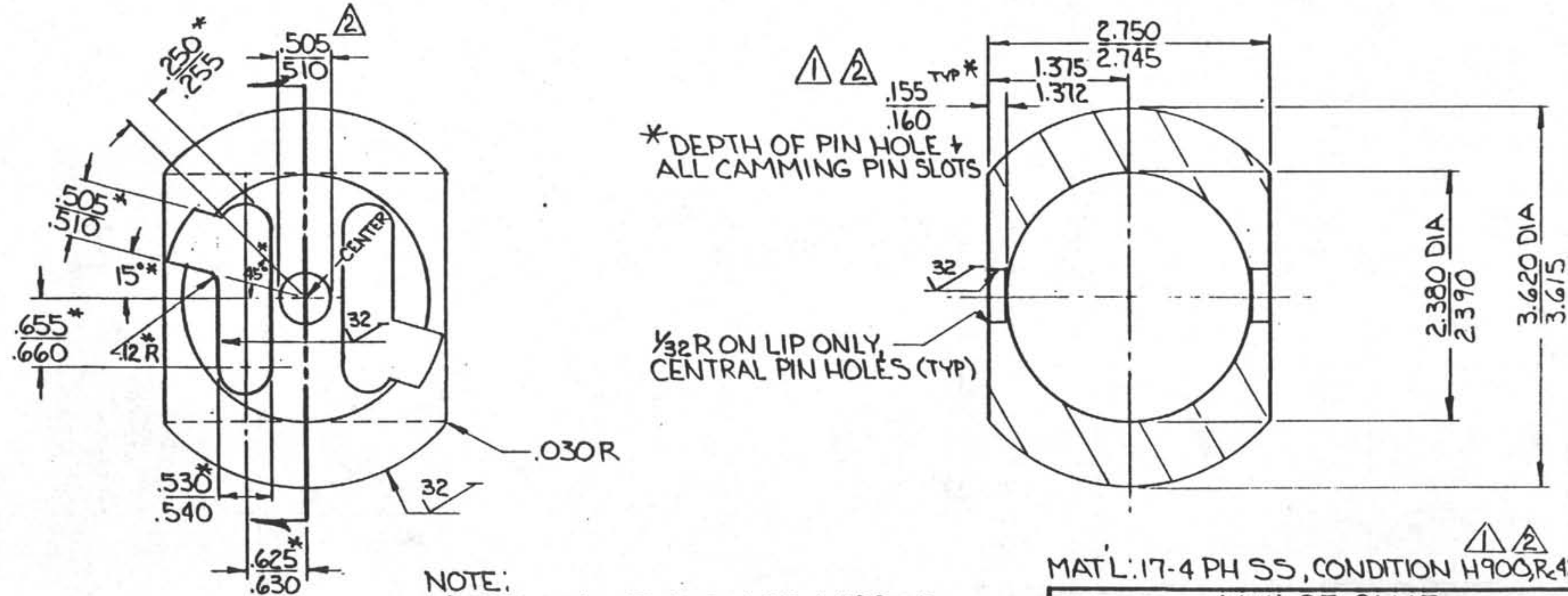
2 PINS REQ'D

TOLERANCES
FRAC. = 1/64 IN DIRECTION OF MACHINING

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: FULL	APPROVED BY:	DRAWN BY RK
DATE: 2-12-79		REVISED
PULLER PINS ~ PCB II-III BVA		
PART No. OP 4545		DRAWING NUMBER A-OP4545

8 1/2 X 11 PRINTED ON NO. 1000H CLEARPRINT

REVISIONS					
No.	DESCRIPTION	DATE	BY	CH	AP
1	.157/.162 WAS .187/.192, C-36 WAS C-52				
2	17-4 PH SS WAS CARPENTER A-286 Rc 42-46 WAS C-36, PIN HOLE WAS .125 OBLONG, .155/.160 WAS .157/.162	2.9.79	RK		

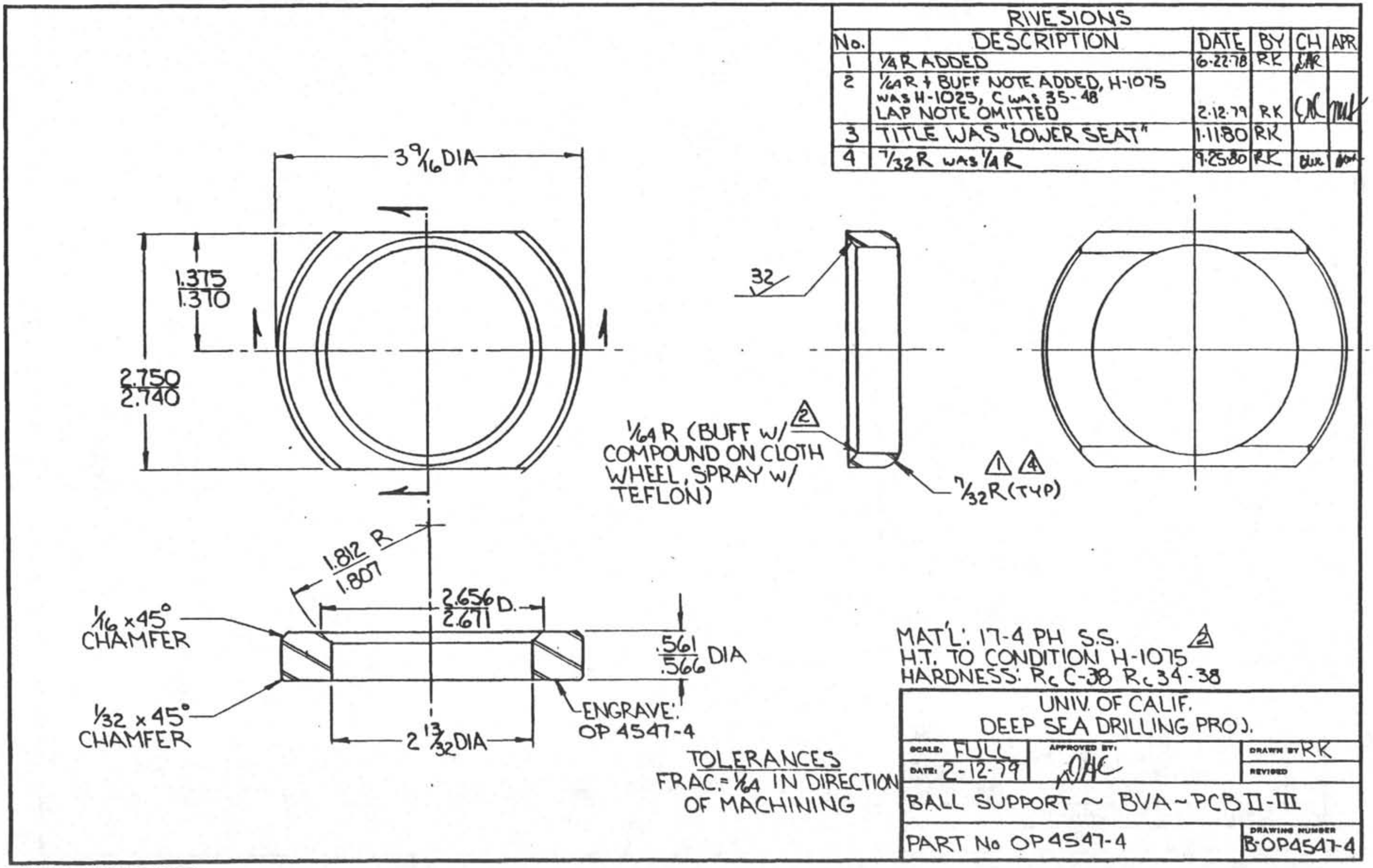


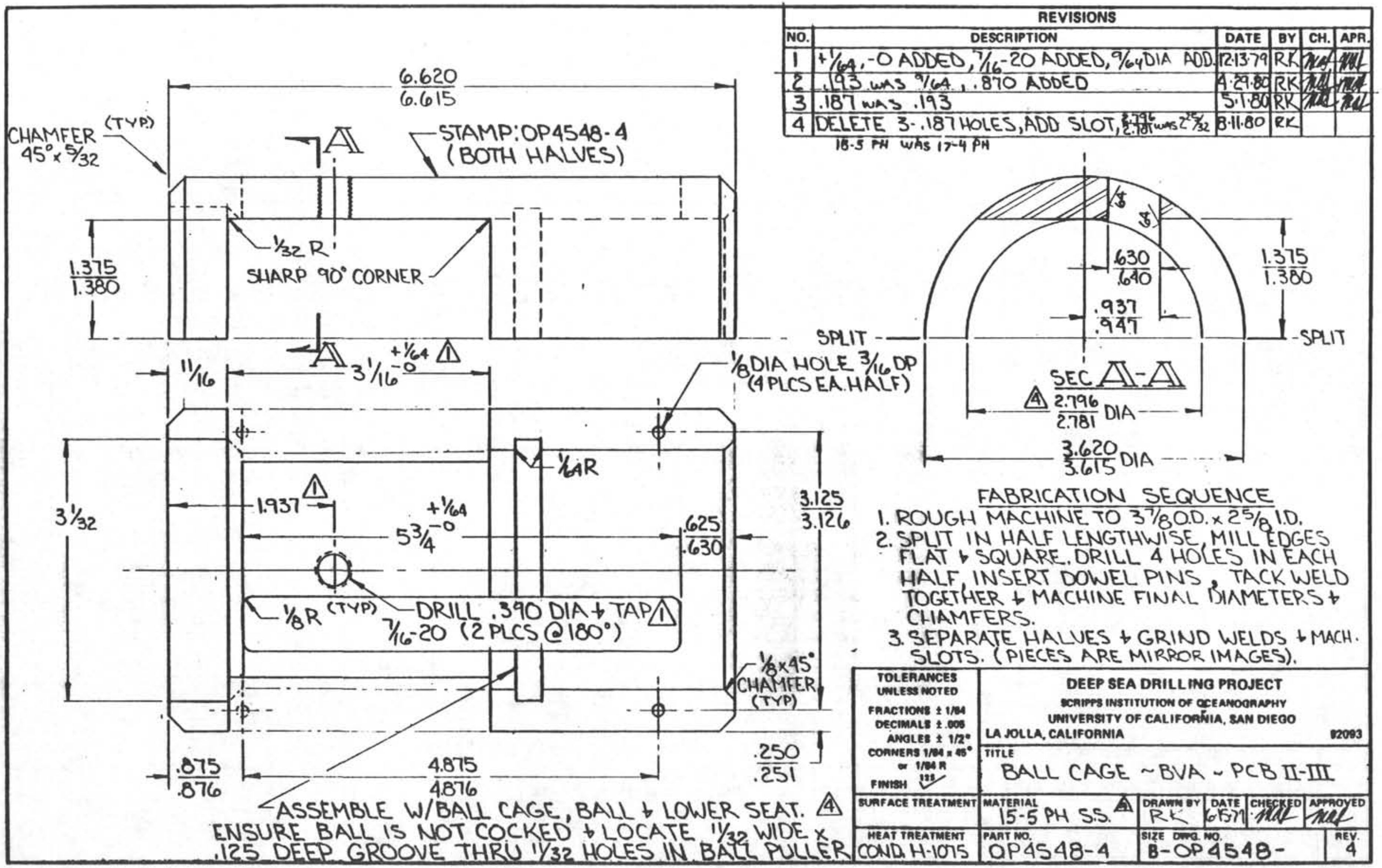
NOTE:
1) THE TWO FLATS ARE MIRROR IMAGES OF EACH OTHER.

2) SPHERICAL TOLERANCE = .0005
3) RAD. ALL SHARP CORNERS .015 R.MAX.
* TYP 2 PLCS EA. SIDE.

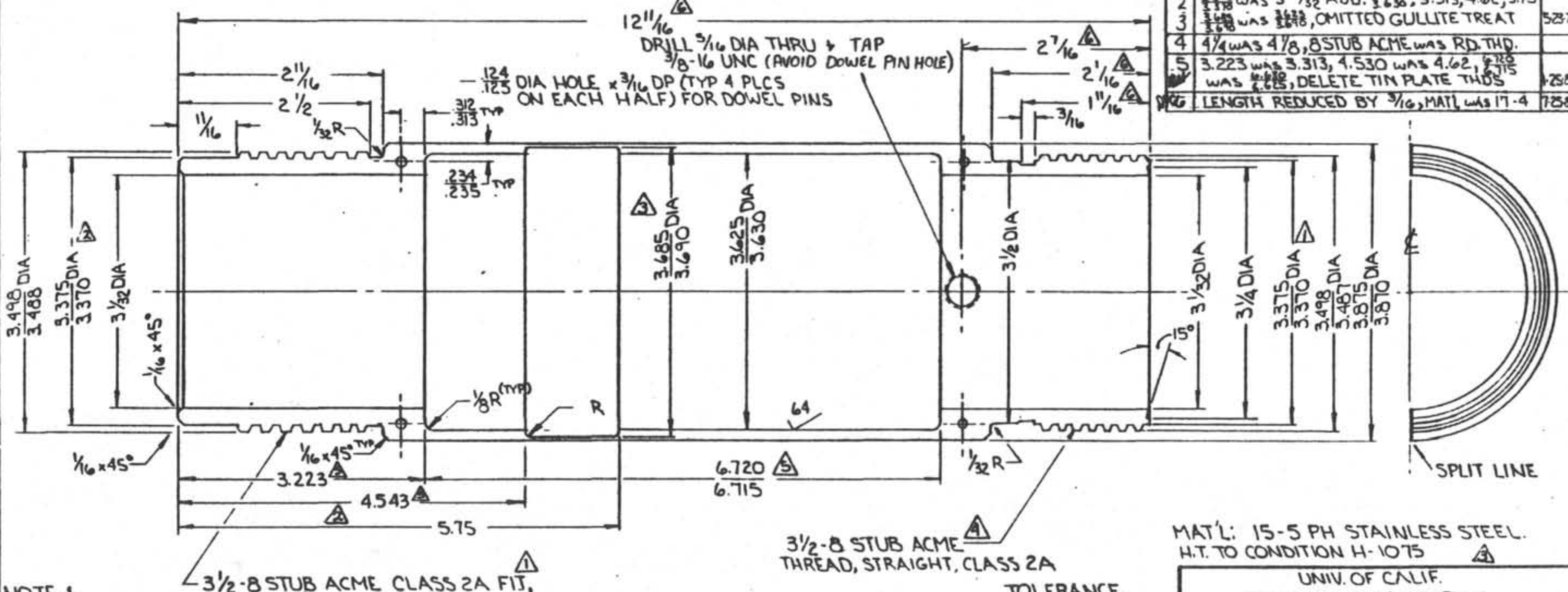
① ② MAT'L: 17-4 PH SS, CONDITION H900, Rc 42-46

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.			
SCALE: FULL	APPROVED BY:	L.R. #1	DRAWN BY RK (L.R.)
DATE: 2-9-79			REVISED
BALL ~ BVA - PCBII-III			
PART No. OP4546-2			DRAWING NUMBER B-OP4546-2


RIVESIONS
No. DESCRIPTION DATE BY CH APR
1 1/4 R ADDED 6-22-78 RK
2 1/64 R + BUFF NOTE ADDED, H-1075 WAS H-1025, C WAS 35-48 LAP NOTE OMITTED 2-12-79 RK
3 TITLE WAS "LOWER SEAT" 1-11-80 RK
4 7/32 R WAS 1/4 R 9-25-80 RK
3 9/16 DIA
1.375 / 1.370
2.750 / 2.740
32
1/64 R (BUFF w/ COMPOUND ON CLOTH WHEEL, SPRAY w/ TEFLON) 2
1 4
7/32 R (TYP)
1.812 / 1.807 R
2.656 / 2.671 D.
1/16 x 45° CHAMFER
1/32 x 45° CHAMFER
.561 / .566 DIA
ENGRAVE: OP 4547-4
2 13/32 DIA
TOLERANCES
FRAC.= 1/64 IN DIRECTION OF MACHINING
MAT'L: 17-4 PH S.S. 2
H.T. TO CONDITION H-1075
HARDNESS: Rc C-38 Rc 34-38
UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.
SCALE: FULL
DATE: 2-12-79
APPROVED BY:
DRAWN BY RK
REVISED
BALL SUPPORT ~ BVA~PCB II-III
PART No OP 4547-4
DRAWING NUMBER B-OP4547-4


REVISIONS
NO. | DESCRIPTION | DATE | BY | CH. | APR.
1 +1/64, -0 ADDED, 7/16-20 ADDED, 9/64 DIA ADD. 12.13.79 RK
2 .193 WAS 9/64, .870 ADDED 4.29.80 RK
3 .187 WAS .193 5.1.80 RK
4 DELETE 3-.187 HOLES, ADD SLOT, 2.796/2.781 WAS 2 25/32 8.11.80 RK
15-5 PH WAS 17-4 PH
6.620
6.615
CHAMFER (TYP) 45° x 5/32
STAMP: OP4548-4 (BOTH HALVES)
1/32 R
SHARP 90° CORNER
1.375
1.380
SPLIT
11/16
3 1/16 +1/64 -0
1/8 DIA HOLE 3/16 DP (4 PLCS EA. HALF)
1/64 R
3 1/32
1.937
5 3/4 +1/64 -0
.625
.630
3.125
3.126
1/8 R (TYP)
DRILL .390 DIA & TAP 7/16-20 (2 PLCS @ 180°)
1/8 x 45° CHAMFER (TYP)
.875
.876
4.875
4.876
.250
.251
ASSEMBLE W/BALL CAGE, BALL & LOWER SEAT. ENSURE BALL IS NOT COCKED & LOCATE 1/32 WIDE x .125 DEEP GROOVE THRU 1/32 HOLES IN BALL PULLER
.630
.640
.937
.947
SEC A-A
2.796
2.781 DIA
3.620
3.615 DIA
FABRICATION SEQUENCE
1. ROUGH MACHINE TO 3 7/8 O.D. x 2 5/8 I.D.
2. SPLIT IN HALF LENGTHWISE, MILL EDGES FLAT & SQUARE. DRILL 4 HOLES IN EACH HALF, INSERT DOWEL PINS, TACK WELD TOGETHER & MACHINE FINAL DIAMETERS & CHAMFERS.
3. SEPARATE HALVES & GRIND WELDS & MACH. SLOTS. (PIECES ARE MIRROR IMAGES).
TOLERANCES UNLESS NOTED
FRACTIONS ± 1/64
DECIMALS ± .005
ANGLES ± 1/2°
CORNERS 1/64 x 45° or 1/64 R
FINISH 125
DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA, SAN DIEGO
LA JOLLA, CALIFORNIA 92093
TITLE
BALL CAGE ~ BVA ~ PCB II-III
SURFACE TREATMENT
MATERIAL 15-5 PH S.S.
DRAWN BY RK
DATE 6.15.71
CHECKED
APPROVED
HEAT TREATMENT COND. H-1075
PART NO. OP4548-4
SIZE DWG. NO. B-OP4548-
REV. 4

No	REVISIONS	DATE	BY
1	3.375/3.370 was 3.390/3.385, 8 S. ACME was 10 RD THD.		
2	3.375/3.370 was 3 11/32 ADD: 3.625/3.630, 3.313, 4.62, 5.75		
3	3.685/3.690 was 3.623/3.618, OMITTED GULLITE TREAT	5-23-79	RK
4	4 1/4 was 4 1/8, 8 STUB ACME was RD. THD.		
5	3.223 was 3.313, 4.530 was 4.62, 6.720/6.715 was 6.630/6.625, DELETE TIN PLATE THDS	1-25-80	RK
6	LENGTH REDUCED BY 3/16, MAT'L was 17-4	7-25-80	RK



MAT'L: 15-5 PH STAINLESS STEEL.
H.T. TO CONDITION H-1075

NOTE 1.
FIRST ROUGH MACHINE TO 4 1/4 O.D. + 2 7/8 I.D., SPLIT LENGTHWISE, THEN MILL EDGES FLAT + SQ. NEXT DRILL + INSERT DOWEL PINS, CLAMP + TACK WELD TOGETHER, FINISH MACHINING, SPLIT APART + MACHINE ENDS REMOVING WELDS.

NOTE 2. FLARE, SMOOTH + DEEPEN THD GROOVES + REDUCE THD. CREST HEIGHT AT SPLIT TO DULL CUTTING EDGE.

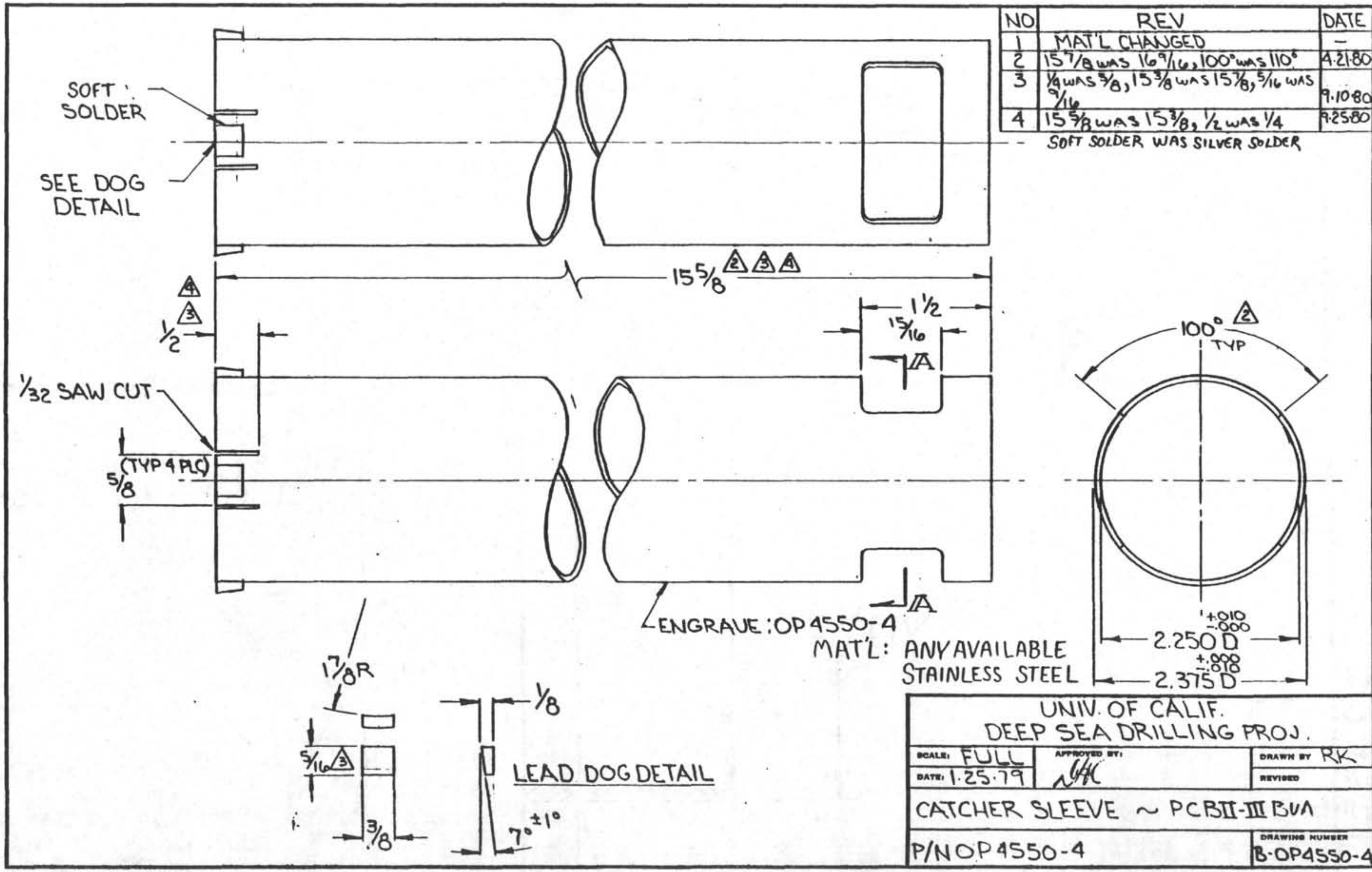
TOLERANCE
FRACTION: 1/64 IN DIRECTION OF MACHINING.

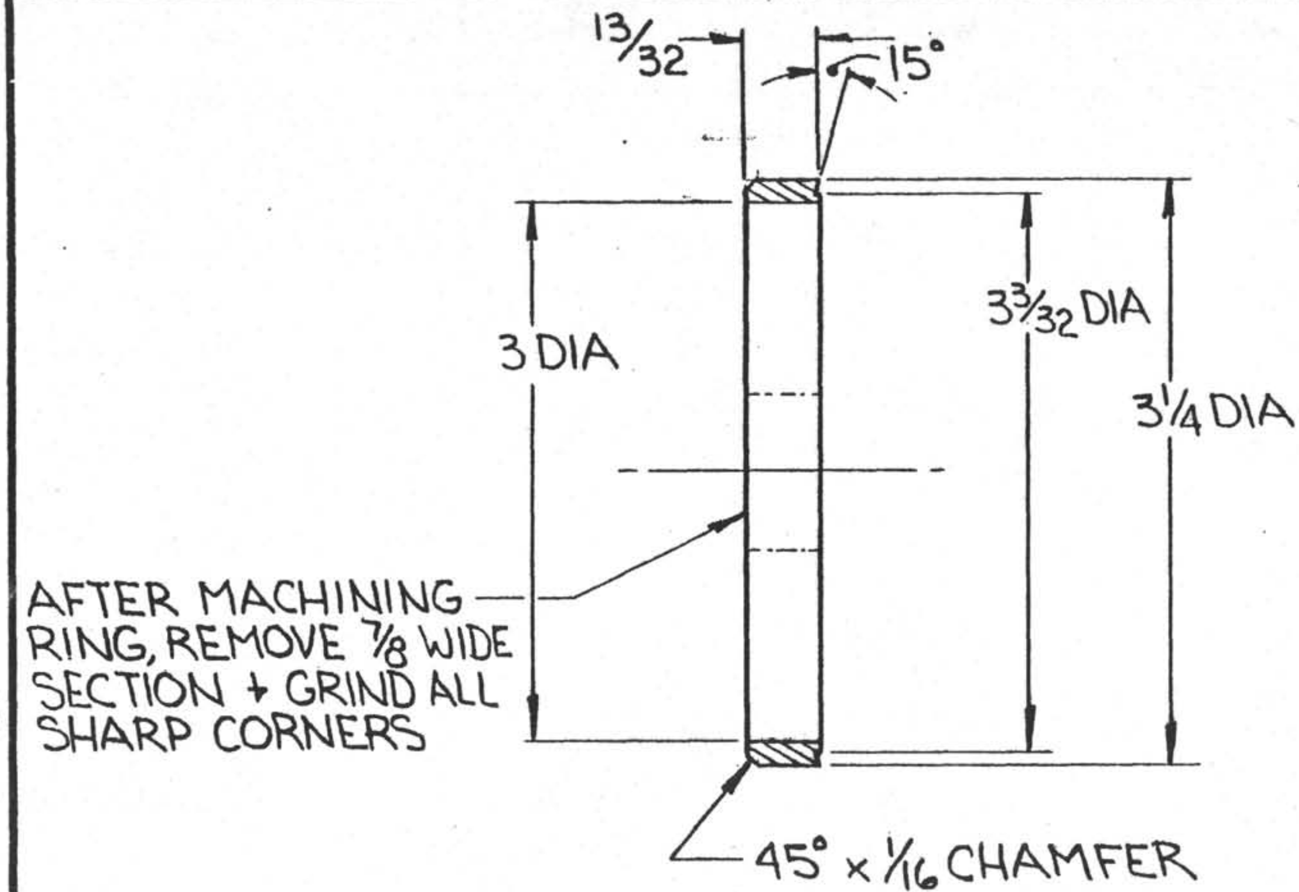
UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.

