OCEAN DRILLING PROGRAM

LEG 142 ENGINEERING AND SCIENTIFIC PROSPECTUS

EAST PACIFIC RISE

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This Engineering Prospectus is based on pre-cruise site survey information and JOIDES panel discussions. The operational plans within reflect JOIDES Planning Committee and thematic panel priorities. During the course of the cruise, actual site operations may indicate to the Assistant Manager of Engineering and Drilling Operations and the Chief Scientist that it would be operationally and scientifically advantageous to amend the plan detailed in this prospectus. It should be understood that any proposed changes to the plan presented here are contingent upon approval of the Director of the Ocean Drilling Program at TAMU in consultation with the Planning Committee and the Pollution Prevention and Safety Panel.

INTRODUCTION: ENGINEERING TESTS AT THE EAST PACIFIC RISE

Leg 142 (Engineering Leg III) is the third of a series of cruises designed to support the development and operational refinement of hardware and techniques that will be required to meet the ODP scientific mandate of the future. Since the technological complexity of high-priority scientific problems continues to grow, so too does the demand for dedicated ship time. Although ODP/TAMU continues to emphasize thorough shore-based testing of developmental equipment, thesetests cannot adequately model the offshore marine environment in which the tools are to be operated. Dedicated engineering legs are therefore invaluable to successful attainment of the required technology.

ODP is developing a high-speed, slim-hole "Diamond Coring System" (DCS) designed for deployment in deep water from the dynamically-positioned drill ship, JOIDES Resolution. High-speed, narrow-kerf, slim-hole diamond coring has been demonstrated in land drilling operations as a very effective way to core fractured, unstable, crystalline rock. In those operations, the significant reduction in hole size, coupled with the technique of grinding the rock at high speed and low bit weight, rather than crushing the rock, resulted in extremely high recovery rates (typically 90 percent or better), minimized core jamming, and improved hole stability over that possible with conventional rotary drilling. Three specific types of formations have been identified as candidates for diamond coring by ODP: fractured basalt formations, formations with alternating layers of chalk/chert, and formations composed of eroded reefal limestone. Previous attempts by ODP and the Deep Sea Drilling Project (DSDP) to core these types of formations using conventional large-diameter, tungsten-carbide-insert roller cone (TCI-RC) bits have resulted in unsatisfactory core recovery.

Leg 142 is dedicated to engineering tests of Phase IIB of the DCS at the East Pacific Rise (EPR). The EPR is an area of high scientific interest, where it is hoped that the DCS will prove valuable in meeting ODP scientific objectives in the course of a multi-leg scientific program. Leg 142 is scheduled to depart Valparaiso, Chile, on 18 January 1992 and arrive in Honolulu, Hawaii, on 19 March 1992 (Fig. 1). The proposed engineering operations will take place entirely on the East Pacific Rise at 9°30.8'N and 104°14.6'W (EPR-2); this site is located at the axis of the East Pacific Rise, a sediment-free, fast-spreading mid-ocean ridge.

Of the 66.0 total days allocated to the leg, 5.0 are designated for the port call in Valparaiso, Chile. Total transit time for the leg is estimated at 25.1 days. Assembly and rig-up of the DCS will take place during the 12.5 day transit from Valparaiso to the EPR-2 drill site. Rig-down and off-loading shipping preparations will take place during the 12.6 day transit from the drill site to Honolulu. The remaining 35.9 days will be available for on-site operations.

DCS DEVELOPMENT

Phase I: ODP Leg 124E/Luzon Strait

During the Phase I development of the diamond coring system, ODP deployed and evaluated slim-hole coring equipment from the JOIDES Resolution. Although this equipment resulted from proven technology on land, modifications were necessary to provide adequate weight-on-bit (WOB) control from a floating vessel at sea. In addition, the long, slim-hole tubing (coring) string had to be configured to work with offshore drillship dynamics.

Phase I tests were conducted during ODP Leg 124E, which drilled for 2 weeks in the Luzon Strait off the coast of the Philippine Islands. The prototype Phase I system (Fig. 2) had only a 2000 m total depth (water depth plus penetration depth) capability. The slim-hole coring system was integrated into a 40-ft mast and suspended in the Resolution's derrick. The DCS coring string was deployed inside standard ODP drill pipe, to which a narrow-kerf diamond core bit (3.96 in. by 2.20 in. diameter) was attached. All coring and wireline equipment was deployed from the DCS work platform (Fig. 3). All drilling controls were mounted on the platform console and were operated by a two-man drill crew. Operational efficiency was compromised with the members of the drill crew working 45 ft above the rig floor, where they were constantly subjected to the motion of the suspended platform. The entire system was suspended from the primary 400-ton passive-heave-compensator system. An active secondary-heave-compensator system (single cylinder) was mounted on the DCS platform to remove from the tubing string the heave motion/weight fluctuation residual from the primary compensator. The system was designed to maintain extremely accurate WOB control. Rotational torque for the diamond bit was provided by a 3-1/2 in. coring string, rotated from the surface by a high-speed, mining-type, hydraulic top drive, mounted in the DCS platform.

Limited sediment coring was conducted during Leg 124E with the prototype system in heavy seas (4 to 6 ft, coupled with a heave period of 4 to 6 sec). Examination of the recovered core samples revealed little or no coring disturbance, which was interpreted as an indication that the bit remained on the bottom of the hole, with good WOB control. Constant drilling torques at the surface and steady pump pressures confirmed this assessment. These results indicated that the concept of adapting slim-hole coring techniques to a floating vessel was promising. Because of the myriad of problems experienced with hole instability during Leg 124E, we also concluded that a coherent seafloor structure and upper-hole stabilizing capability were critical to successful deployment of the system in the future.

Phase IIA: ODP Leg 132/Bonin Ridge

During the Phase IIA development of the diamond coring system, a number of significant improvements were made (Fig. 4). These included (1) extending the total operating depth of the system from 2000 to 4500 m; (2) replacing the hydraulic top drive with a high-load, high-speed, electric top drive system to maintain constant RPM while drilling torque varied; (3) integrating electronic control technology into the shipboard electrical systems to allow fine control of the circulating pumps for the low (3-40 gallons/min) flow rates required for DCS operations; (4) extending the secondary heave compensation capability (now dual cylinder design) to +/-12 in. of residual heave within the same 6-sec period; (5) developing a "mini" hard rock guide base (HRB) to allow deployment of the base without the need for steel cables, and also for tensioning the drill string against the seafloor structure in much the same manner as an oilfield drilling riser; (6) developing a drill-in-bottom hole assembly (DI-BHA) system for use in spudding a bare rock hole and isolating the upper, unstable portion of the formation; and, (7) eliminating weaknesses in the wireline core barrel components identified during Leg 124E.

Testing of the Phase IIA DCS system was conducted in the Bonin backarc region during ODP Leg 132. Numerous problems and component failures were experienced during DCS deployment and testing of the prototype seafloor/DI-BHA hardware. In spite of those developmental problems, all systems were eventually made operational. By the end of Leg 132, a 79+ m penetration into young, highly fractured, basaltic crust was achieved at Site 809 (Storms, Natland, et al., 1990).

With the exception of some friable volcanic tuff zones, which yielded little or no recovery, the majority of the fractured rock was recovered at a rate greater than 64%. In addition, the nominal 4-in. DCS hole exhibited no instability whatsoever. As a bonus, it was demonstrated that the new, "mini" HRB can be moved, and, when required, recovered back aboard ship.

Phase IIB: ODP Leg 142/East Pacific Rise

Phase IIB of the DCS development continues to build on the prototype systems tested on Engineering Legs 124E and 132. The "mini" HRB has been redesigned (Fig. 5) into a hex-sided configuration, nominally 13 ft across, and will be fitted with three legs, rather than four, as in previous models. The reentry cone diameter has been reduced to 8 ft, similar to ODP's free-fall-funnel design, and is now mounted on a counter-balanced gimbal, negating the need for syntactic foam buoyancy panels. The improved guide-base design currently has a 2.5:1 factor of safety on its positive righting moment and will handle slopes of up to 25°. A redundant-angle measuring capability will be available, using both mechanical "bull's eye" and electronic tilt-beacon technology.

The DI-BHA system has been expanded into a two-stage, "nested" design (Fig. 6) allowing a second-stage DI-BHA to be deployed after initial DCS coring operations have been attempted through the upper unstable crust. An optional slim-hole diamond coring system, using a 7-1/4 in. diamond bit, 6-3/4 in. drill collars, and slightly-modified RCB-wireline core-barrel components is also under development (Fig. 7) and will be available for deployment.

The DCS platform-mounted coring rig now has improved low-friction seals on the feed cylinders to alleviate the intermittent frictional sticking or "crabbing" experienced during Leg 132 operations. Improvements have been made to the secondary compensation system to allow operations in a wider range of sea states and water depths. The winch control system has been improved, and the hydraulic power pack has been outfitted with a high-pressure filter system. The coring system has more core catcher options and also optional sampler-type systems for use in friable, sandy, or otherwise difficult unconsolidated-recovery situations.

In general, the diamond coring system to be used on Leg 142, including all seafloor and drilling systems, consists of the technology tested successfully on Leg 132, with many enhancements designed to improve performance and operational efficiency.

PROPOSED LEG 142 SITES

Site EPR-2 is the primary drill site identified for Leg 142 operations. Alternate sites have been identified, in case the engineering objectives of the leg cannot be achieved at EPR-2. The alternate sites include EPR-1, EPR-1A, EPR-2A, and EPR-3.

Site EPR-2 is located at 9°30.85'N, 104°14.66'W, with a water depth of 2590 m. Recent high-resolution bottom-seismic-refraction studies (Purdy and Fryer, 1991) show that EPR-2 has 50-60 m of low-velocity (~2.0 km/sec) material at the surface. This low-velocity layer overlies basalt with a velocity of ~5.5 km/sec, interpreted to be massive and highly drillable. The geology of the site is well known from ARGO surveys (Haymon et al., in press) and ALVIN studies conducted in March-April 1991.

Alternate sites EPR-1 and EPR-3 are located off-axis (Fig. 8), whereas EPR-2 is on the axis and within the zone of youngest volcanism. Site EPR-1 (9°30.2'N, 104°15.1'W, water depth 2600 m) is the most favored alternate site for Leg 142. EPR-1 is located about 1 km west of EPR-2. Purdy and Fryer (1991) show that EPR-1 and other off-axis sites consistently have thicker surface low-velocity layers (typically 150-200 m thick) overlying basalt with a velocity of 4.2 to 4.7 km/sec.

The geology of EPR-1 and its surroundings is well known from ALVIN submersible studies by Fornari, Haymon, and others in 1991.

The area of Sites EPR-1 and EPR-2 is particularly well-studied, so that scientific drilling at either site should provide results which can be interpreted within a broader regional context from numerous mapping, geophysical and sampling studies already completed or in progress. Multi-channel reflection and seismic topography (Detrick et al., 1987; Vera et al., 1990; Toomey et al., 1990) show the location of the axial magma chamber beneath the EPR at 9°30'N (Figs. 9, 10). Detailed deep-tow mapping by ARGO, plus ongoing studies of hydrothermal activity (Haymon et al., 1991; ALVIN studies in April 1991), allow flow-by-flow mapping in the vicinity of the drill site and a good understanding of the hydrothermal flow pattern and fluid/rock interaction occurring at depth. Previous and on-going petrologic studies shed light on questions of magmatic plumbing systems and magma chamber process. Very recent near-bottom seismic refraction studies (Purdy and Fryer, 1991) provide high-resolution views of the seismic velocity structure in the uppermost levels of the oceanic crust in the vicinity of 9°30'N (Fig. 11). Given this wealth of existing knowledge, the Leg 142 EPR sites are ideally suited to provide definitive answers to questions about the origin of EPR-generated ocean crust. Leg 142 is planned to provide the first new rock samples and other information (e.g., downhole logging) needed to answer these questions and formulate new ones.

Alternate sites in the 12°50'N area of the EPR include EPR-1A and EPR-2A. These will be considered for drilling during Leg 142 only if the 9°30'N area proves completely unsuitable; these sites are potentially very valuable for the multi-leg program at the EPR.

LEG 142 OBJECTIVES

Engineering and Logging Objectives

The primary engineering and operational objective for Leg 142 is to maximize coring time with the DCS. To accomplish this task, it will be necessary to deploy a refined version of the mini-hard-rock guide-base and to anchor the guide-base by drilling in the primary stage of the new nested drill-in BHA system. Depending upon hole stability through the upper 50-to-60-m low-velocity zone, it may be necessary to deploy the second stage drill-in BHA and then resume DCS coring operations.

Coring with the DCS will continue until the system has proven itself as a viable coring system in fractured crustal formations, or until excessive borehole temperatures require that operations be curtailed for the safety of the personnel working on the DCS platform. We hope to achieve a minimum penetration of 100 m into fractured young crustal material with a minimum 50% recovery.

Once the DCS coring capabilities have been amply demonstrated, remaining time will be spent testing ancillary, but complementary, developmental systems. These tests could include the following: (1) deployment of slim-hole temperature/caliper logging tools into DCS holes; (2) reaming a nominal 4-in. DCS hole out to 7-1/4 in.; (3) evaluating the ability to maintain adequate hole stability in a reamed DCS hole, and deploying conventional temperature/caliper logging tools; (4) deploying a second stage DI-BHA through the upper, unstable, low-velocity part of the hole; and (5) testing the developmental 7-1/4-in. diamond core barrel (DCB) coring system.

Assuming that reaming is successful, and hole stability is adequate (objectives 2 and 3, above), logging runs with standard tools are desirable. These runs are of lower prority than other objectives. They are designed to gain the information that is most useful for evaluating the DCS drilling/reaming effort, which cannot be obtained through the second-stage drill-in BHA (objective 4, above). Three deployments are anticipated in the reamed hole to evaluate fracturing of the rock and define the actual hole size. The following "standard" logging runs are listed in order of priority. Three distinct logging runs are recommended because the penetration below seafloor is likely to be shallow, and the standard tool strings will take up a significant portion of the hole.

Run No. 1 Resistivity/density/gamma--the resistivity measurement will yield fracture porosity data. The density tool also has a high quality caliper tool for verifying hole size, and natural gamma activity should help to determine flow boundaries.

Run No. 2 Velocity/gamma--velocity information can be used to compare the cored hole to appropriate site survey information, and the neutral gamma data will help to depth shift the different runs to each other.

Run No. 3 Either FMS or BHTV--these tools will provide images of the formation drilled and images of drilling-induced damage, as well as orientation of the borehole.

Scientific Objectives

The scientific objectives of the multi-leg EPR drilling program are to investigate magmatic, tectonic, and hydrothermal processes that result in the formation of ocean crust at fast-spreading ridges. The East Pacific Rise Detailed Planning Group (EPR-DPG) developed a drilling strategy and recommendations to achieve these objectives. In essence, the strategy calls for an L-shaped array of moderately deep (200-500 m) holes together with one deep (~1.5 km) hole near the EPR axis to approach or penetrate the subaxial magma reservoir. Sites within a kilometer or so of the ridge axis (such as EPR-1 and EPR-2) would be useful for studying (1) the physical structure and composition of "zero-age" crust; (2) the nature of fluid/rock interactions; (3) the nature of hydrothermal flow; and (4) the temporal variability of lava compositions to provide calibration for remote sensing data available for larger portions of the EPR.

Within this context, the purpose of Leg 142 is to use the DCS to establish and deepen one or more of the near-EPR axis sites (Fig. 8). Leg 142 represents the first attempt to use the DCS at an active ridge crest. As such, it represents an important test of the system's capabilities and limitations as well as an opportunity to obtain the first scientific returns of the multi-leg effort.

Fluid sampling is a high scientific priority for the multi-leg drilling program, and it may be possible to begin this effort on Leg 142. If the situation and time permit, we may be able to collect borehole fluid samples with the WSTP tool after the drill hole has been reamed to 7-1/4-in. diameter. However, recognizing the great importance of fluid sampling in the multi-leg EPR drilling program, the most prudent long-term course of action is to plan for extensive fluid sampling on the next EPR leg.

OPERATIONS PLAN

The engineering and drilling operations test plan for Leg 142 is vastly simpler than those of previous engineering legs. A great deal of effort has gone into the selection of a drilling target on the East Pacific Rise that will yield the best opportunity for success in spudding and deepening a hole on a young crustal spreading center.

During Alvin dive 2358 of the Haymon and Fornari East Pacific Rise site survey, an extensive ponded lava flow was observed at EPR-2. This relatively flat area was identified as an excellent location to deploy a mini-hard-rock guide-base and attempt the initiation of a DCS penetration into the ridge crest (Fig. 12). Given this location, the engineering and drilling operations test plan is as follows:

(1) Deploy the newly refined hex-sided mini-hard-rock guide-base with its counter-balanced righting system and 8-ft-diameter reentry cone. Un-jay and remove the running tool (Fig. 13).

(2) Reenter the guide base with the first stage (primary) drill-in BHA. Drill-in the first stage drill-in-BHA system to approximately 4 or 5 mbsf and back-off in the HRB casing hanger (Fig. 14).

> Note: This may be done with a 12-1/4-in. TCI roller cone bit or an 11-1/4-in. diamond core bit.

(3) Lower tensioning sub and reenter the HRB with the bit guide. Latch-in and tension-up against the HRB, then release the bit guide via wireline. Deploy the DCS, and attempt coring out the bottom of the ponded lava flow, through the low-velocity layer, anticipated to be 50 to 60 m in thickness, and into the underlying basaltic formations. Pending acceptable temperature gradients, the minimum desired penetration is 100 mbsf (Fig. 15).

> Note: If unstable hole conditions are prevalent in the low-velocity layer, the second stage drill-in BHA may be deployed prior to achieving the DCS depth objective. Upon setting the second-stage DI-BHA, DCS coring operations may be continued to the original depth goal. At this point, limited logging should be attempted with the slim-hole tools.

(4) Upon achieving or exceeding the DCS depth objective (as qualified by the note above), and prior to removing the DCS tubing string from the hole, slim-hole caliper logging will be attempted. If successful, then slim-hole temperature logging will be conducted.

(5) After slim-hole logging operations have been completed, an attempt will be made to ream the 3.96-in. DCS hole to 7-1/4 in., using a special piloted-diamond-bit and center-bit assembly (Fig. 16).

(6) If time is available, the reaming operation successful, and hole stability adequate, an attempt may be made to make three conventional logging tool runs in the 7-1/4-in. open hole. Run No. 1 would consist of a resistivity/density/gamma suite, No. 2, a velocity/gamma suite, and No. 3, either a Formation Microscanner (FMS) or Borehole Televiewer (BHTV) tool.

(7) Once all efforts at reaming and/or logging the 7-1/4-in. hole have been completed, the

second-stage DI-BHA will be deployed and backed-off inside the primary-stage DI-BHA (Fig. 17).

ANCILLARY ENGINEERING AND SCIENCE OPERATIONS PLAN

It is unlikely that any time will be available for coring or logging operations beyond those described in the preceeding drilling operations plan. It must be kept in mind that the DCS-coring, seafloor, and drill-in-BHA systems described above are still in the developmental stage, and an accurate time estimation for the various operations is impossible.

Should all other objectives be completed on Leg 142, with time to spare, then the following ancillary engineering and science options will be considered:

(1) Deployment of a second mini-HRB to allow evaluation of the Diamond Core Barrel (DCB) coring system is a highly ranked secondary engineering priority.

(a) Consideration will be given to deployment of the second HRB either adjacent to the first HRB where the most definitive comparison of 4 in. versus 7-1/4 in. diamond coring can be made.

(b) An alternative plan would be to deploy the second HRB in the "clam field" area identified during the Atlantis II site survey where warm water is venting at the seafloor.

(c) A third option under consideration would be to move off-axis and attempt DCB coring through the thicker (200-m ???) low-velocity zone. This should help to provide valuable engineering and operational data relating to attempted 200-m penetrations into low-velocity zones.

(2) Due to great interest in the geochemistry of hydrothermally active crustal spreading centers, the attempt to obtain at least limited fluid samples is a high scientific priority. Time permitting, an attempt may be made to acquire appropriate fluid samples with the WSTP.

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Table 1
Leg 142 Site Information

Site	Latitude (N)	Longitude (W)	Water Depth (meters)	Drilling Time (days)	Logging Time (days)	Total Time (days)
			Primary Site			
EPR-2	09°30.85'	104°14.66'	2590	34.9	1.0	35.9
			Alternate Sites			
EPR-1	09°30.2'	104°15.1'	2600			
EPR-1A	12°44.0'	103°56.0'	2660			
EPR-2A	12°50.0'	103°55.3'	2630			
EPR-3	09°30.2'	104°18.3'	2840			

Table 2
Site Occupation Schedule

Site	Location	Transit Time[a]	Operations Time	Date
In port, Valparaiso				13-17 January 1992
Depart Valparaiso				18 January 1992
In transit		12.5 days		
EPR-2	9°30.85'N, 104°14.66'W		35.9 days	
In transit		12.6 days		
Arrive Honolulu				19 March 1992
TOTAL TIME:	61.0 days			

[a]Calculated at a transit speed of 10.5 kt.

Site number: EPR-2

Position: 9°30.85'N, 104°14.66'W

Jurisdiction: N/A

Sediment thickness: None (bare rock)

Priority: 1

Water depth: 2590 m

Proposed drilling program: Hole A -- Deploy hard rock guide base (HRB) on ponded lava flow. Drill-in first stage (primary) drill-in-bottom hole assembly (DI-BHA) to approximately 5 mbsf to stabilize HRB. Deploy diamond coring system (DCS) and conduct slim-hole coring operations to a minimum 100 mbsf. Determine base of low-velocity zone. Deploy slim-hole logging tools. Attempt reaming 3.96-in. DCS hole out to 7.25 in. through low-velocity zone. Deploy standard logging tools. Set second stage (secondary) DI-BHA though low-velocity zone (estimated at 40-60 mbsf).

Engineering objectives: The primary engineering objective is to evaluate slim-hole DCS with maximized coring time. Other secondary objectives include evaluation of the new version of the mini HRB, nested drill-in-BHA, reaming capabilities, and diamond core barrel (DCB). A limited evaluation of slim-hole logging tools is also desired.

Science objectives (secondary): Lithology, composition, structure, and geological and hydrological processes of the uppermost crust at the axis of a fast-spreading ridge.

Logging: Slim-hole temperature/gamma ray-caliper in DCS hole. Standard temperature/caliper in 7-1/4-in. reamed hole, if possible.

Sediment type: None

Basement type: Young crustal basalt

Site number: EPR-1

Position: 9°30.2'N, 104°15.1'W

Jurisdiction: N/A

Sediment thickness: None (bare rock)

Priority: 2

Water depth: 2600 m

Proposed drilling program: Same as EPR-2

Engineering objectives: Same as EPR-2

Science objectives (secondary): Lithology, composition, structure, and geological and hydrological processes of the uppermost crust near the axis of a fast-spreading ridge.

Logging: Same as EPR-2

Sediment type: None (bare rock)

Basement type: Young crustal basalt

Site number: EPR-1A

Position: 12°44.0'N, 103°56.0'W

Jurisdiction: N/A

Sediment thickness: None (bare rock)

Priority: 2

Water depth: 2660 m

Proposed drilling program: Same as EPR-2

Engineering objectives: Same as EPR-2

Science objectives (secondary): Same as EPR-1

Logging: Same as EPR-2

Sediment type: None (bare rock)

Basement type: Young crustal basalt

Site number: EPR-2A

Position: 12°50.0'N, 103°55.3'W

Jurisdiction: N/A

Sediment thickness: None (bare rock)

Priority: 2

Water depth: 2630 m

Proposed drilling program: Same as EPR-2

Engineering objectives: Same as EPR-2

Science objectives (secondary): Same as EPR-2

Logging: Same as EPR-2

Sediment type: None (bare rock)

Basement type: Young crustal basalt

Site number: EPR-3

Position: 9°30.2'N, 104°18.3'W

Jurisdiction: N/A

Sediment thickness: None (bare rock)

Priority: 2

Water depth: 2840 m

Proposed drilling program: Same as EPR-2

Engineering objectives: Same as EPR-2

Science objectives (secondary): Lithology, composition, structure, and geological and hydrological processes of the uppermost crust on the flank of a fast-spreading ridge.

Logging: Same as EPR-2

Sediment type: None (bare rock)

Basement type: Young crustal basalt

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LEG 142

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Marine Specialist:	Jon Lloyd Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77845-9547
Marine Specialist:	Anne Pimmel Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77845-9547
Marine Specialist:	TBN

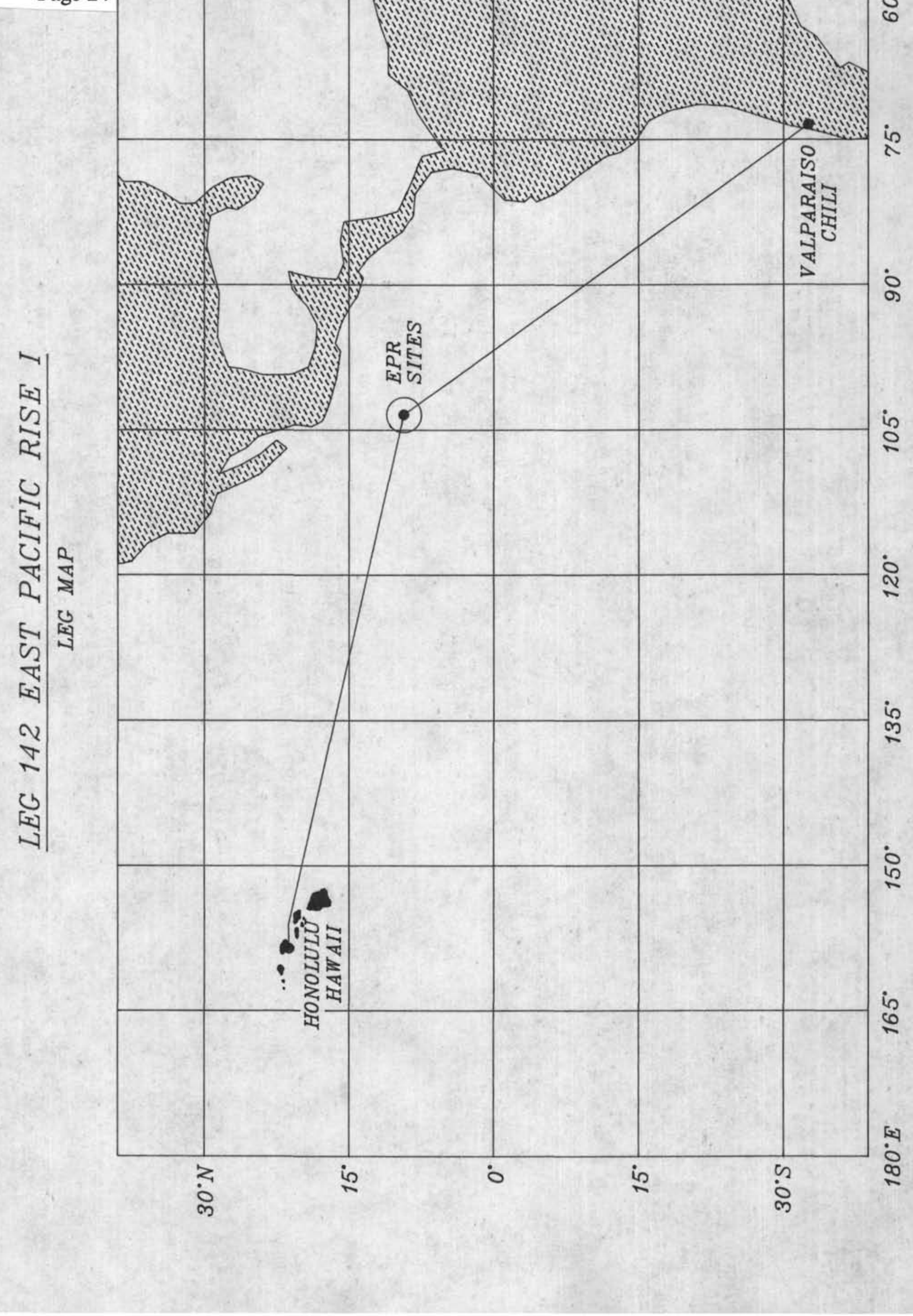

LEG 142 EAST PACIFIC RISE I
LEG MAP
HONOLULU
HAWAII
EPR
SITES
VALPARAISO
CHILI
30°N
15°
0°
15°
30°S
180°E
165°
150°
135°
120°
105°
90°
75°
60°E

Figure 1

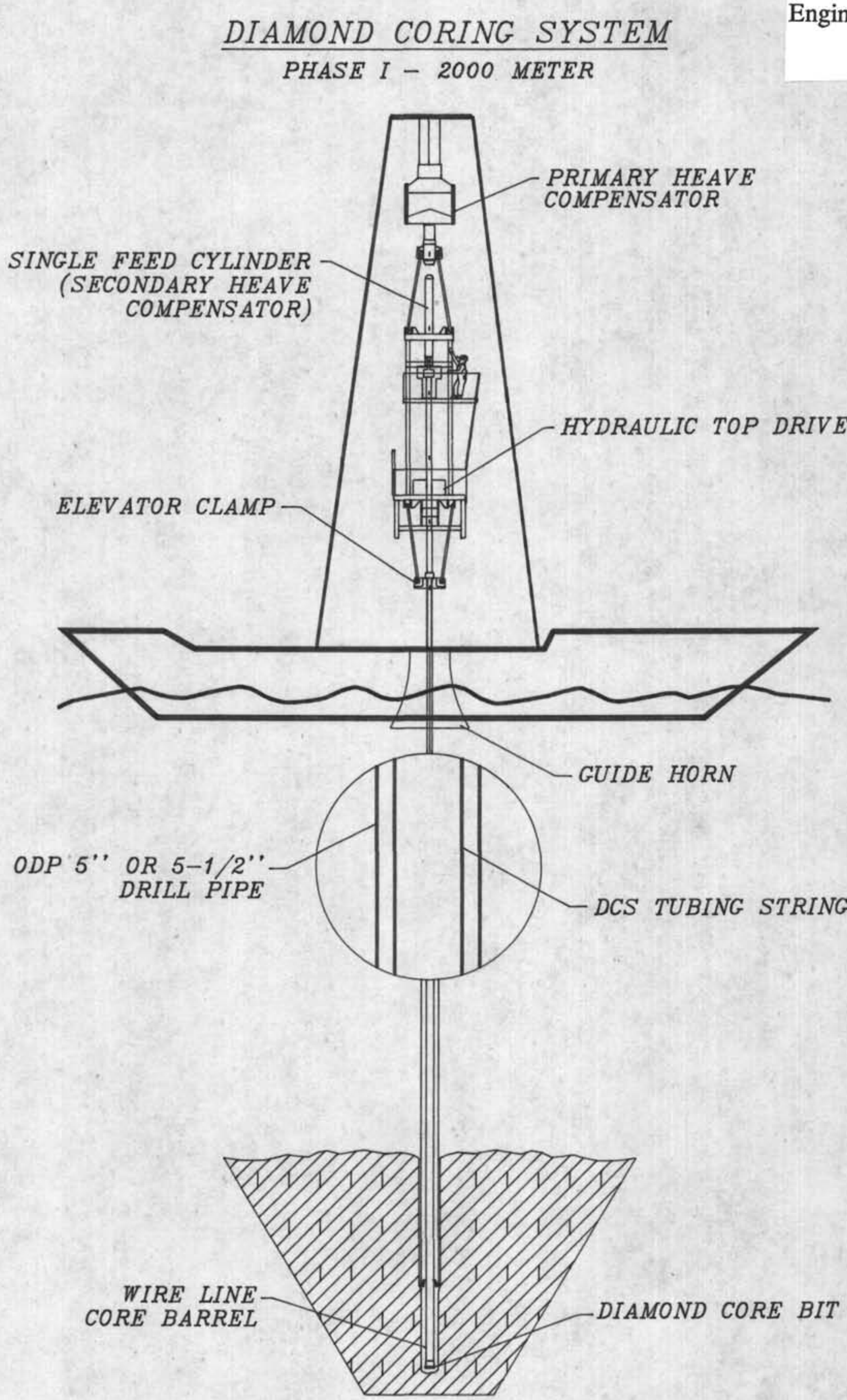

DIAMOND CORING SYSTEM
PHASE I - 2000 METER
PRIMARY HEAVE COMPENSATOR
SINGLE FEED CYLINDER (SECONDARY HEAVE COMPENSATOR)
HYDRAULIC TOP DRIVE
ELEVATOR CLAMP
GUIDE HORN
ODP 5'' OR 5-1/2'' DRILL PIPE
DCS TUBING STRING
WIRE LINE CORE BARREL
DIAMOND CORE BIT