SCALE FULL
DATE 5-7-79
DRAWN BY RK

OUTER BODY ~ BVA - PCB II-III

PART No. OP 4549-6
DRAWING NUMBER R-OP4549-6


NO | REV | DATE
1 | MAT'L CHANGED | —
2 | 15 7/8 WAS 16 9/16, 100° WAS 110° | 4.21.80
3 | 1/4 WAS 3/8, 15 3/8 WAS 15 7/8, 5/16 WAS 9/16 | 9.10.80
4 | 15 5/8 WAS 15 3/8, 1/2 WAS 1/4 | 9.25.80
SOFT SOLDER WAS SILVER SOLDER
SOFT SOLDER
SEE DOG DETAIL
15 5/8
1 1/2
15/16
1/2
100° TYP
1/32 SAW CUT
(TYP 4 PLC)
5/8
A
ENGRAVE: OP 4550-4
MAT'L: ANY AVAILABLE STAINLESS STEEL
+.010 -.000
2.250 D
+.000 -.010
2.375 D
1 7/8 R
1/8
5/16
LEAD DOG DETAIL
3/8
7° ±1°
UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.
SCALE: FULL
APPROVED BY:
DRAWN BY RK
DATE: 1.25.79
REVISED
CATCHER SLEEVE ~ PCB II-III BVA
P/N OP 4550-4
DRAWING NUMBER
B-OP4550-4



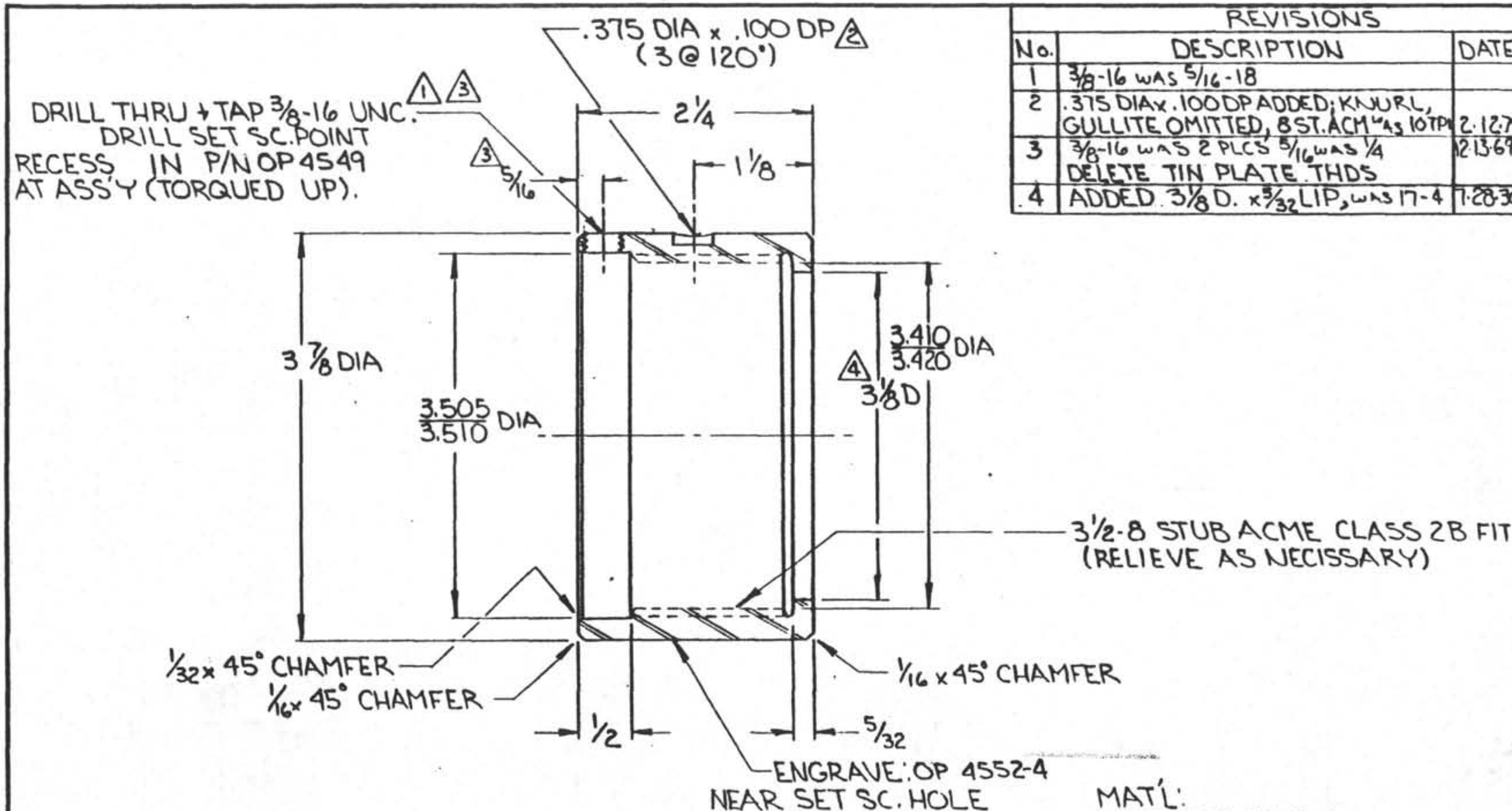
P/N: OP4551

MAT'L: 17-4 PH CONDITION H-1025

TOLERANCES (EXCEPT AS NOTED)	REVISIONS NO.	DATE	BY	SNAP RING ~ BVA - PCB II-III		
DECIMAL ±	1			UNIV OF CALIF DEEP SEA DRILLING PROJ.		
	2					
FRACTIONAL ± 1/64	3			DRAWN BY RK	SCALE FULL	MATERIAL
ANGULAR	4			CHK'D [illegible]	DATE	DRAWING NO.
±	5			TRACED	APP'D	A-OP4551

TELEDYNE POST 18AE-01E-8½X11

OP4551



REVISIONS					
No.	DESCRIPTION	DATE	BY	CH.	AP.
1	3/8-16 WAS 5/16-18			JAC	
2	.375 DIA x .100 DP ADDED; KNURL, GULLITE OMITTED, 8 ST. ACM WAS 10 TPI	2.12.79	RK	JAC	
3	3/8-16 WAS 2 PLCS 5/16 WAS 1/4 DELETE TIN PLATE THDS	12.13.69	RK	[illegible]	
4	ADDED 3 1/8 D. x 3/32 LIP, WAS 17-4	7.28.80	RK	[illegible]	

MAT'L:
NITRONIC 60

TOLERANCES
FRAC. = 1/64 IN DIRECTION OF MACHINING

NOTE: –
BREAK ALL SHARP EDGES
RADIUS ALL [illegible]

UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.

SCALE: FULL	APPROVED BY: JAC		DRAWN BY RK
DATE: 2-12-79			REVISED

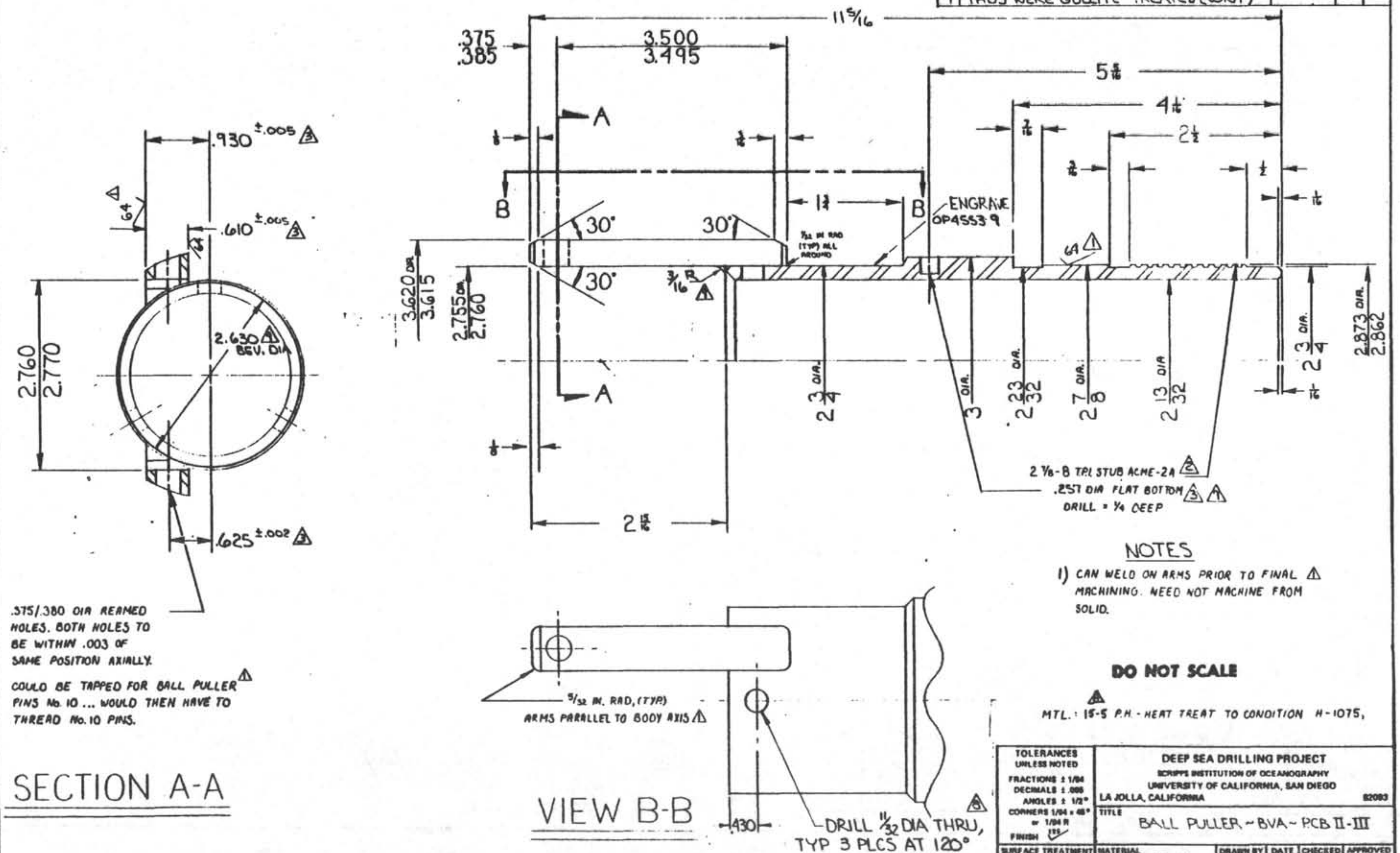
RETAINER RING ~ BVA-PCB II-III

PART No. OP 4552-4 — DRAWING NUMBER B-OP4552-4

11217 PRINTED ON NO. 1000H CLEARPRINT

REVISIONS (CON'T)					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
7	NOTE 2 WAS 5 5/16, .257 WAS 7/16	5·16·80	RK		
8	DELETE .189 DIA HOLES, ADD 11/32 HOLES	8·11·80	RK		
9	ADD 2.630 BEV DIA, 3/16 R WAS 3/64 R	9·25·80	RK		

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	ADDED: "THRU DRILL," COULD BE TAPPED, ARMS PARALLEL &	6·18·78	RK		
2	8TPI WAS 10TPI STRAIGHT RD	5·22·71	RK		
3	.930 WAS .905/.915, .625 WAS .620/.630, 7/16 D WAS 2 PLCS 3/32 / 1/8 MILL NOTE REVISED	12·13·71	RK		
4	1/8 THRU WAS 1/8 x 1/8 DP + 3/32 THRU	4·25·80	RK		
5	.187 WAS 1/8	5·1·80	RK		
6	REAM .189 WAS DRILL .187	5·7·80	RK		
7	THDS WERE GULLITE TREATED (CONT)				



NOTES

1) CAN WELD ON ARMS PRIOR TO FINAL MACHINING. NEED NOT MACHINE FROM SOLID.

DO NOT SCALE

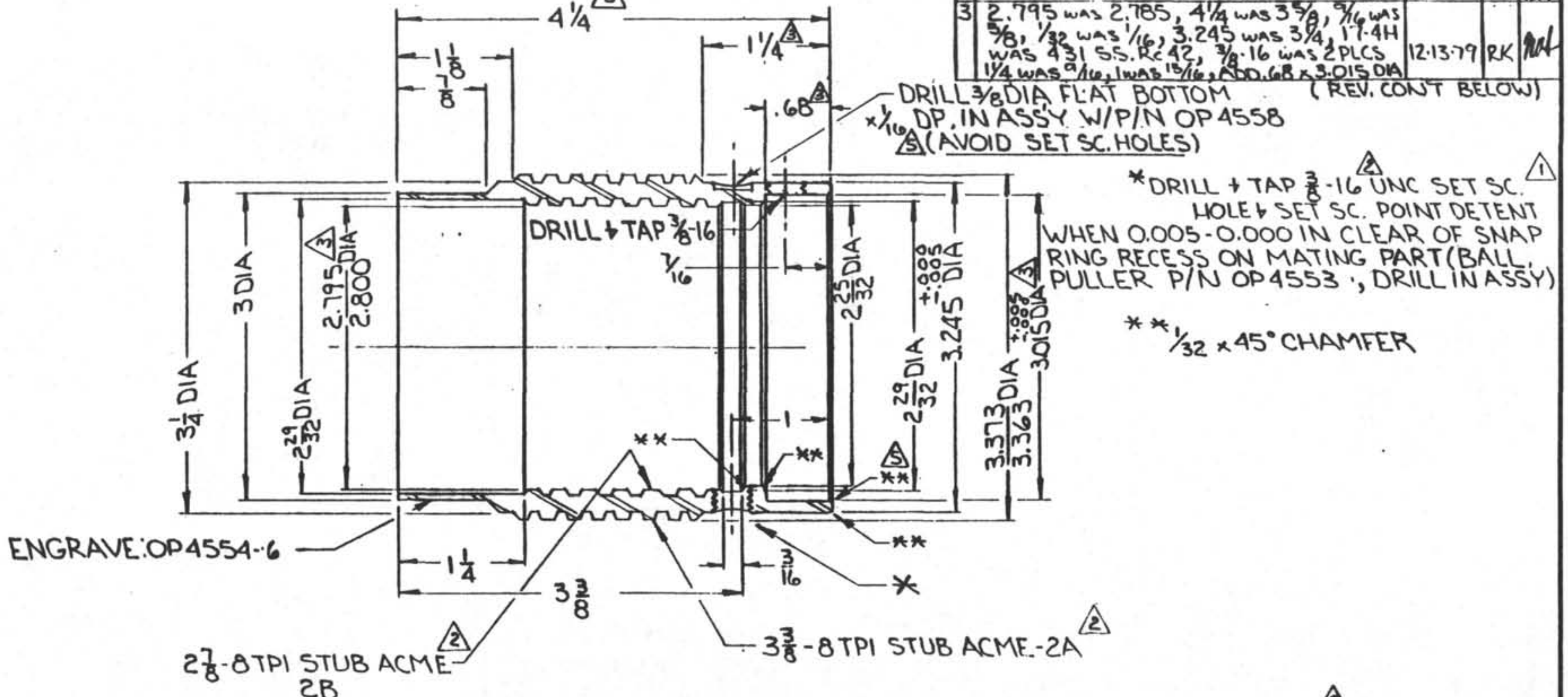
MTL.: 15-5 P.H. - HEAT TREAT TO CONDITION H-1075,

TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE: BALL PULLER ~ BVA ~ PCB II-III				
SURFACE TREATMENT: SEE DWG	MATERIAL: SEE DWG	DRAWN BY: LEE S.	DATE: FEB 71	CHECKED: RK	APPROVED:
HEAT TREATMENT: SEE DWG	PART NO. OP4553-9	SIZE DRG. NO. C-OP4553-			REV. 9

UNLESS NOTED,
ALL ANGLES 45°; TOLERANCE ON FRACTIONS 1/64 INCH IN DIRECTION OF MACHINING.

	REVISIONS			
1	ADDED: "ALSO DRILL" NOTE, Rc42.	6.20.78	RK	[illegible]
2	3/8-16 was 5/16-18, 8 STUB ACME was 10 RD THD	5.7.79	RK	[illegible]
3	2.795 was 2.785, 4 1/4 was 3 5/8, 9/16 was 5/8, 1/32 was 1/16, 3.245 was 3/4, 17-4H was 431 S.S. Rc 42, 3/8-16 was 2 PLCS 1 1/4 was 9/16, 1 was 13/16, ADD .68 x 3.015 DIA	12.13.79	RK	[illegible]

(REV. CON'T BELOW)



*DRILL + TAP 3/8-16 UNC SET SC. (2) HOLE + SET SC. POINT DETENT WHEN 0.005-0.000 IN CLEAR OF SNAP RING RECESS ON MATING PART (BALL PULLER P/N OP4553 ; DRILL IN ASSY) (1)

** 1/32 x 45° CHAMFER

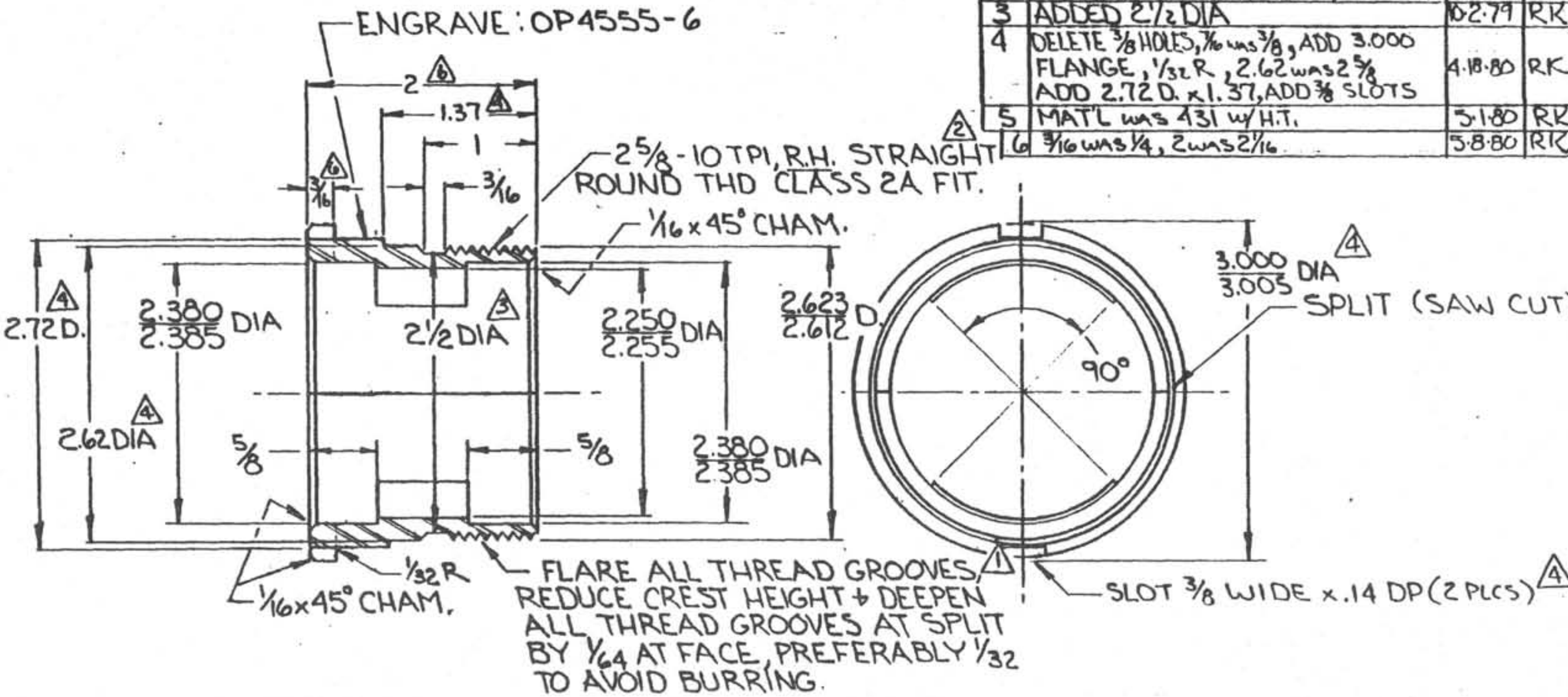
NO.	REVISIONS (CON'T)	BY	DATE	AP.
4	DELETE 4-3/8 HOLES, 3/8 FLT. BOTTOM WAS 4@90°, 1/16 WAS 5/32	RK	5.1.80	[illegible]
5	1/32 X 45° CHAM WAS .06 x 30° CHAM	RK	5.8.80	[illegible]
6	ADD. 3/8-16 HOLE	RK	9.23.80	[illegible]

MAT'L: 17-4 PH H.925 (3)

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: 1:1	APPROVED BY: [signature]	DRAWN BY RK
DATE: 4/18/79		REVISED 4/18/79
Title: SNAP RING RETAINER - BVA		
PART No. OP4554-6		DRAWING NUMBER B-OP4554-6

All Angles 45°; Tolerance On Fractions 1/64 in. In Direction of Machining.

REVISIONS					
No.	DESCRIPTION	DATE	BY	CH	AP
1	THD. NOTE ADDED	6-21-78	RK	[illegible]	[illegible]
2	TIN PLATE NOTE ADDED, 2A WAS 1A	2-13-79	RK	[illegible]	[illegible]
3	ADDED 2½ DIA	10-2-79	RK	[illegible]	[illegible]
4	DELETE ⅜ HOLES, 7/16 was ⅜, ADD 3.000 FLANGE, 1/32 R, 2.62 was 2⅝ ADD 2.72 D. x 1.37, ADD ⅜ SLOTS	4-18-80	RK	[illegible]	[illegible]
5	MAT'L was 431 w/H.T.	5-1-80	RK	[illegible]	[illegible]
6	3/16 was 1/4, 2 was 2 1/16	5-8-80	RK	[illegible]	[illegible]



NOTE:
ROUGH MACHINE TO 2 3/16 I.D. x 2 7/8 O.D.
SPLIT LENGTH WISE + MILL FLATS SMOOTH.
TACK WELD TOGETHER AGAIN + FINISH MACHINING.
SPLIT AGAIN + GRIND WELDS SMOOTH.

MAT'L:
17-4 PH SS H 1075

TOLERANCES
FRAC = 1/64 IN DIRECTION OF MACHINING

UNIV. OF CALIF
DEEP SEA DRILLING PROJ.

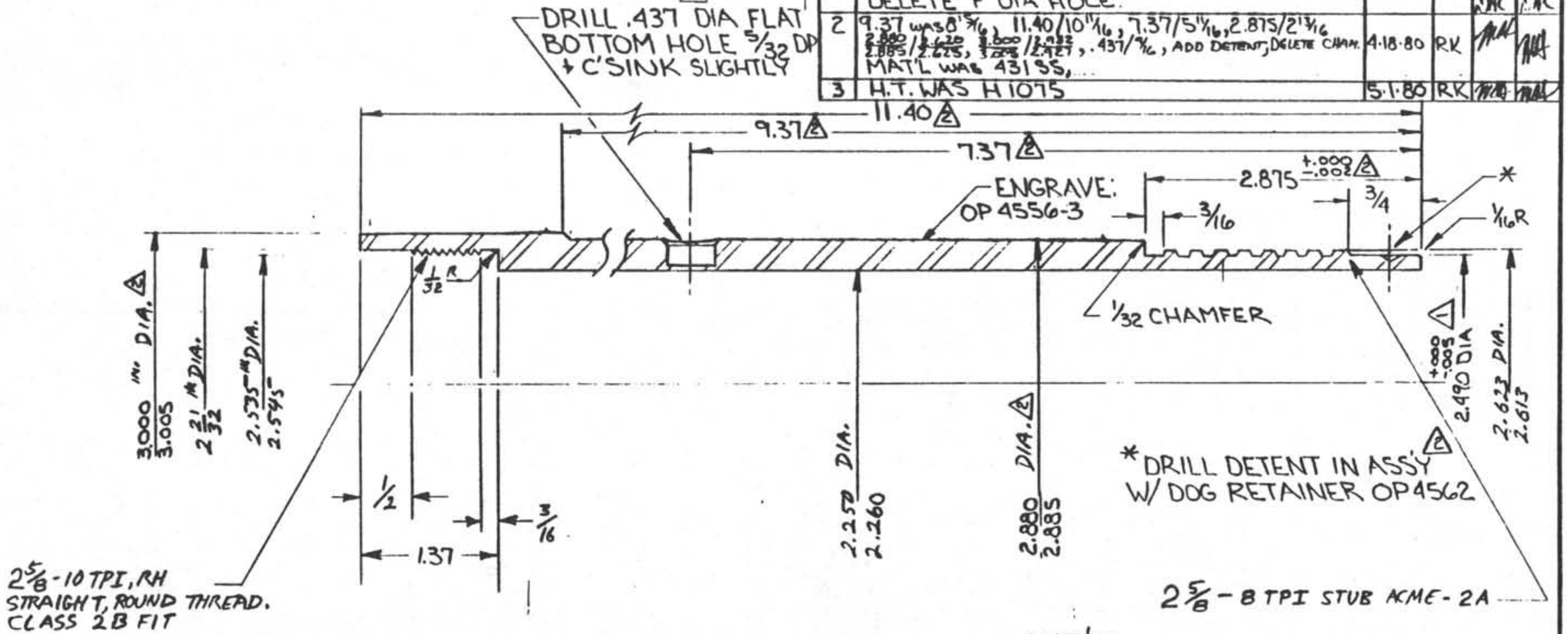
SCALE: FULL
DATE: 2-12-79
APPROVED BY: [illegible]
DRAWN BY
REVISED

SPLIT RETAINER NUT ~ BVA-PCB II-III

PART No. OP 4555-6
DRAWING NUMBER B-OP4555-6

-168-

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	3/8-16 WAS 5/16-18 ; 2.490 +.000 -.005 WAS 2 1/2 DELETE 'F' DIA HOLE.	6.12.79	RK		
2	9.37 was 8 13/16, 11.40/10 11/16, 7.37/5 11/16, 2.875/2 13/16, 2.880/2.885 / 2.620/2.625, 3.000/3.005 / 2.932/2.927, .437/7/16, ADD DETENT; DELETE CHAM. MAT'L WAS 431SS, ...	4.18.80	RK		
3	H.T. WAS H1075	5.1.80	RK		



MAT'L:
17-4PH H925 COND.

REVISIONS - CONT					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
4					

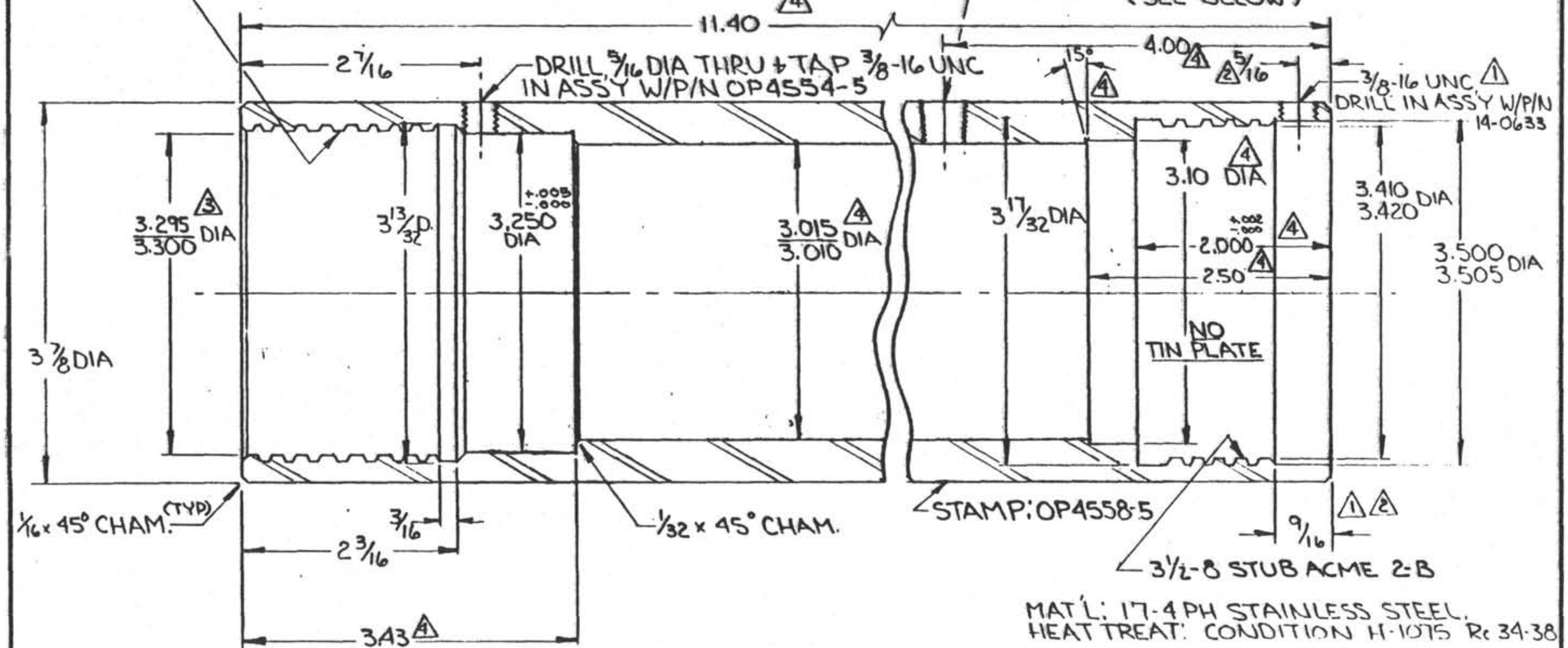
UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.

SCALE: 1:1	APPROVED BY:	DRAWN BY DRW 2.17.77
DATE: 4/17/79		REVISED 4/17/79
TITLE: INNER EXTENSION BODY ~ BVA - PCB II-III		
PART No. OP 4556-3		DRAWING NUMBER B-OP4556-3

NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

ALL ANGLES 45°; TOLERANCE ON FRACTIONS ± 1/64

No.	DESCRIPTION	DATE	BY	CH
1	3/8-16 ADDED, 1/2 WAS 1/8	6-20-78	RK	
2	5/16 WAS 1/4, 7/16 WAS 1/2, S. ACME WAS 3 1/2-10 (SEE BELOW)	5-22-79	RK	



MAT'L: 17-4 PH STAINLESS STEEL.
HEAT TREAT: CONDITION H-1075 Rc 34-38

REVISIONS

3	3.295/3.300 WAS 3.285/3.295, ADDED ROLL PIN	12-15-79	RK	
4	3.015/3.010 WAS 3.385/3.390, 1/4 NPT WAS 9/16-12 UNC, 11.40 WAS 11 3/16, ADDED ALL OTHER 4	4-21-80	RK	
5	DELETE TIN PLATE THDS	5-15-80	RK	

All Angles ±.5°; Tolerance on Fractions ± 1/64 IN. IN Direction of Machining

UNIV. OF CALIF.
DEEP SEA DRILLING PROJ

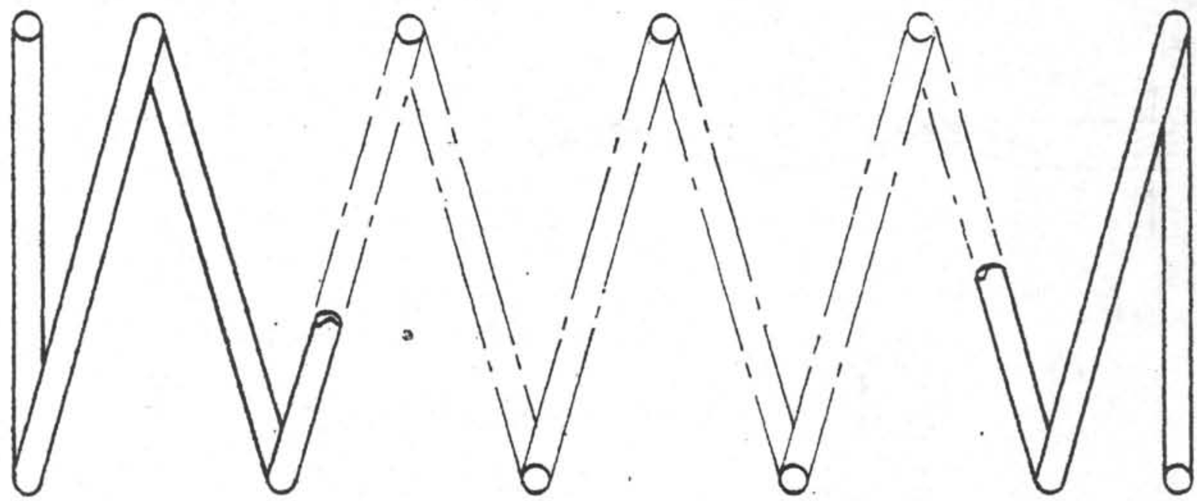
SCALE: 1:1	APPROVED BY:	DRAWN BY P.K.
DATE: 4/18/77		REVISED 9/13/79

~ OUTER EXTENSION BODY ~ BVA
PCB II-III

PART No OP 4558-5 | DRAWING NUMBER B-OP4558-5

REVISIONS

NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	3.20 WAS 3.172, 2.82 WAS 3.788, 2.817 WAS 2.766, 3.250 WAS 3.264, ENDS WERE PLAIN	12.15.79	RK		
2	5.5 WAS 7.7, 2.25 WAS 5.45, REDRAWN	9.4.80	RK		



WIRE: USSWG #6 GAGE (.192 DIA) △1
ENDS CLOSED & GROUND
FREE LENGTH: 5.5 IN △2 PITCH 1.711 IN/COIL
UNLOADED O.D: 3.204 IN.
" I.D. 2.82 IN. △1
" MEAN DIA 2.980 IN.
TO WORK OVER 2.817 DIA ROD.
TO WORK IN 3.250 DIA CYL △1
MAX LOAD 82 LB, MAX COMPRESSION 2.25 IN △2

DO NOT SCALE

CONCENTRICITY ALL DIAMETERS: TIR .003

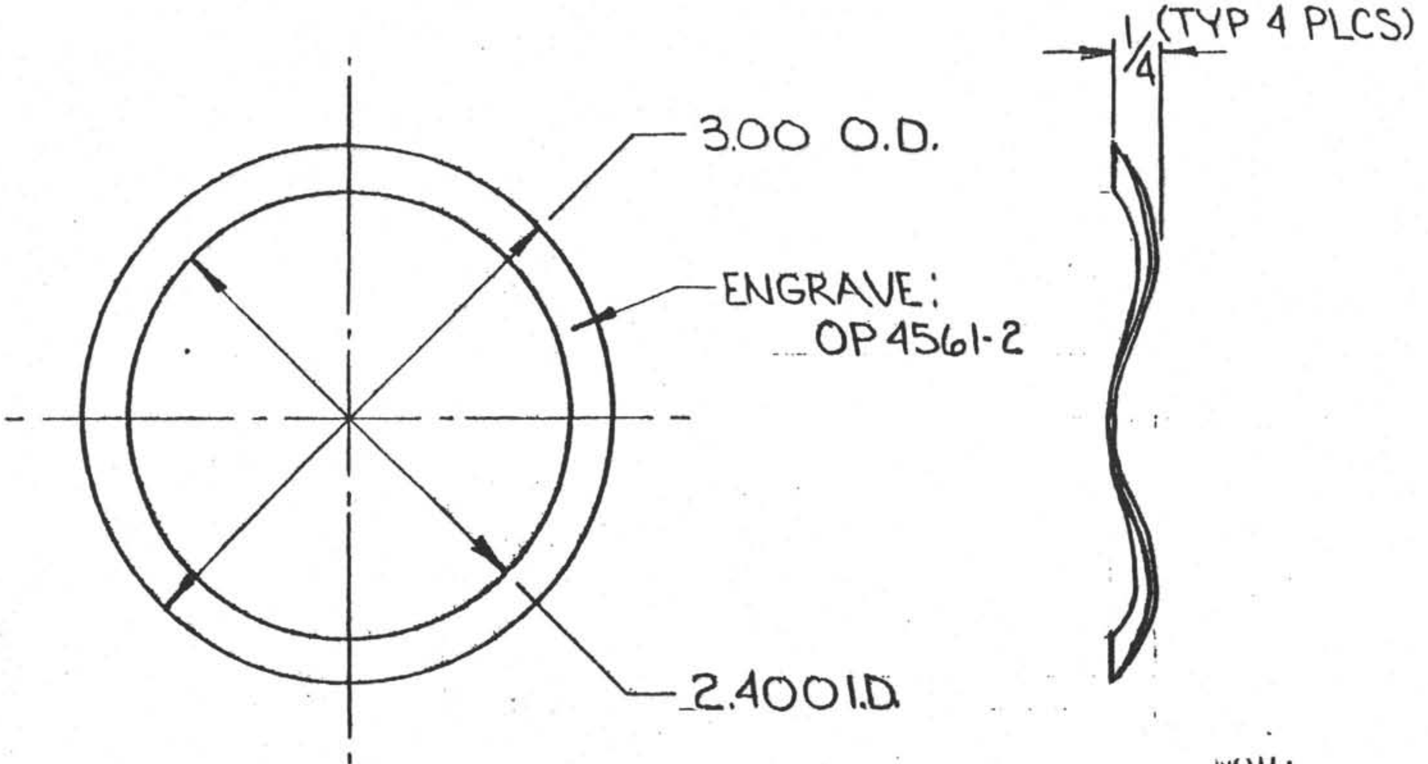
TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE: COMPRESSION SPRING PCB II-III (BVA)

SURFACE TREATMENT	MATERIAL	DATE	BY	CHECKED	APPROVED
⊖	17-7 PH S.S.	9.4.80	RK	[signature]	

HEAT TREATMENT	SCALE	REQ'D/ASS'Y	PART NO.	DWG. NO. (REV.)
⊖	1-1	1	OP4560-2	A-OP4560-2

	REVISIONS			
1	WAVE PROFILE REDRAWN	1·2·80	RK	[illegible]
2	2.400 WAS 2 1/4	4·21·80	RK	

OP4561



NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

MAT'L: Be Cu 1/16 THK

TOLERANCES
UNLESS OTHERWISE SPECIFIED

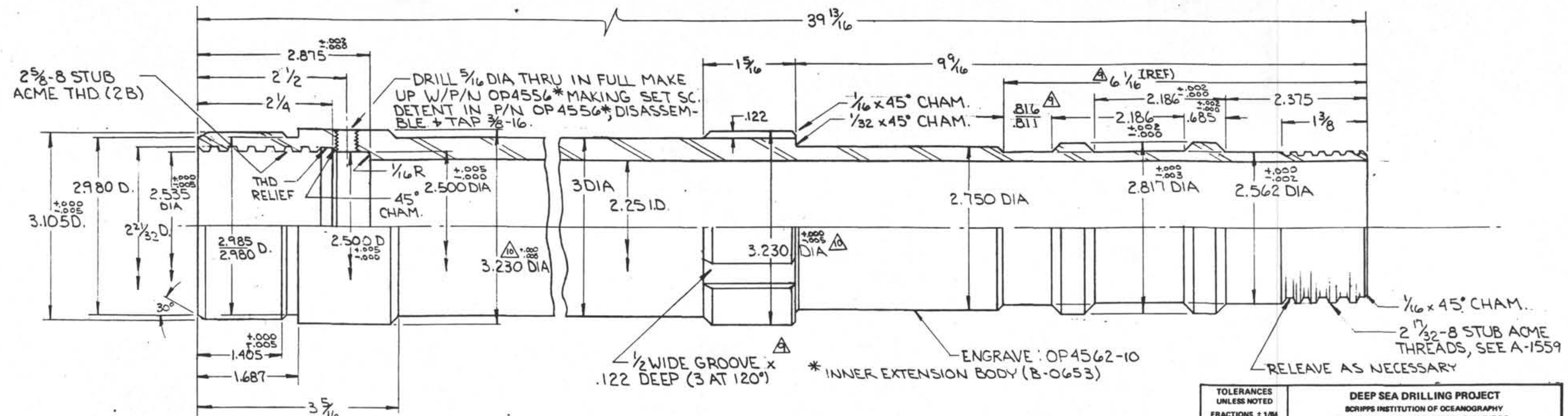
.X = ±.1
.XX = ±.01
.XXX = ±.001

ANGLES ±30′

UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: FULL	APPROVED BY: [signature]	DRAWN BY RK
DATE: 1-25-79		REVISED
WAVY WASHER "TYPE B" ~ PCB MOD II (BVA)		
PART No. OP4561-2		DRAWING NUMBER A-OP4561-2

8½ X 11 PRINTED ON NO. 1000H CLEARPRINT

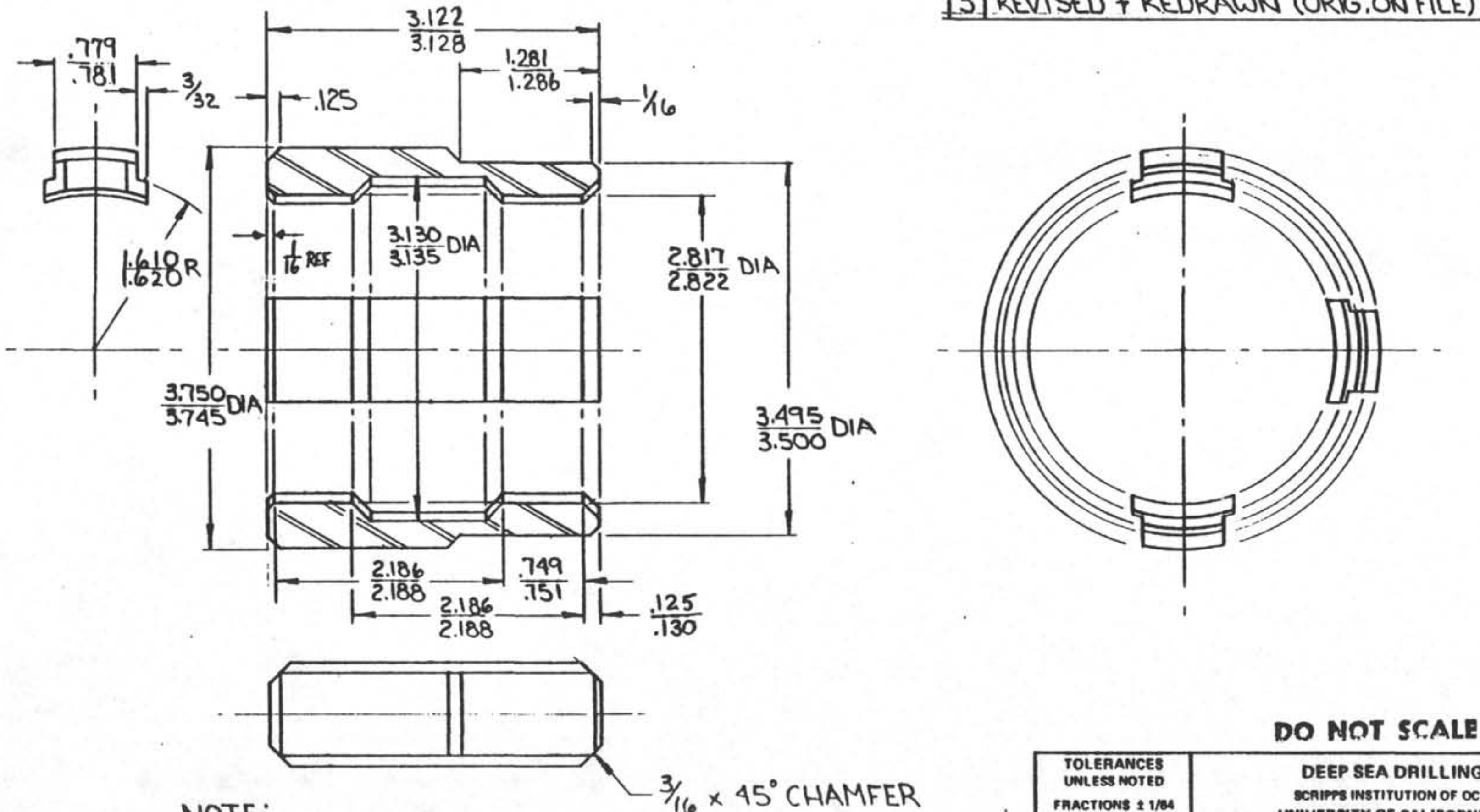
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
8	REVISED + REDRAWN (ORIG. ON FILE)	8-1-80	RK		
9	ADDED: GROOVES, .816/.811, 1.405 was 1.420, 6 1/16 was 5 31/32	9-3-80	RK		
10	3.230 DIA was 3.245	9-25-80	RK	[illegible]	[illegible]



NOTICE: UNLESS NOTED ANGLES ARE 45°

TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE: DOG RETAINER BVA - PCB II-III				
SURFACE TREATMENT: SEE NOTE	MATERIAL: 15-5PH SS	DRAWN BY: RK	DATE: 8-1-80	CHECKED: [illegible]	APPROVED:
HEAT TREATMENT: H-1100, Rc32-36	PART NO.: OP4562-10	SIZE DWG. NO.: R-OP4562-			REV.: 10

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
3	REVISED + REDRAWN (ORIG. ON FILE)	8-5-80			

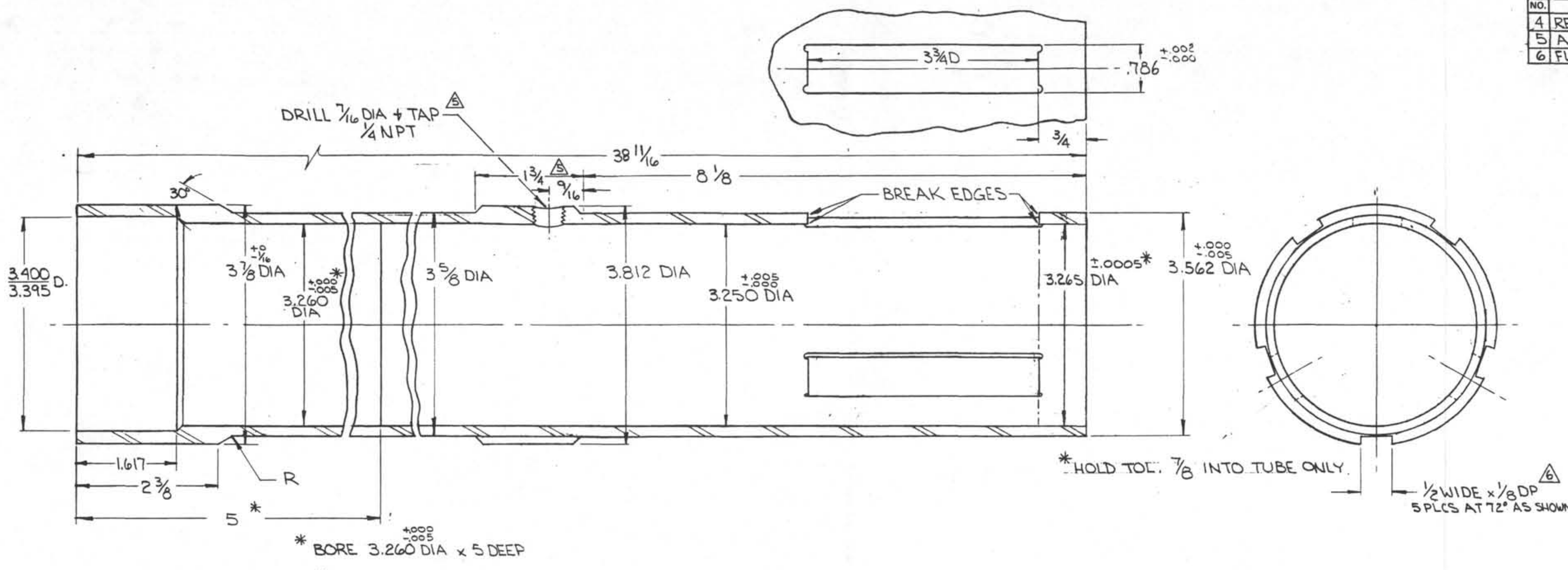


NOTE:
1) ALL ANGLES 45°.
2) CUT ALL DOGS FROM SAME CYLINDER FOR UNIFORMITY.
3) ALL SURFACES 32-64 ✓

DO NOT SCALE

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 × 45° or 1/64 R FINISH 125 ✓	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE: DOGS BVA-PCB II-III					
SURFACE TREATMENT: PHOSPHATE	MATERIAL: 4140 ALLOY	REQ'D: 3	DRAWN BY: RK	DATE: 8-5-80	CHECKED: GHC	APPROVED: BWA
HEAT TREATMENT: 45 Rc	PART NO.: OP4563-3		SIZE DWG. NO.: B-OP4563-			REV.: 3

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
4	REVISED + REDRAWN (ORIG. ON FILE)	8-6-80	RK		
5	ADD: 1/4 NPT, 1 3/4 WAS 1 1/8	9-3-80	RK		
6	FLUTES ADDED	11-14-80	RK		



CONCENTRICITY
ALL DIAMETERS
TIR .003

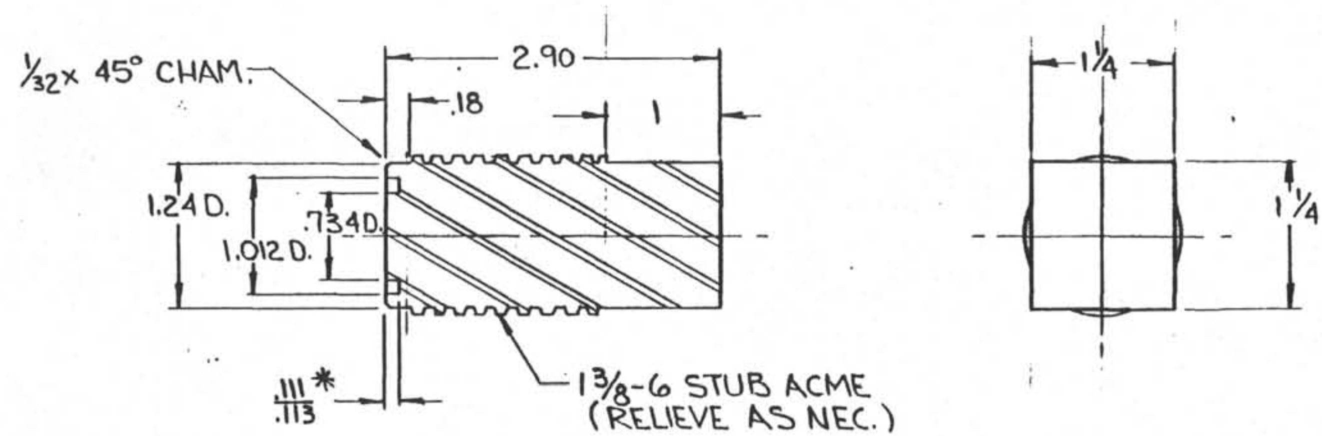
NOTE: —
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

DO NOT SCALE

TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE DOG CAGE ~ BVA - PCB ~				
SURFACE TREATMENT	MATERIAL 4130 TUBE	DRAWN BY RK	DATE 7-31-80	CHECKED	APPROVED
HEAT TREATMENT Rc 30-32	PART NO. OP 4564-6	SIZE DWG. NO. R-OP4564-			REV. 6

REVISIONS

NO.	DESCRIPTION	DATE	BY	CH.	APR.



* FOR O-RING # 2-210

NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

DO NOT SCALE

CONCENTRICITY ALL DIAMETERS: TIR .003

TOLERANCES UNLESS NOTED
FRACTIONS ± 1/64
DECIMALS ± .005
ANGLES ± 1/2°
CORNERS 1/64 x 45° or 1/64 R
FINISH 125

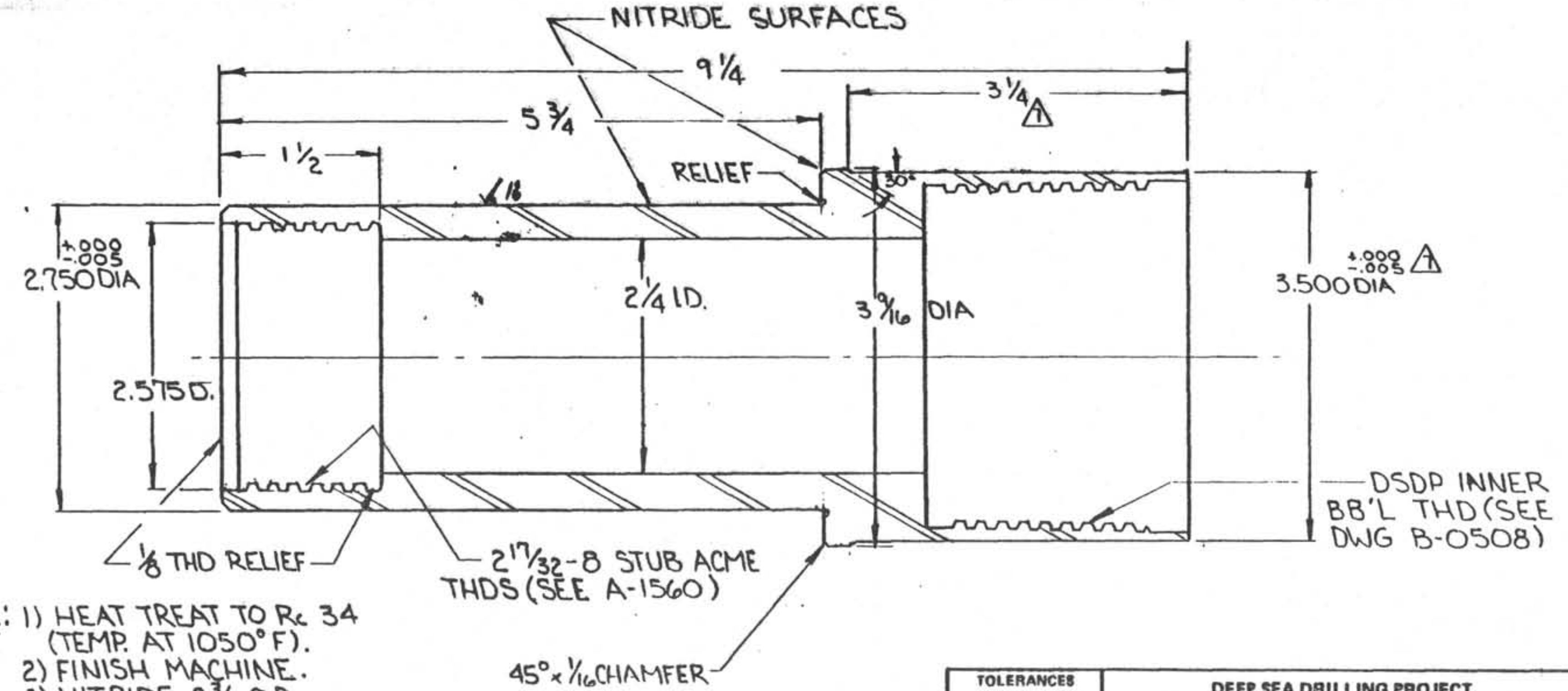
DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA, SAN DIEGO
LA JOLLA, CALIFORNIA 92093

TITLE: SAMPLER SUB TEST PLUG ~ PCB ~

SURFACE TREATMENT | MATERIAL: STAIN. STEEL | DATE: 9-16-80 | BY: R.K. | CHECKED | APPROVED

HEAT TREATMENT | SCALE: 1:1 | REQ'D/ASS'Y: 1 | PART NO.: OP4565- | DWG. NO.: 80P4565 | (REV.)

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
6	REVISED & REDRAWN	9.3.80	RK		
7	ADDED 3.500 DIA x 3¼	9.3.80	RK		



NOTE: 1) HEAT TREAT TO Rc 34 (TEMP. AT 1050° F).
2) FINISH MACHINE.
3) NITRIDE 2¾ O.D. INCLUDING SHOULDER. "STOP OFF" OTHER SURFACES.

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
	TITLE BOTTOM CONNECTION ~BVA - PCB II-III				
SURFACE TREATMENT PHOSPHATE	MATERIAL 4140/4135	DRAWN BY RL	DATE 8.8.80	CHECKED [illegible]	APPROVED BVA
HEAT TREATMENT SEE NOTE	PART NO. OP4566-7	SIZE DWG. NO. B-OP4566-			REV. 7

NO.	DWG. NO.	PART NO.	DESCRIPTION	REQD
1	B-OP4546	OP4546	BALL	1
2	B-OP4548	OP4548	BALL CAGE	1
3	R-OP4549	OP4549	OUTER BODY	1
4	B-OP4587	OP4587	SEAT	1
5	A-OP4568	OP4568	SPACER RING	2
6	R-OP4541	OP4541	TOP CONNECTION	1
7	B-OP4600 & 07	OP4600 & 07	8 OR 10 FINGER CORE CATCHER	1
8	B-OP4547	OP4547	BALL SUPPORT	1
9	C-OP4553	OP4553	BALL PULLER	1
10	A-OP4545	OP 4545	PULLER PINS	1
11	B-OP4545	OP 4552	RETAINER RING	1
12	A-OP4551	OP 4551	SNAP RING	1
13	B-OP4554	OP 4554	SNAP RING RETAINER	1
14	B-OP4558	OP4558	OUTER EXTENSION BODY	1
15	A-OP4622	OP4622	SPRING RING	1
16	B-OP4620	OP4620	COLLET SLEEVE	1
17	B-OP4562	OP4562	DOG RETAINER	1
18	B-OP4556	OP4556	INNER EXTENSION BODY	1
19	B-OP4555	OP4555	SPLIT RETAINER NUT	1
20	B-OP4550	OP4550	CATCHER SLEEVE	1
21	B-OP4566	OP4566	BOTTOM CONNECTION	1
22	A-OP4639	OP4639	DISK SPRINGS	
23	B-OP4564	OP4564	DOG CAGE	1
24	B-OP4563	OP4563	DOGS	3
25	———	OP4597	O-RING 2-210 (BUNA N)	1
26	———	OP4595	SET SCREWS 3/8-16 x 1/4 LG.	3
27	A-OP4618	OP4618	SPACER-CORE CATCHER	1
28	———	OP4591	O-RING # 2-337, PARBAK # 8-337	1 & 2
29	———	OP4570	SHEAR PIN 1/8 D x .500 L ALUM	7
30	B-OP4617	OP4617	2 1/4" CORE CATCHER SUB	1
31	A-OP4560	OP4560	SPRING, COMPRESSION	1
32	A-OP4561	OP4561	WAVY WASHER	2
33	———	OP4517	O-RING # 2-037 (TEFLON)	1
34	———	OP4543	SPIROLOX RETAINER RING	1
35	———	OP4598	SET SCREWS 3/8-16 x .37 LG. (NYLOC)	3
36	———	OP4536	LOCKING BALLS, 5/16 DIA	3
37	A-OP4621	OP4621	DOG CAGE CAP	1

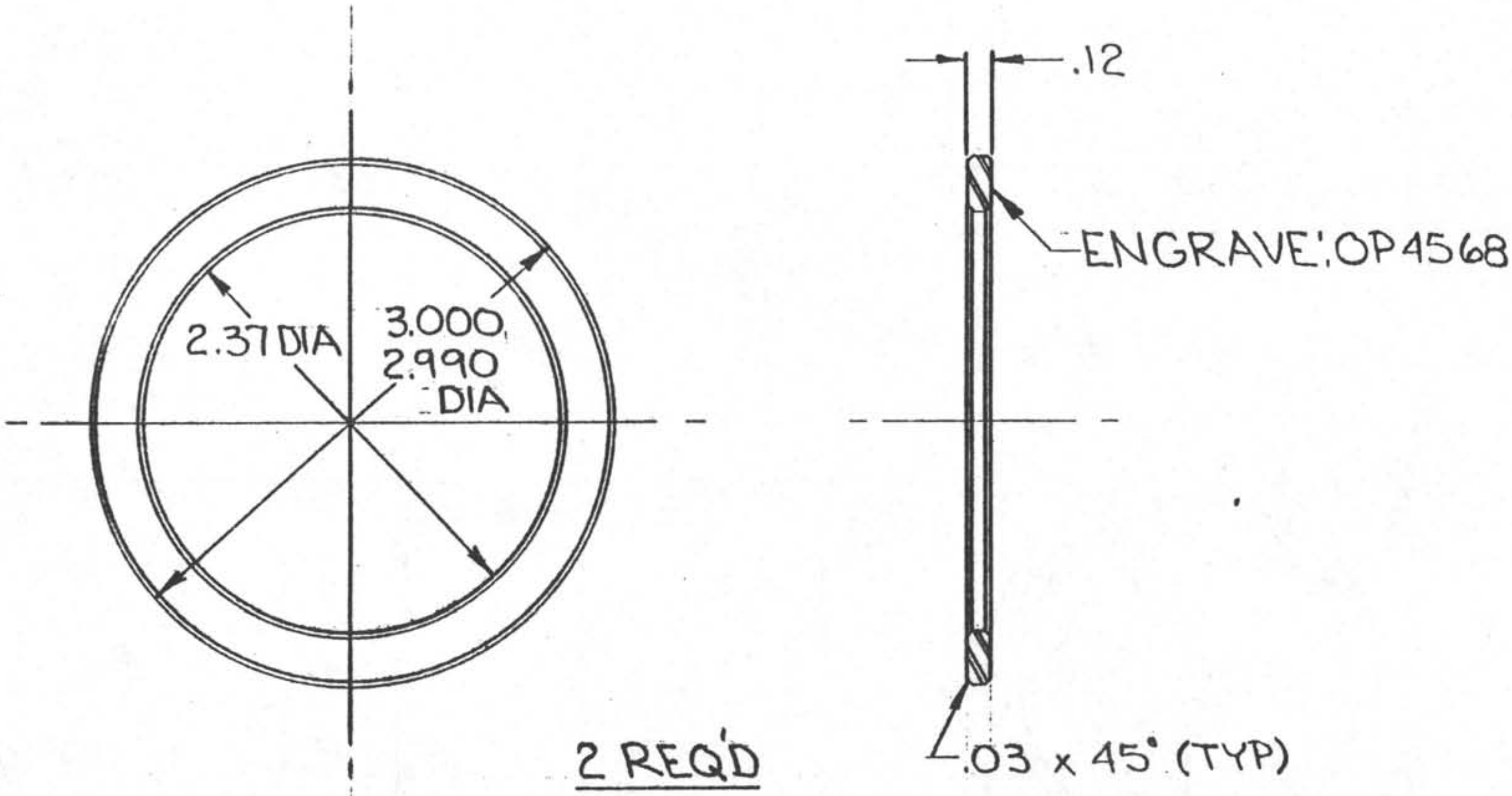
TOLERANCES UNLESS NOTED
FRACTIONS ± 1/64
DECIMALS ± .005
ANGLES ± 1/2°
CORNERS 1/64 x 45°
OR 1/64 R
FINISH 125

DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA, SAN DIEGO
LA JOLLA, CALIFORNIA 92093