Figure 2

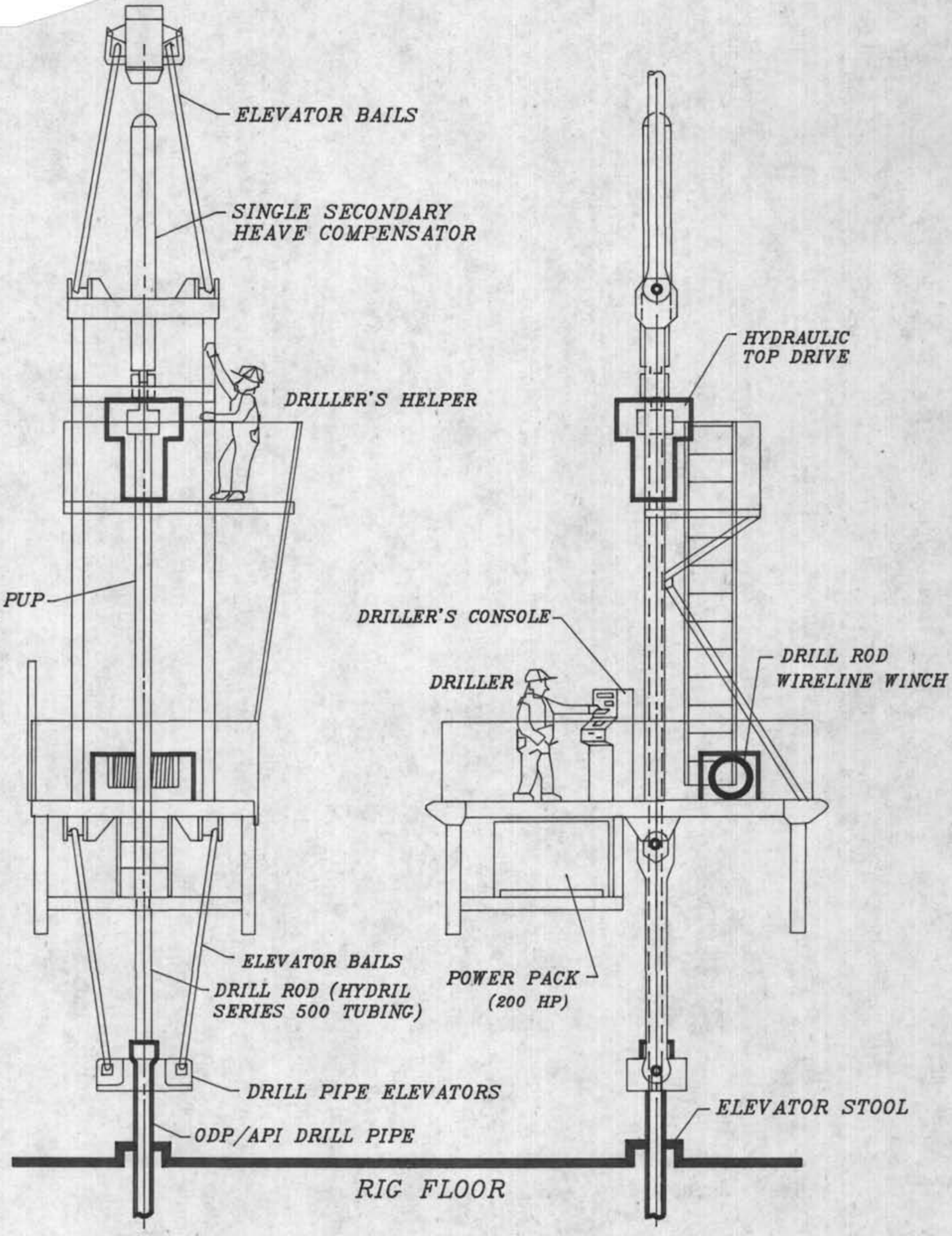


Figure 3

DIAMOND CORING SYSTEM

PHASE I – 2000 METER

PLATFORM CONFIGURATION

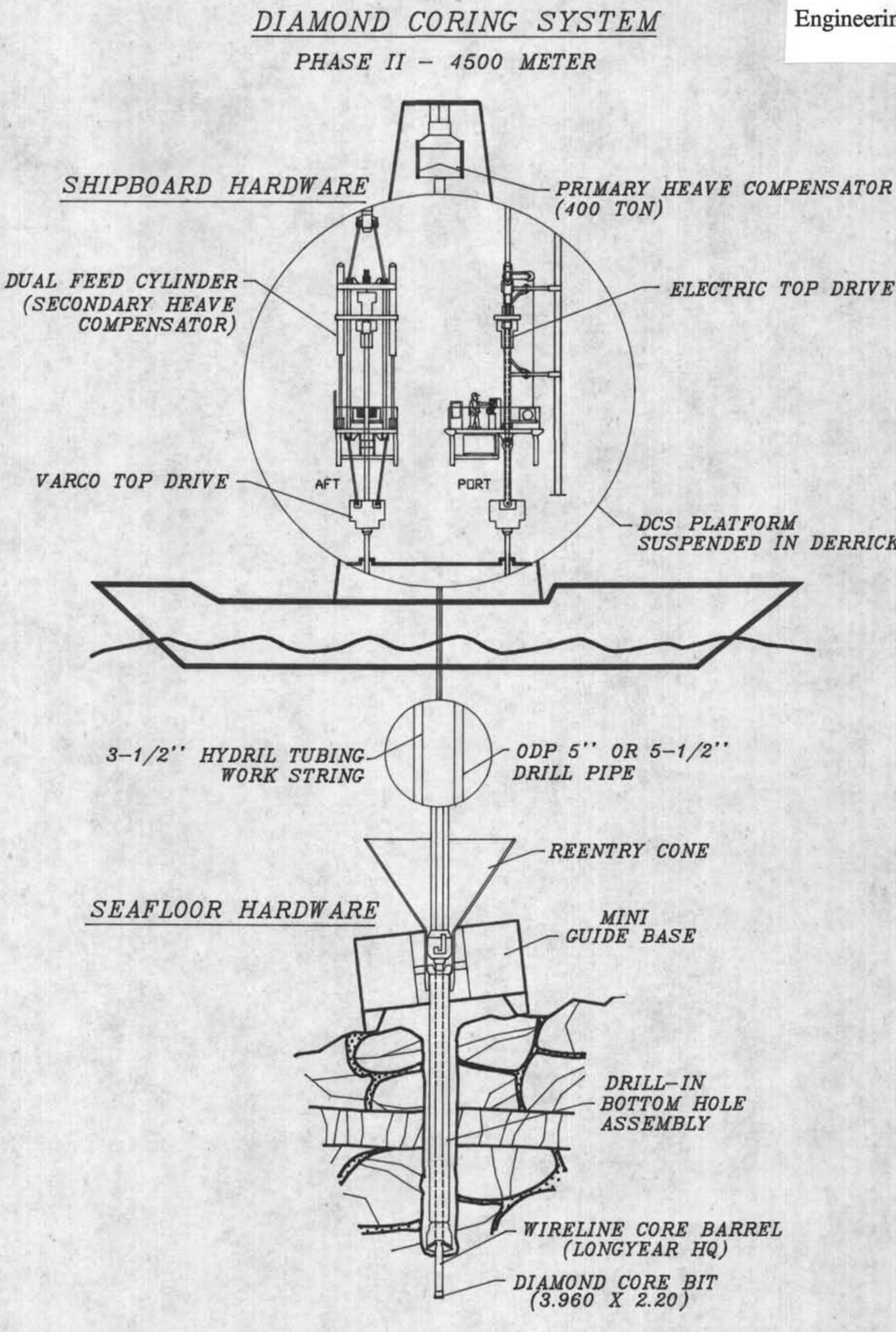

DIAMOND CORING SYSTEM
PHASE II - 4500 METER
SHIPBOARD HARDWARE
PRIMARY HEAVE COMPENSATOR (400 TON)
DUAL FEED CYLINDER (SECONDARY HEAVE COMPENSATOR)
ELECTRIC TOP DRIVE
VARCO TOP DRIVE
AFT
PORT
DCS PLATFORM SUSPENDED IN DERRICK
3-1/2'' HYDRIL TUBING WORK STRING
ODP 5'' OR 5-1/2'' DRILL PIPE
REENTRY CONE
SEAFLOOR HARDWARE
MINI GUIDE BASE
DRILL-IN BOTTOM HOLE ASSEMBLY
WIRELINE CORE BARREL (LONGYEAR HQ)
DIAMOND CORE BIT (3.960 X 2.20)

Figure 4

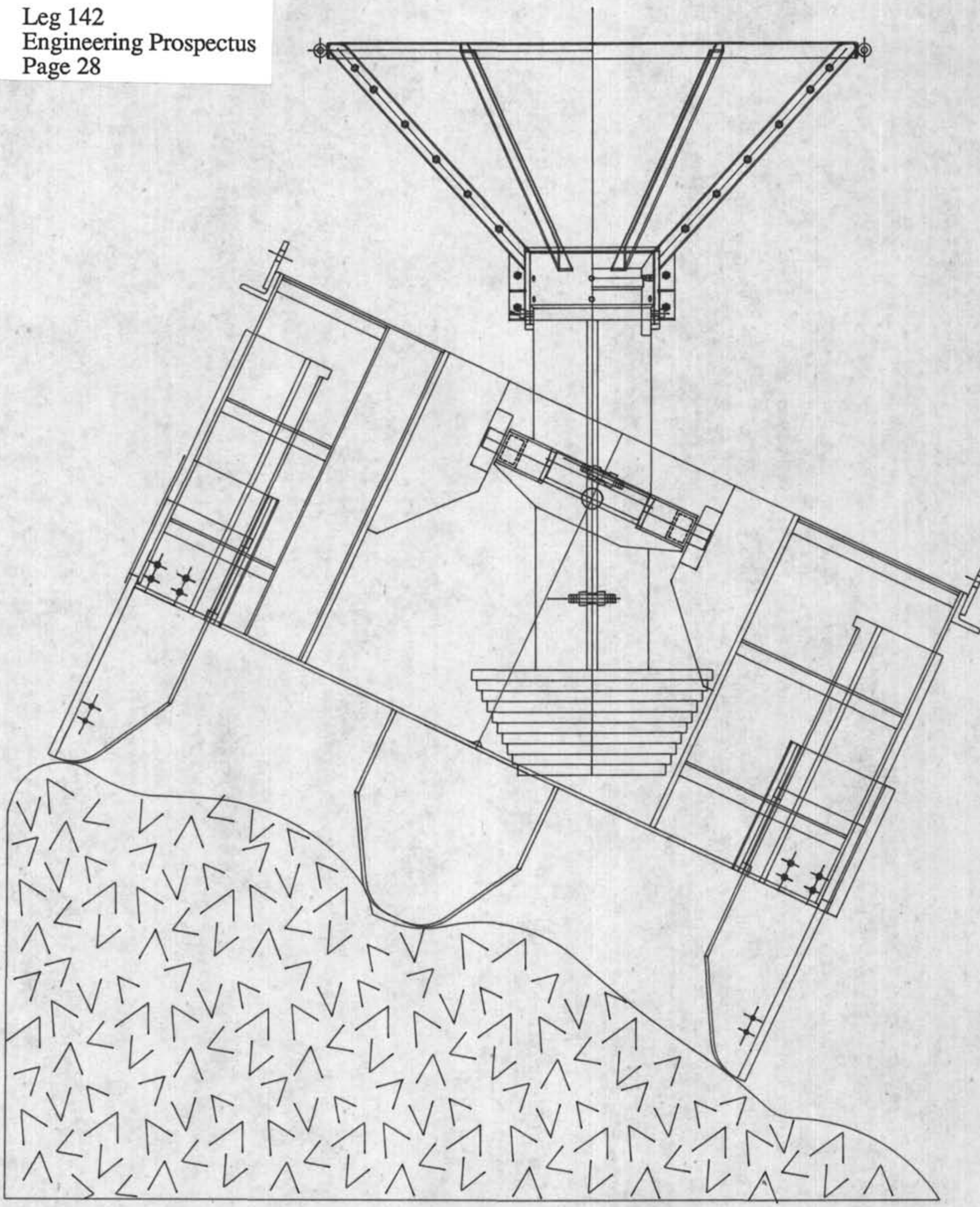


Figure 5

MINI HEX–BASE POSITIONED AT 25° MAXIMUM TILT

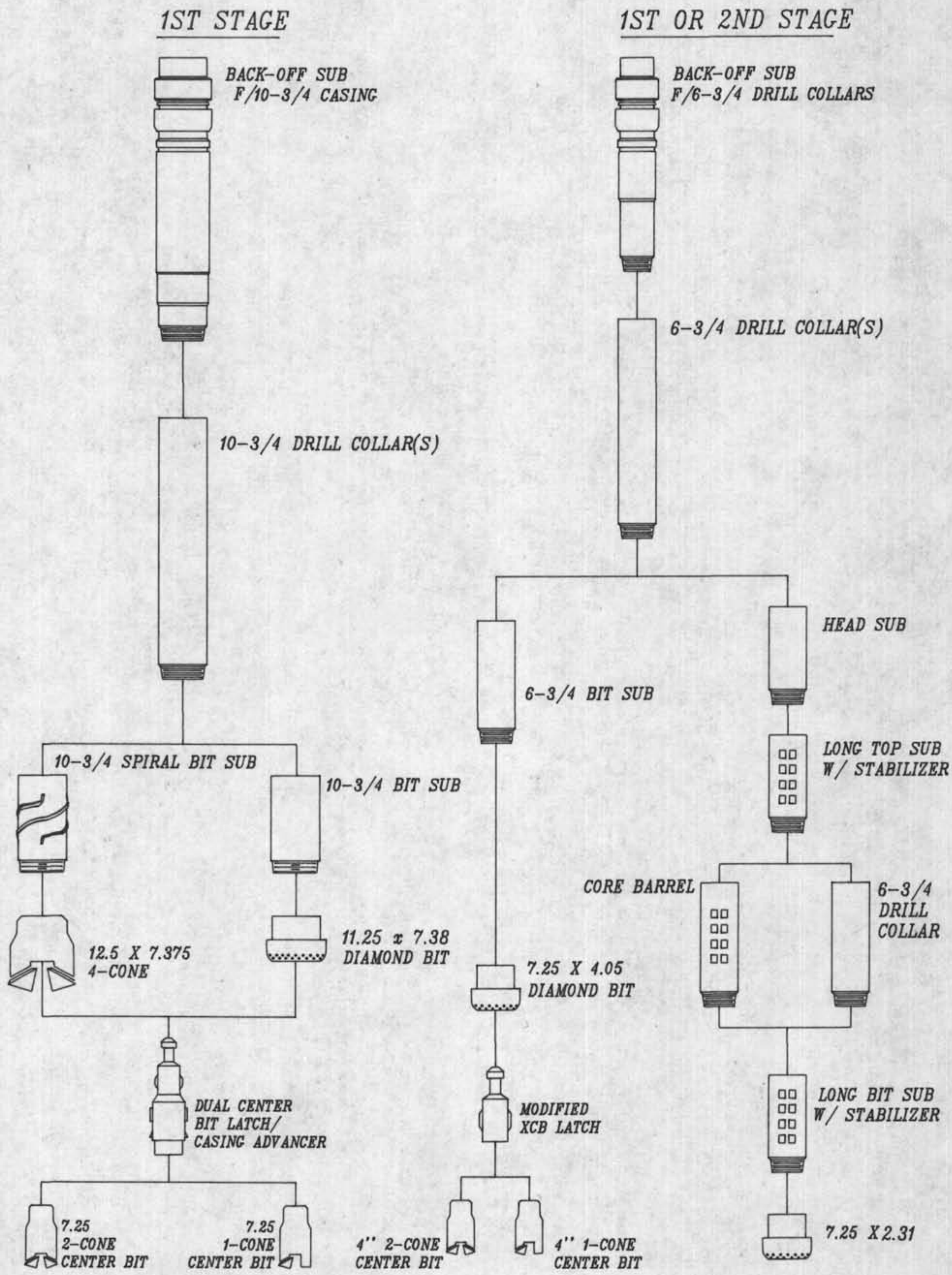


Figure 6

NESTED DRILL-IN BOTTOM HOLE ASSEMBLY

Note: Uses a modified RCB wireline core barrel assembly recovering a nominal 2.3'' dia. core by 30' long.

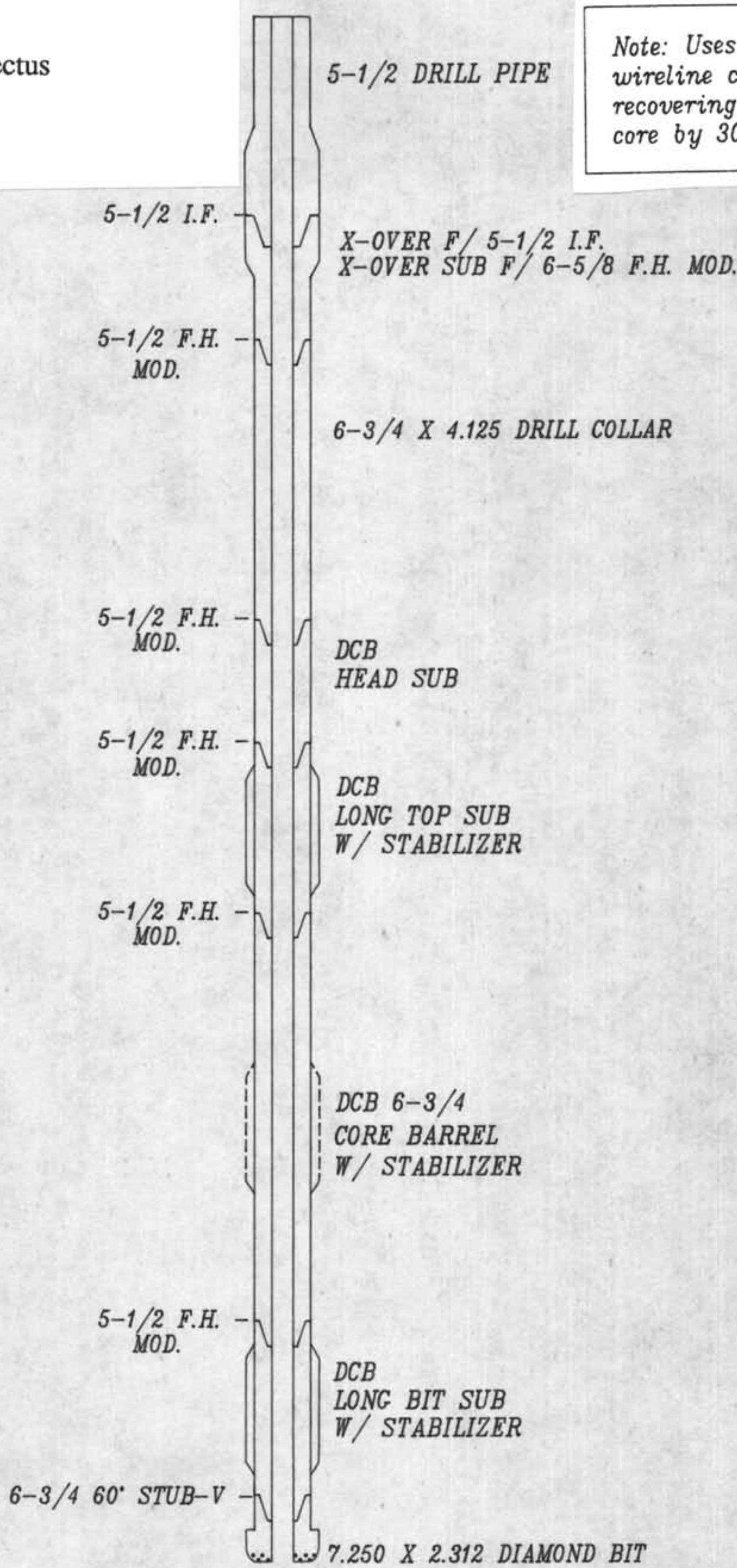


Figure 7
6-3/4 DIAMOND CORE BARREL (DCB)

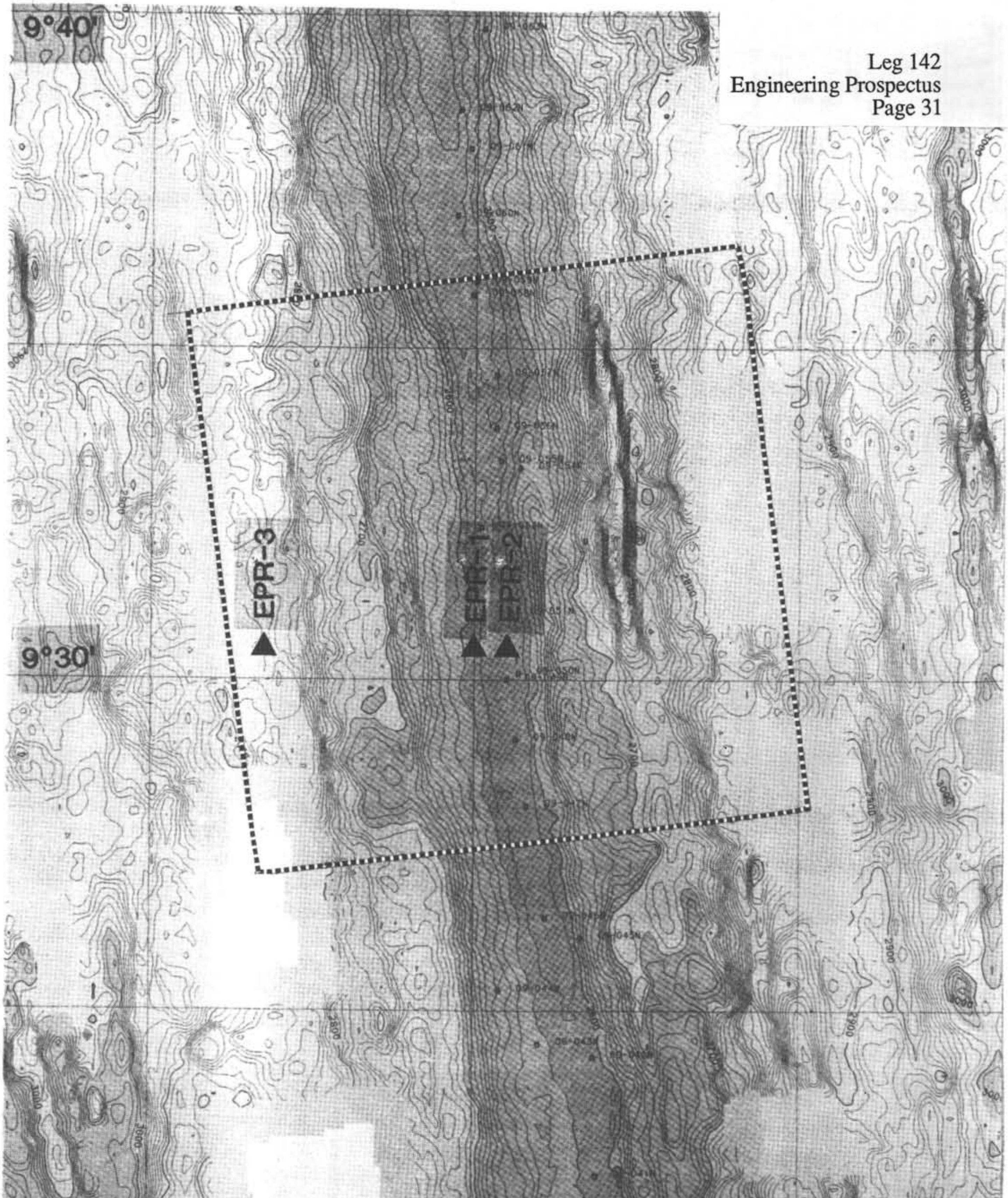


Figure 8 - Bathymatric map (Seabeam) of the 9°30'N area of the East Pacific Rise from the JOI/USSAC EPR Data Synthesis.