TITLE: STEPS FOR BALL VALVE ASSEMBLY - P.C.B. II-III

SURFACE TREATMENT	MATERIAL	DRAWN BY	DATE	CHECKED	APPROVED
—⊖—	—⊖—	RK	1/21/80		

HEAT TREATMENT	PART NO.	SIZE DWG. NO.	REV.
—⊖—	OP4567	R-OP4567-	0



OP4568

2 REQ'D

MAT'L:
316 STAINLESS STEEL

DO NOT SCALE

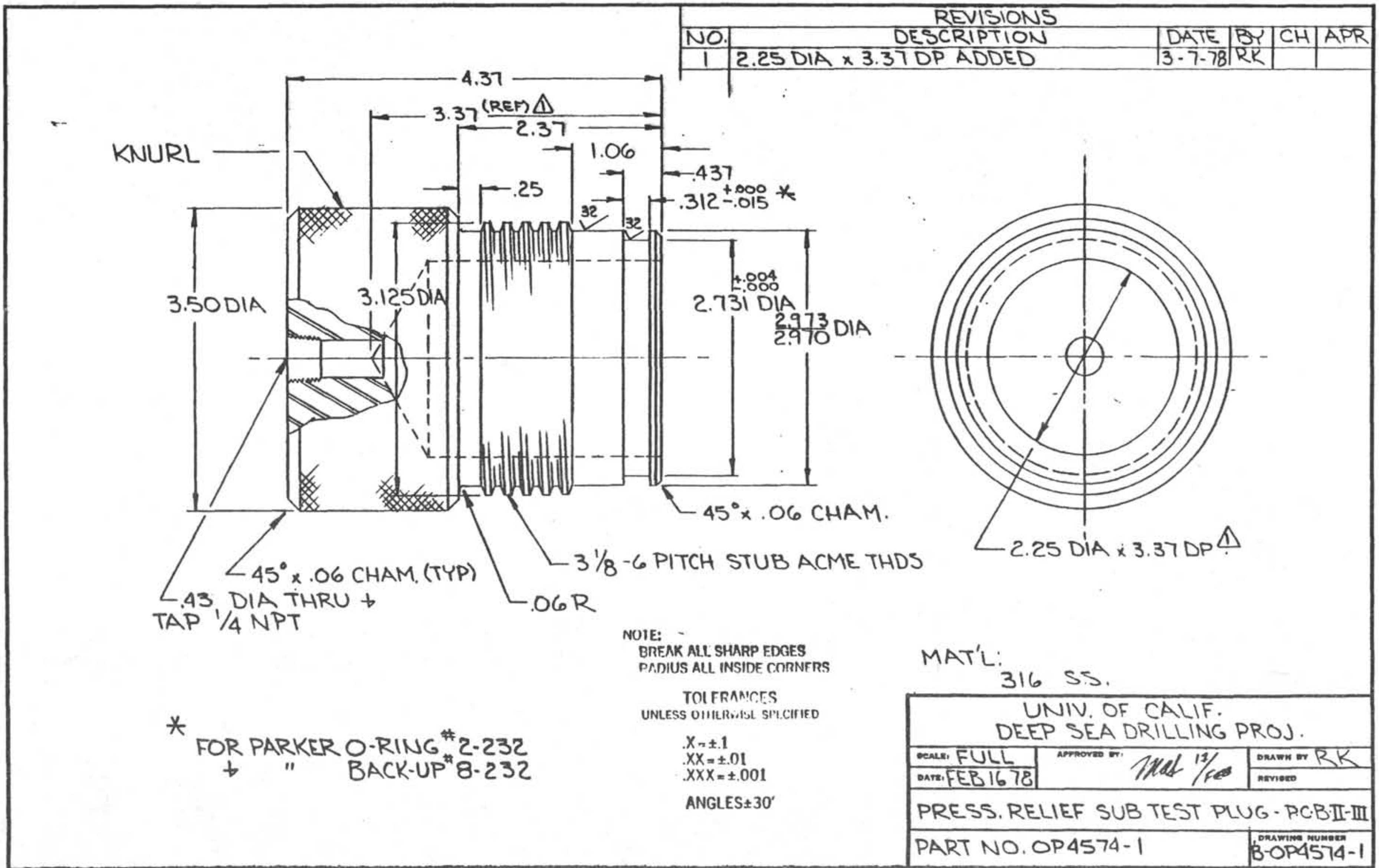
TOLERANCES
UNLESS OTHERWISE SPECIFIED

.X = ±.1
.XX = ±.01
.XXX = ±.001

ANGLES ±30'

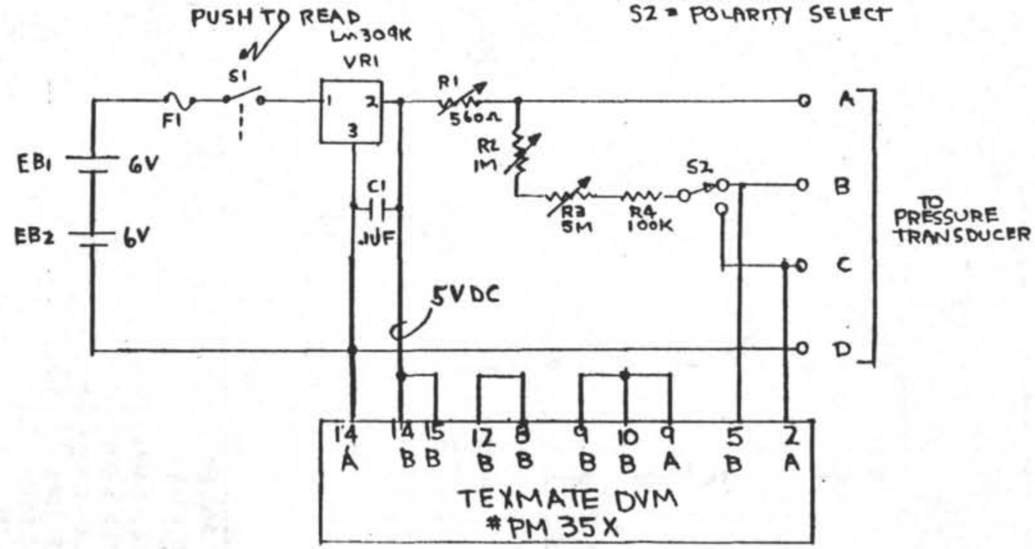
UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
SCALE: FULL DATE:	APPROVED BY: L.R. # [signature] 1/12/78	DRAWN BY RK REVISED
SPACER RING · PCB MOD II		
PART NO OP4568		DRAWING NUMBER A-OP4568

8½ X 11 PRINTED ON NO. 1000H CLEARPRINT

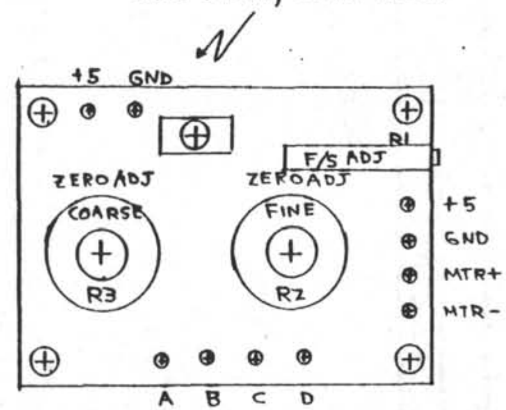

REVISIONS
NO. DESCRIPTION DATE BY CH APR
1 2.25 DIA x 3.37 DP ADDED 3-7-78 RK
4.37
3.37 (REF) 1
2.37
1.06
.437
.312 +.000 -.015 *
.25
32
32
KNURL
3.50 DIA
3.125 DIA
+.004 -.000
2.731 DIA
2.973/2.970 DIA
45° x .06 CHAM.
45° x .06 CHAM. (TYP)
3 1/8 -6 PITCH STUB ACME THDS
2.25 DIA x 3.37 DP 1
.43 DIA THRU + TAP 1/4 NPT
.06 R
NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS
TOLERANCES
UNLESS OTHERWISE SPECIFIED
.X = ±.1
.XX = ±.01
.XXX = ±.001
ANGLES ±30'
MAT'L:
316 SS.
* FOR PARKER O-RING # 2-232
+ " BACK-UP # 8-232
UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.
SCALE: FULL
DATE: FEB 16 78
APPROVED BY:
DRAWN BY RK
REVISED
PRESS. RELIEF SUB TEST PLUG - PCB II-III
PART NO. OP4574-1
DRAWING NUMBER B-OP4574-1

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.

R1 = FULL SCALE ADJUST
R2 = FINE ZERO ADJUST
R3 = COARSE " "
S2 = POLARITY SELECT



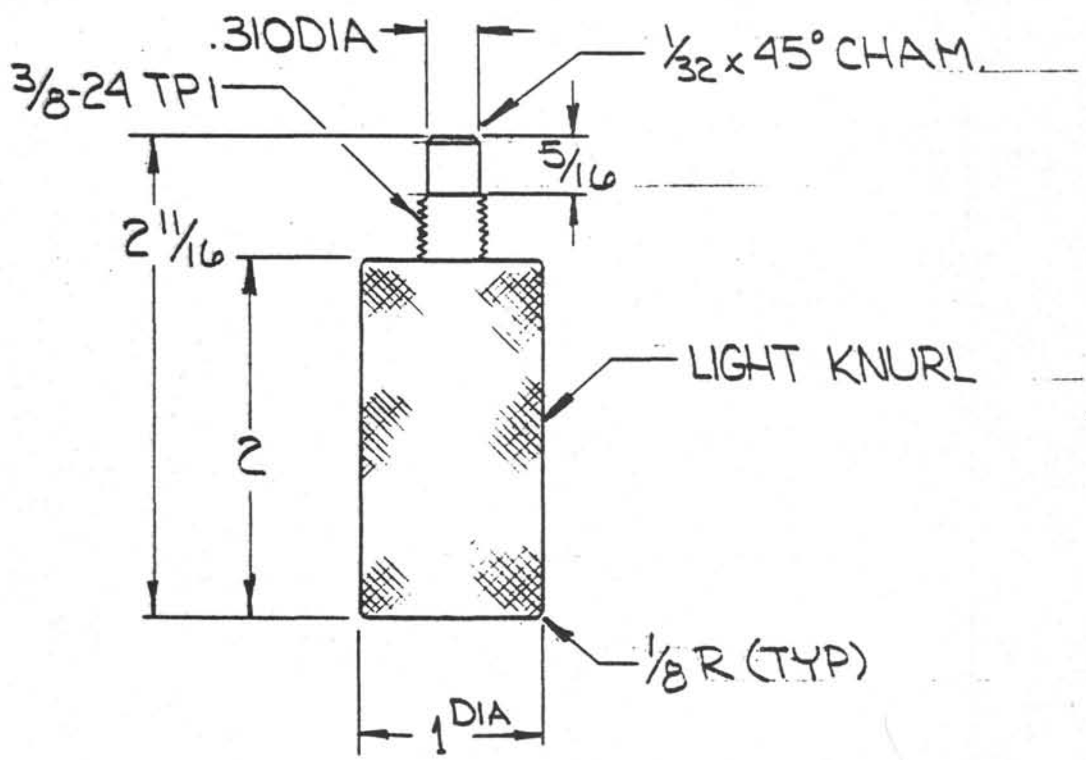
END VIEW, CONTROLS



NOTE: 3A THRU 13A ARE BUSSED TOGETHER

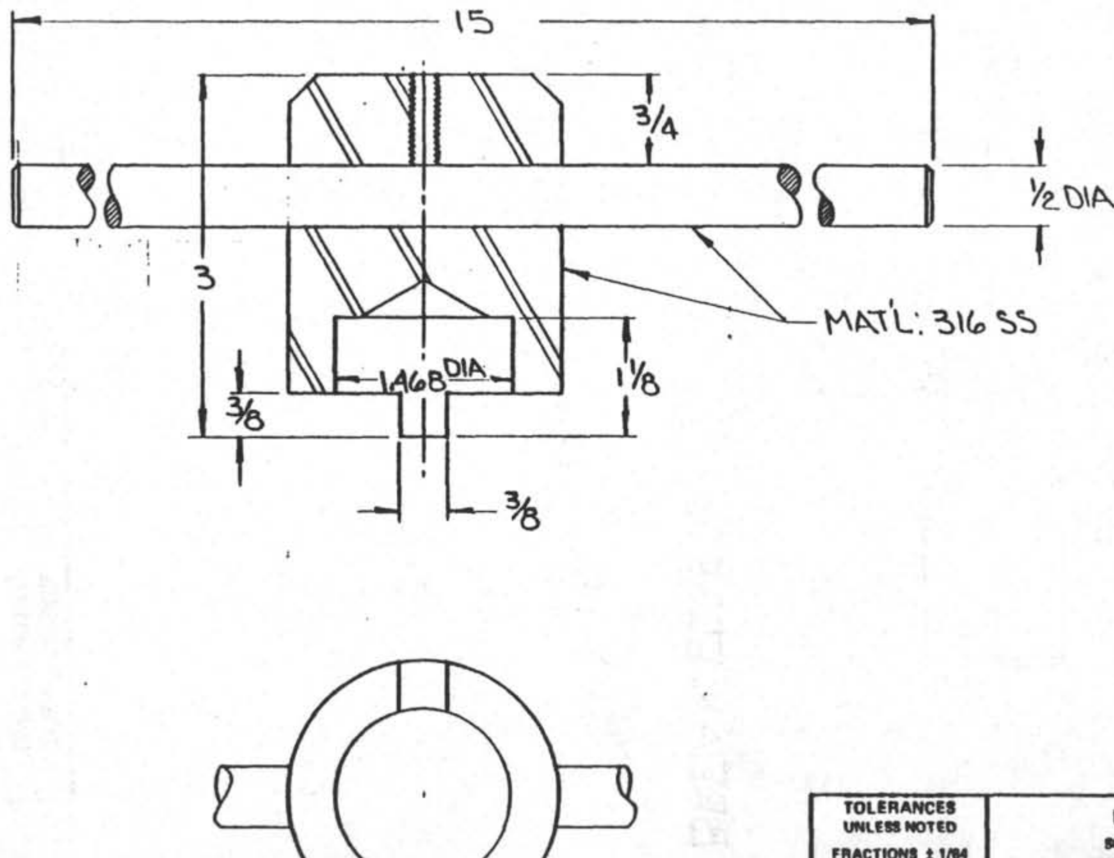
TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE DIGITAL PRESSURE METER PCB II-III				
SURFACE TREATMENT	MATERIAL	DRAWN BY P.P.	DATE	CHECKED	APPROVED
HEAT TREATMENT	PART NO. 0P4576	SIZE B DWG. NO. 0P4576			REV.

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



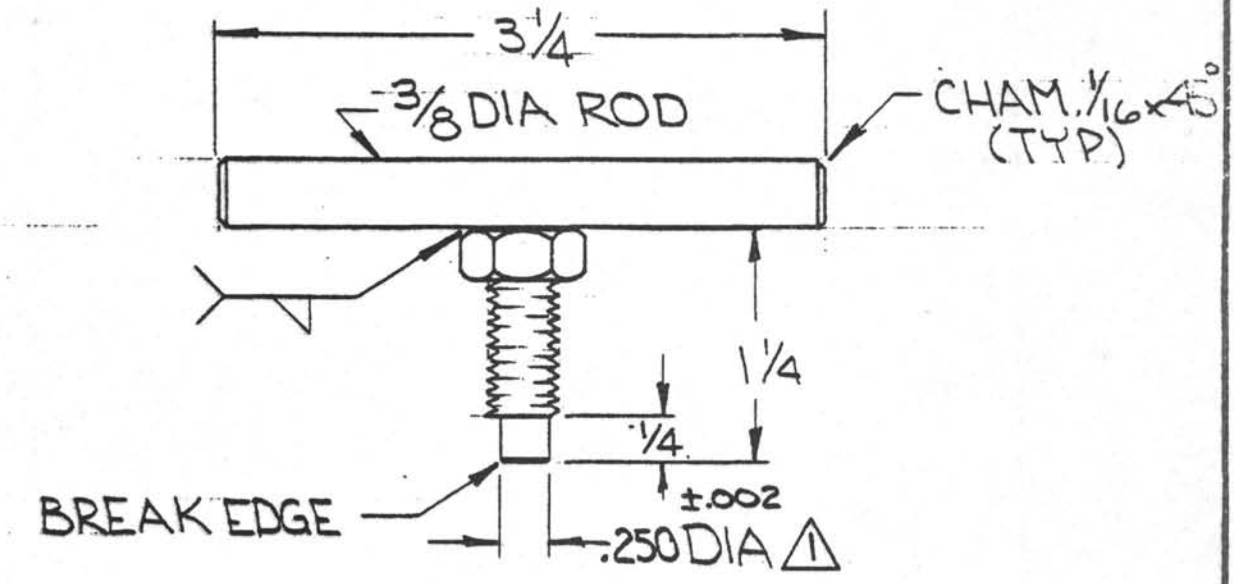
TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE VENT SUB LOCK ~ PCB II-III				
SURFACE TREATMENT —⊖—	MATERIAL 316 S.S.	DRAWN BY RK	DATE 1·14·80	CHECKED	APPROVED
HEAT TREATMENT —⊖—	PART NO. OP 4581	SIZE DWG. NO. A-OP4581			REV.

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	REVISED DESIGN	9.10.80	RK		



TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE FACE SPANNER VENT SUB ASS'Y TOOL ~ PCB II-III				
SURFACE TREATMENT	MATERIAL SEE DWG	DRAWN BY RK	DATE 1.14.80	CHECKED [illegible]	APPROVED [illegible]
HEAT TREATMENT	PART NO. OP 4582-1	SIZE DWG. NO. B-OP4582-			REV. 1

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	.250 ±.002 WAS 1/4 DIA	6·16·80	RK	[illegible]	

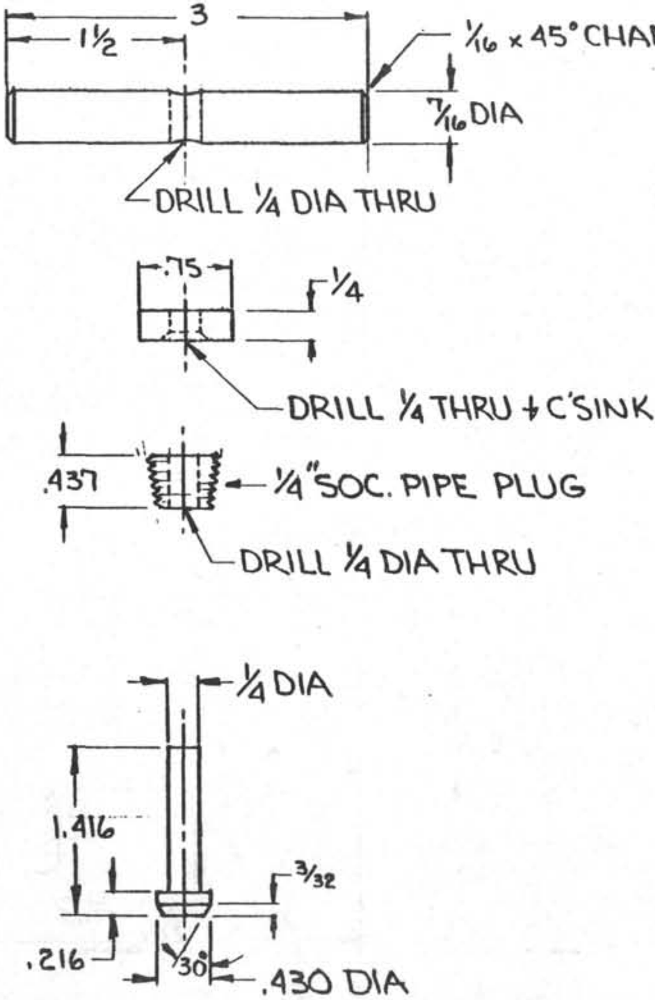


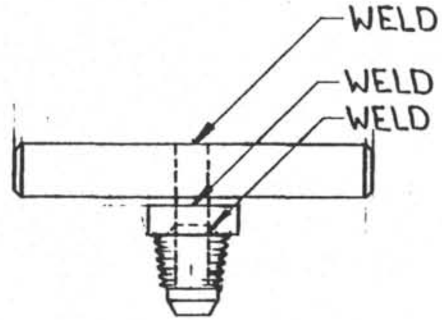
MATL:
3/8-16 316 S.S. BOLT 1 1/4 LG.

CONCENTRICITY:
ALL DIAMETERS
TIR .003

TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125 ✓	SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
	TITLE: ASSEMBLY LOCK SCREW ~PCB II-III~				
SURFACE TREATMENT: —⊖—	MATERIAL: —⊖—	DRAWN BY: RK	DATE: 1·23·8	CHECKED: mal	APPROVED: mal
HEAT TREATMENT: —⊖—	PART NO.: OP 4583-1	SIZE DWG. NO.: A-OP4583-			REV.: 1

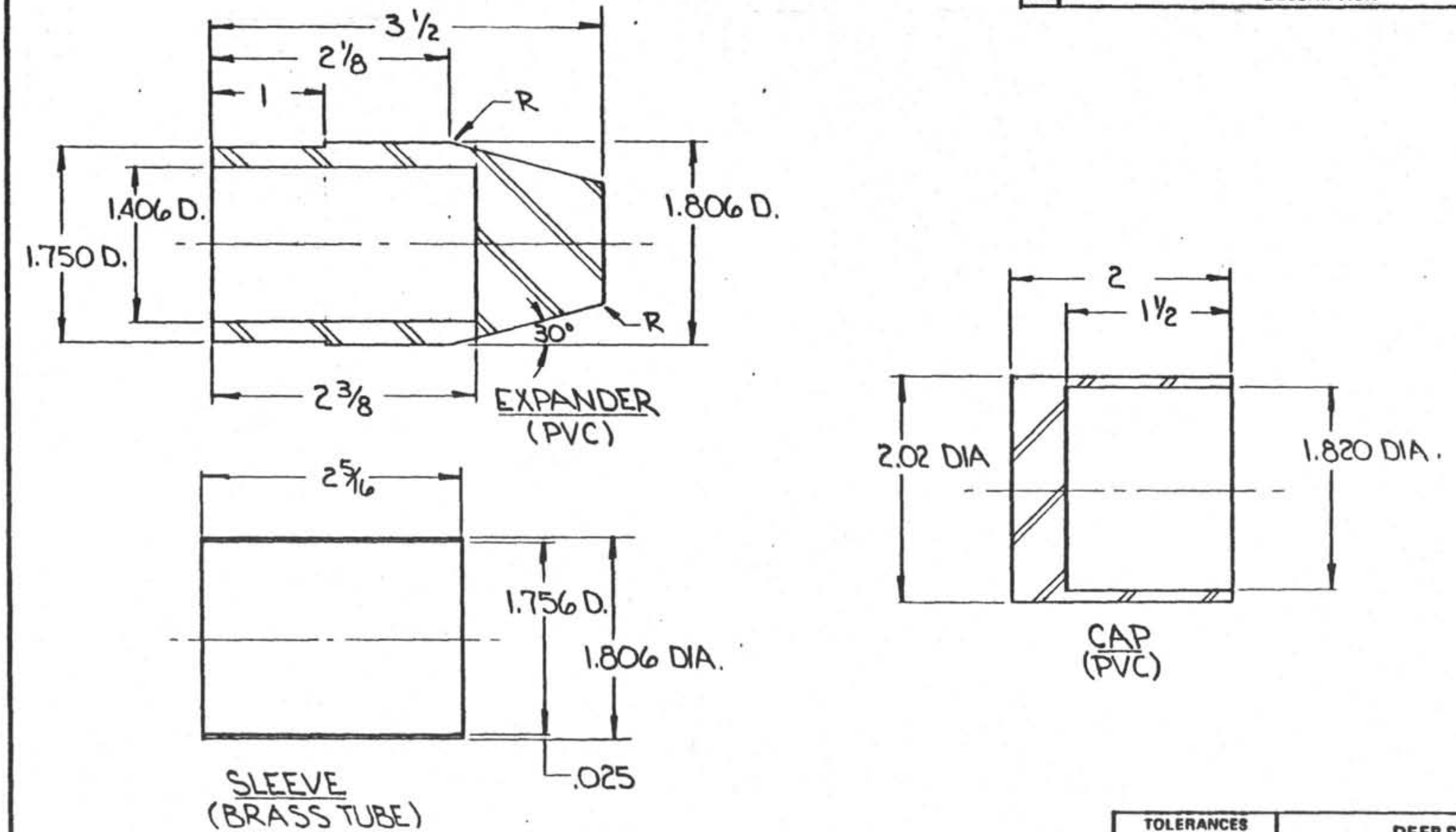
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	1/4 NPT was 9/16-12, .680 was 1 1/2	4-22-80	RK		
2	REDRAWN, WAS "A" SIZE	4-27-80	RK	TOW	





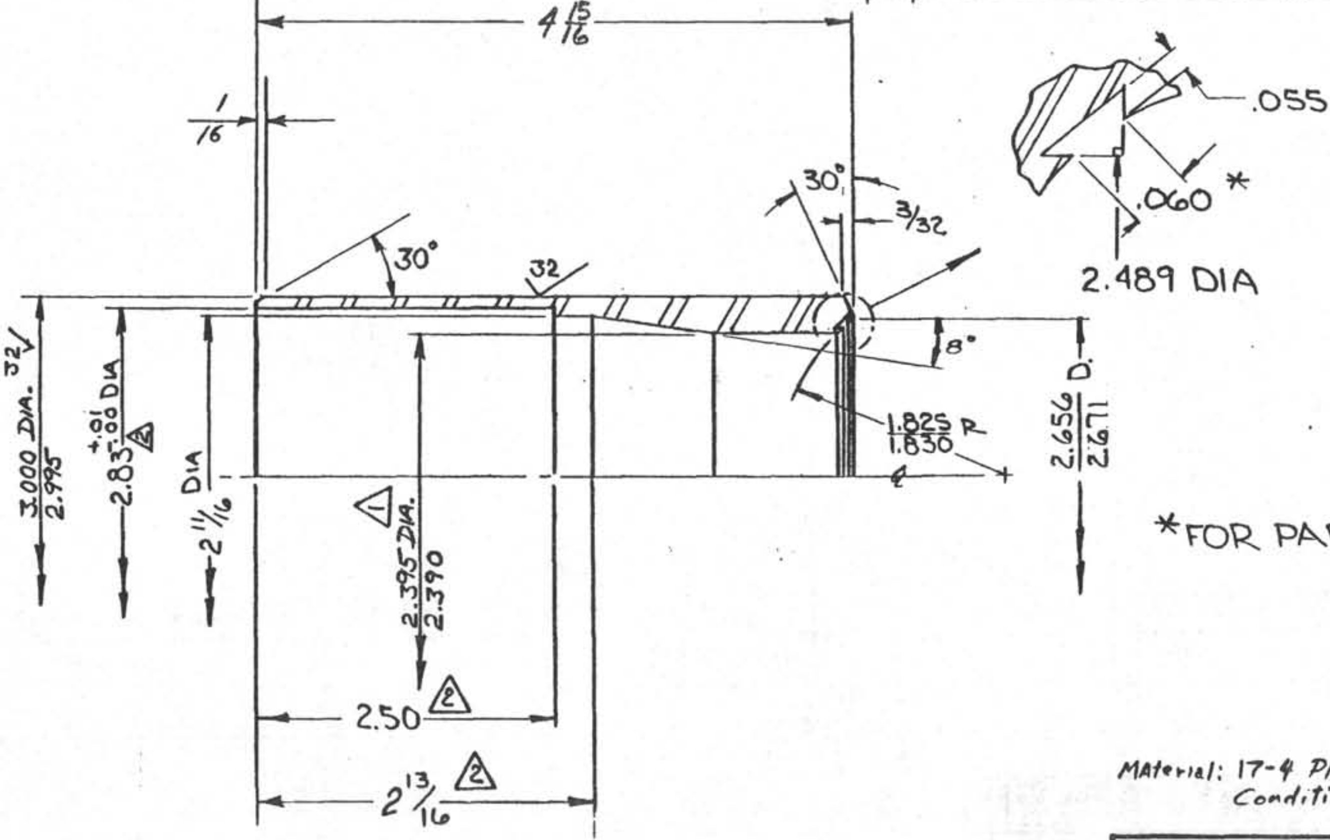
TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
	TITLE: ASSEMBLY LOCK BOLT ~PCB II-III				
SURFACE TREATMENT	MATERIAL: 316 S.S.	DRAWN BY: RK	DATE: 4-27-80	CHECKED	APPROVED
HEAT TREATMENT	PART NO.: OP4584-2	SIZE: B	DWG. NO.: OP4584 -		REV.: 2

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093			
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE POLYPAK INSTALLATION TOOL ~ PCB II ~			
SURFACE TREATMENT —	MATERIAL SEE DWG.	DRAWN BY RK	DATE 1-14-80	CHECKED / APPROVED
HEAT TREATMENT —	PART NO. OP 4585	SIZE B DWG. NO. OP 4585		REV.

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	HEAT TREAT WAS H-1150	2.14.80	RK		
2	ADDED 2.83 DIA x 2.50, 2 13/16 WAS 2 9/16	4.22.80	RK		



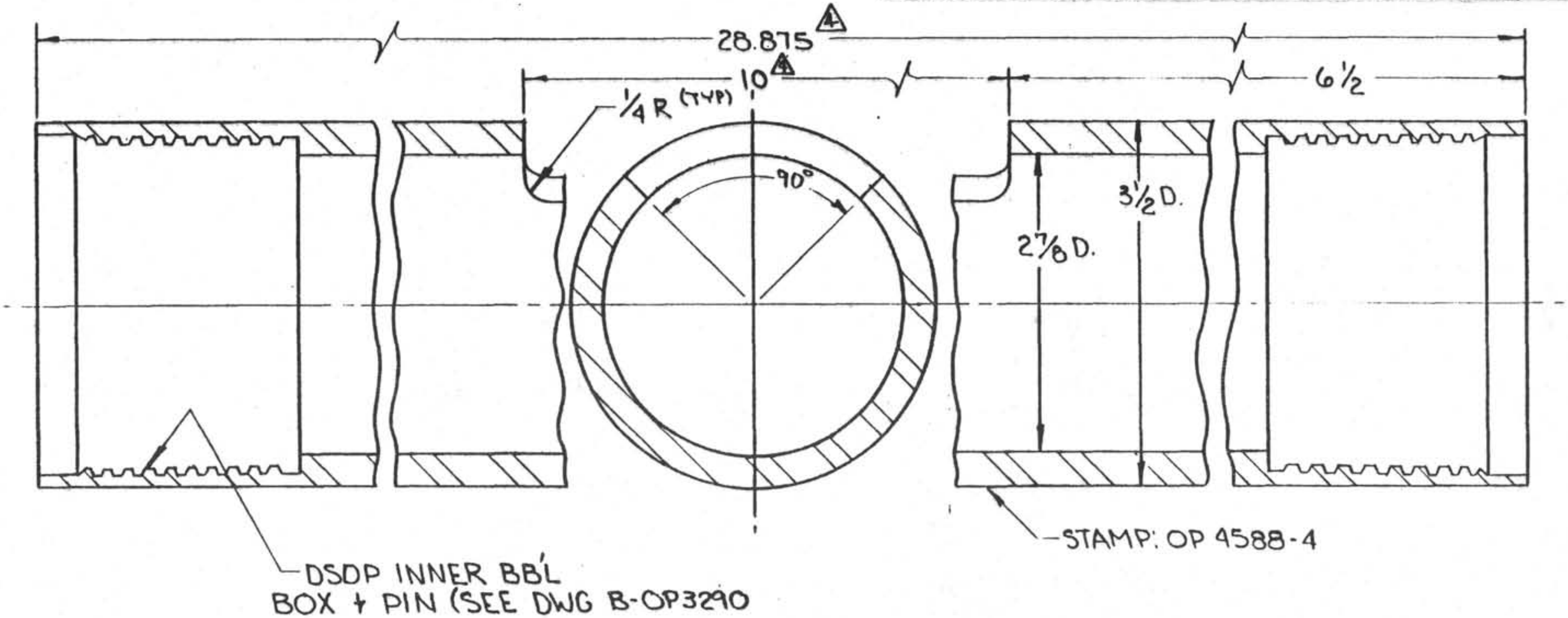
*FOR PARKER TEFLON O-RING No. 2-037

Material: 17-4 PH Stainless Steel Heat Treat to Condition H-1025

Unless Noted,
All Angles 45°; Tolerance on Fractions 1/64 in. IN DIRECTION OF MACHINING.