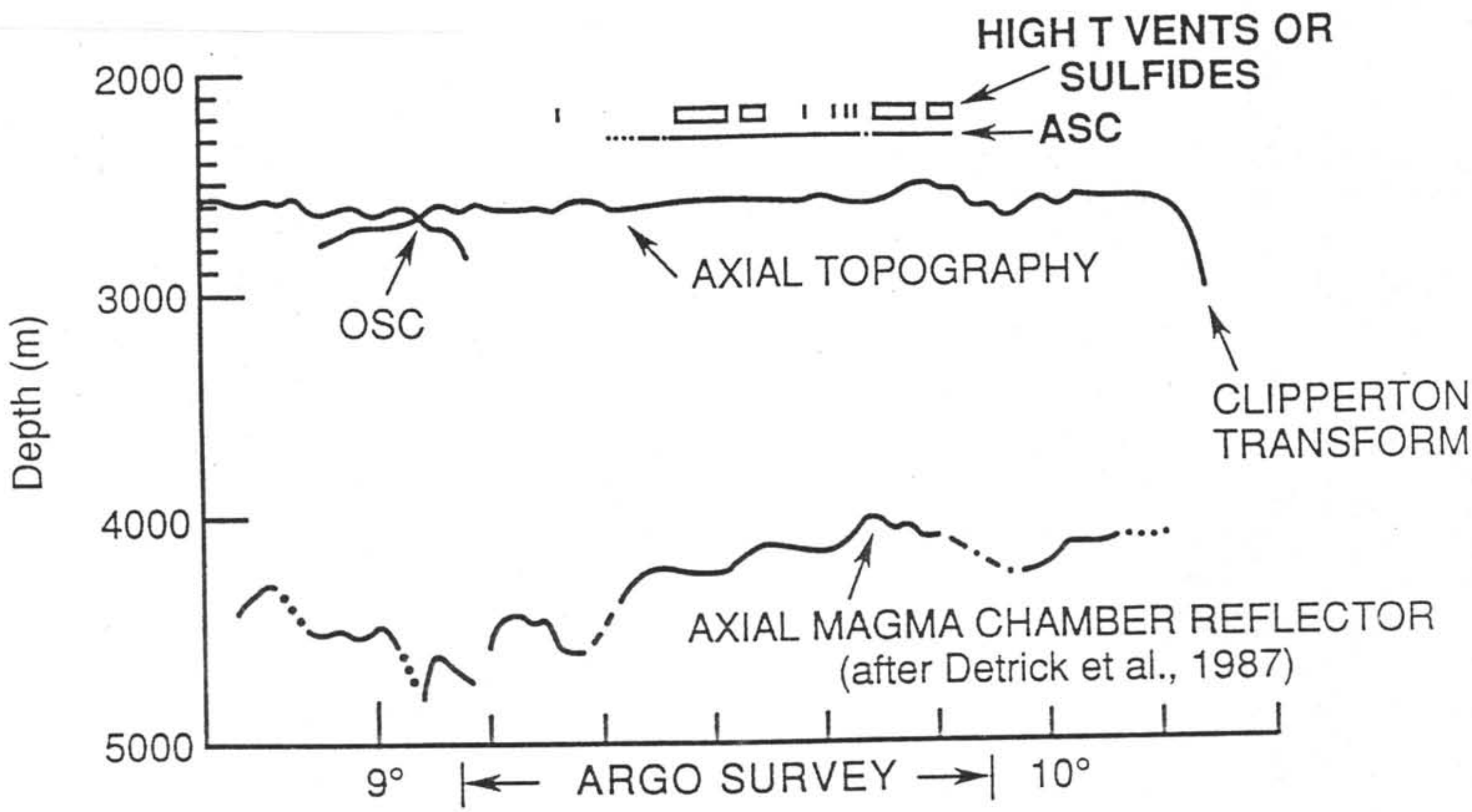
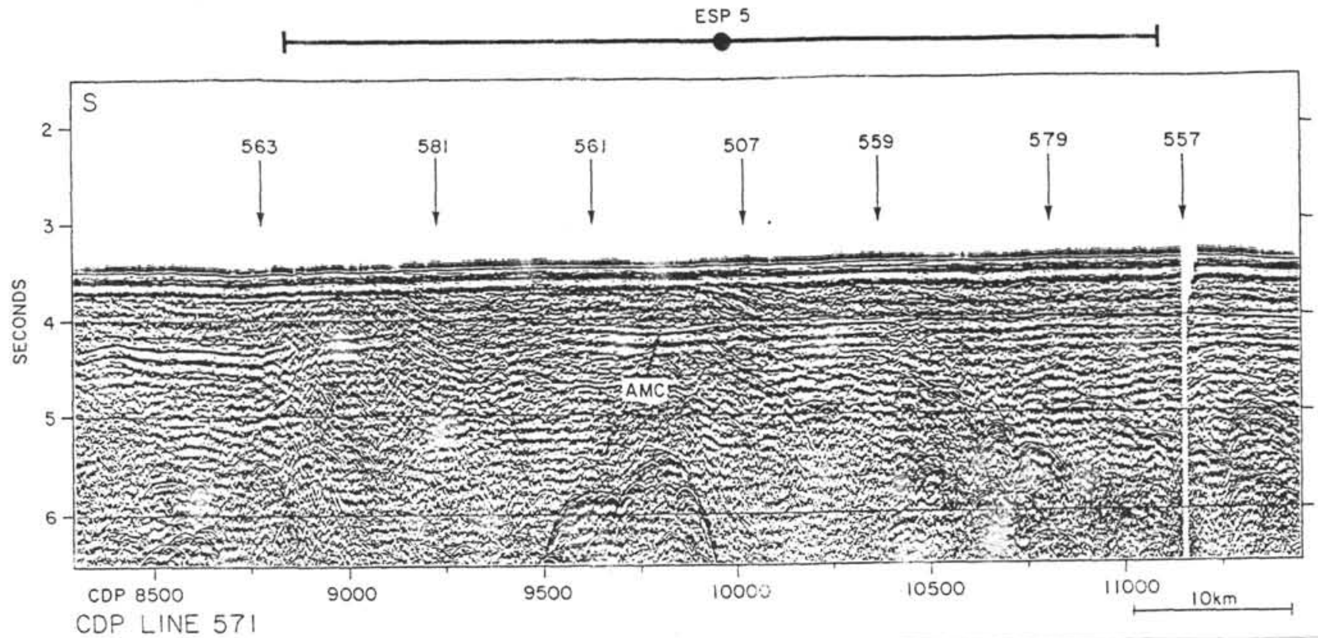


Fig 9 - Along-Axis topography and magma chamber reflector beneath the EPR (9°-10°N) from Haymon et. al. (1991).



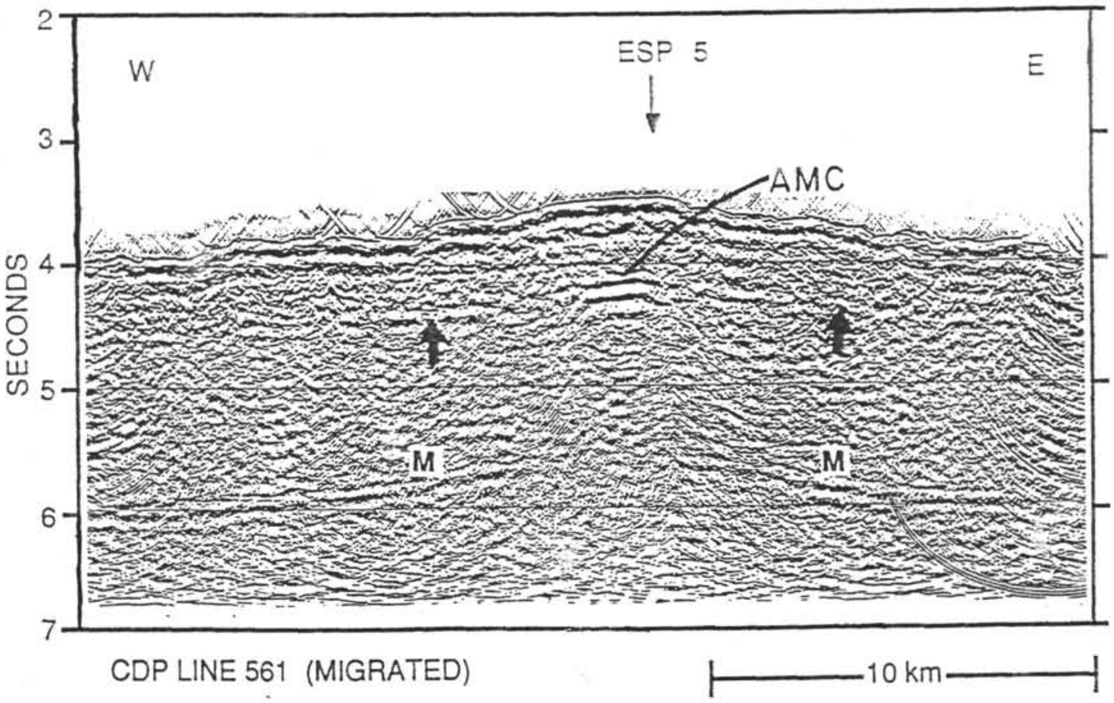


Figure 10 - Portion of MCS lines 571 (above) along strike of axis, showing the axial magma chamber (AMC) event. The crossing with seven CDP lines and the ESP 5 midpoint and extent are also shown. Portion of MCS line 561 (below), across strike at about 9°30'N, from Vera, et al. (1990), also showing the AMC event.

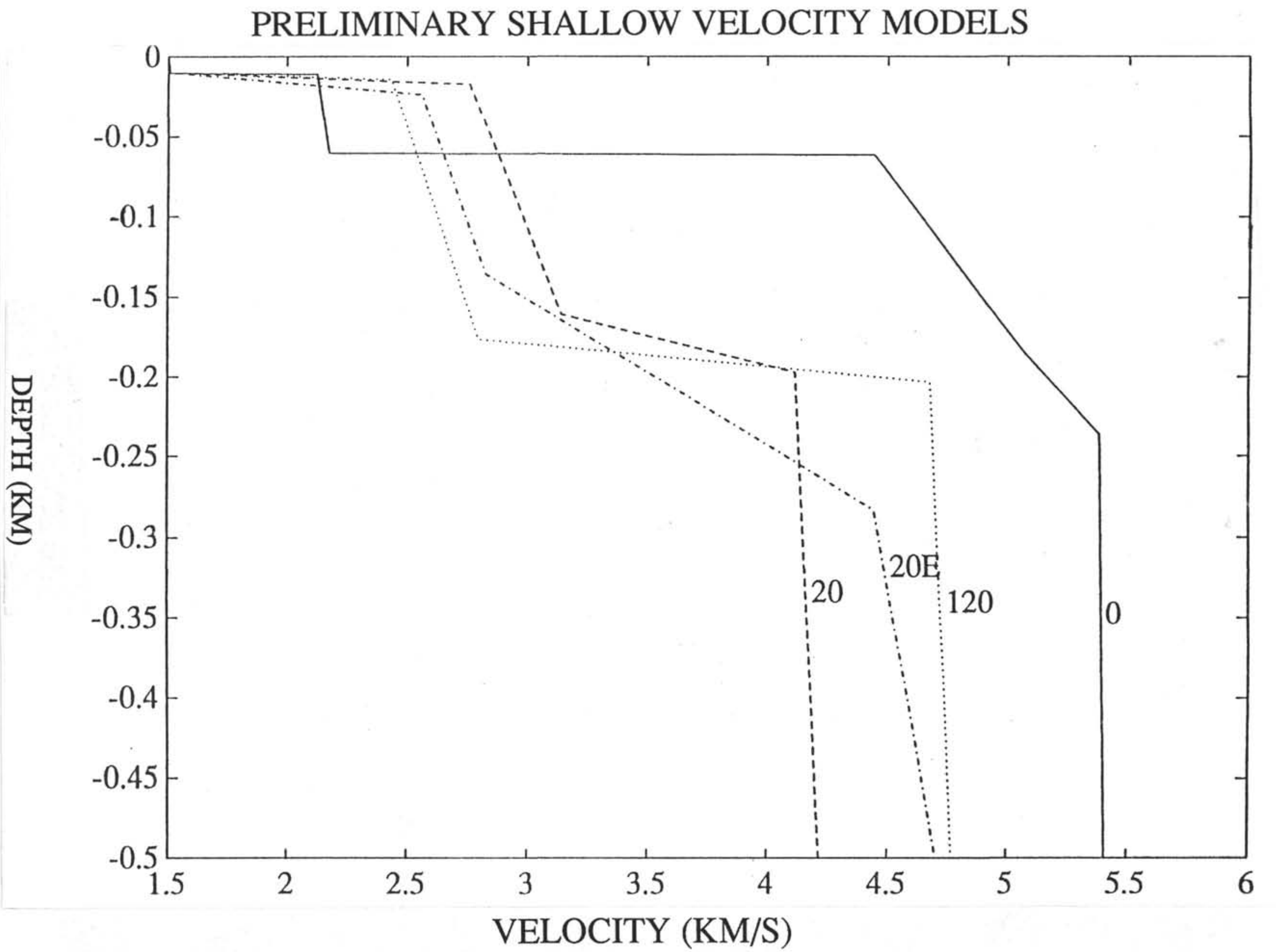


Figure 11 - Preliminary velocity models for EPR-2 (line 0), EPR-1 (line 20), and EPR-3 (line 120) from Purdy and Fryer (1991).

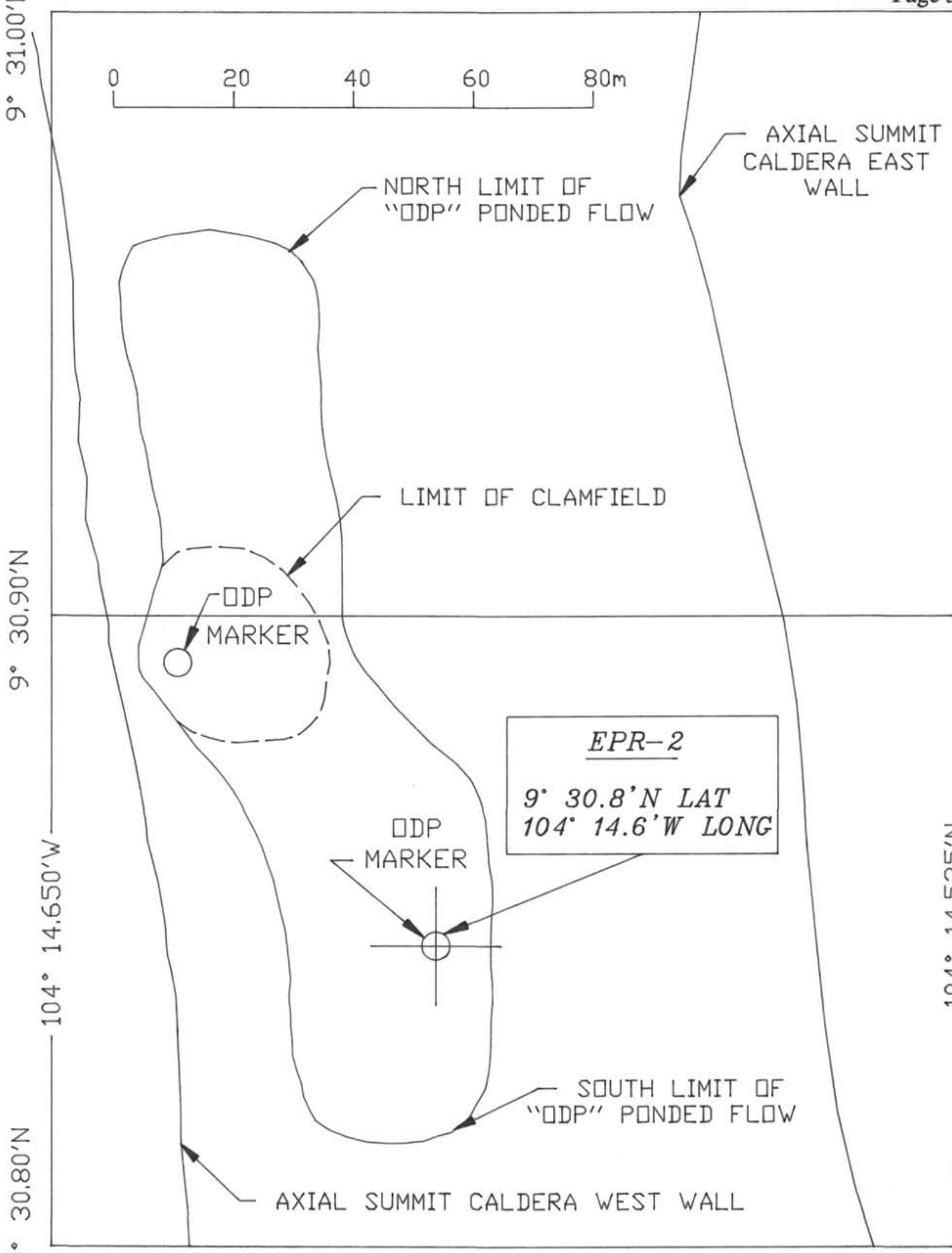


Figure 12
Alvin dive-2358 survey of east pacific rise crest for bare rock drilling

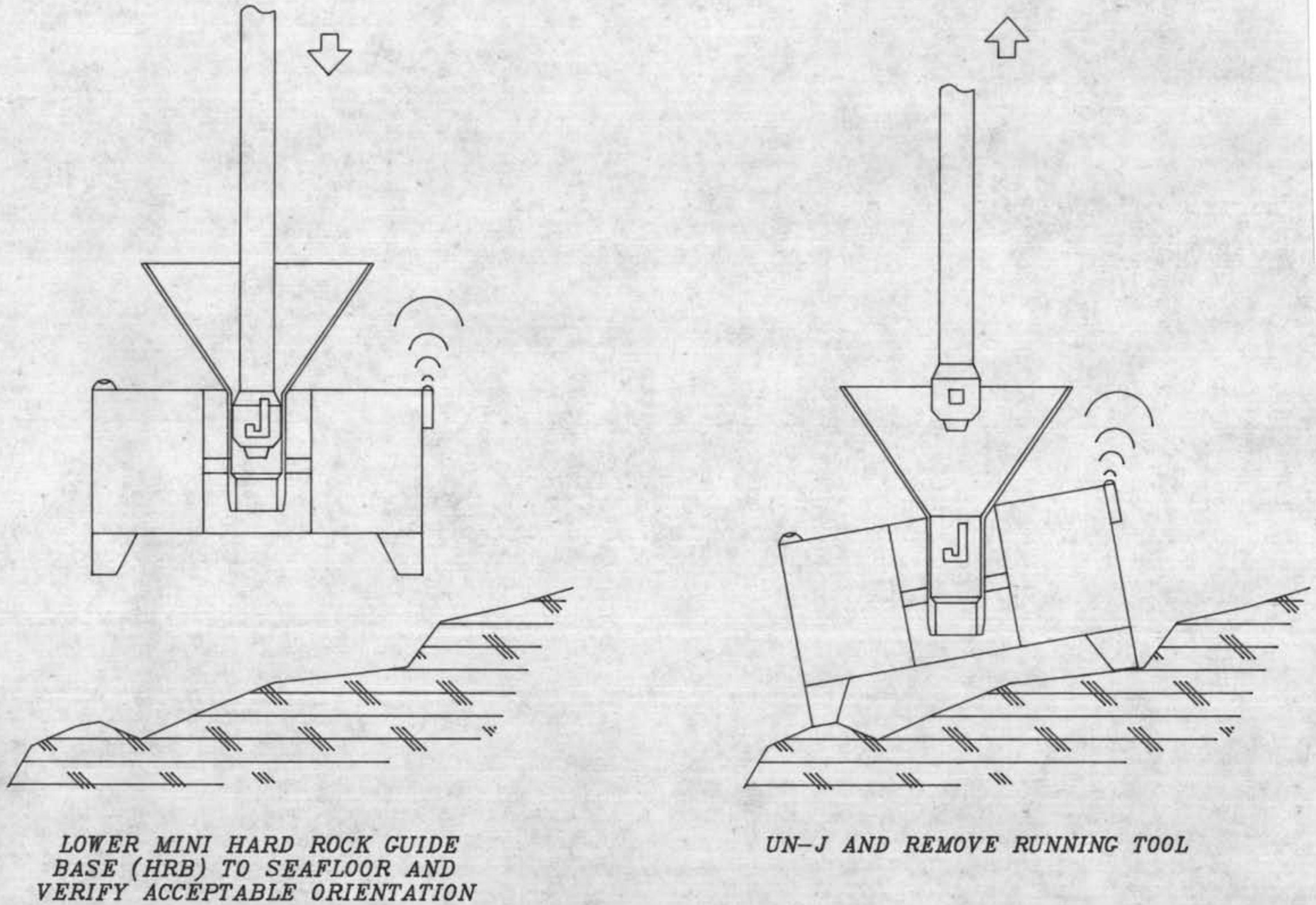


Figure 13

Deployment Scheme for Hex-sided Hard Rock Guide Base

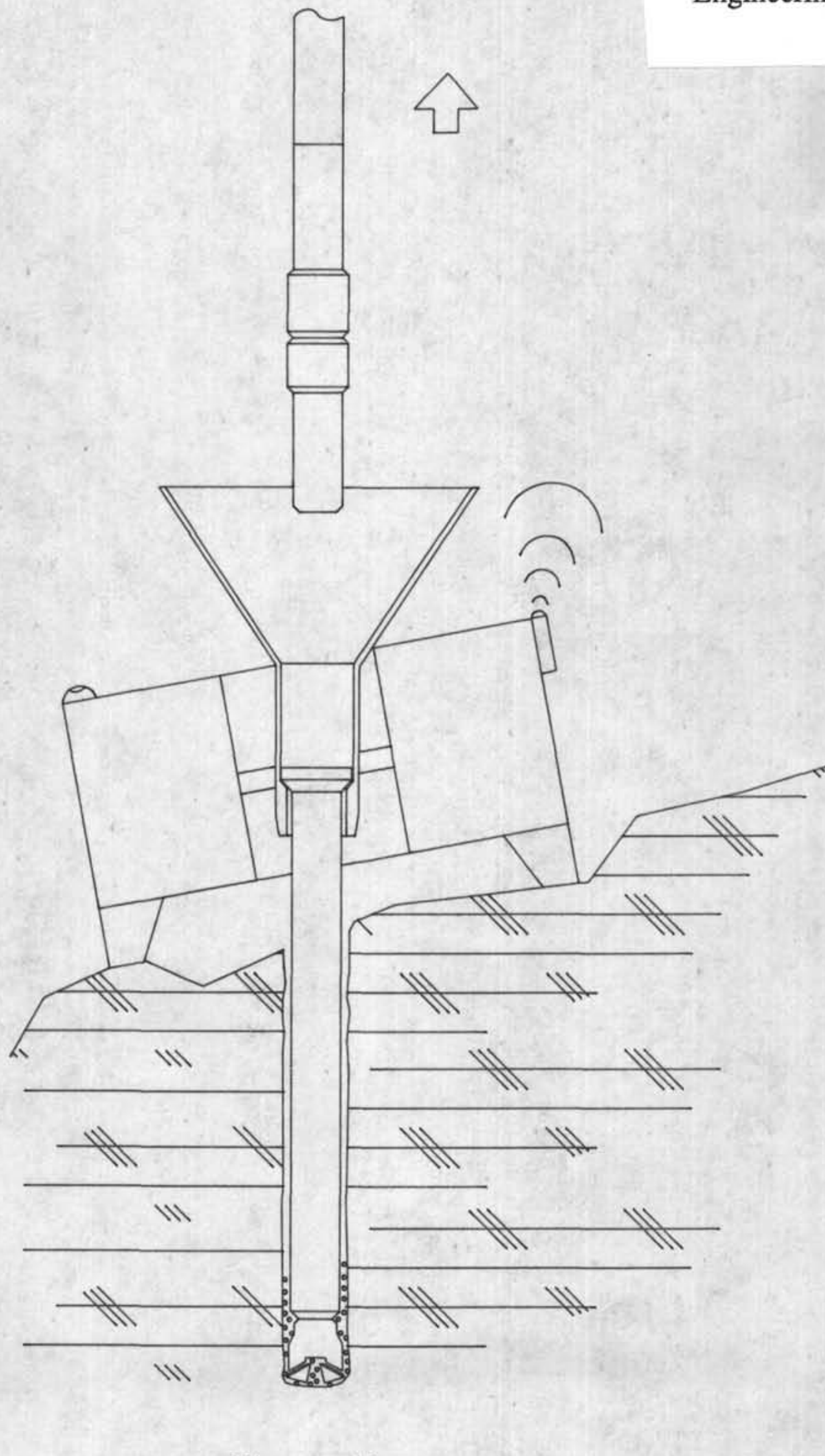


Figure 14
Deployment Scheme for Primary Drill-in BHA System
BACKOFF PRIMARY DI-BHA
AND RETRIEVE STRING

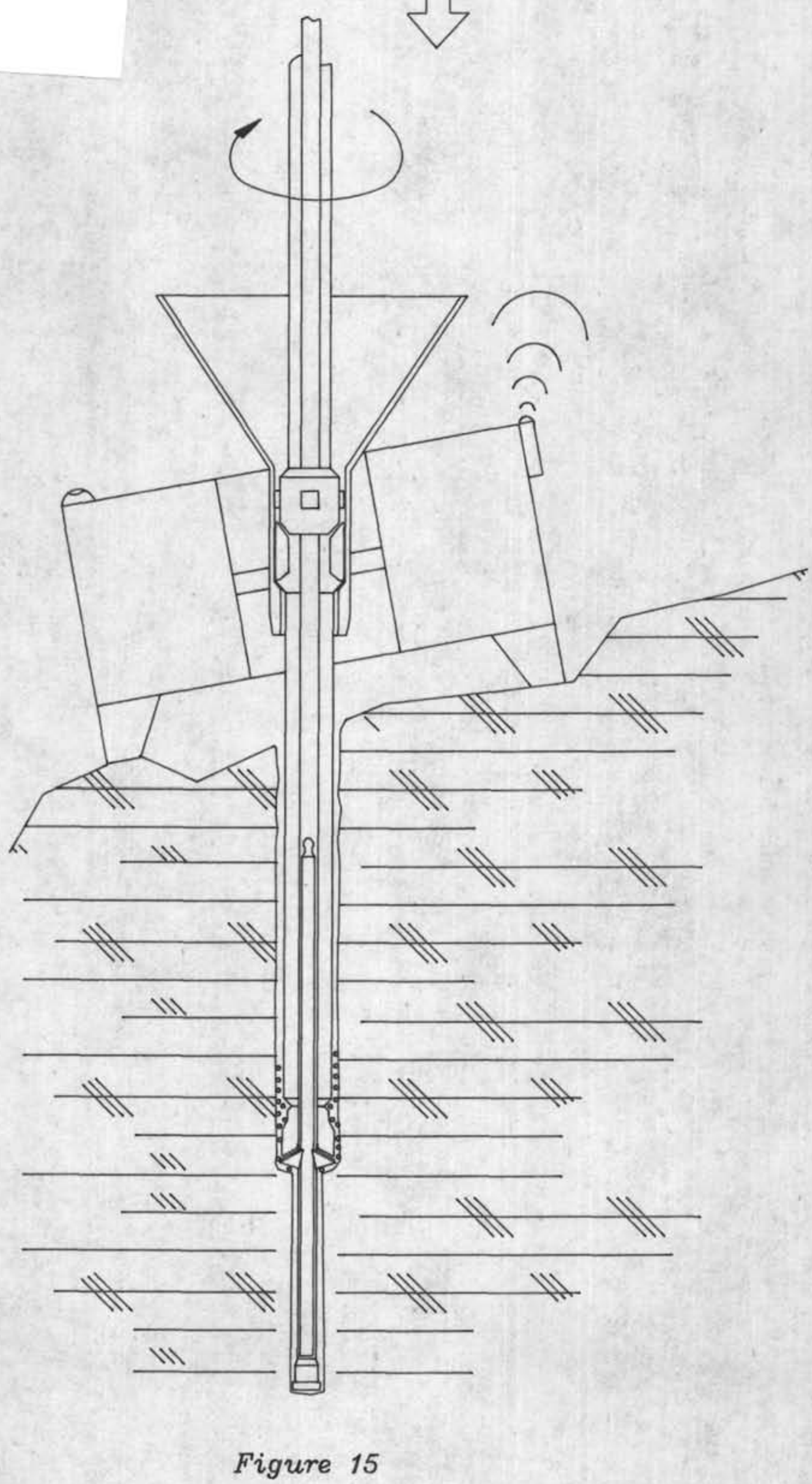


Figure 15

CORE WITH DCS STRING TO DEPTH OBJECTIVE

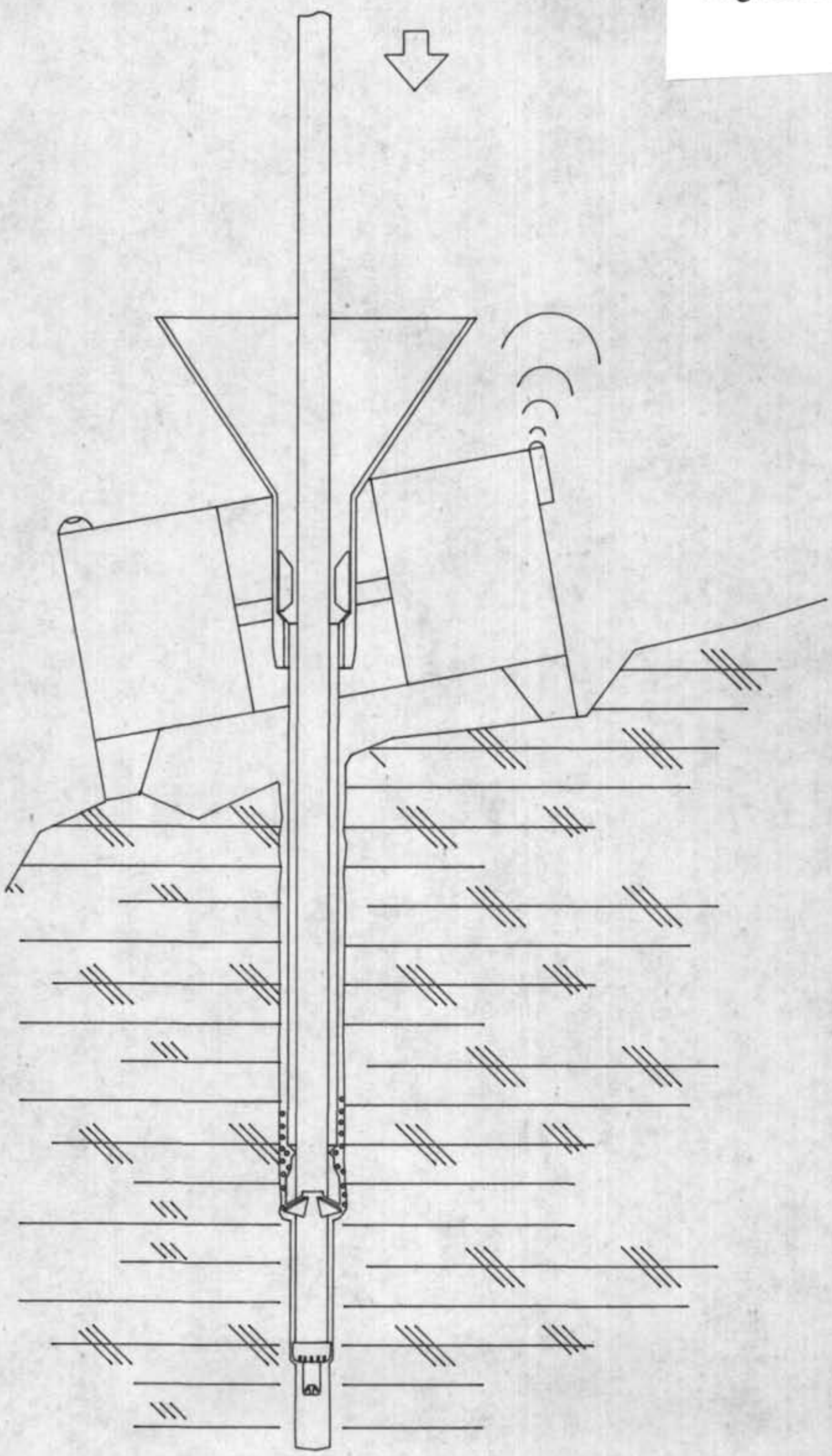


Figure 16
REAM DCS HOLE TO PRE-DETERMINED DEPTH

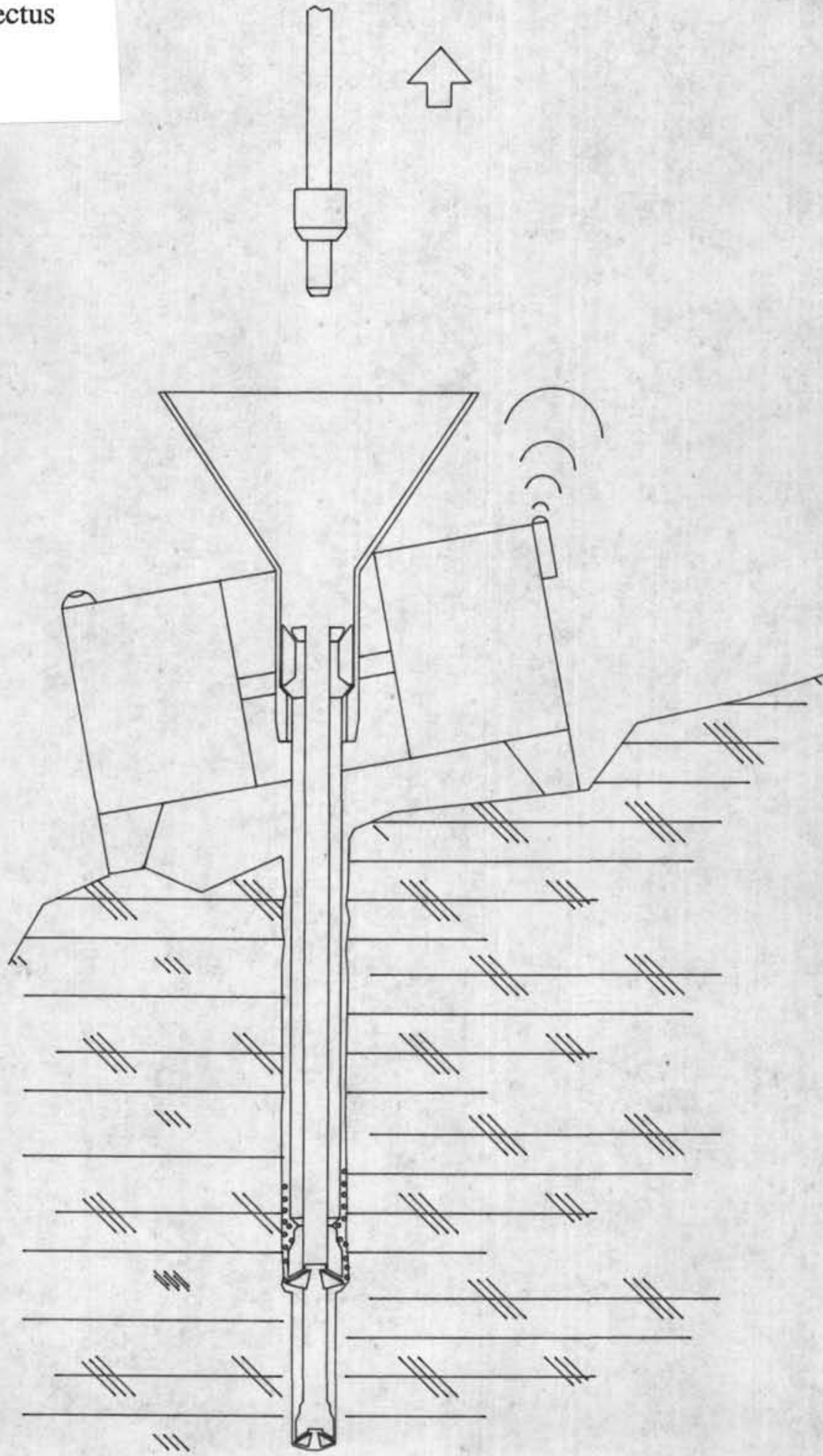


Figure 17
Deployment Scheme for Second Stage Drill-in BHA System
BACK-OFF SECONDARY DI-BHA
AND RETRIEVE STRING

APPENDIX A

ODP DIAMOND CORING SYSTEM PHASE IIB

DIAMOND CORING SYSTEM PLATFORM

Introduction

The DCS platform built for Leg 132 has been upgraded for use on Leg 142. Much of the upgrading has been associated with better safety equipment, along with a complete full scale test of the shock cylinder damping system. The shock cylinders are used to reduce the amount of acceleration the platform would see should a catastrophic failure occur in the drill string/mini riser between the guide base platform. Modifications to the secondary heave compensator have been made in order to eliminate the noise problems which affected the acceleration sensors in the system. Some of the hydraulic controls have also been redesigned in order to provide greater sensitivity control for the wireline winch and other operations.

Background

The DCS is a small, self contained, diamond coring rig, equipped with a secondary heave compensator to permit accurate weight on bit control. The drilling rig was originally designed for Leg 124E in an attempt to prove the feasibility of secondary-compensated high-speed diamond coring offshore. Since the initial leg, numerous upgrades in both hardware and software have allowed the DCS to progress to a depth capability of 4500 ft and an accuracy of -/+ 500 lb weight on bit control. A schematic of the current platform configuration and design is presented in Figs. A1 and A2.

The DCS system is composed of two main pieces of hardware. These include (1) the mast, which supports the electric top drive and feed cylinders, and (2) the platform, which contains all the drilling control panels, secondary heave compensation control console, hardware/software, and hydraulic power pack system. As illustrated in Fig. A3, the platform is suspended about 45 ft above the ship's rig floor and is supported by the ship's primary 400-ton compensator. The secondary DCS compensator is then used to remove any residual heave not removed by the primary compensator. The 800-horsepower electric top drive is capable of rotating at over 500 revolutions per minute. This provides ideal parameters for slim hole diamond coring. Additional platform system descriptions are provided in Table A1.

Heave Compensation System

The heave compensation system provided for Leg 132 experienced noise problems which prevented the successful use of platform-mounted accelerometer data for driving the secondary compensation system. The system was finally made to work using an accelerator mounted in the ship's moonpool for use with the LDGO/BRG compensated logging line. However, accelerometer drift problems continued to plague the system.