UNIV OF CALIF DEEP SEA DRILLING PROJ.		
SCALE: 1:1	APPROVED BY:	DRAWN BY RK
DATE: 1.17.80		REVISED
Title: SEAT ~ BVA - PCB II		
PART NO. OP 4587-2		DRAWING NUMBER B-OP4587-2

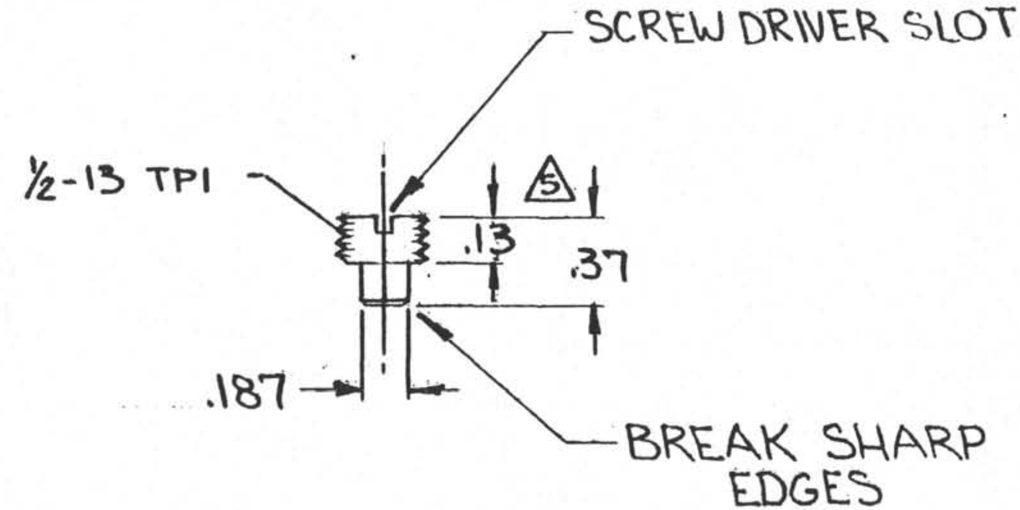
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	21½" WAS 35½", 3'-7" WAS 5'-11"	3-6-80	RK	MAS	
2	3'-6.25" WAS 3'-7"	4-22-80	RK	MAS	
3	REDRAWN, ADD SLOT, 33.5 WAS 3'-6.25	8-15-80	RK		
4	28.875 WAS 3.500, 10 WAS 7	9-3-80	RK		



TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093			
	TITLE: DOUBLE BOX SUB ~PCB II-III			
SURFACE TREATMENT	MATERIAL 4130 CD	DRAWN BY RK	DATE 8-13-80	CHECKED / APPROVED
HEAT TREATMENT	PART NO. OP4588-4	SIZE B	DWG. NO. B-OP4588-	REV. 4

	REVISIONS				
1	1/4 WAS 1/8 TOP & BOTTOM,	11.29.7[illegible]	RK	[illegible]	[illegible]
2	.18 WAS .20	1.15.80	RK	[illegible]	[illegible]
3	.187 WAS .18, MAT'L WAS SET SC	5.1.80	RK	[illegible]	[illegible]
4	MAT'L WAS BRASS	5.19.80	RK	[illegible]	[illegible]
5	.19 WAS .25, .43 WAS .49	5.27.80	RK	[illegible]	
6	.13 WAS .19, .37 WAS .43	9.5.80	RK		

OP4589



PART No: OP4589-6

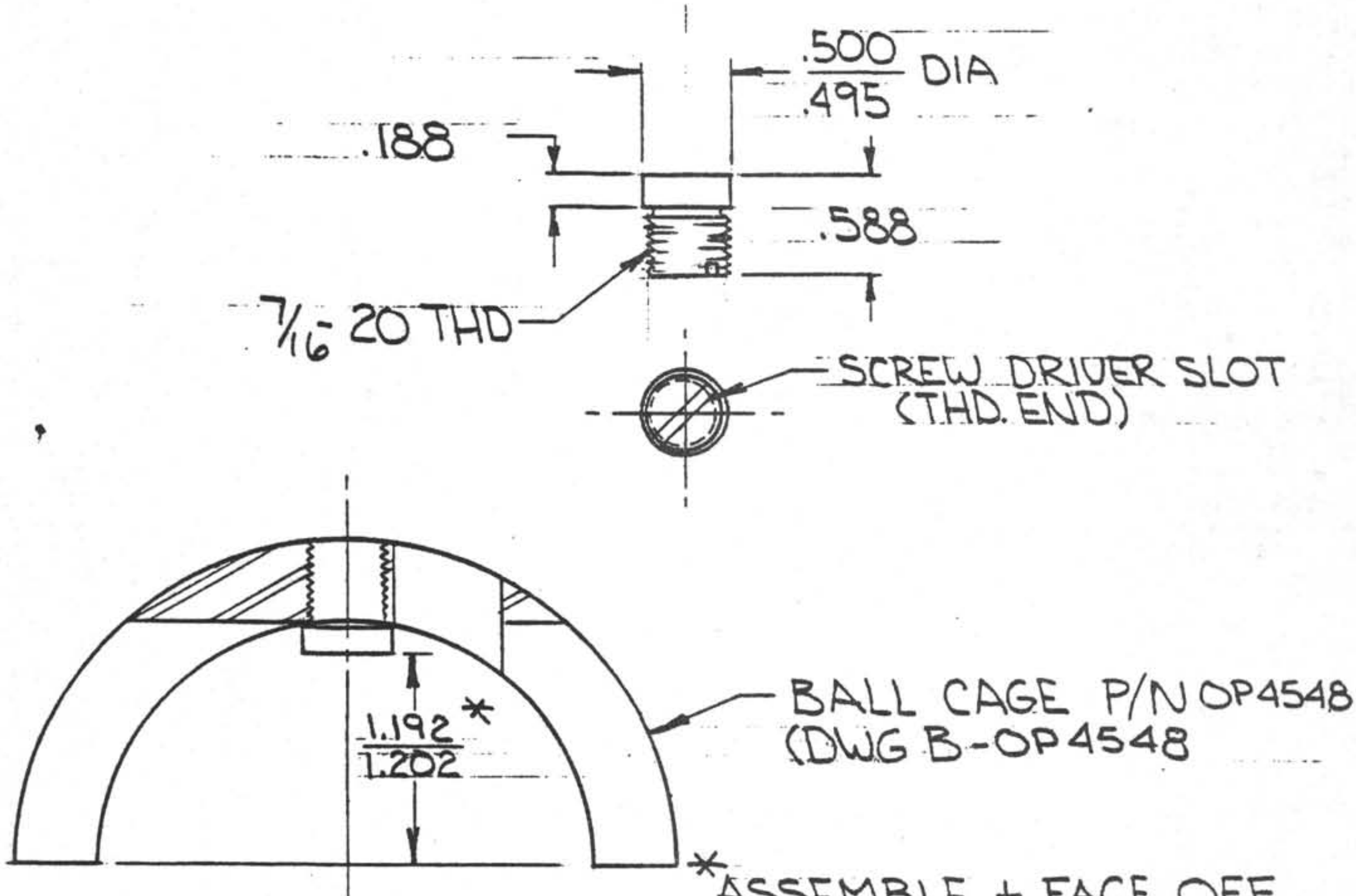
MAT'L: 1/2-13 THREADED ROD
QQB626 ALLOY 360 HALF HARD (4)

TOLERANCES (EXCEPT AS NOTED)	REVISIONS			UNIV. OF CALIF. DEEP SEA DRILLING PROJ.		
	NO.	DATE	BY			
DECIMAL	1			SHEAR PIN ~ M.V.A. ~ P.C.B. II		
±	2					
FRACTIONAL	3			DRAWN BY	SCALE	MATERIAL
±	4			CHK'D	DATE	DRAWING NO.
ANGULAR ±	5			TRACED	APP'D	A-OP4589-6

TELEDYNE POST 18AE-01E-8½X11

REVISIONS

NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	MAT'L WAS AQUAMET 18, YIELD 127,K	11-13-80	RK		



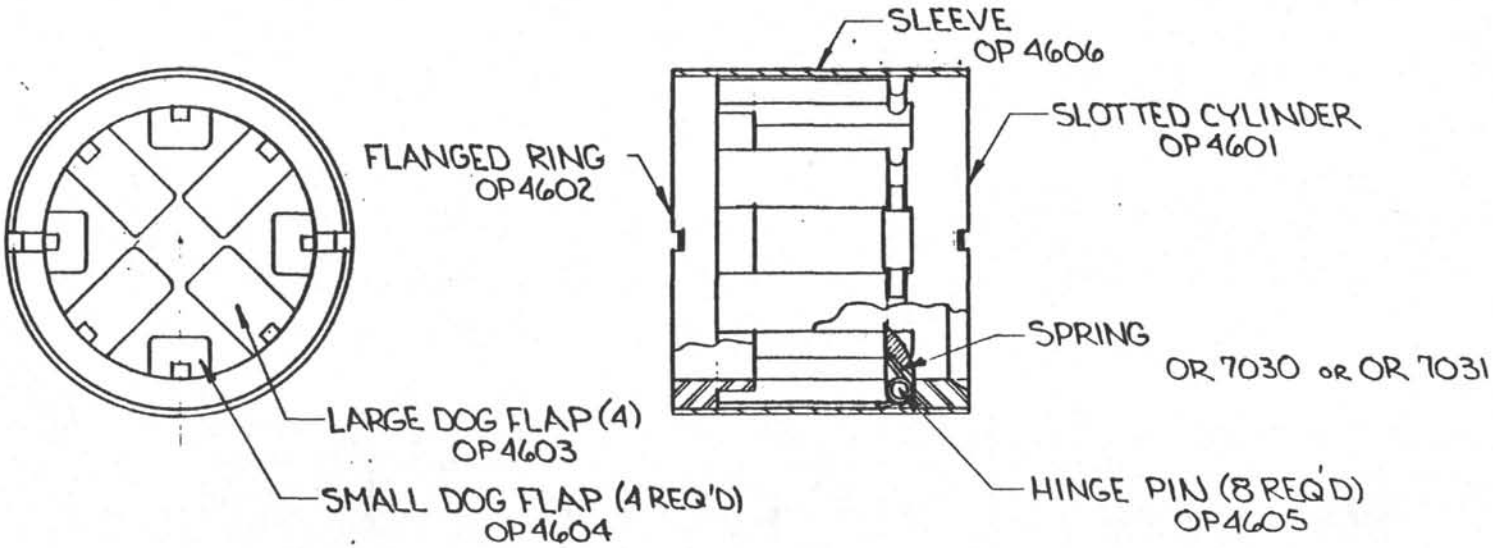
*ASSEMBLE + FACE OFF

2 REQ'D

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093					
	TITLE PIVOT PINS ~BVA — PCB II-III					
SURFACE TREATMENT	MATERIAL 17-4 S.S.	DRAWN BY RK	DATE 12-13-79	CHECKED MA	APPROVED MA	
HEAT TREATMENT H-1025*	PART NO. OP4590-1	SIZE DWG. NO. A-OP4590-				REV. 1

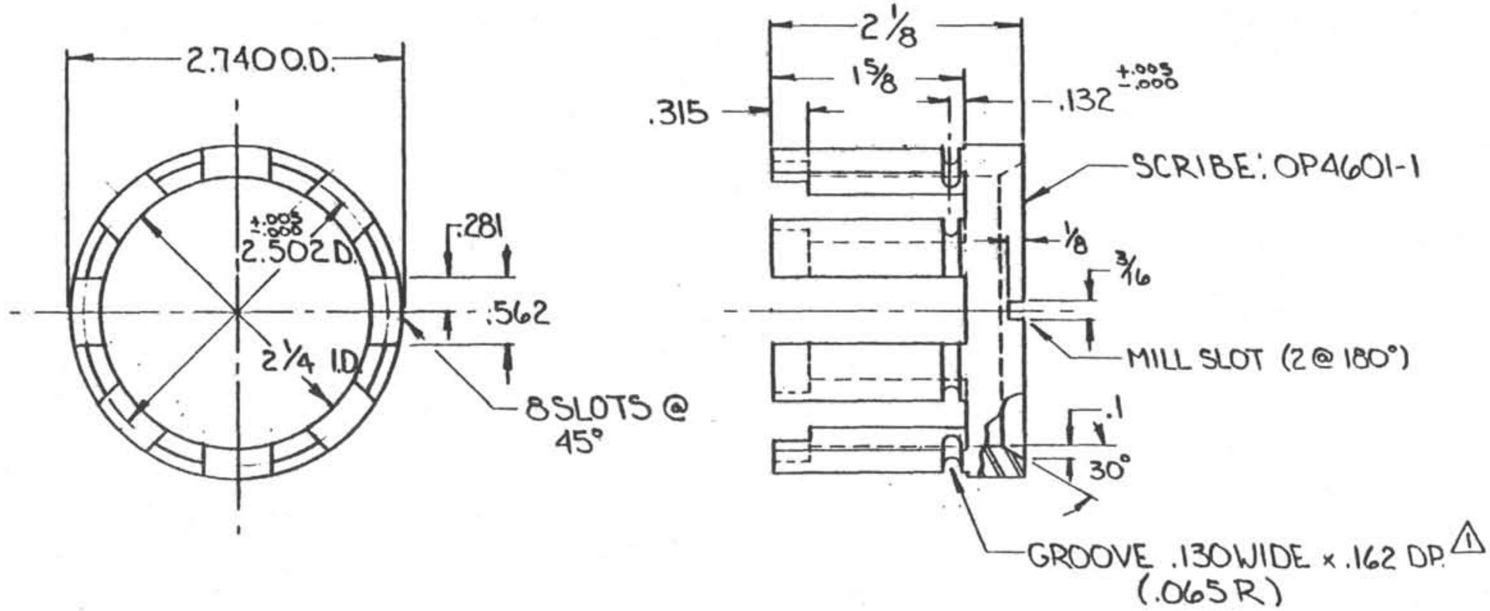
*YIELD 165,000

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



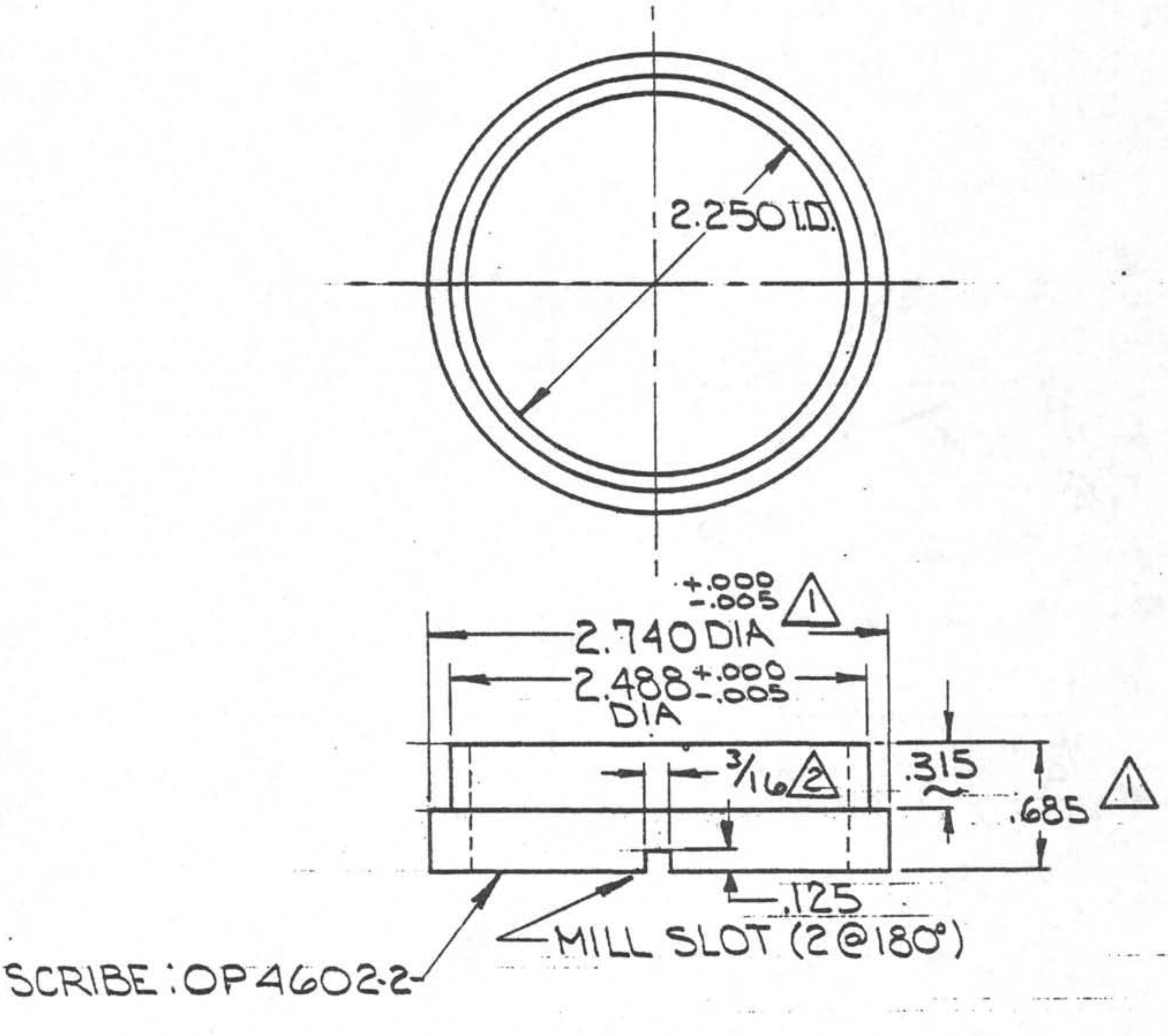
TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE 8 FINGER CORE CATCHER ASS'Y PCB II - III				
SURFACE TREATMENT	MATERIAL —o—	DRAWN BY RK	DATE 4/28/80	CHECKED	APPROVED
HEAT TREATMENT —o—	PART NO. OP 4600	SIZE DWG. NO. B-OP 4600			REV.

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	.162 WAS .187	5·16·80	RK		



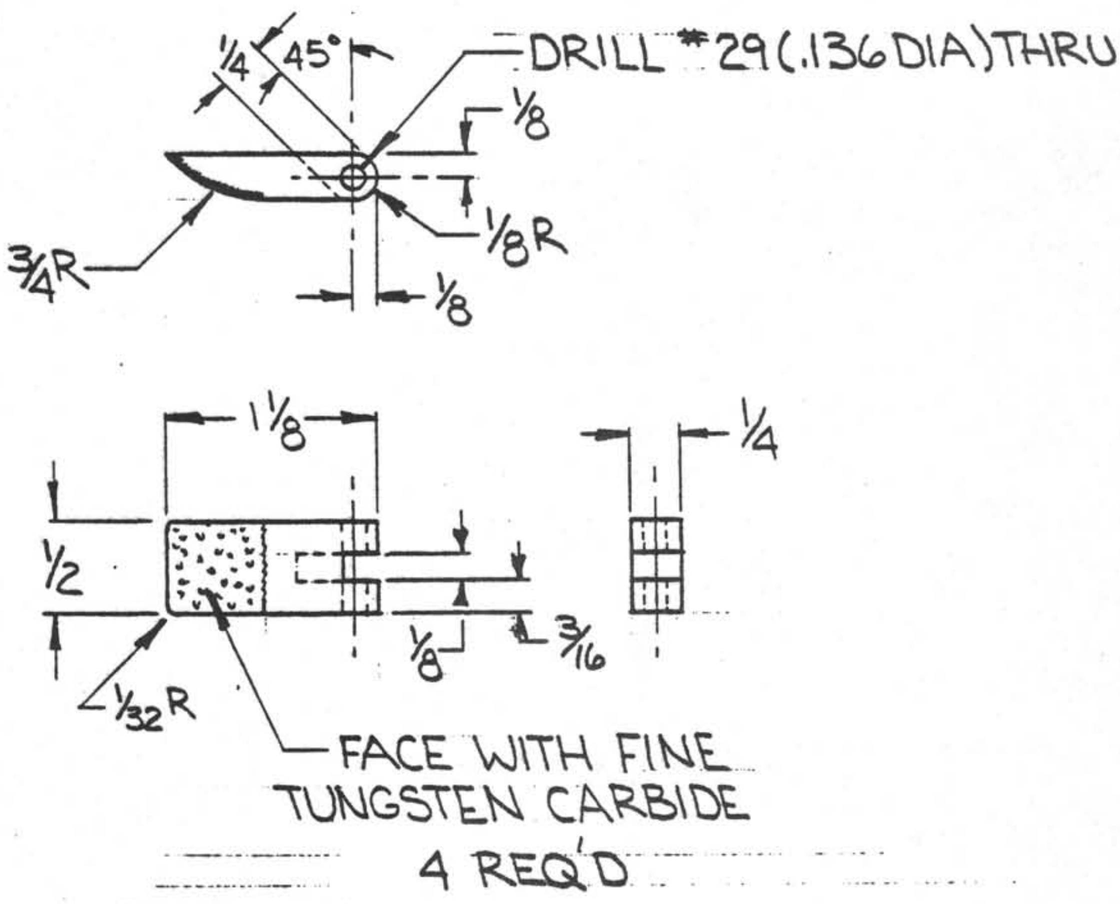
TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE 8 FINGER SLOTTED CYLINDER PCB CORE CATCHER				
SURFACE TREATMENT	MATERIAL 4130	DRAWN BY RK	DATE 4·28·80	CHECKED	APPROVED
HEAT TREATMENT 28-32 Rc	PART NO. OP4601-1	SIZE DWG. NO. B-OP4601-			REV. 1

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	.315 WAS .400, 2.740 WAS 2.745, .685 WAS .700	9.10.80	RK	[illegible]	[illegible]
2	3/16 WAS .130	9.24.80	RK		



TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE FLANGED RING (8+10 FINGER) PCB CORE CATCHER				
SURFACE TREATMENT	MATERIAL 4130	DRAWN BY RK	DATE 4.28.80	CHECKED [illegible]	APPROVED [illegible]
HEAT TREATMENT 28-32Rc	PART NO. OP4602-2	SIZE A	DWG. NO. OP4602		REV. 2

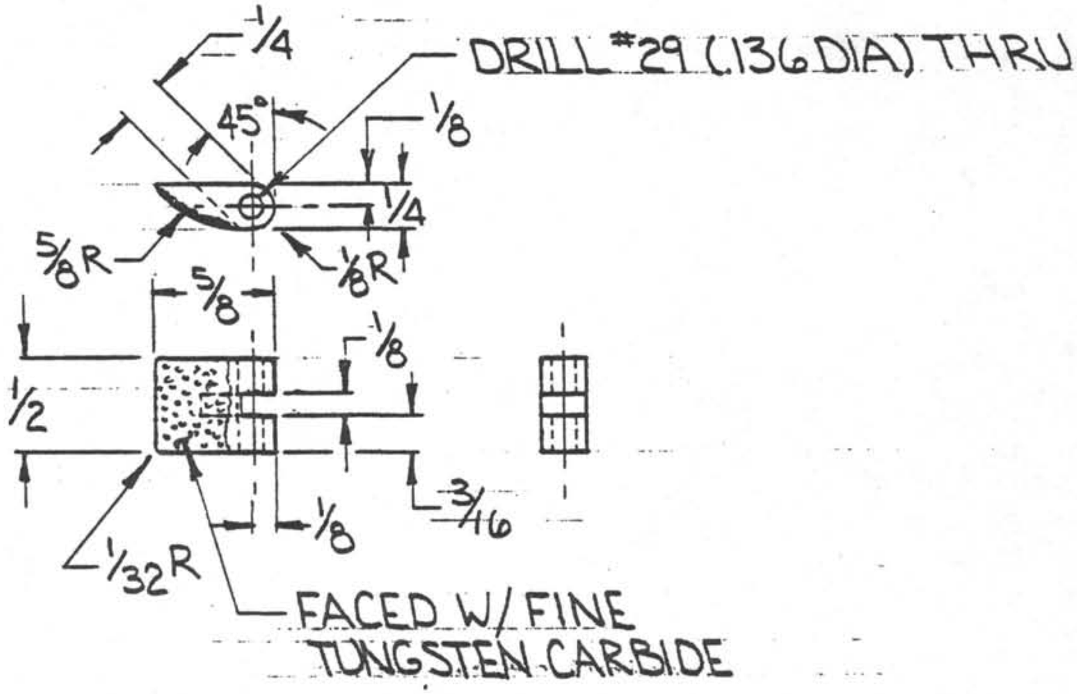
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE 8 FINGER LARGE DOG FLAP PCB CORE CATCHER				
SURFACE TREATMENT	MATERIAL 4130	DRAWN BY RK	DATE 4·28·80	CHECKED	APPROVED
HEAT TREATMENT 28-32 Rc	PART NO. OP4603	SIZE DWG. NO. A-OP4603			REV.

REVISIONS

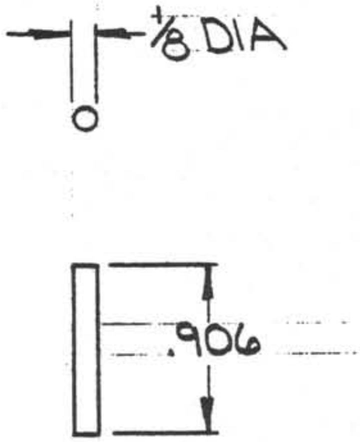
NO.	DESCRIPTION	DATE	BY	CH.	APR.



4 REQ'D

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ±.005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125 ✓	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE 8 FINGER SMALL DOG FLAP PCB CORE CATCHER				
SURFACE TREATMENT	MATERIAL 4130	DRAWN BY RK	DATE 4-28-80	CHECKED	APPROVED
HEAT TREATMENT 28-32 Rc	PART NO. OP4604	SIZE DWG. NO. A-OP4604			REV.

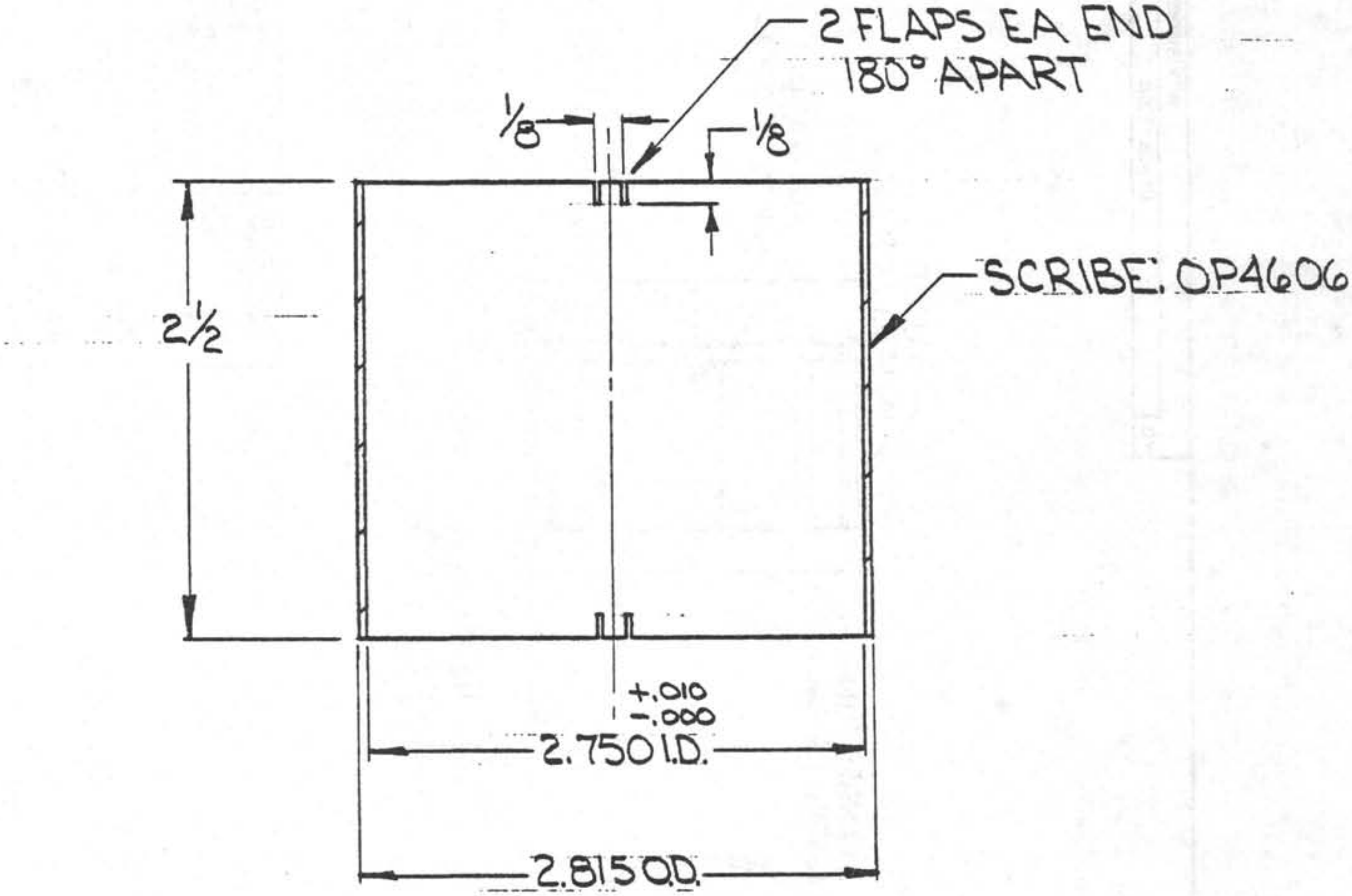
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



8 REQ'D

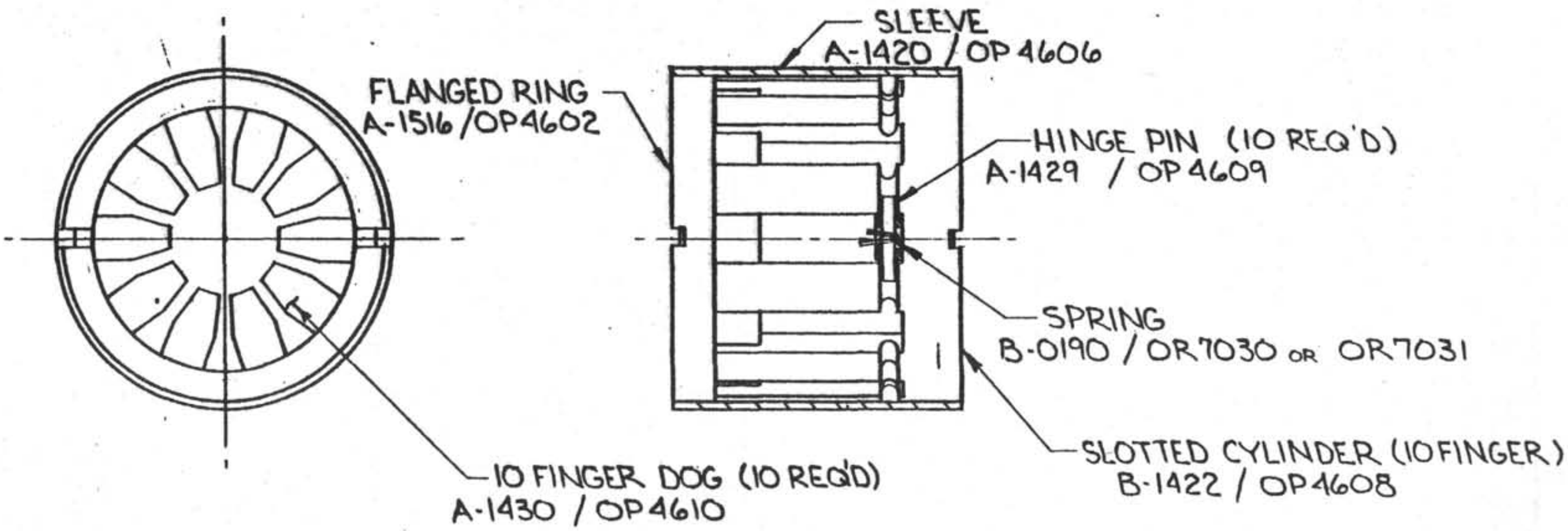
TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125✓	SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE 8 FINGER HINGE PIN PCB CORE CATCHER				
SURFACE TREATMENT	MATERIAL 4130	DRAWN BY RK	DATE 4-28-80	CHECKED	APPROVED
HEAT TREATMENT 30-32 Rc	PART NO. OP4605	SIZE DWG. NO. A-OP4605			REV.

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



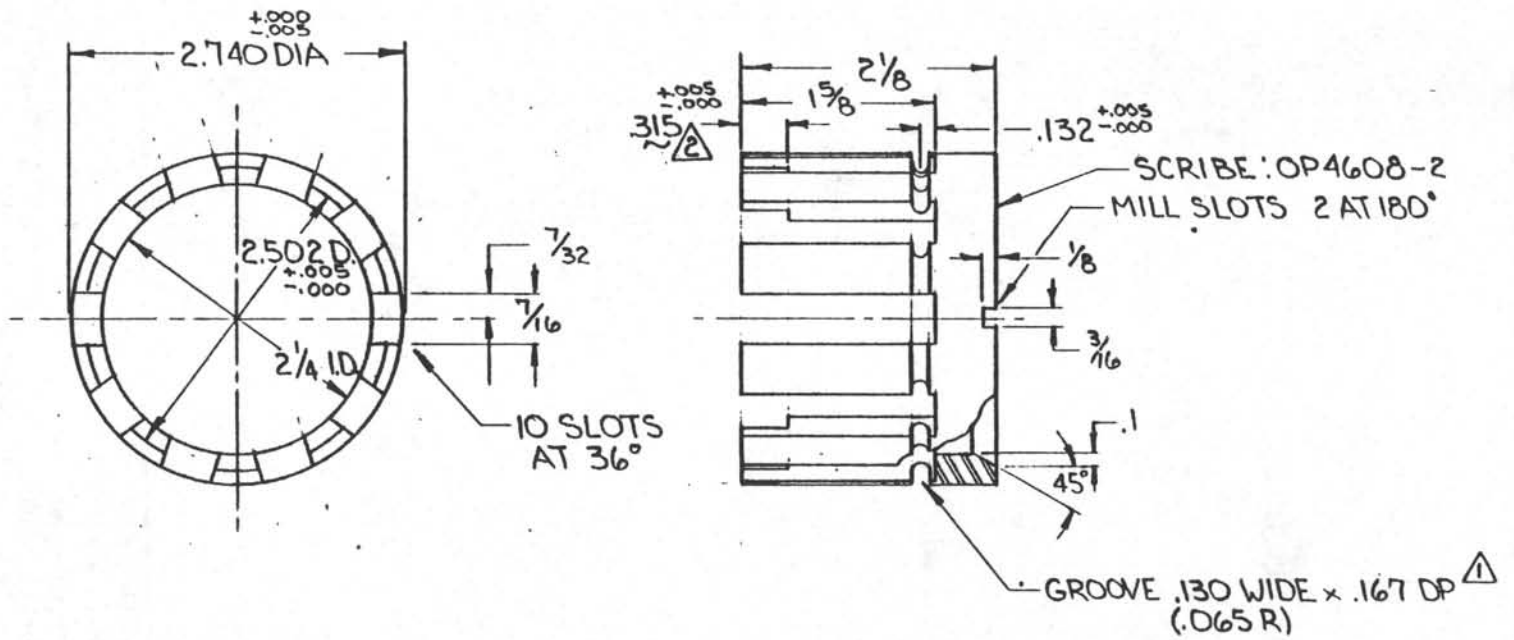
TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125 ✓	TITLE SLEEVE 8 + 10 FINGER PCB CORE CATCHER				
SURFACE TREATMENT	MATERIAL C.R. ST. TUBE	DRAWN BY RK	DATE 4-28-80	CHECKED	APPROVED
HEAT TREATMENT	PART NO. OP4606	SIZE DWG. NO. A-OP4606			REV.

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



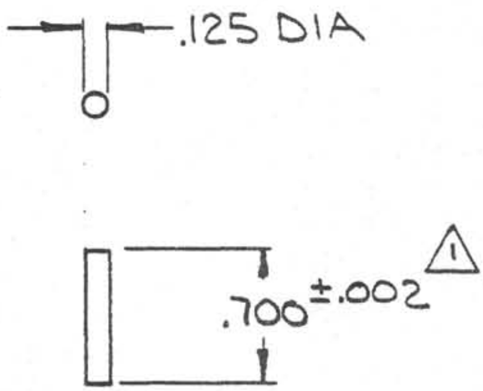
TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT			
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE 10 FINGER CORE CATCHER ASS'Y PCB II-III			
SURFACE TREATMENT —	MATERIAL —	DRAWN BY RK	DATE 4-30-80	CHECKED	APPROVED
HEAT TREATMENT —	PART NO. OP4607	SIZE DWG. NO. B-OP4607		REV.

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	.167 WAS .187	5-16-80	RK		
2	.315 WAS .400	9-10-80	RK		



TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 × 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE 10 FINGER SLOTTED CYLINDER PCB CORE CATCHER				
SURFACE TREATMENT	MATERIAL 4130	DRAWN BY RK	DATE 4-30-80	CHECKED [illegible]	APPROVED [illegible]
HEAT TREATMENT 28-32 Rc	PART NO. OP 4608-2	SIZE DWG. NO. B-OP4608-			REV. 2

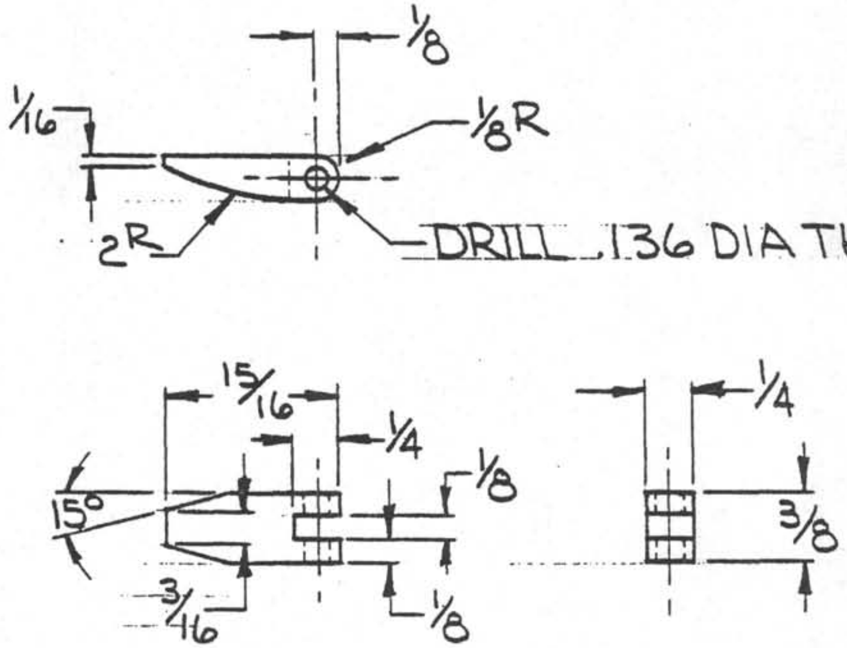
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	.700 WAS 23/32	5·16·80	RK		



10 REQ'D

TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ±.005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE HINGE PIN (10 FINGER) PCB CORE CATCHER				
SURFACE TREATMENT	MATERIAL 4130	DRAWN BY RK	DATE 4·30·80	CHECKED	APPROVED
HEAT TREATMENT 30-32 Rc	PART NO. OP4609	SIZE DWG. NO. A-OP4609			REV.

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



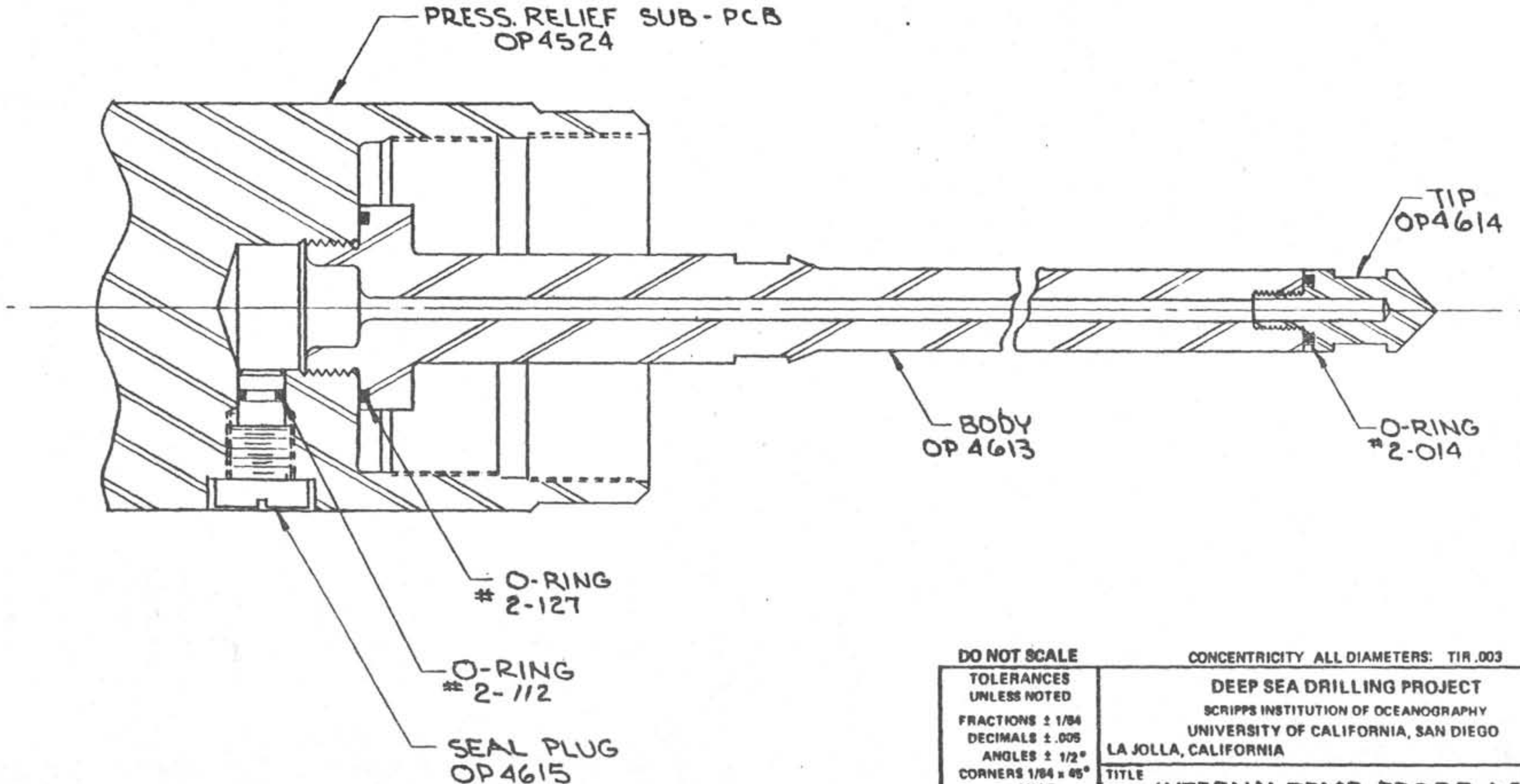
10 REQ'D

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125 ✓	**DEEP SEA DRILLING PROJECT** SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE 10 FINGER DOG PCB CORE CATCHER

SURFACE TREATMENT	MATERIAL	DRAWN BY	DATE	CHECKED	APPROVED
	4130	RK	43080		

HEAT TREATMENT	PART NO.	SIZE DWG. NO.	REV.
28-32Rc	OP4610	A-OP4610	

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



DO NOT SCALE

CONCENTRICITY ALL DIAMETERS: TIR .003

TOLERANCES UNLESS NOTED
FRACTIONS ± 1/64
DECIMALS ± .005
ANGLES ± 1/2°
CORNERS 1/64 x 45° or 1/64 R
FINISH 125

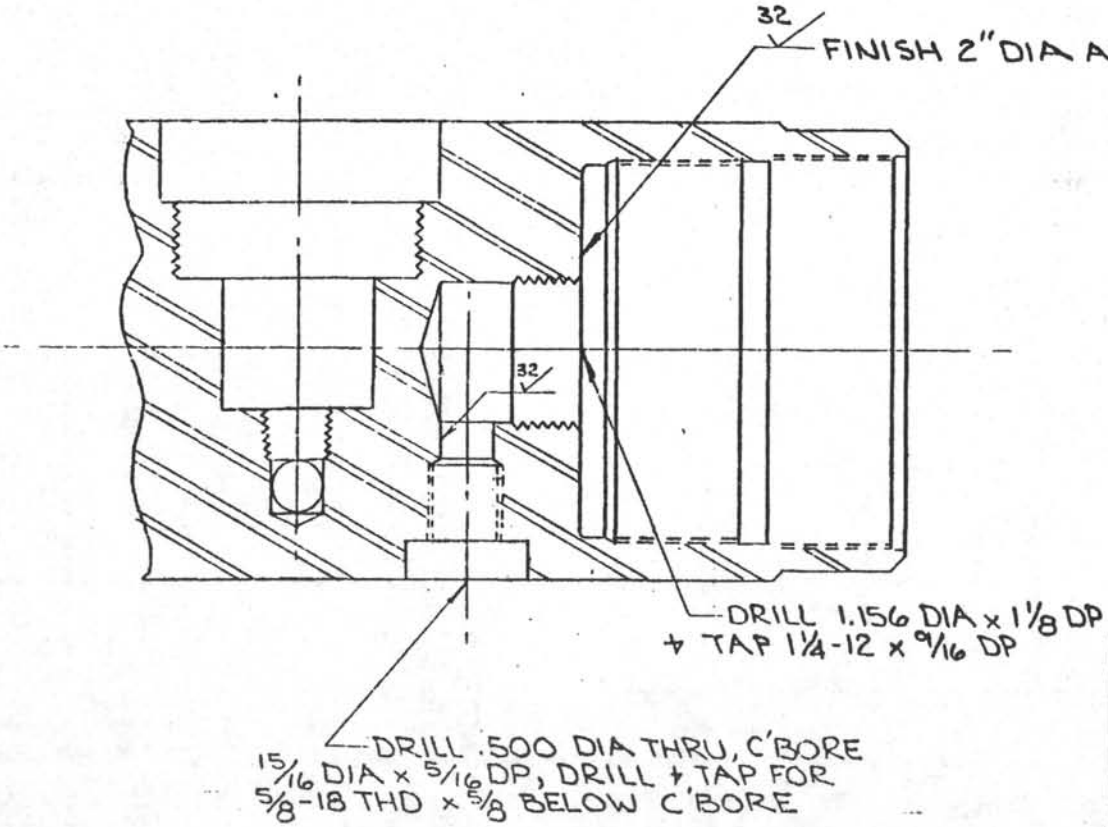
DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA, SAN DIEGO
LA JOLLA, CALIFORNIA 92093

TITLE: INTERNAL TEMP. PROBE ASS'Y ~ P.C.B ~

SURFACE TREATMENT	MATERIAL	DATE	BY	CHECKED	APPROVED
—θ—		10·21·81	RK	DAC	

HEAT TREATMENT	SCALE	REQ'D/ASS'Y	PART NO.	DWG. NO. (REV)
—θ—	1:1	1	OP4611	B-OP4611-0

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APH.



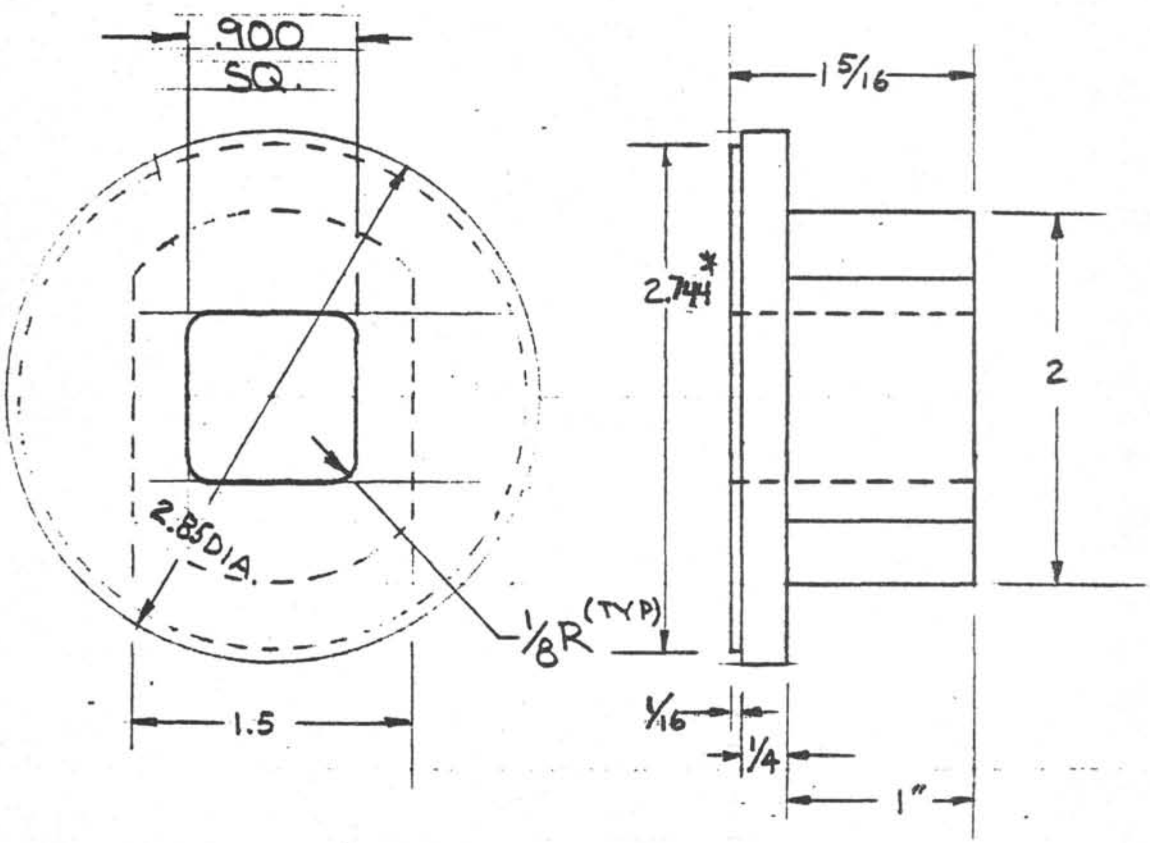
DO NOT SCALE

CONCENTRICITY ALL DIAMETERS: TIR .003

TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 × 45° or 1/64 R FINISH 125	TITLE PRESS. RELIEF SUB MODIFICATION PCB INTERNAL TEMP. PROBE				
SURFACE TREATMENT	MATERIAL 17-4PH S.S.	DATE 10-26-81	BY RK	CHECKED	APPROVED
HEAT TREATMENT	SCALE 1:1	REQ'D/ASS'Y 1	PART NO. OP4612	DWG. NO. (REV) B-OP4612-0	

REVISIONS

NO.	DESCRIPTION	DATE	BY	CH.	APR.



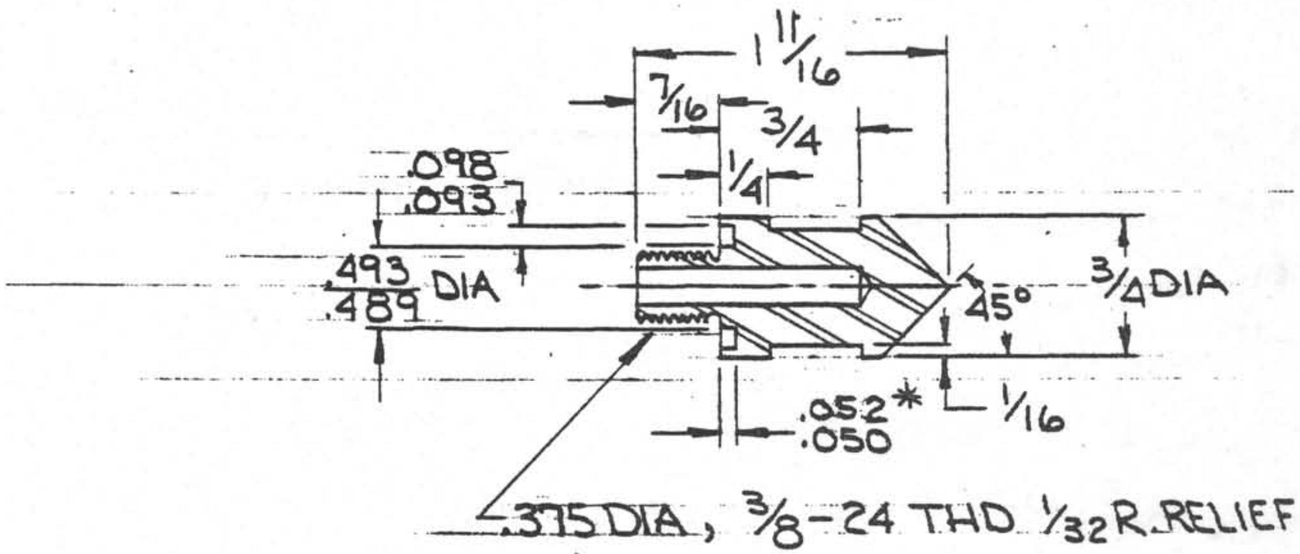
NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

* To fit inside cylinder # OP 4615

TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE PLUG SAMPLING ASSY. - PCB				
SURFACE TREATMENT	MATERIAL NITRONIC 60 S.S.	DRAWN BY 4t	DATE 7/28/80	CHECKED [illegible]	APPROVED
HEAT TREATMENT	PART NO. OP4613	SIZE DWG. NO. A-OP4613			REV.

NO.	DESCRIPTION	DATE	BY	CH.	APR.

REVISIONS



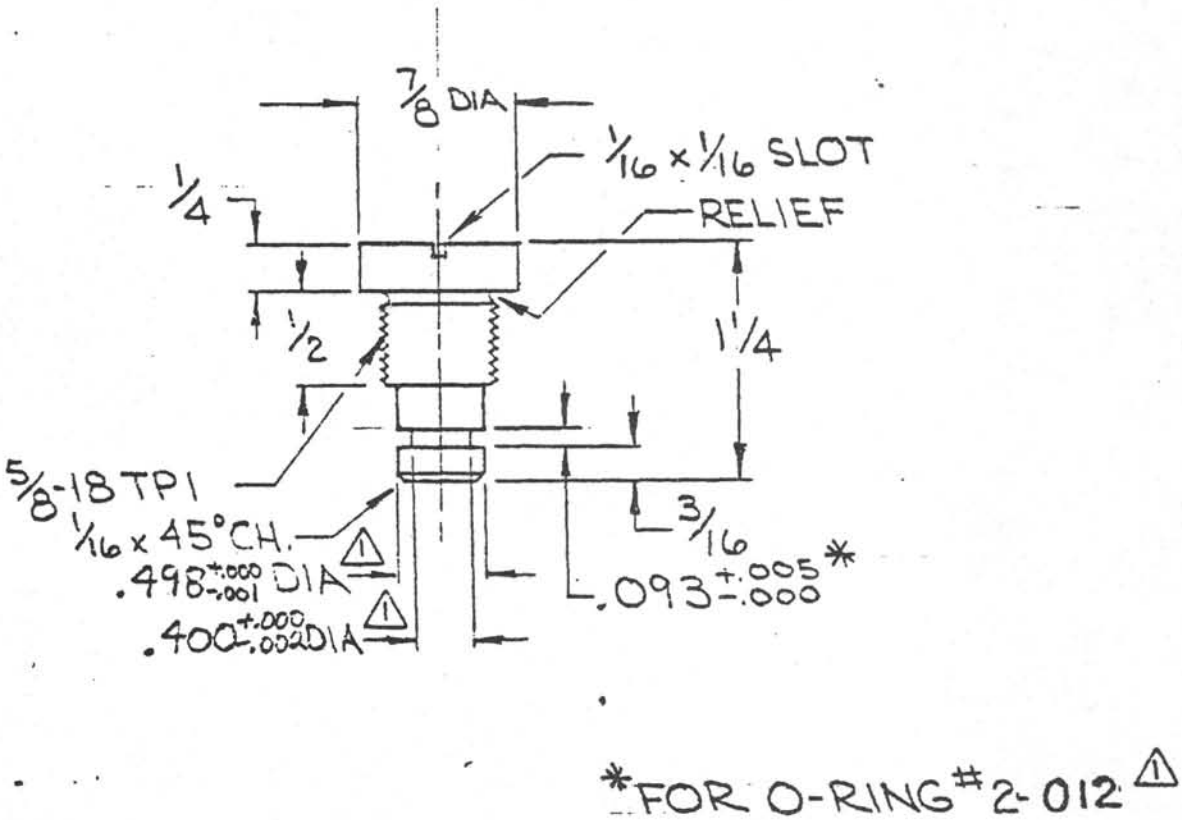
* FOR PARKER O-RING #2-014

DO NOT SCALE

CONCENTRICITY ALL DIAMETERS: TIR .003

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE TIP P.C.B. INTERNAL TEMPERATURE PROBE				
SURFACE TREATMENT	MATERIAL 316 S.S.	DATE 10-21-81	BY RK	CHECKED DM	APPROVED
HEAT TREATMENT	SCALE 1:1	REQ'D/ASS'Y 1	PART NO. OP 4614	DWG. NO. (REV.) A-OP 4614-0	

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
-	.498 WAS .484, .400 WAS .359, O-RING WAS 2-006	12-1-83	RK	[illegible]	---

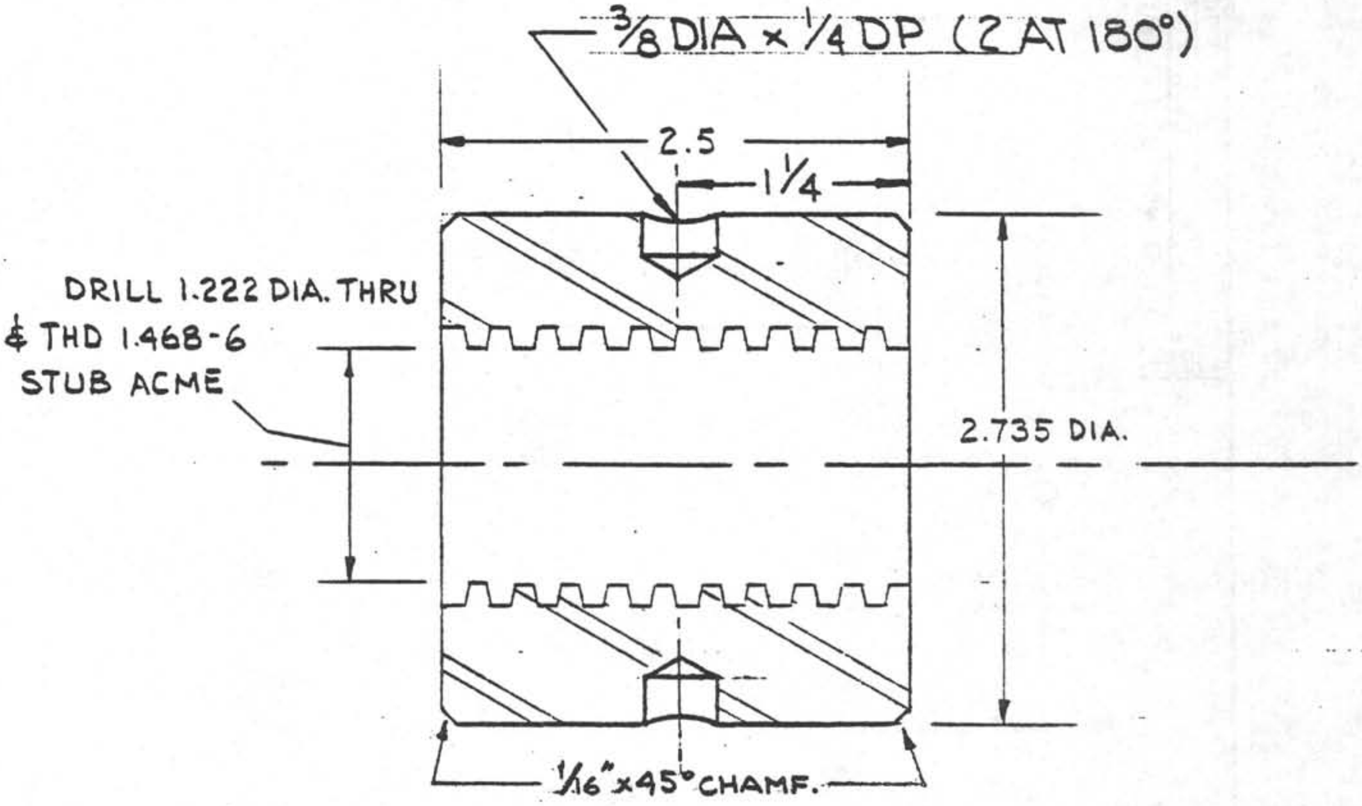


DO NOT SCALE

CONCENTRICITY ALL DIAMETERS: TIR .003

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE SEAL PLUG ~P.C.B~				
SURFACE TREATMENT —⊖—	MATERIAL	DATE 9-29-82	BY RK	CHECKED [illegible]	APPROVED
HEAT TREATMENT —⊖—	SCALE 1:1	REQ'D/ASS'Y 1	PART NO. OP4615-1	DWG. NO. A-OP4615-1	(REV.)