Improvements for Leg 142 include a dedicated accelerometer mounted in the moonpool area at the center of the ship's pitch and roll. A closed-loop-velocity-control capability will be implemented to correct for accelerometer drift experienced during Leg 132 operations. Data will be gathered from both the primary compensator's rod position and the moonpool mounted accelerator to remove residual heave and pipe stretch, thus providing secondary compensation control. Some sticking problems experienced with the hydraulic seals on the two 16-ft feed cylinders also contributed to secondary heave compensator confusion in attempting to maintain constant weight on bit control. These seals were replaced with a "low-friction" version for Leg 142.

Safety System

Two full-scale tests were completed during the summer, 1991, in order to verify the platform shock-absorbing characteristics. These tests included an off-the-platform test of the new shock cylinders and plumbing hardware, along with a full-scale slingshot test of the platform/mast as it would be configured on the ship. The drop test conducted on the cylinders confirmed how the relief valves perform at different settings and how well the plumbing design allows for adequate flow to be moved through the system. Parameters pertaining to flow losses and drag coefficients on the rod/cylinders were obtained. These data were then used in the analytical model of the slingshot test to help predict proper settings of the relief valves for actual drilling conditions.

Three actual slingshot tests were performed at different relief-valve settings and at different simulated drill-string loads. These tests were performed with the DCS platform/mast held in tension between a test cylinder and drill string. A schematic of this set-up is illustrated in Fig. A4. The cylinder was pressured to simulate an actual load before the drill string was severed with an explosive charge. Accelerations of both the platform and mast were measured to verify how effectively the damping system performed.

ODP DIAMOND CORING SYSTEM (PHASE IIB)
PLATFORM SYSTEM DESCRIPTION
Table A1

Secondary Heave Compensator
Type: WESTECH Gear Corporation

Total working stroke.................................± 12 in.
Total travel... 16 ft.
Piston rods.......................................5 1/4 in. OD
Maxing operating pressure.............................3000 psi
Maximum tripping pressure.............................3500 psi
Load cell.............................Metrox compression type
Dynamic test cylinder rods............................3 in. OD
Test cylinder rod extension............................48 in.
Power pack...............200 HP, 1800 12 RPM, 60 HZ, 460 VOLT
Accumulator bank...40 gal.
Oil reservoir...150 gal.

Electric Top Drive/Swivel
Type: PARTECH

Power rating...800 HP
Drilling coring torque...........................8300 ft. lbs
Maximum make and break torque...................11,000 ft lbs
Air break.......................................12,000 ft lbs
Maximum drilling speed................................540 RPM
Dead load rating of swivel...........................650 Tons
API bearing rating...................................425 Tons
Max operating pressure................................5000 psi
Minimum fluid passage dia...........................4.125 in.

Wire Line Winch

Drum size......11 in. dia. X 49.91 in. length X 33.0 flange OD
Drum capacity...............18,000 ft of 3/8 in. (7X19 cable)
Continuous line pull.........bare drum, 10,090 lbs at 5.5 rad
Continuous line pull..........full drum, 3,580 lbs at 15.5 rad
Intermittent line pull..................bare drum, 11,772 lbs
Intermittent line pull....partial drum, 8,587 lbs at 15,000 ft
Intermittent line pull.......full drum, 4,177 lbs at 18,000 ft
Line speed............................600 ft/min at bare drum
Motor RPM................................208 RPM at bare drum
Motor RPM.................................74 RPM at full drum

Tubing String

Tubing OD...........3.500 in.
Wall thickness.......0.254 in.
Tubing ID...........2.992 in.
Pin bore............2.942 in.

Connection OD.........3.868
Yield strength......130 KSI
Weight /ft......9.30 lb/ft.
Connections: Hydril series type 501

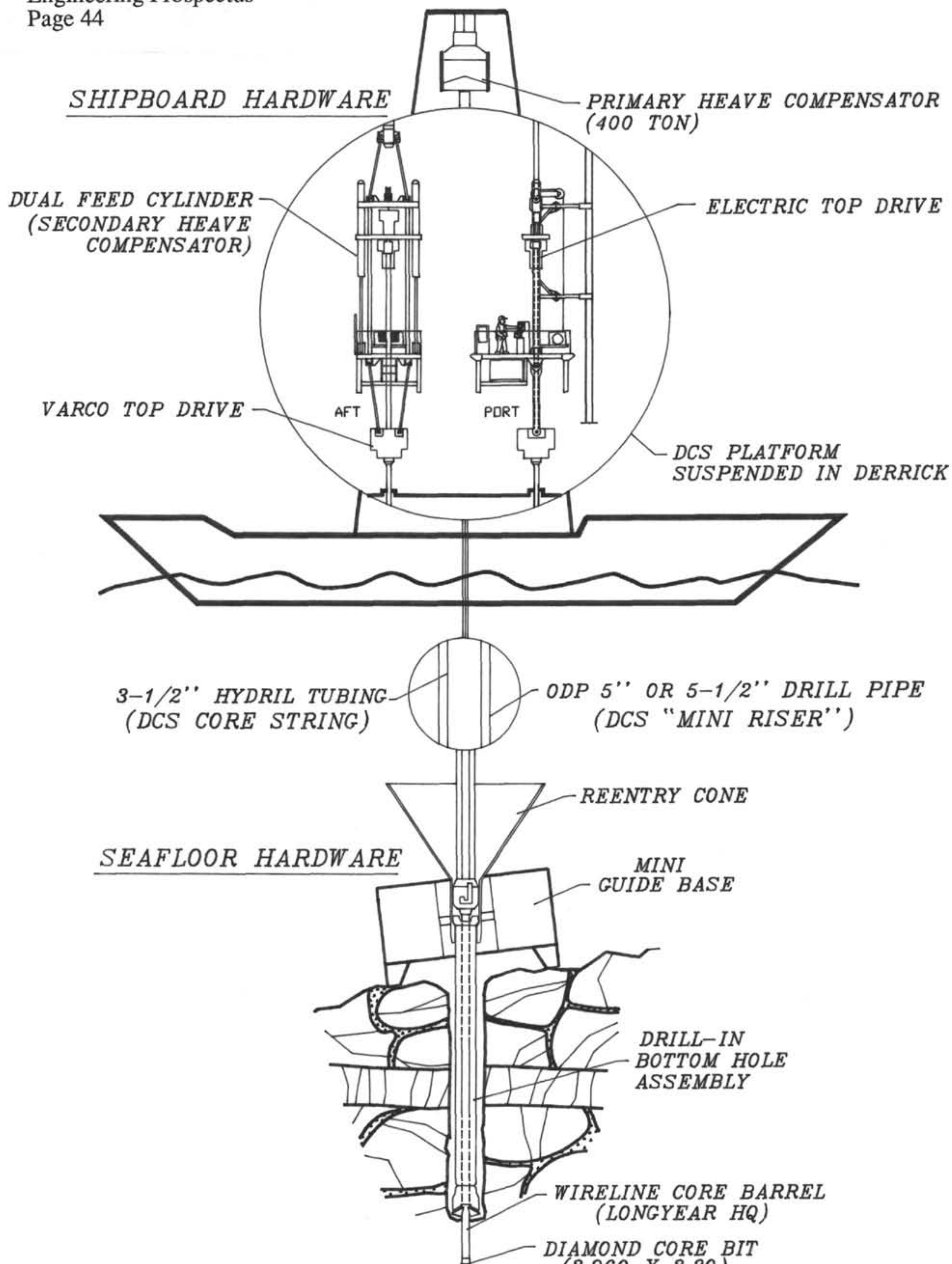


Figure A1

DIAMOND CORING SYSTEM
PHASE II – 4500 METER

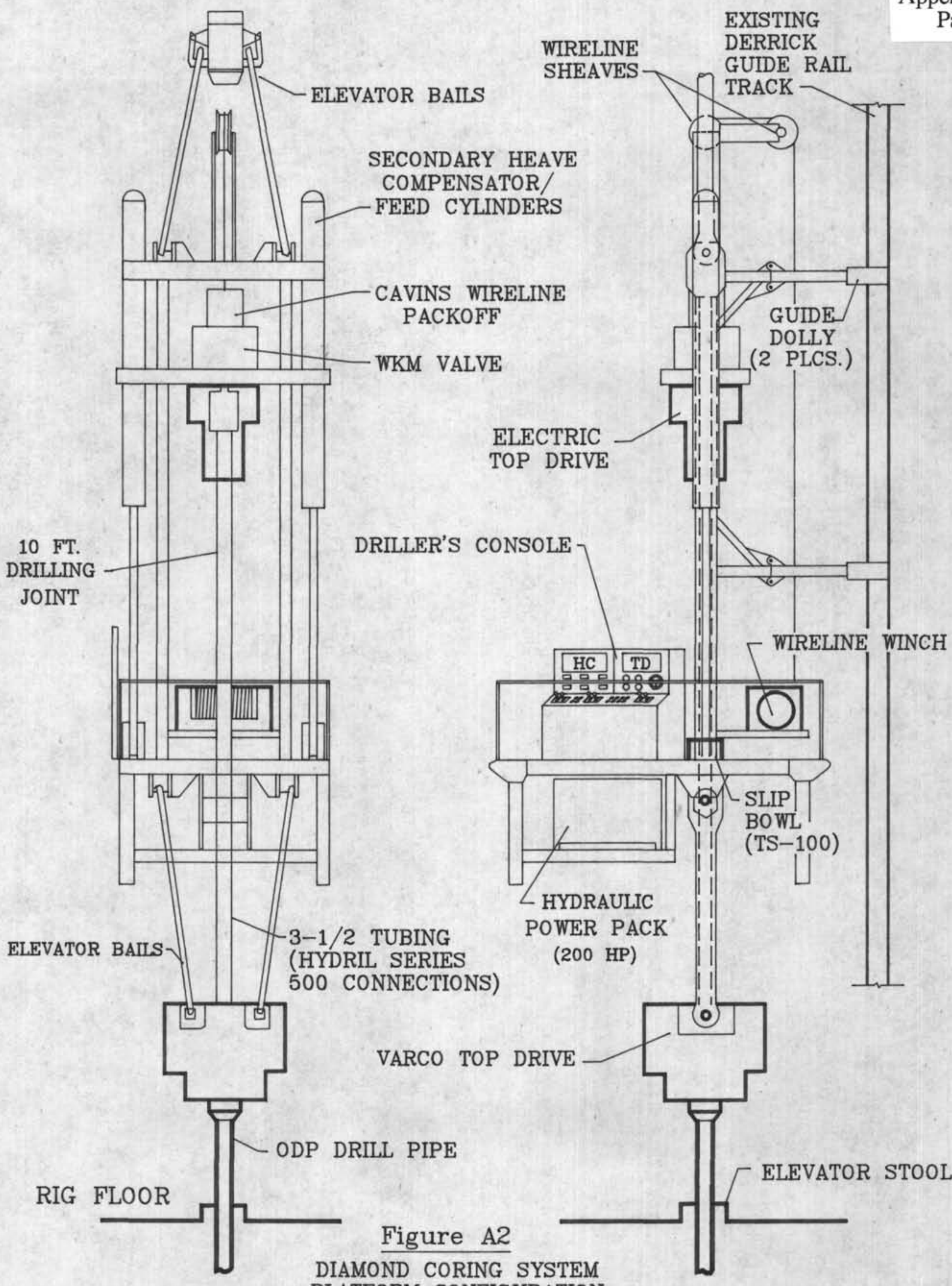


Figure A2

DIAMOND CORING SYSTEM
PLATFORM CONFIGURATION
PHASE II - 4500 METER DEPTH CAPACITY

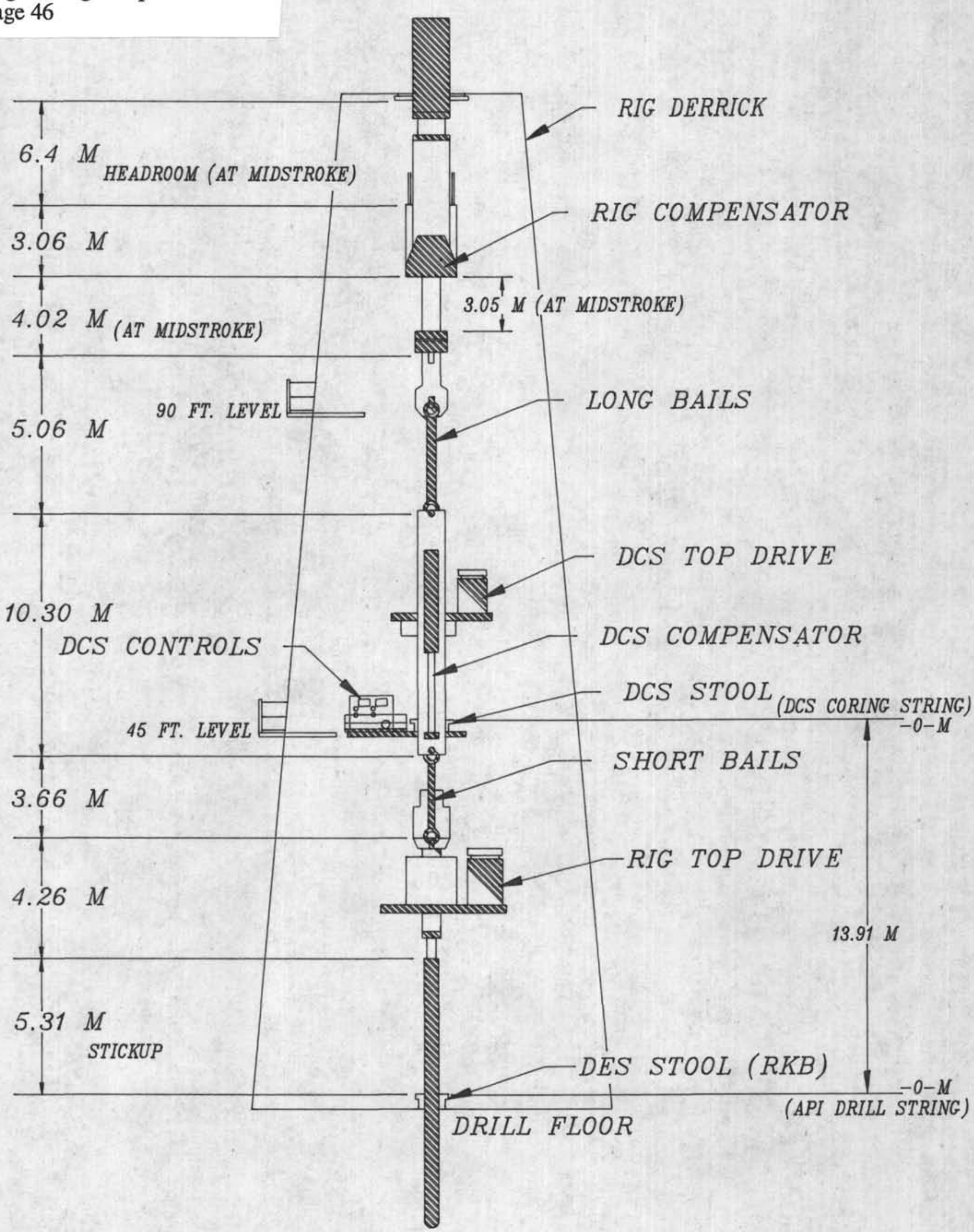


Figure A3

DCS DERRICK STACK-UP

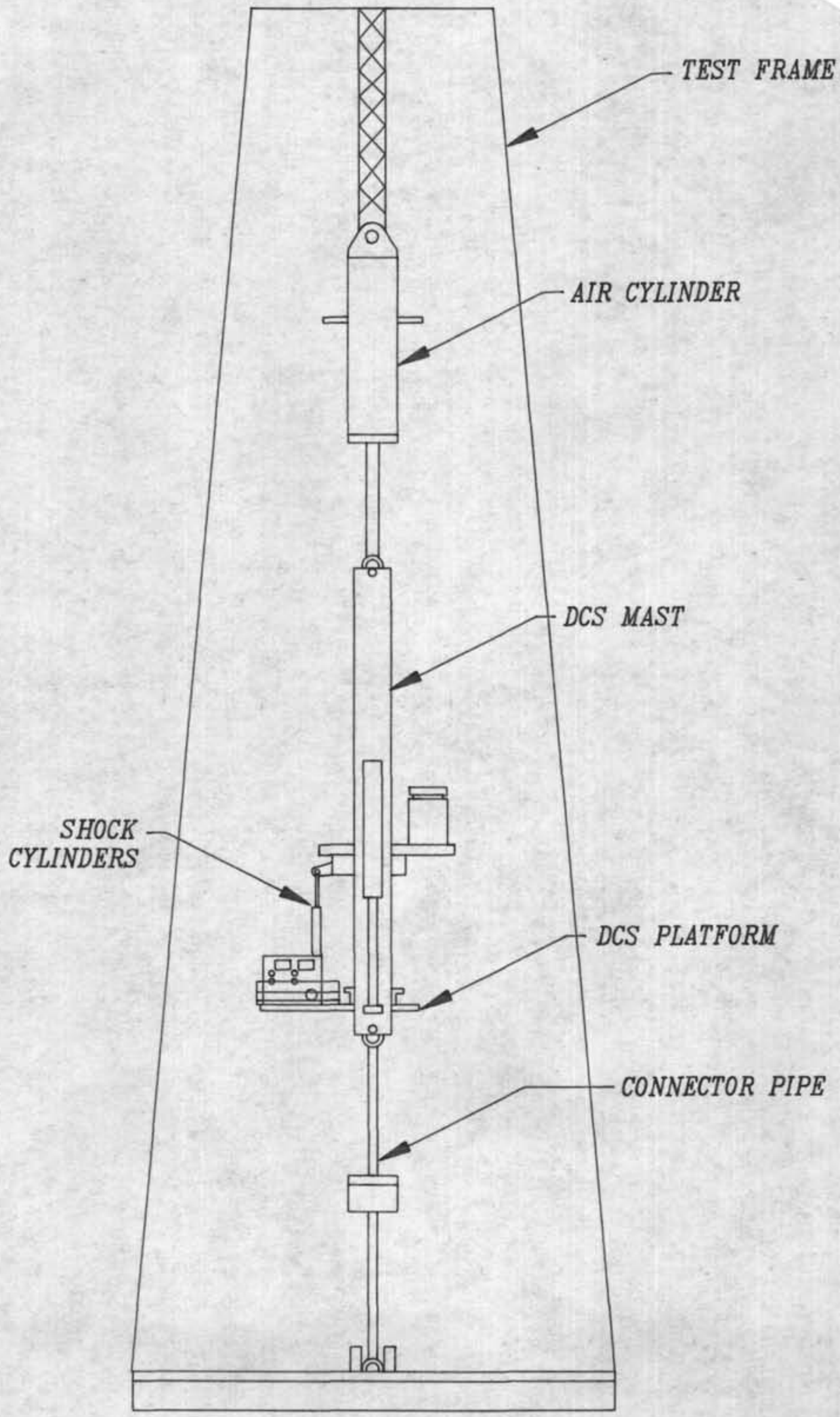


Figure A4

DCS PLATFORM TEST

APPENDIX B

ODP DIAMOND CORING SYSTEM PHASE IIB

CORING/SAMPLING CAPABILITIES WITH DCS

Introduction

A modified coring system was developed for use with the DCS drilling equipment. This system integrated both mining and oilfield technology to produce a system that would withstand the rigors of deep-water offshore drilling. This system was first deployed on Leg 132. The hardware worked almost flawlessly while coring the hard basalt, but was unable to recover granular volcanic-tuff-type material that was present throughout the remainder of the borehole. Sizes and dimensions of the core barrel components are presented in Table BI. Another limitation of the DCS identified during Leg 132 was that approximately 24 hr weas needed to change out a bit. This length of time was dependent on the rigging down/up of the DCS platform and not the coring hardware itself. However, bits with a longer life would greatly increase the on-bottom coring time with the bit. With these two areas needing improvement, several new tools were added to the DCS inventory during the Phase IIB development.