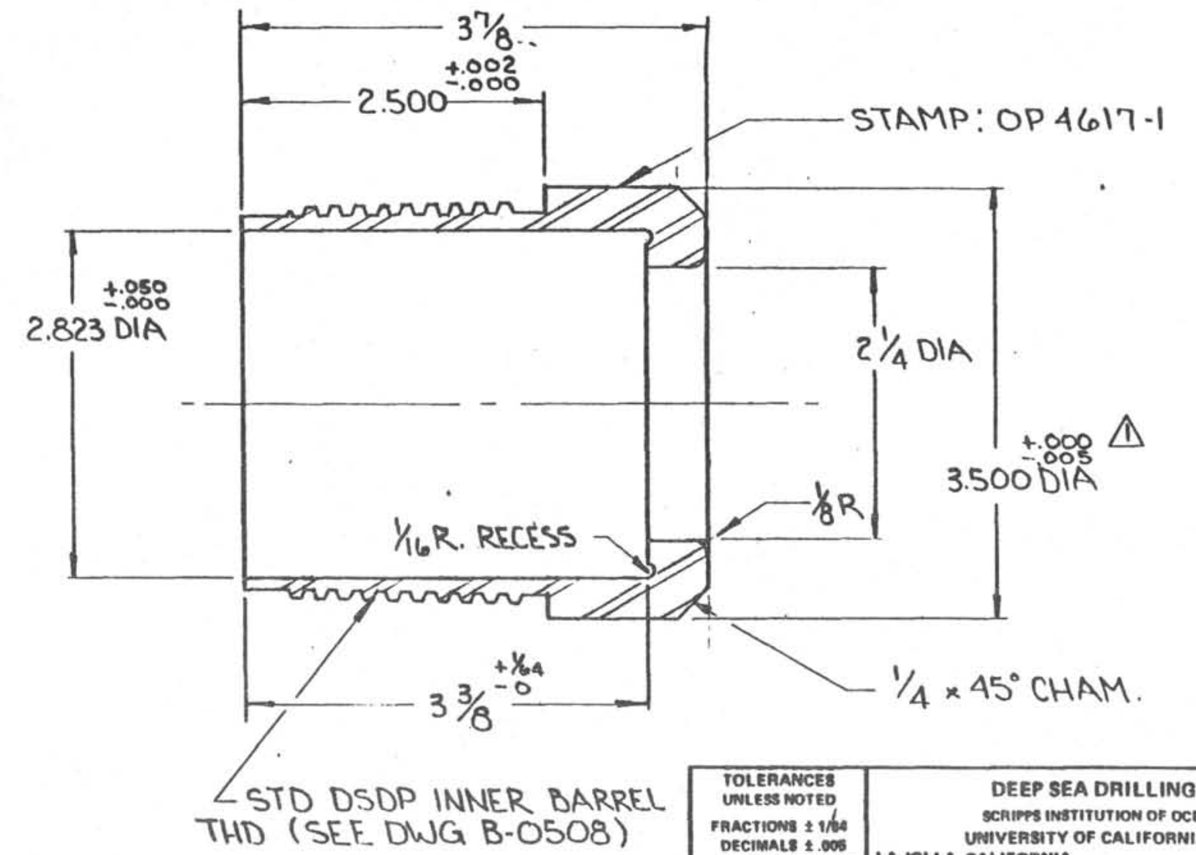
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

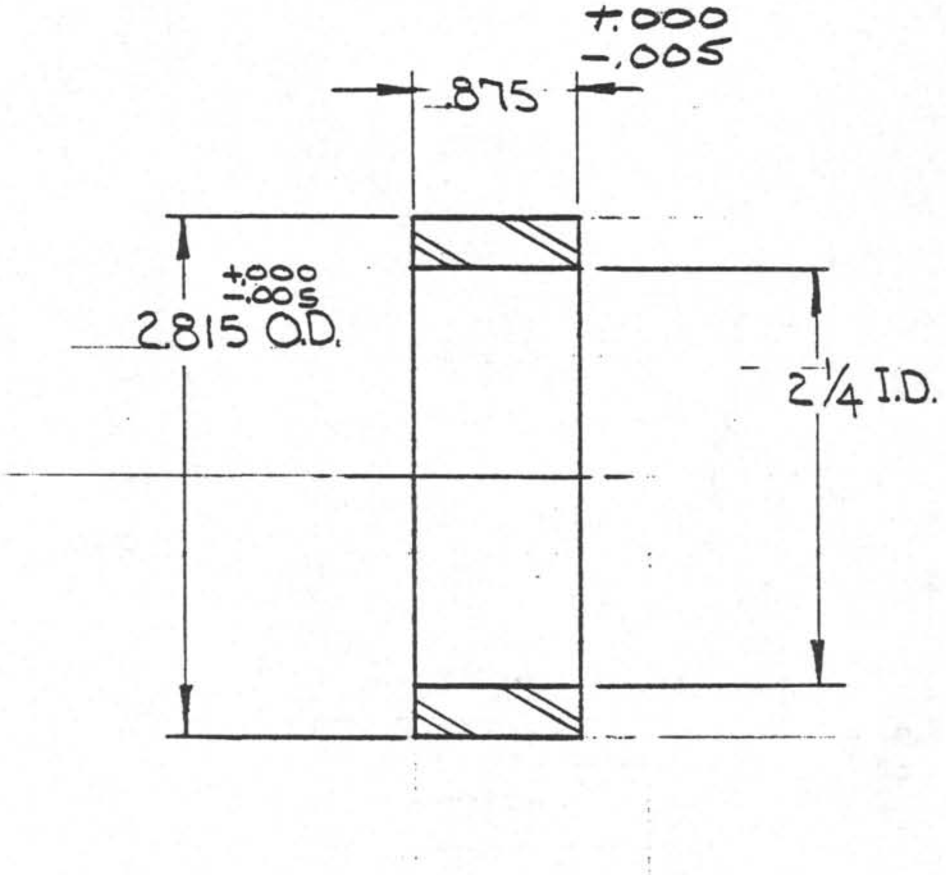
TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE CYLINDER GUIDE SAMPLING ASSY. - PCB				
SURFACE TREATMENT	MATERIAL NITRONIC 60 S.S.	DRAWN BY 4	DATE 7/28/80	CHECKED WHC	APPROVED
HEAT TREATMENT	PART NO. OP4616	SIZE DWG. NO. A-OP 4616			REV.

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	3.500 WAS 3.562, 4135 WAS 4140	9-3-80	RK		



TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 × 45° or 1/64 R FINISH 125	TITLE 2 1/4 CORE CATCHER SUB ~ PCB II-III				
SURFACE TREATMENT PHOSPHATE	MATERIAL 4135 ⚠1	DRAWN BY RK	DATE 8-4-80	CHECKED [illegible]	APPROVED [illegible]
HEAT TREATMENT 30-32 Rc	PART NO. OP4617-1	SIZE DWG. NO. B-OP4617-			REV. 1

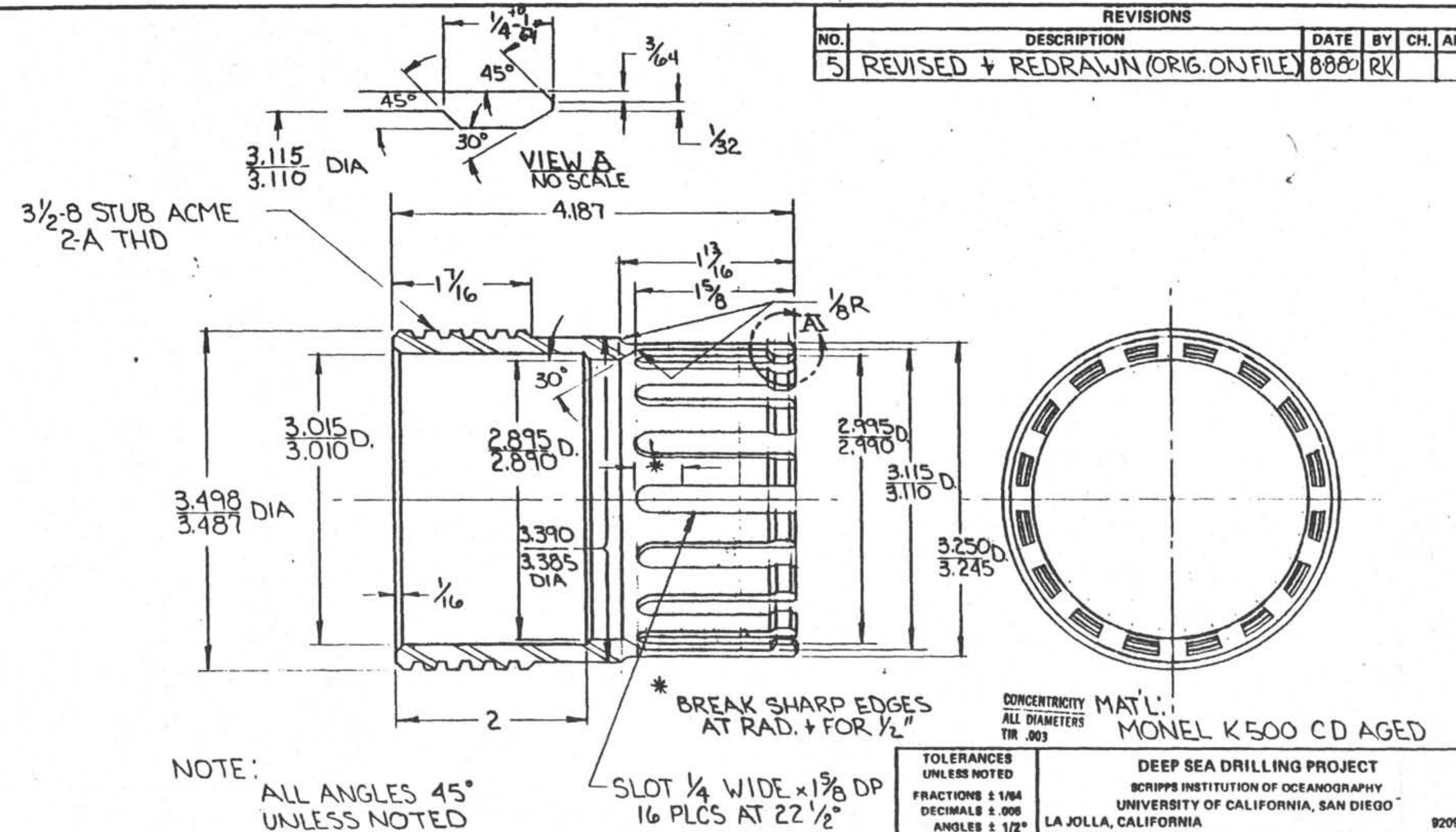
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



CONCENTRICITY
ALL DIAMETERS
TIR .003

NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
	TITLE: SPACER - CORE CATCHER ~PCB-II-III~				
SURFACE TREATMENT: —	MATERIAL: S.S.	DRAWN BY: RK	DATE: 8.5.80	CHECKED	APPROVED: [illegible]
HEAT TREATMENT: —	PART NO.: OP4618	SIZE DWG. NO.: A-OP4618			REV.

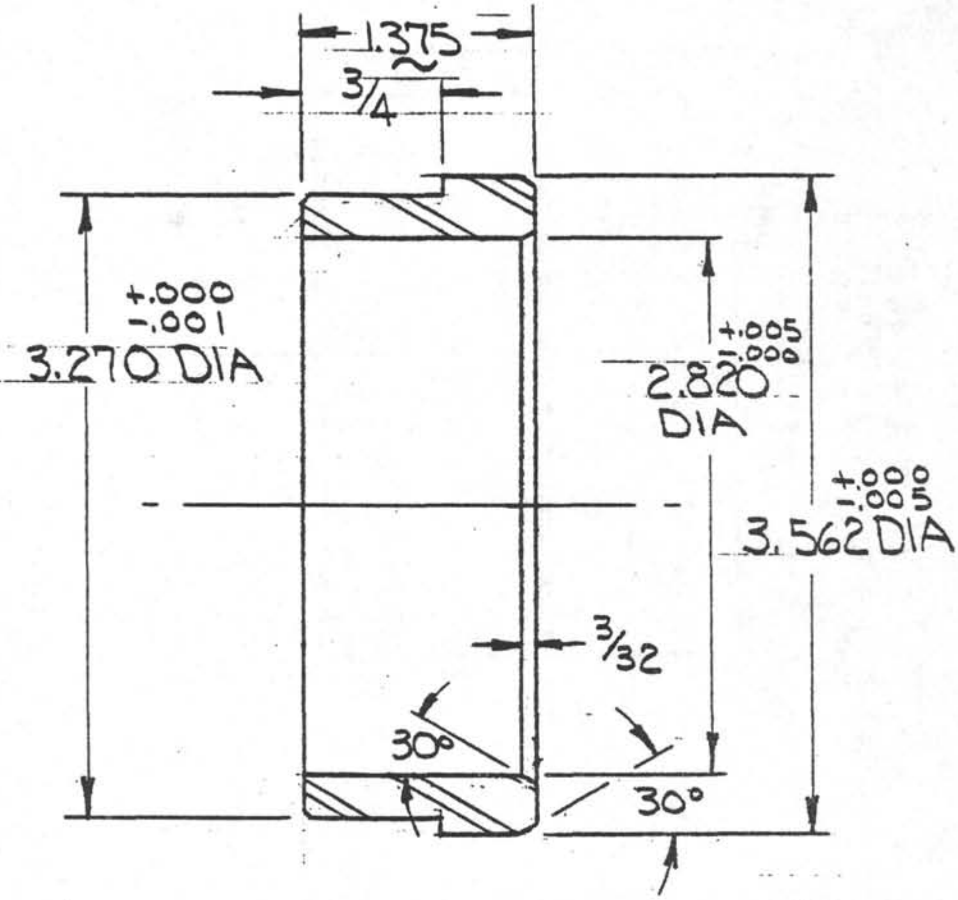


REVISIONS

NO.	DESCRIPTION	DATE	BY	CH.	APR.
5	REVISED & REDRAWN (ORIG. ON FILE)	8-8-80	RK		

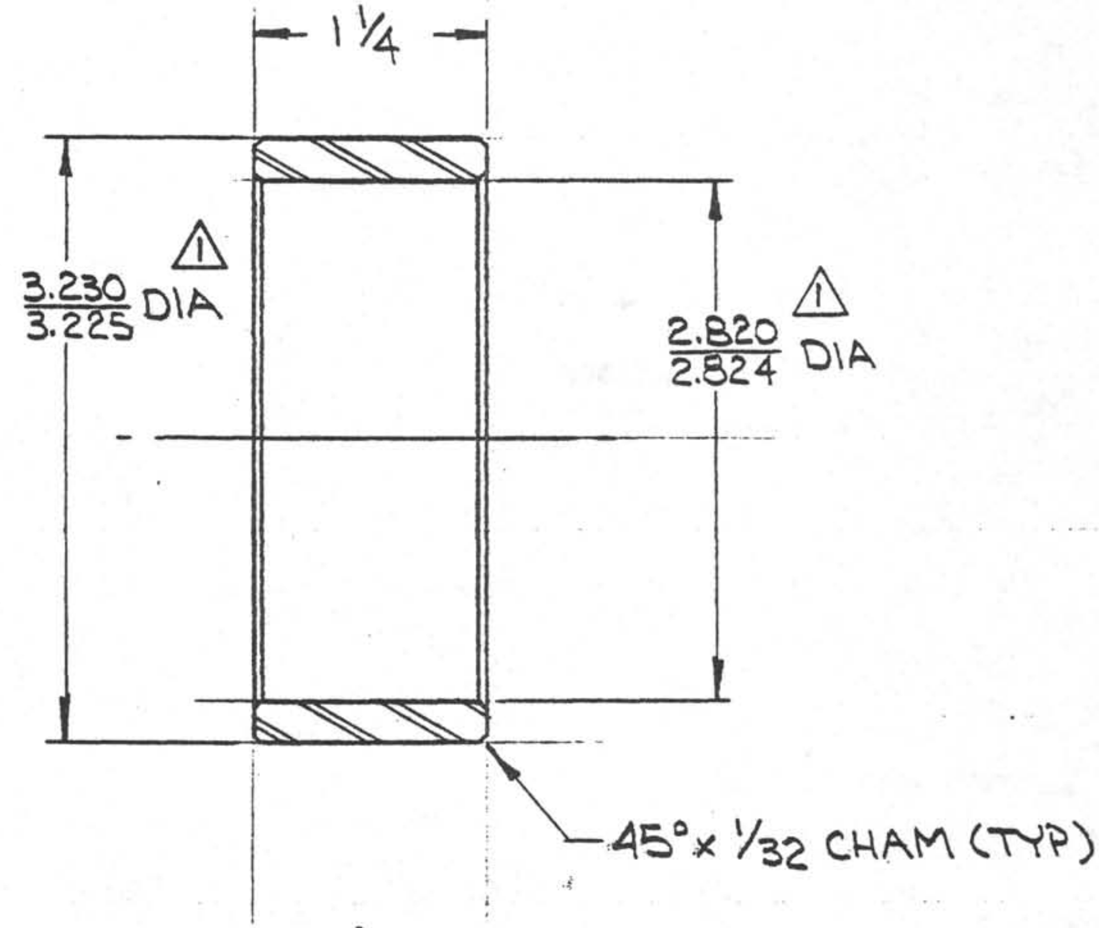
TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 × 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE: COLLET SLEEVE ~BVA - PCB II-III
SURFACE TREATMENT: —	MATERIAL: SEE ABOVE; DRAWN BY: RK; DATE: 8-8-80; CHECKED: [illegible]; APPROVED: [illegible]
HEAT TREATMENT: AGED	PART NO.: OP4620.-5; SIZE: B; DWG. NO.: OP4620; REV.: 5

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093			
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE DOG CAGE CAP ~PCB II-III~			
SURFACE TREATMENT PHOSPHATE	MATERIAL 4140 ALLOY	DRAWN BY / DATE	CHECKED GHK	APPROVED Bwa
HEAT TREATMENT 36 Rc	PART NO. OP4621	SIZE DWG. NO. A-OP4621		REV.

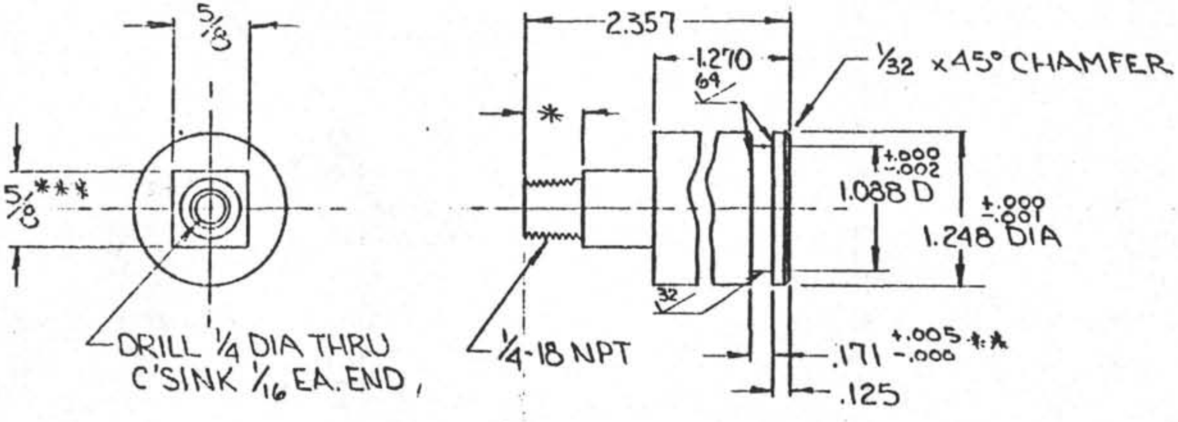
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	2.820/2.824 WAS 2.790/2.785, 3.230/3.225 WAS 3.245/3.240	9.3.80	RK		



NOTE: —
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093 TITLE SPRING RING ~ PCB II-III BVA ~				
SURFACE TREATMENT —0—	MATERIAL ANY STAINLESS	DRAWN BY RK	DATE 8.14.80	CHECKED	APPROVED
HEAT TREATMENT —0—	PART NO. OP4622-1	SIZE A	DWG. NO. OP4622-		REV. 1

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR



*LENGTH REQ'D FOR 1/4 NPT
**FOR O-RING #2-121 + BACK-UP #8-121
***TO FIT THRU P/N OP 4532

NOTES —
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS

* (AQUAMET 18)

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
	TITLE SEDIMENT TRAP SEAL ~ PCB II - III				
SURFACE TREATMENT	MATERIAL NITRONIC 32*	DRAWN BY	DATE	CHECKED	APPROVED
HEAT TREATMENT	PART NO. OP 4623	SIZE B	DWG. NO. OP4623		REV.

-217-

SPECIFICATION SHEET

PART NUMBER : OP-4627

DESCRIPTION :

ITEM : HOld Down (for Fike Rupture Unit)

MANUFACTURER : Fike

P/N FOR ORDERING : ½-100 SM, ¼ NPT

DIMENSIONS : 1-1/8" across Hex Flats

OTHER INFORMATION : Part of set which includes ring (OP-4628)

VENDOR : Vossler & Co.
4917 Lankershim Blvd.
No. Hollywood, CA 91601

877-0611

OP-4627

SPECIFICATION SHEET

PART NUMBER	:	OP-4628
DESCRIPTION	:	
ITEM	:	Ring (for Fike Rupture Unit)
MANUFACTURER	:	Fike
P/N FOR ORDERING	:	½-100 SM, ¼ NPT
DIMENSIONS	:	
OTHER INFORMATION	:	Part of set which includes hold down (OP-4627)
VENDOR	:	Vossler & Co. 4917 Lankershim Blvd. No. Hollywood, CA 91601 877-0611

SPECIFICATION SHEET

PART NUMBER	:	OP-4629
DESCRIPTION	:	
ITEM	:	Burst Disc
MANUFACTURER	:	Fike
P/N FOR ORDERING	:	1/2-100 SM, 7000 psi or 8000 psi
DIMENSIONS	:	

OTHER INFORMATION :

VENDOR : Vossler & Co.
4917 Lankershim Blvd.
No. Hollywood, CA 91601

877-0611

SPECIFICATION SHEET

PART NUMBER : OP-4630

DESCRIPTION :

ITEM : Ball VAlve

MANUFACTURER : Hoke

P/N FOR ORDERING : 7223F8Y

DIMENSIONS : Length = 3½"

OTHER INFORMATION : Handle is removed when valve is in use.

VENDOR : Castle Controls Inc.
7370 J Opportunity Rd.
San Diego, CA 92111

(619) 268-3491

SPECIFICATION SHEET

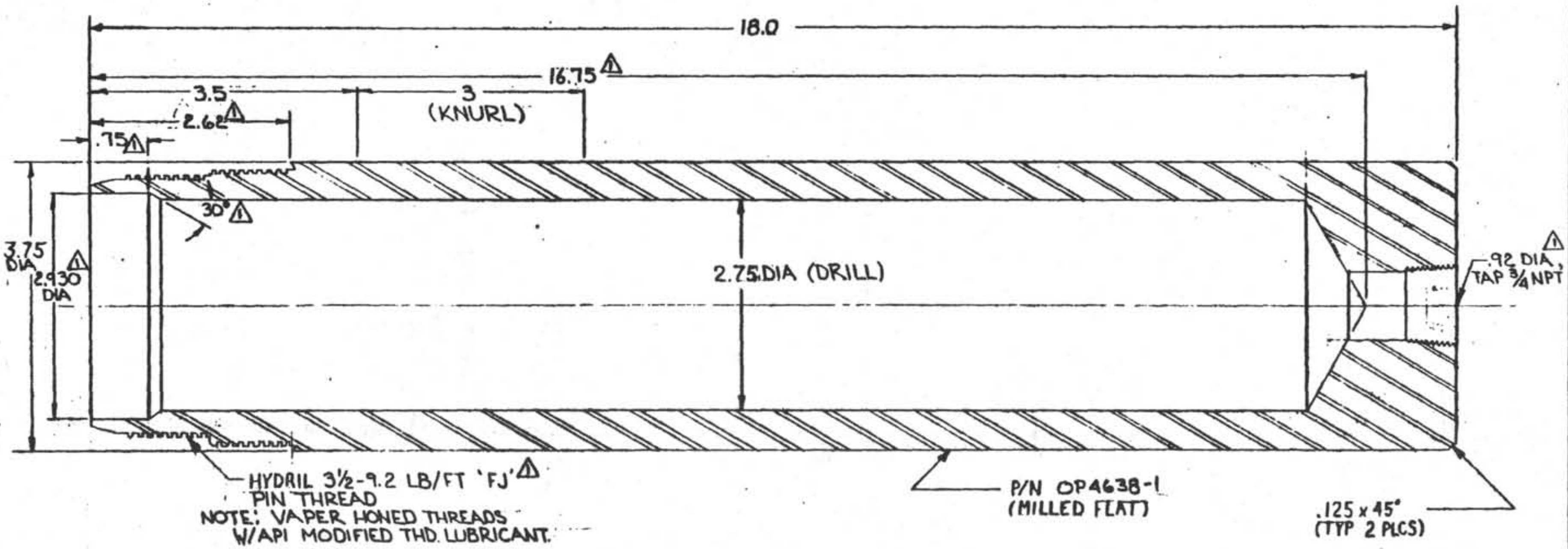
PART NUMBER	:	OP-4633
DESCRIPTION	:	Port Adapter
ITEM	:	Haskel
MANUFACTURER	:	26250-3
P/N FOR ORDERING	:	
DIMENSIONS	:	
OTHER INFORMATION	:	Adapts from 3/8" Female Superpressure to 1/4" NPT Male.
VENDOR	:	Haskel Engineering & Supply Co. 100 East Graham Place Burbank, CA 91502 (800) 232-2720

SPECIFICATION SHEET

PART NUMBER	:	OP-4634
DESCRIPTION	:	
ITEM	:	Accumulator
MANUFACTURER	:	Haskel
P/N FOR ORDERING	:	15811-2SS
DIMENSIONS	:	Length : 32-1/4" Diameter: 2-3/8"
OTHER INFORMATION	:	Female threaded ports each end. Super pressure tube O.D. size.
VENDOR	:	Haskel Engineering & Supply Co. 100 East Graham Place Burbank, CA 91502 (800) 232-2720

OP-4634

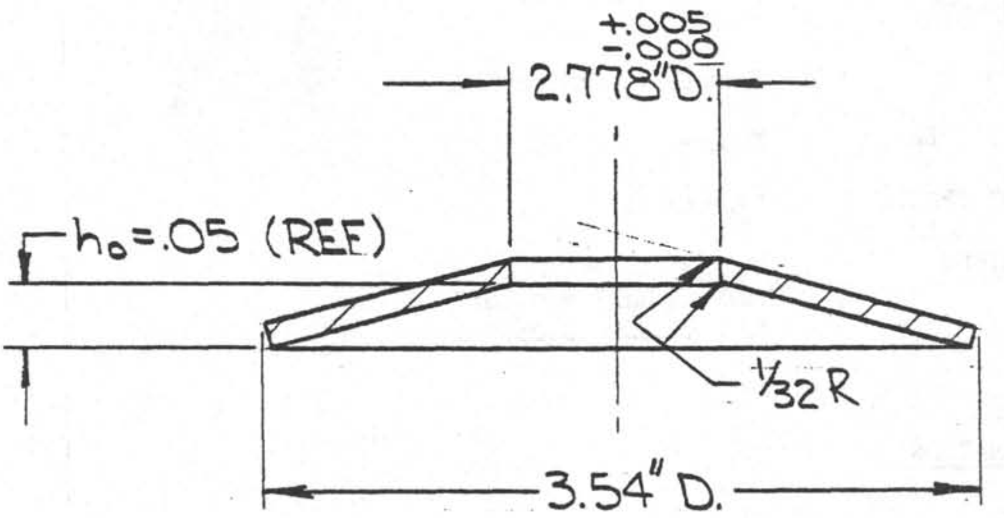
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH	APP
1	2.62 WAS 1.81, .75 x 2.930 DIA + 30° ADDED, 3½-9.2 LB/FT WAS FJ-40, ¾ WAS ¼, 16.75 WAS 16	3-7-78	RK		



MAT'L:
17-4 PH SS HT. CONDITION H1025

UNIV OF CALIF DEEP SEA DRILLING PROJ.		
SCALE: FULL	APPROVED BY:	DRAWN BY DHC
DATE: FEB 21 78		REVISED
P.C.B. HYDRIL 3½-9.2 LB/FT 'FJ' TEST PLUG ⚠1		
PART NO. OP 4638-1		DRAWING NUMBER OP4638-1

REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.



1. ORIGIONAL SCHNORR SPRING DIMENSIONS:
   90mm × 46m × 2.5mm THK, h_o = 3.2mm
2. BORE OUT I.D. TO 2.778
3. CHAMFER I.D. AS SHOWN

MAT'L: SCHNORR DISK SPRING XZZ CR MO V 121

DO NOT SCALE

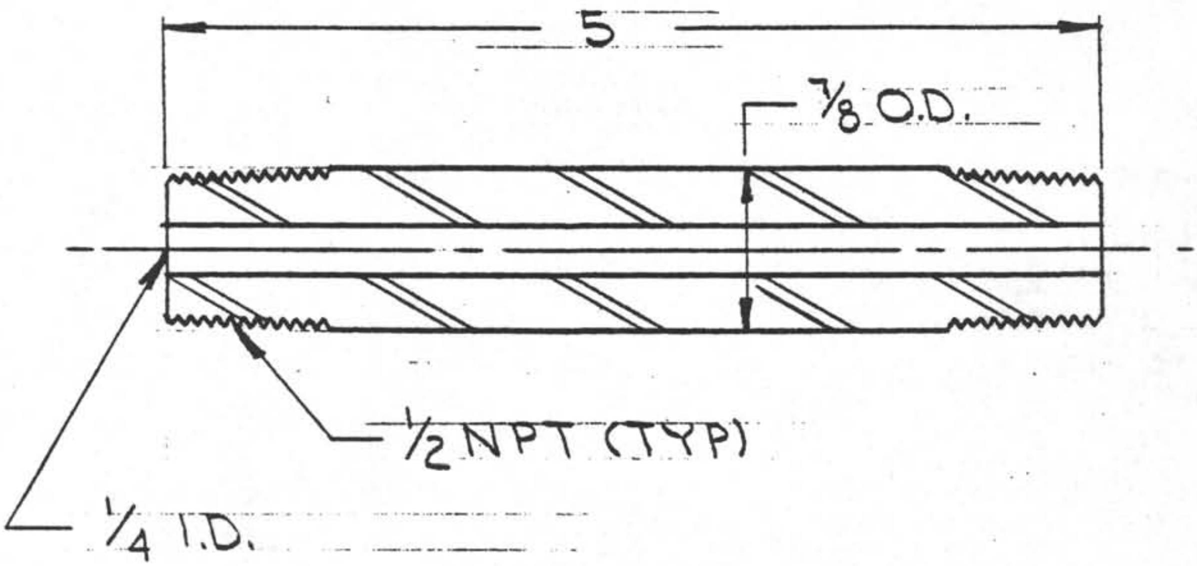
CONCENTRICITY ALL DIAMETERS: TIR .003

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 × 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
	TITLE DISK SPRING ~PCB III~				
SURFACE TREATMENT —⊖—	MATERIAL SEE ABOVE		DATE 9·17·80	BY RK	CHECKED OHC / APPROVED
HEAT TREATMENT —⊖—	SCALE NONE	REQ'D/ASS'Y 38 TO 45	PART NO. OP4639-0		DWG. NO. A-OP4639 (REV.)

SPECIFICATION SHEET

PART NUMBER	:	OP-2865
DESCRIPTION	:	
ITEM	:	Spiralox Retainer Ring
MANUFACTURER	:	Ramsey
P/N FOR ORDERING	:	RRT-300-S
DIMENSIONS	:	O.D. = 3.188" Radial Wall = 0.188" Thickness = 0.093"
OTHER INFORMATION	:	
VENDOR	:	Winn Supply Co. San Diego, CA (619) 233-5311 or Ramsey Corporation P.O. Box 513 St. Louis, MO 63166 (314) 394-3700

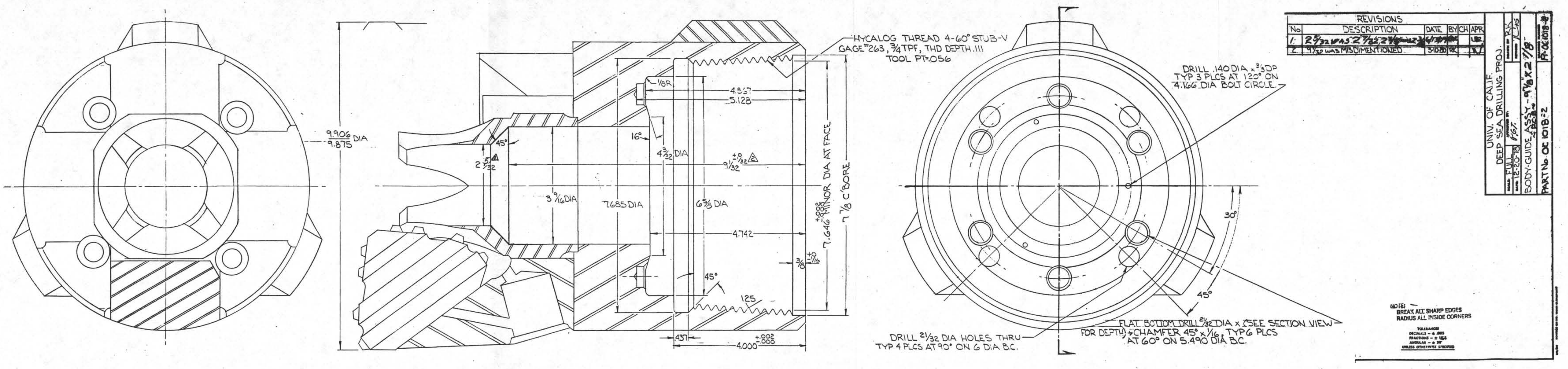
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.

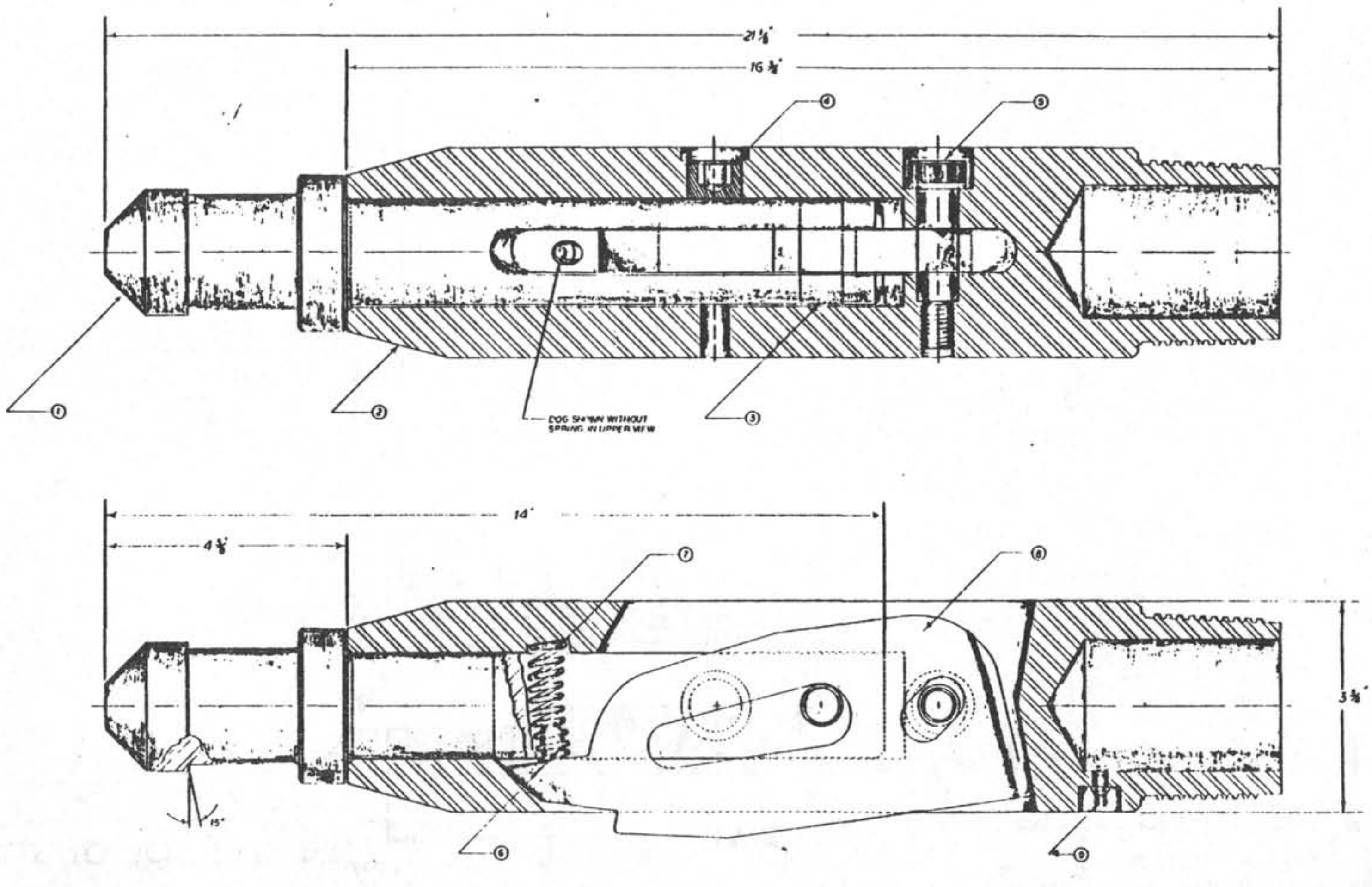


DO NOT SCALE

CONCENTRICITY ALL DIAMETERS: TIR .003

TOLERANCES UNLESS NOTED FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
	TITLE 5" NIPPLE ~PCB III - SAMP. ASSY~				
SURFACE TREATMENT —⊖—	MATERIAL S.S.	DATE 9.10.80	BY RK	CHECKED [illegible]	APPROVED
HEAT TREATMENT —⊖—	SCALE FULL	REQ'D/ASS'Y 1	PART NO. OP2873	DWG. NO. A-OP 2873	(REV.)


REVISIONS
No DESCRIPTION DATE BY CH APR
1. 25/32 WAS 27/32
2. 9/32 WAS MISDIMENTIONED 3-10-80 RK
UNIV. OF CALIF.
DEEP SEA DRILLING PROJ.
FULL
12-20-78
BODY-GUIDE ASSY - 9 7/8 X 2 7/8
PART No. OC 1018-2
HYCALOG THREAD 4-60° STUB-V
GAGE=.263, 3/4 TPF, THD DEPTH .111
TOOL PT=.056
9.906
9.875 DIA
7.685 DIA
6 5/8 DIA
3 9/16 DIA
4 3/32 DIA
7.646 MINOR DIA AT FACE
7 7/8 C'BORE
4.742
4.567
5.128
4.000
.437
DRILL .140 DIA x 3/8 DP
TYP 3 PLCS AT 120° ON
4.166 DIA BOLT CIRCLE.
DRILL 21/32 DIA HOLES THRU
TYP 4 PLCS AT 90° ON 6 DIA B.C.
FLAT BOTTOM DRILL 25/32 DIA x 2 (SEE SECTION VIEW FOR DEPTH)
CHAMFER 45° x 1/16, TYP 6 PLCS
AT 60° ON 5.490 DIA B.C.
NOTE:
BREAK ALL SHARP EDGES
RADIUS ALL INSIDE CORNERS
TOLERANCES
DECIMALS - ± .005
FRACTIONS - ± 1/64
ANGULAR - ± 30'
UNLESS OTHERWISE SPECIFIED



WEIGHT: 44 1/2 LBS

OP3010

PARTS LIST					
ITEM	PART DESCRIPTION	QTY.	DSOP DRAWG NO.	PART NO.	ASS. DRAWG. NO.
1	PULL BAR	1	B-OP3011	OP3011	NA
2	LATCH BODY	1	C-OP3015	OP3015	NA
3	PULL BAR PIN	1	A-OP3012	OP3012	NA
4	PIPE PLUG	1	OP3017 (SPECS)	OP3017	NA
5	SHOULDER BOLT	1	OP3018 (SPECS)	OP3018	NA
6	LATCH DOG SPRING PIN	1	A-OP3013	OP3013	NA
7	LATCH DOG SPRING	1	OP3016 (SPECS)	OP3016	NA
8	LATCH ASSY DOG	1	B-OP3020	OP3020	NA
9	GREASE FITTING	1	NA	NA	NA

1 MODIFIED HEEL ON LATCH DOG

SEE INDIVIDUAL DRAWGS

FULL

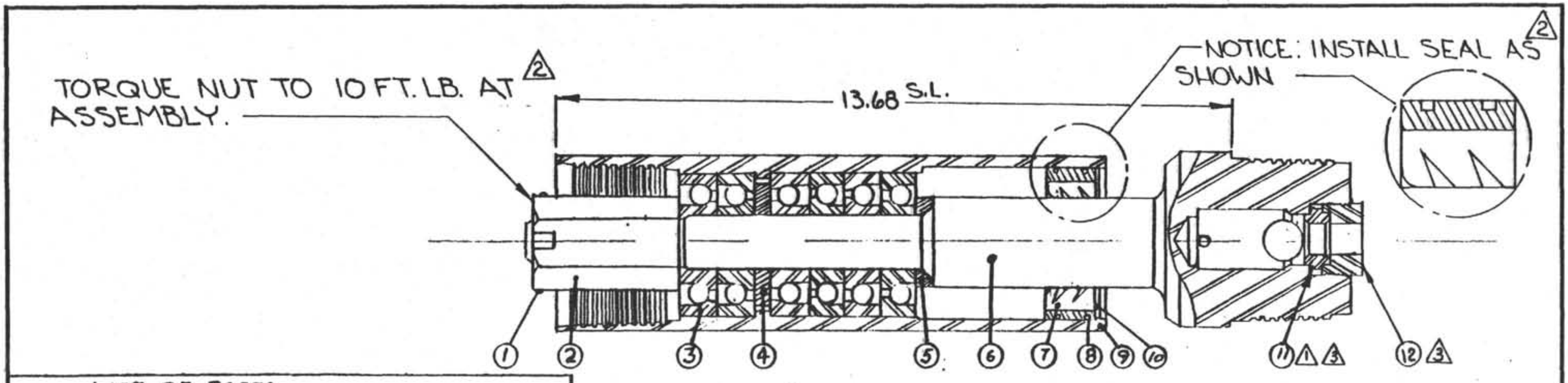
UNIVERSITY OF CALIFORNIA
SCRIPPS INSTITUTION OF OCEANOGRAPHY

INNER BARREL LATCH ASS'Y

DSOP NSF

D-OP3010 1

OP3010



LIST OF PARTS

ITEM	PART#	DESCRIPTION	QTY	
1	OP3103	COTTER KEY 1/8 x 2 1/2	1	
2	OP3112	BEARING SHAFT NUT	1	
3	OP3104	FAFNIR BEARING	6	
4	OP3113	BEARING SPACER	1	
5	OP3111	BEARING SHAFT BUSHING	1	
6	OP3110	BEARING SHAFT	1	
7	OP3114	GREASE SEAL	1	
8	OP3105	"O" RING	2	
9	OP3109	BEARING HOUSING	1	
10	OP3106	SNAP RING	1	
11	OP 3107	HARBISON-FISCHER CHECK BALL & SEAT	1	1 3
12	OP3108	VALVE SEAT RETAINER	1	3

WEIGHT: 28 LBS

APR	NO.	DESCRIPTION	DATE	BY
	03	06-0146-00/06-0147-02 W/S 06-0542-00	MAY 8-78	RK
KS	02	TORQ. & SEAL NOTES ADDED	4 MAY 78	RK
	01	NEW DESIGN-BALL CHK. RETAIN.	7 JAN 77	RK

REVISIONS

SCALE: NONE
APPROVED BY:
DRAWN BY P.G.T.
DATE: 7-3-73
REVISED

UNIVERSITY OF CALIF. AT SAN DIEGO
DEEP SEA DRILLING PROJECT

INNER BARREL SWIVEL ASSEMBLY

DRAWING NUMBER B-OP3100-3

PART# OP3100-3

11217 PRINTED ON NO. 1000H CLEARPRINT

SPECIFICATION SHEET

PART NUMBER : OP-3107

DESCRIPTION :

ITEM : Check Ball & Seat

MANUFACTURER : Harbison-Fischer

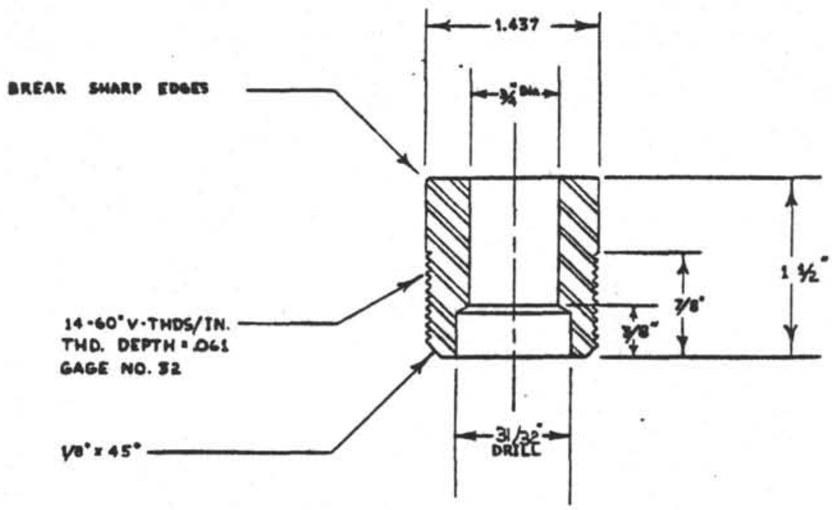
P/N FOR ORDERING : 2E3 1½" RIB-15/16" Ball

DIMENSIONS :

OTHER INFORMATION :

VENDOR : Harbison-Fischer Mfg. Co.
P.O. Box 2477
Fort Worth, Texas 76101

(817) 355-4381



VALVE SEAT RETAINER

OP3108

PART NO. OP 4522 MAT'L: MILD STEEL

SCALE FULL

UNIVERSITY OF CALIFORNIA
SCRIPPS INSTITUTION OF OCEANOGRAPHY
LA JOLLA, CALIFORNIA

PART VALVE SEAT RETAINER FOR 1 1/2"
VALVE SEAT – P.C.B.
D.S.D.P. PART NO. OP 3108

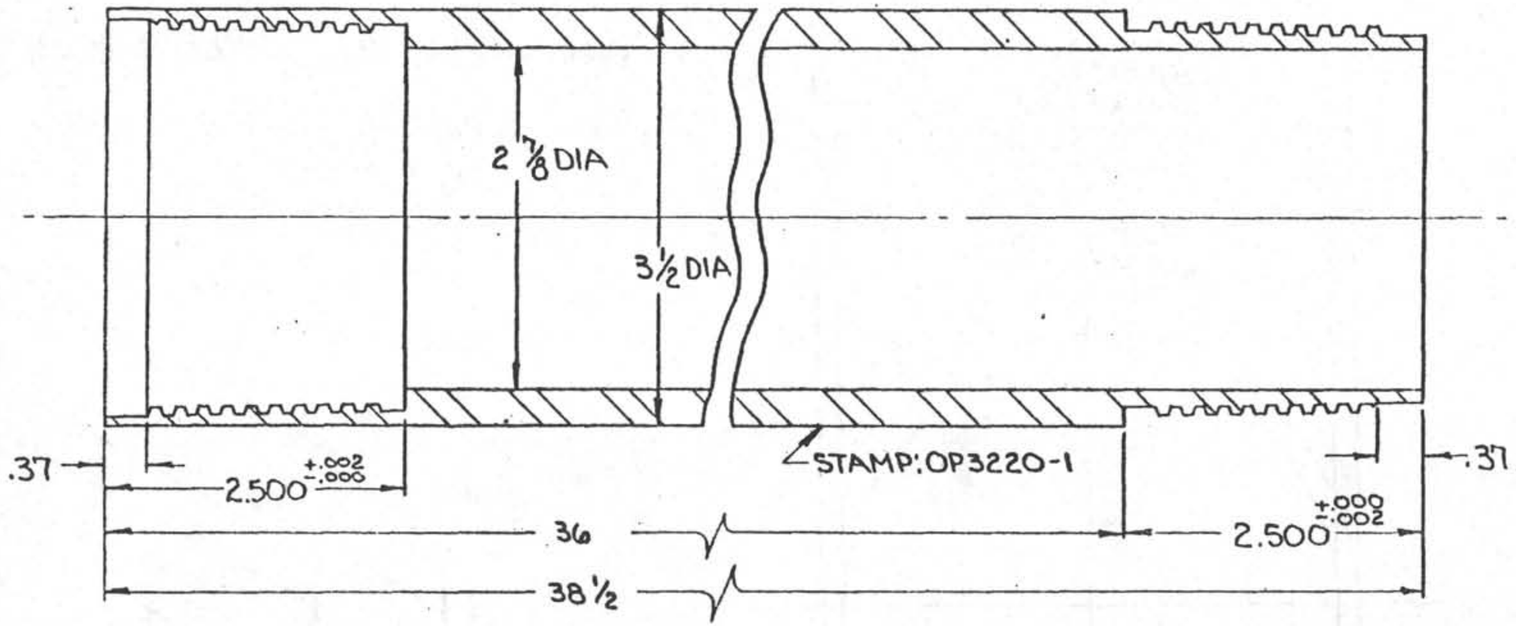
MATERIAL 316 SS

DRAWN Gonzalez 2-22-74

D.S.D.P.

B-OP 3108

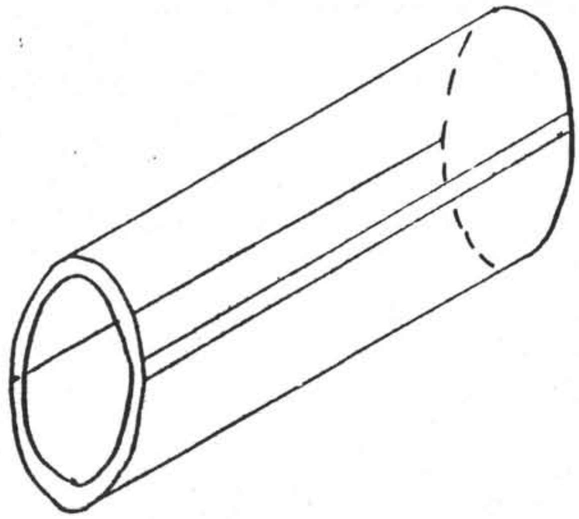
REVISIONS					
NO.	DESCRIPTION	DATE	BY	CH.	APR.
1	REDRAWN, ADDED PARKOLUB.	8-6-81	RK	AGI	

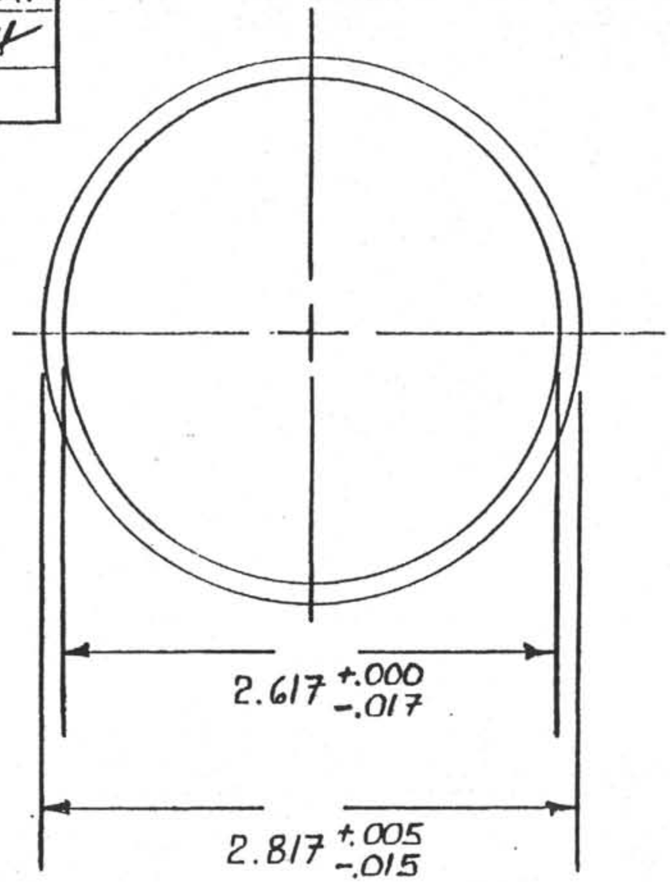


DSDP INNER BARREL THDS
SEE DWG No. B-0508

TOLERANCES UNLESS NOTED	DEEP SEA DRILLING PROJECT SCRIPPS INSTITUTION OF OCEANOGRAPHY UNIVERSITY OF CALIFORNIA, SAN DIEGO LA JOLLA, CALIFORNIA 92093				
FRACTIONS ± 1/64 DECIMALS ± .005 ANGLES ± 1/2° CORNERS 1/64 x 45° or 1/64 R FINISH 125	TITLE 36 IN. INNER BBL SUB				
SURFACE TREATMENT PARKOLUB.	MATERIAL 4130 C.D.	DRAWN BY RK	DATE	CHECKED	APPROVED
HEAT TREATMENT —	PART NO. OP3220-1	SIZE DWG. NO. B-OP3220-			REV. 1

No.	DESCRIPTION	DATE	BY	APR.
1	H.P.C. NOTE ADDED , 3/4 WAS 2.76	11.27.78	RK	MAA
2	DELETE H.P.C. NOTE	11.11.80	RK	





MATERIAL: CLEAR BUTYRATE PLASTIC

NOTE: COLOR LINER ON QTR.
ONE DOUBLE - THREE SINGLE
1/16" WIDE LINES
- NO PROTUBERANCE AT
CORE LINER SURFACE -

MINIMUM WALL: 0.092"
CONCENTRICITY WITHIN .050"

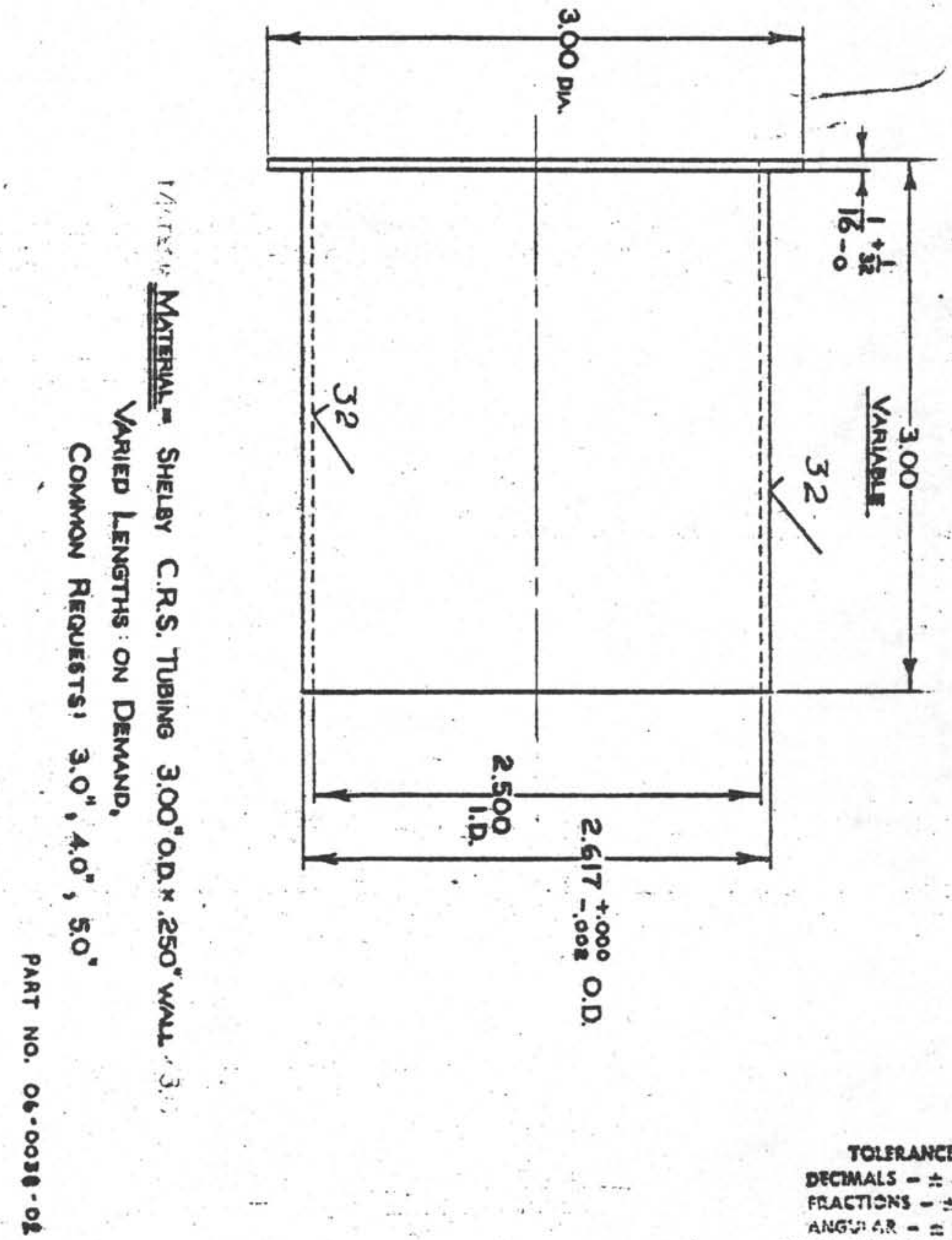
DSDP STANDARD CORE LINER

SCALE: NONE	APPROVED BY: MAA 10/4	DRAWN BY MAL
DATE: 15 OCT. 74		REVISED MAA
SKETCH No. 1	PART No. OP 3400-2	
FOR USE IN 3 1/2" INNER C'BBL.		DRAWING NUMBER A-OP3400-2

8½x11 PRINTED ON NO. 1000H CLEARPRINT

REVISIONS

NO.	DESCRIPTION	DATE	BY	CH.	APR
1	ADD TOL AND FINISH MARKS	5/30/78	PGT.	V	5/30



TOLERANCES
DECIMALS – ± .005
FRACTIONS – ± 1/32
ANGULAR – ± 30'
UNLESS OTHERWISE SPECIFIED

OP 3410-1

SCALE	FULL	
DRAWN	D. BETTS	8/18/72
DESIGNED	VFL	–
CHECKED		
APPROVED		

UNIVERSITY OF CALIFORNIA, SAN DIEGO
SCRIPPS INSTITUTION OF OCEANOGRAPHY
RESEARCH SUPPORT SHOP, LA JOLLA, CALIF.

SUPPORT SLEEVE

DEEP SEA DRILLING PROJECT 182-420

MATERIAL SHELBY TUBING
FINISH SMOOTH MACHINE
DRAWING NO. A-OP 3410-1