Sampling Hardware

Several sampling options have been designed to complement the hard-rock-coring capabilities of the core barrel. These include a hydraulically actuated piston sampler, a thin-walled push sampler, a bit de-plugger, a thick-wall split-spoon sampler, and a drill-ahead center bit. These options are illustrated in Fig. B1. All of the alternative sampling options are compatible with the outer core barrel; therefore, these samplers may be alternated should drilling or formation conditions require their use. All of the soft sediment samplers have full-closure basket-style core catchers incorporated into the design. The hydraulic piston sampler is designed and operates in a manner similar to ODP's Advanced Piston Corer (APC). Two lengths (30 and 54 in.) of samplers are available for the piston sampler. The push sampler can use the same two sample tubes as the piston sampler. This sampler is pushed into the formation by lowering the feed cylinders on the DCS top drive. The split spoon sampler is designed to be driven into harder or denser type formations with the aid of a downhole hammer (mini-jar) operated via wireline.

Core Barrel Improvements

Several improvements to the core barrel have been made in response to Leg 132 experience. The first major improvement allows two types of core catchers (basket and collet) to be run together. This is in response to fractured or friable formations which might tend to fall out of the barrel, if only being held in with a collet style catcher. The collet is still the primary means to capture hard, competent rock, but can now be supplemented with the basket catcher as needed. The use of both core catchers still enables the core barrel to be deployed with or without core liners.

Another addition to the core barrel is the introduction of a device to prohibit flow and/or cuttings from being sucked into the tubing while the core barrel is being retrieved. This device serves the same purpose as a float valve in ODP's larger coring systems, but does not have any of the traditional mechanical flapper valve parts. This is primarily due to the extremely thin wall of the DCS inner core barrel. The device resembles a multi-fingered basket core catcher, but is installed upside down. The float valve is attached to the inner-core-barrel stabilizer, which rests just behind the DCS core bit. Schematics of this float valve and the other styles of core catchers are presented in Fig. B2.

Two types of liners will be provided for Leg 142. These include the traditional butyrate liners and a new extruded-aluminum liner. The aluminum liner can be used in environments where elevated temperatures are likely to damage the butyrate liners. It was learned on Leg 132 that the split steel liners developed for the DCS core barrel were extremely difficult to handle and install; therefore, the new aluminum liners are a one-piece design.

Diamond Core Bits

Upon returning from Leg 132, it was obvious that longer life bits should be designed for the DCS, if possible. This would result in more time for coring because less time would be spent rigging up/down the platform every time the core bit needed to be replaced. Several diamond bit manufacturers were approached with the concept of building a bit for ODP with a harder, more abrasive resistance matrix and/or a design which would allow for a stacked or longer matrix crown. The bit manufacturers were also asked to see if water courses could be designed with rounded, instead of square, shoulders and if a higher concentration of diamonds could be added to the matrix. Several bit designs from three different manufacturers were then selected to be made with a variety of improvements/enhancements for use on Leg 142.

DCS CORE BARREL DIMENSIONS
Table B1

Type: Longyear modified HQ-3 Core Barrel

Hole size	3.960 in.
Core size	2.200 in.
Outer Tube, OD	3.625 in.
Outer Tube, ID	3.063 in.
Outer Tube Wall Thickness	0.281 in.
Inner Tube OD	2.625 in.
Inner Tube ID	2.375 in.
Inner Tube Wall Thickness	0.150 in.
Liner OD	2.343 in.
Liner ID	2.243 in.
Liner Wall Thickness	0.048 in.
Barrel length	5 & 10 ft.
Landing shoulder width	0.111 in.
Landing shoulder impact area	0.871 in.
R (Hole OD/Core OD)	1.80 in.
Bit Kerf width	0.88 in.

Type: Hydraulic Piston Sampler/Push Sampler

Sample diameter	1.625 in.
Sample length	30,54 in.
Sample tube O.D.	2.125 in.
Sample tube I.D.	1.935 in.

Type: Split Spoon

Sample diameter	1.375 in.
Sample length	18 in.
Split spoon I.D.	1.750 in.
Split spoon I.D.	1.50 in.

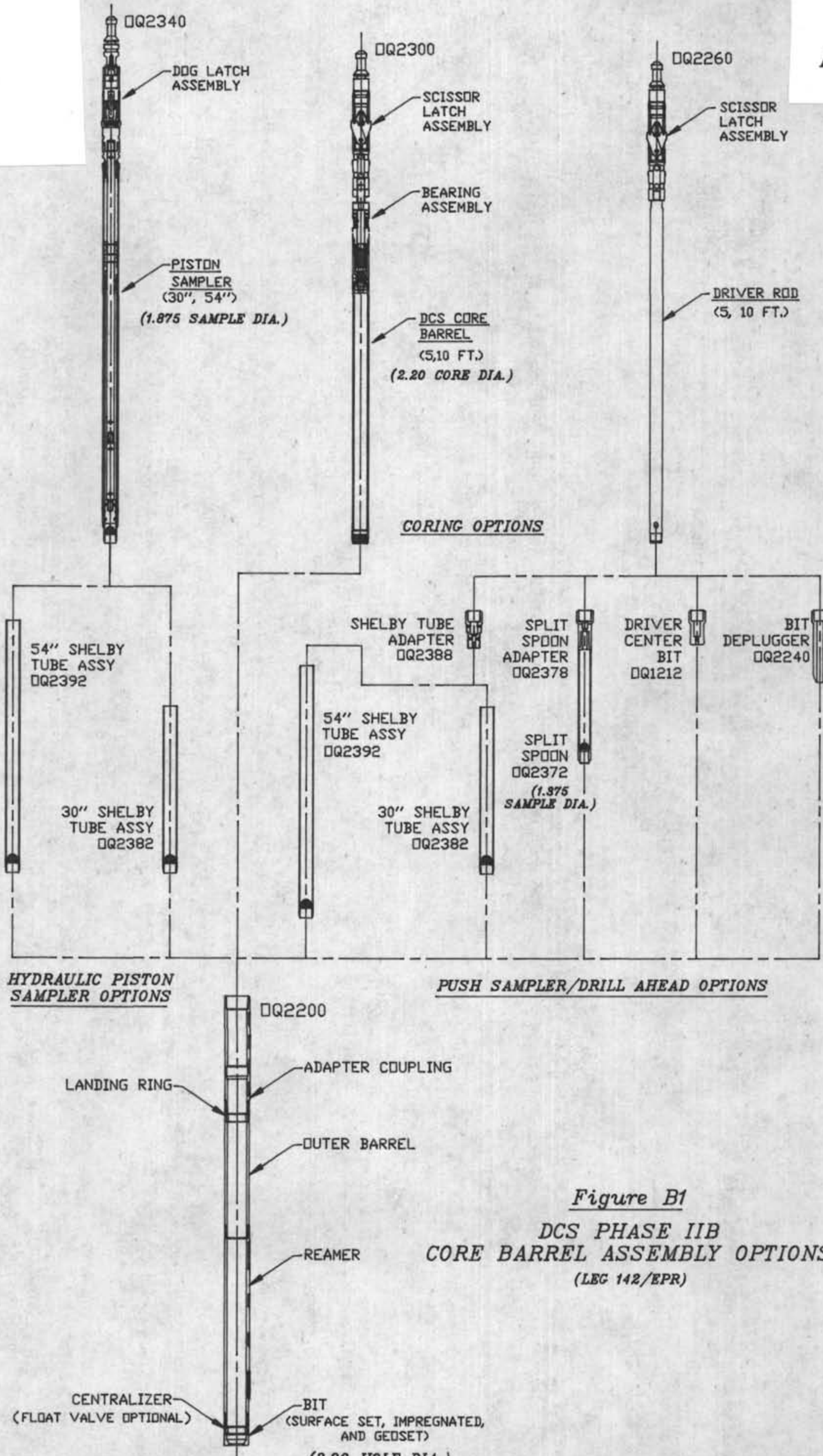


Figure B1

DCS PHASE IIB CORE BARREL ASSEMBLY OPTIONS

(LEG 142/EPR)

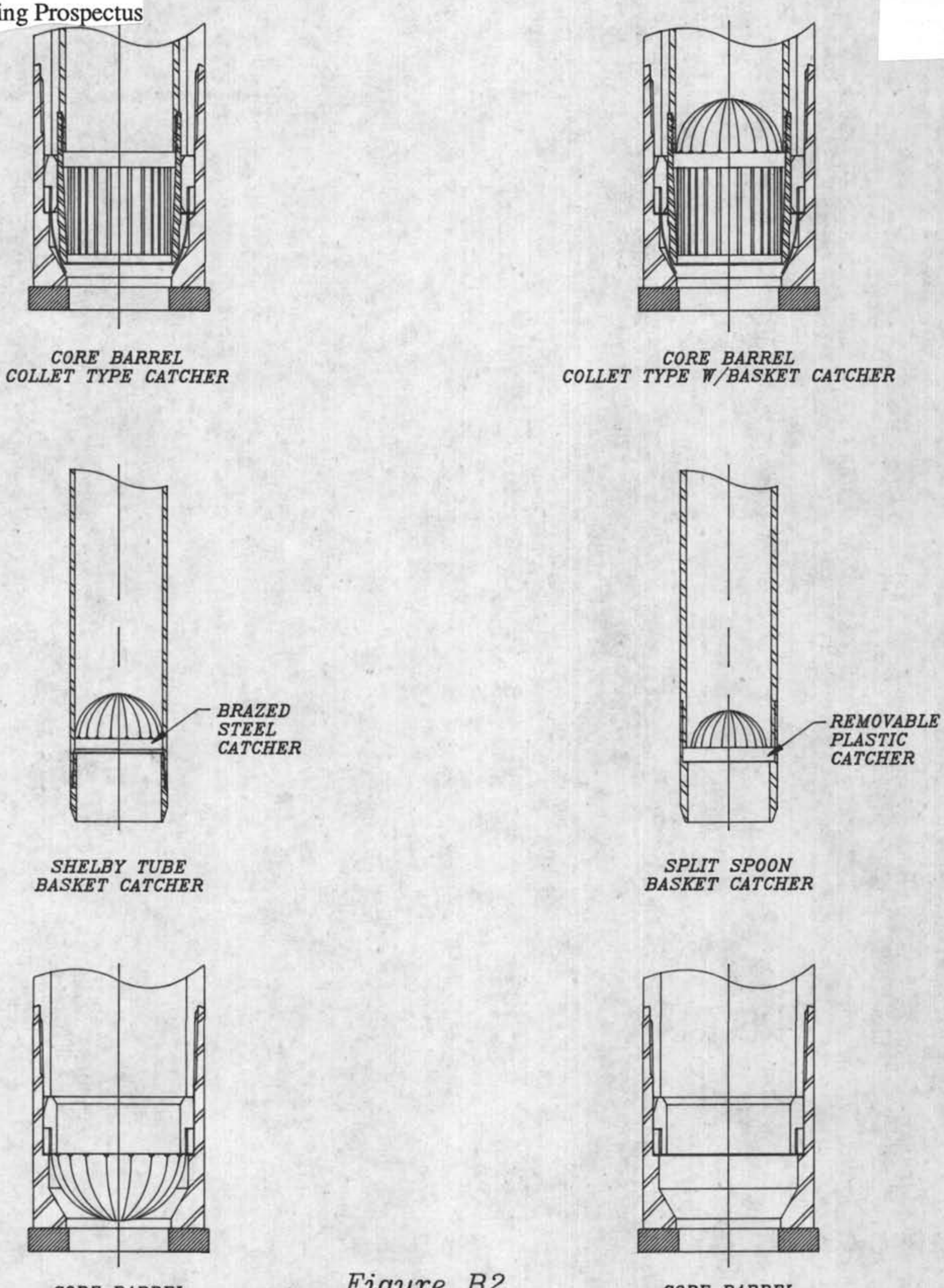


Figure B2

DCS PHASE IIB
CORE CATCHER/FLOAT VALVE
ASSEMBLY OPTIONS
(LEG 142/EPR)

APPENDIX C

ODP DIAMOND CORING SYSTEM PHASE IIB

MINI HARD ROCK GUIDE BASE

Introduction

The mini-hard-rock guide-base (HRB) design was modified slightly after the prototype base was deployed on Leg 132. These changes were initiated in order to improve handling, assembly, deployment, and stability of the HRB. The most notable changes for the redesigned base are reduced height, modified geometric shape and cone diameter, and a method to ensure verticality. Changes are illustrated in Fig. C1. The changes include:

1. Redesign of the base sections into two compartments instead of four (six-sided design);
2. introduction of a counterweight on the casing hanger for uprighting the cone (replaces buoyancy panels);
3. adapting a smaller free-fall style cone funnel (two sections) onto the casing hanger in place of the larger reentry cone (eight panels) used on the prototype version;
4. raising the trunnions on the casing hanger to assist in uprighting the cone;
5. larger angle over which the base can operate with seafloor slopes up to 25°-30° (Fig. C2);
6. strengthening the legs and leg guides;
7. opening the top of the base to facilitate easier loading of ballast; and
8. increased stability with three legs instead of four.

General Description

The newly designed base is a hexagonal shape (six-sided), which allows a minimum of only three legs needed for deployment. The casing hanger has not been modified other than by adding a small landing ring placed around the top and exterior counterweights. The ring allows a stop for the cone to rest on while it is being installed. The cone itself has been reconfigured to resemble the free-fall funnel cone. It is approximately 8.0 ft wide at the largest cross section and 3.5 ft tall. The low profile of the cone helps in reducing the required overturning moment of the casing hanger, while still retaining an adequate target area for reentry.

The new counter-balanced design negates the need for syntactic foam buoyancy panels. The guide base can be set on a slope of up to 25° while maintaining vertical orientation of the cone/casing hanger assembly. The righting moment has a factor of safety of approximately 2.5:1.

The introduction of the larger base diameter to the modified HRB has allowed the base sections to be assembled while the vessel is under way or in port. This not only saves time once on location, but also helps in having the base and other equipment readily accessible without having to move these or additional items around the ship for access to needed components. The new design encompassed redesigning the four tanks into two pieces similar to a clam shell. This design provides a larger area in the middle of the assembled tank section. With this increased area, the upper guide horn can remain installed while the vessel is under way.

Assembly

The modular design of the mini-HRB allows for a reduction in assembly time. These components include two base sections, two cone sections, and the casing hanger. The base has been designed to be completely assembled with bolts. The two base sections are brought together and secured with a total of 18 bolts. These have a factor of safety against shear of 19:1. This safety factor can be increased by welding. Once the two base sections are assembled, the casing hanger is lowered into the gimbal and bolted in place. Next, the preassembled two-piece cone is placed onto the top of the casing hanger. Ballasting the base with the appropriate weight is the final step before deploying the mini-HRB to the seafloor.

The casing hanger is preassembled with the gimbal and counterweights as shown in Fig. C3. The internal landing seat must be installed into the casing hanger once the appropriate BHA is selected. Three sizes of landing seats are available for the various diameters of drill-in-BHA hardware. The appropriate seat must be installed prior to running the base to the seafloor. The two smaller sizes are actually sleeves which bolt into the primary landing seat. They cannot be removed (sheared out) unless the primary landing seat is removed with them. Eight shear pins hold the primary landing seat into the casing hanger with approximately 7000 lb force per pin required to shear out the seat. Key ways which prohibit the landing seat from rotating when the back-off sub lands have also been strengthened.

Ballasting Requirements

The overall 5.5 ft height of the tank sections has not been changed, due to the restrictions of the mezzanine deck. The new base weighs approximately 41,400 lb dry. This is slightly more than the prototype version, which weighed around 31,400 lb dry. Besides the increase in base weight, the overall volume of the new HRB has increased. The volume realized by the new section is 490 cubic ft, whereas the earlier prototype version had a volume of only 468 cubic ft. This is an additional benefit since more cement/barite can be used as ballast rather than steel or lead. This results in a cost savings and reduced time in ballasting the tank sections. The ballast selected for Leg 142 will consist of weighted steel pipes. These pipes will weigh approximately 350 kg each. A schematic of the ballasted base is shown in Fig. C2.

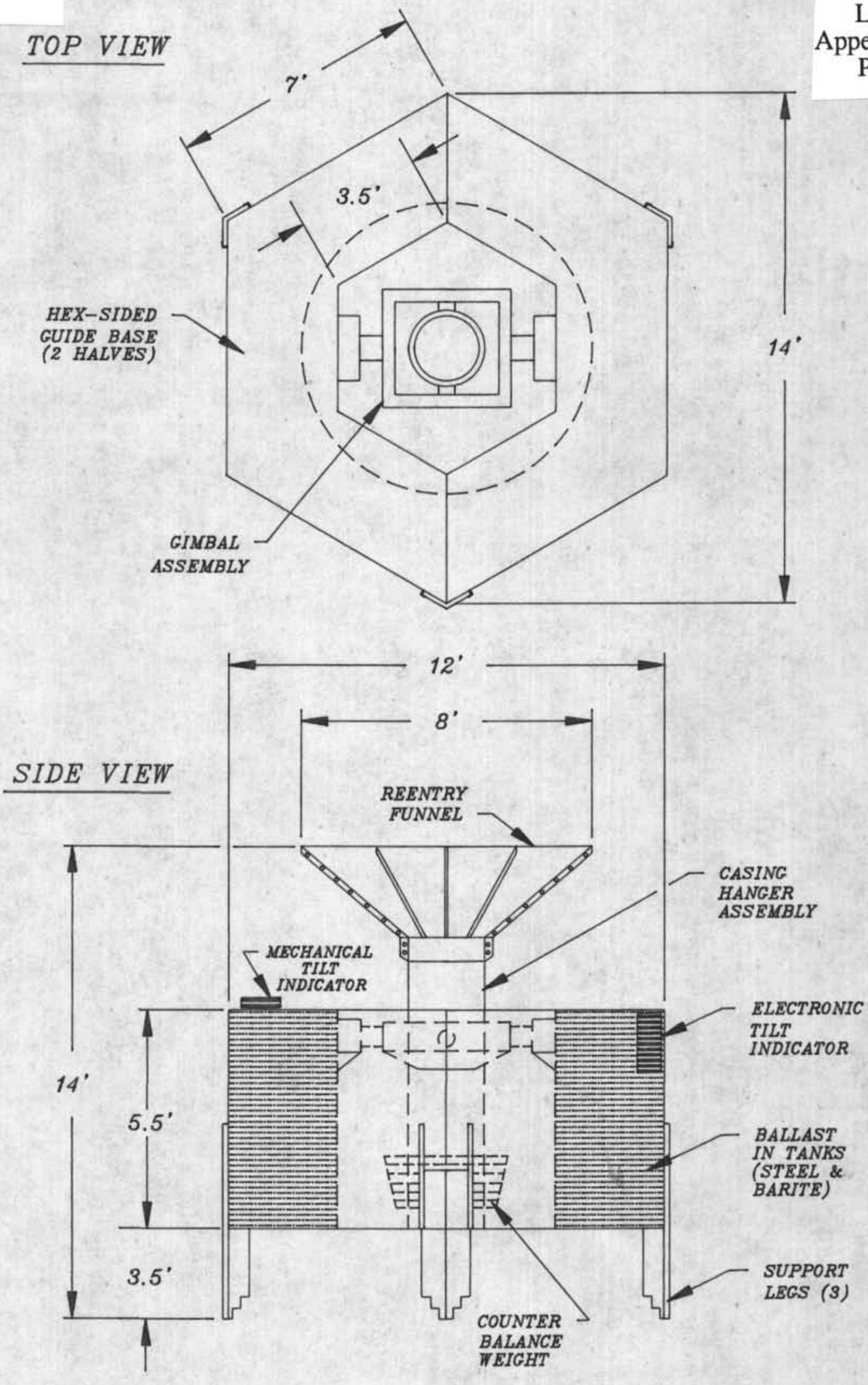
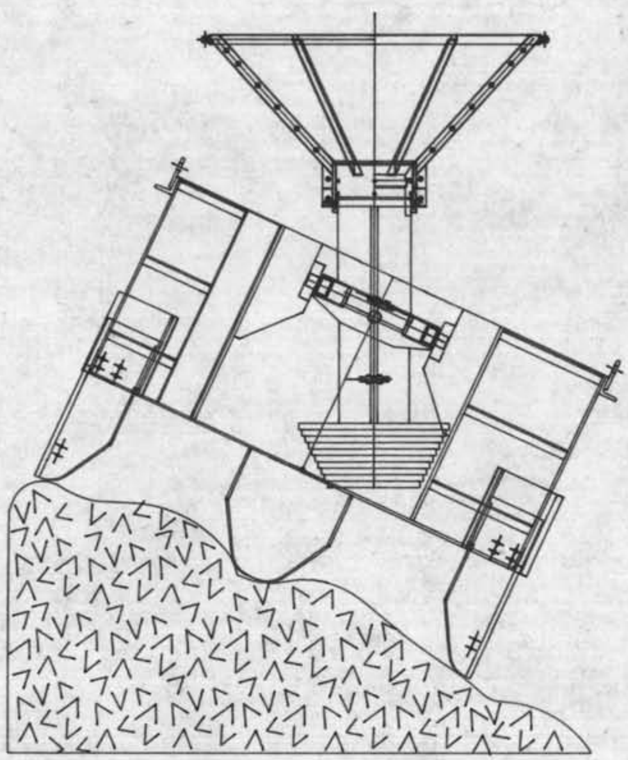


Figure C1

MINI HARD ROCK GUIDE BASE (HRB)

HEXAGONAL DESIGN SCHEMATIC

MINI HRB SPECIFICATIONS



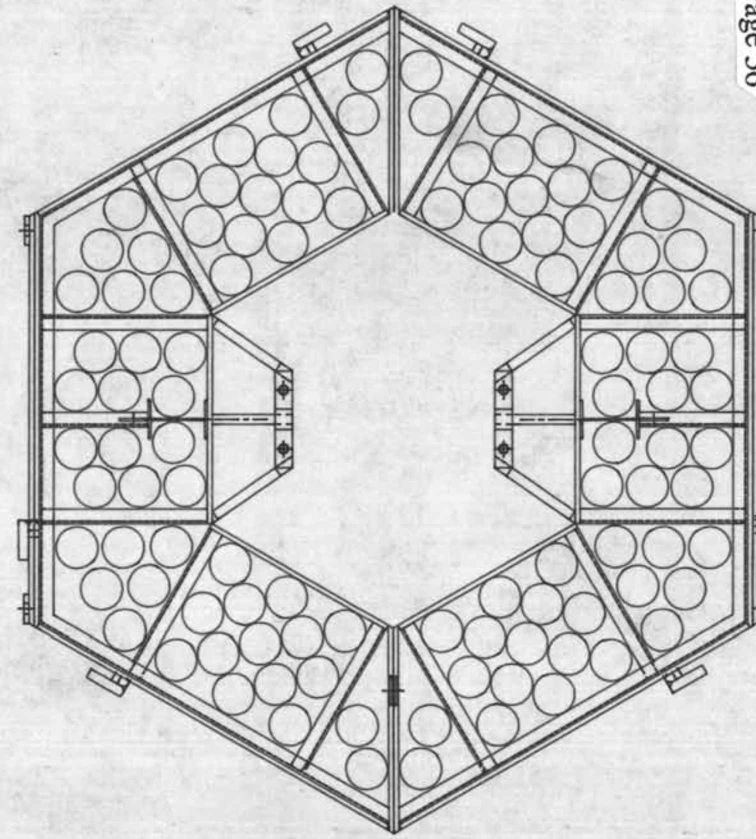
DESIGN REQUIREMENTS

BASE BOLTS – 1 IN. A 372 (18 TOTAL)
LEG BOLTS – 7/8 IN. A 372 (8 PER LEG)
S.F. FOR UPRIGHTING MOMENT – 2.5
S.F. OF BASE BOLTS AGAINST SHEAR – 19:1
MAX TILT (INTO SIDE) – 25° (INTO CORNER) – 30°

DRY BASE COMPONENT WEIGHTS

BASE SECTIONS(2) –	26,500 LBS.	CONE –	1,600 LBS.
GIMBAL –	1,075 LBS.	COUNTERWEIGHT –	5,350 LBS.
CASING HANGER –	4,250 LBS.	LANDING SEAT –	375 LBS.
LEGS (3) –	2,250 LBS.		
		TOTAL	41,400 LBS.

MINI HRB BALLAST FOR LEG 142



BALLAST

STEEL PIPE: 8.62'' (21.9 cm) X 8.22'' (20.9cm) X 5.58' (1.7 m)

TOTAL WEIGHT PER PIPE 770–792 LBS. (350–360 KG.)

MAXIMUM ALLOWABLE PIPES PER BASE: 108 PIPES

TANK VOLUME: 493 $FT.^3$

DRY WEIGHT

STEEL PIPES –	83,160 LBS.
CEMENT –	29,500
BASE –	41,400
TOTAL –	154,060 LBS.

SUBMERGED WEIGHT

STEEL PIPES –	72,350 LBS.
CEMENT –	13,500
BASE –	36,020
TOTAL –	121,870 LBS.

Figure C2

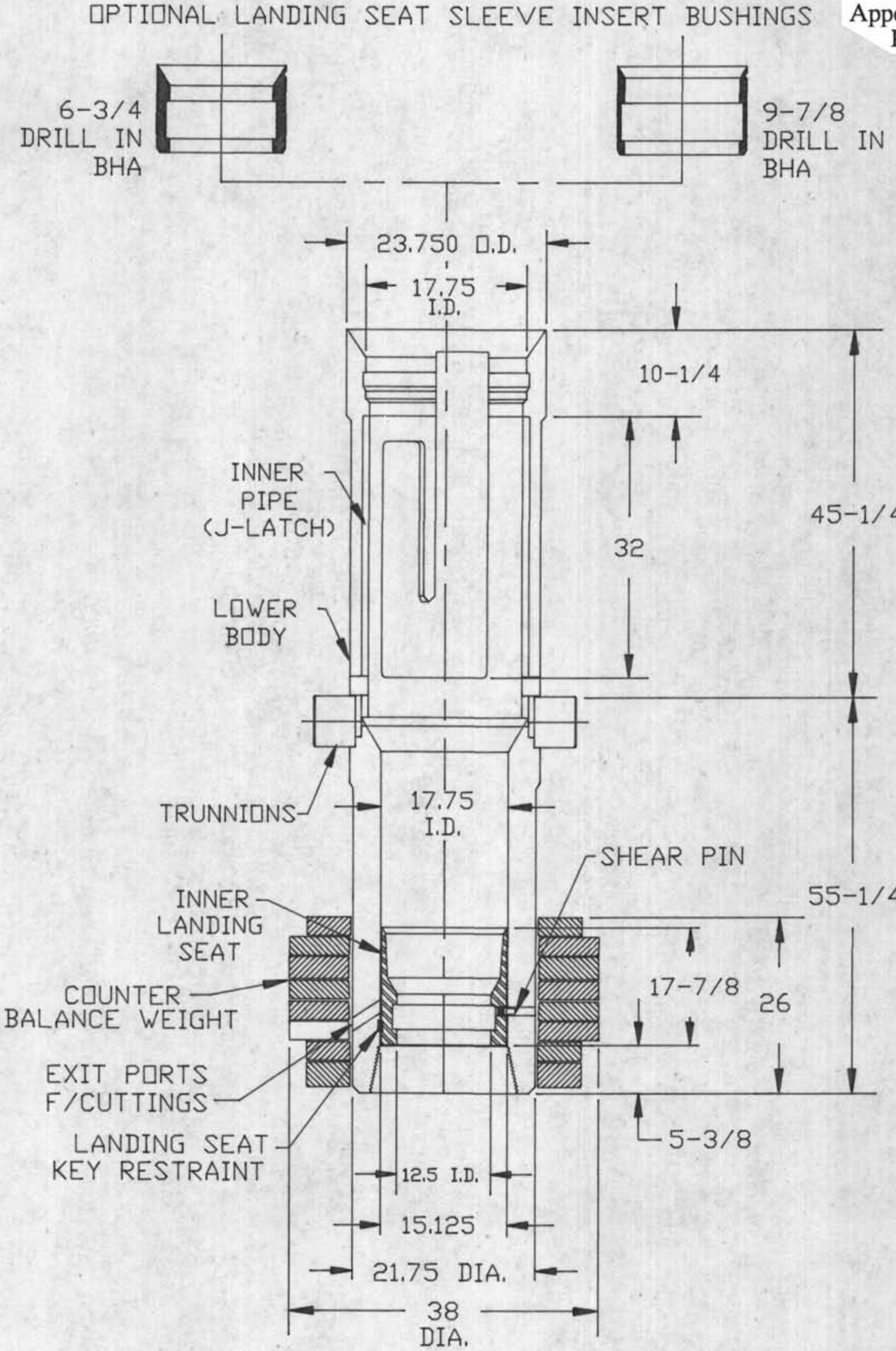


Figure C3

MINI HRB MODIFIED CASING HANGER

APPENDIX D

ODP DIAMOND CORING SYSTEM PHASE IIB

BOTTOM HOLE ASSEMBLY/BACK OFF HARDWARE

Introduction

A drill-in back-off sub was developed for Leg 132 to provide a means to back-off the bottom hole assembly (BHA) in unstable fractured hard rock formations, thus allowing the DCS tubing a cased environment in which to begin coring. The tool is designed with an internal threaded ring, housed inside a larger nut assembly, which holds the upper and lower portions of the tool together. The two pieces separate when the external nut makes contact with a matched landing seat located inside the casing hanger. When contact is made between these two surfaces, the large nut locks itself onto the taper of the landing seat and prevents it from rotating. The drill string itself continues rotating, thus allowing the internal threaded ring to unscrew. Within a few seconds of continued rotation, the upper and lower subs become free to separate. Fig. D1 illustrates this back-off sub/drill-in BHA (DI-BHA) concept.

Background

The prototype drill-in-BHA system (11-5/8 in. and 9-7/8 in.) met with general success on Leg 132, but minor redesign of a few of the back-off sub components was deemed necessary. These changes centered around the taper on the matched surfaces, additional protection for the nut, and the position of the c-ring groove on the lower sub. Besides the changes to the original hardware, a "nested" version has also been developed for anticipated drilling difficulties at the East Pacific Rise (EPR). The nested system allows two drill-in systems to work in tandem. The dual back-off system allows greater depth capability, should hole instability problems limit the depth that the DCS can achieve on its own. The first or primary stage of the nested hardware is 10-3/4-in. drill collars, followed by the second or intermediate string using 6-3/4-in. drill collars. A third option available with the nested system allows the intermediate back-off sub (6-3/4 in.) to be run as an independent system. Therefore, if drilling conditions prohibit the advancement of an initial larger diameter hole, the intermediate string can be substituted as the primary drill-in system.

Hardware Description

Four sizes of DI-BHA are available for Leg 142, with three of these systems designed to be used separately. The different options, combinations, and hole sizes for these components are presented in Figs. D2 and D3. It should also be noted that the intermediate string (6-3/4 in.) for the nested hardware has an added feature which allows it to serve as an independent coring system. This coring system has been designated as "Diamond Coring Barrel" (DCB). It uses the same inner core barrel as the Rotary Core Barrel (RCB), but has been repackaged in a smaller size drill collar. Coring can thus be attempted while drilling in the second stage of the nested back-off hardware, allowing as much information as possible to be gathered while establishing the hole for the DCS. Stabilizers have been added to the outer barrel to enhance the potential for core recovery by reducing the potential for bending with this smaller-size DCB system.

The three larger sizes (9-7/8, 11-5/8, and 12-1/4 in.) of back-off subs use the same hardware, except the lower sub portion which is left behind after backing off. All three of these systems back-off in the same landing seat placed inside the casing hanger. The 9-7/8-in. size requires a sleeve insert to be placed in the landing seat prior to guide-base deployment to provide centralization within the casing hanger. The smaller 6-3/4-in. back-off sub is unique in that it lands and backs-off in the throat of the 10-3/4 in. when run in the nested configuration. The 6-3/4-in. system can also be run independently if a sleeve insert is attached to the landing seat, providing centralization through the casing hanger. Fig. D4 shows the 6-3/4-in. sub backing off inside the 10-3/4-in. string.

Besides the back-off sub hardware, drill collars and bit subs were specially designed for the nested drill-in/back-off application. Part of this task required modifying/designing a thread profile for the 6-3/4 and 10-3/4-in. drill collars/bit subs to accept the internal 4-1/8-in.-diameter bore required. Different lengths of drill collars (10, 20, and 30 ft) have also provided maximum flexibility in the selection of the initial drill-in hardware. Different combinations of drilling hardware for both the nested and single-string systems are presented in Figs. D5 and D6.

In addition to the different sizes of lower subs available, the large nested system is outfitted with two sizes/styles of bits. The first is the larger 12-1/2-in.-diameter roller cone bit, the second an 11-1/4-in. diamond bit. The new roller-cone-style bit uses cones around the circumference, with three compact protected blades/arms between each set of cones. The diamond style bits were designed as a back-up to the larger roller cone bits, since the performance of the smaller cones in this application is unknown. Should premature failure or drilling difficulties be experienced with the bits designed for the primary nested drill-in hardware, several options still exist with smaller single-stage (Leg 132 version) drill-in components/bits.

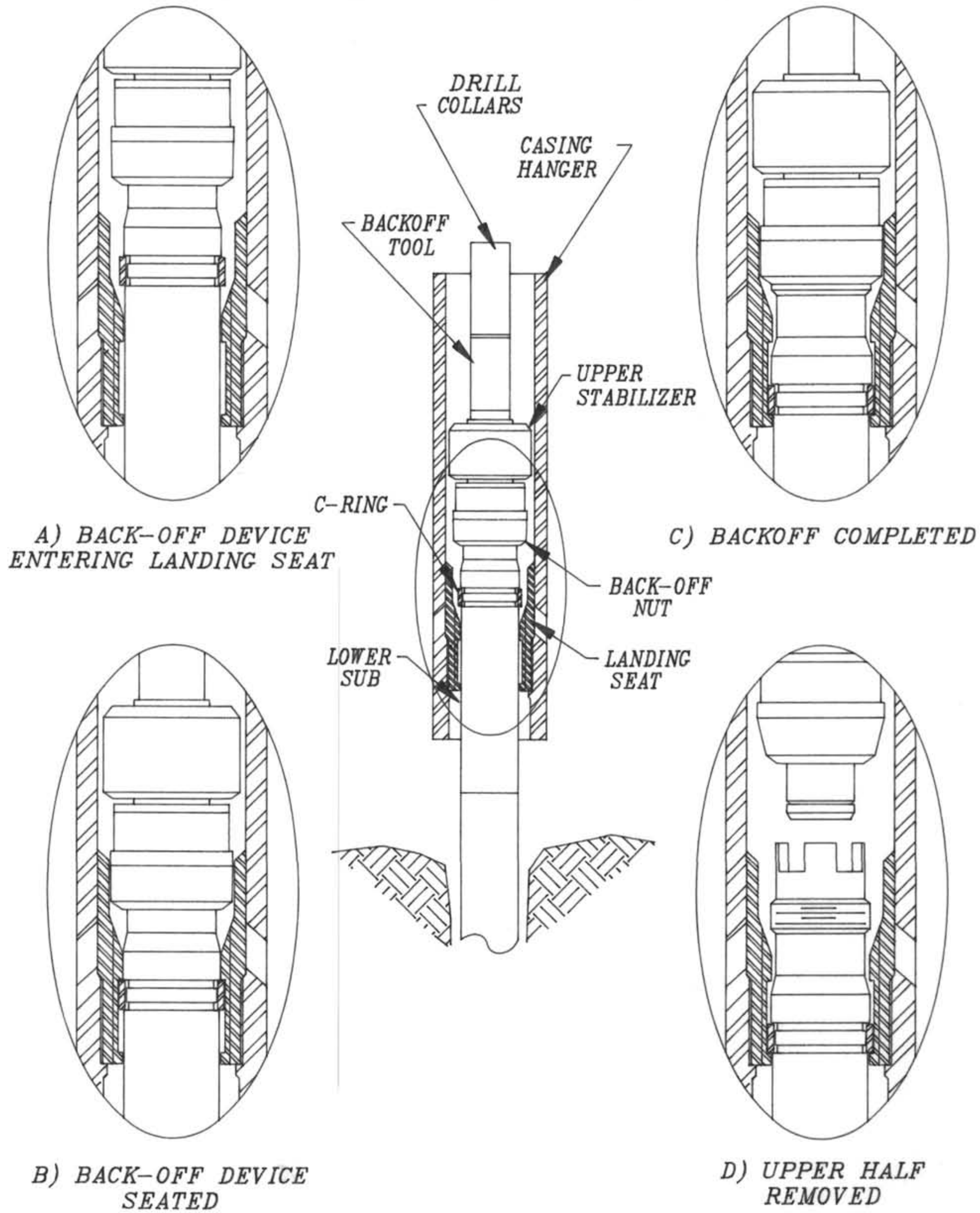


Figure D1

DEPLOYMENT SCHEME FOR MECHANICAL BACK-OFF DEVICE
(SEAFLOOR TEMPLATE NOT SHOWN FOR CLARITY)

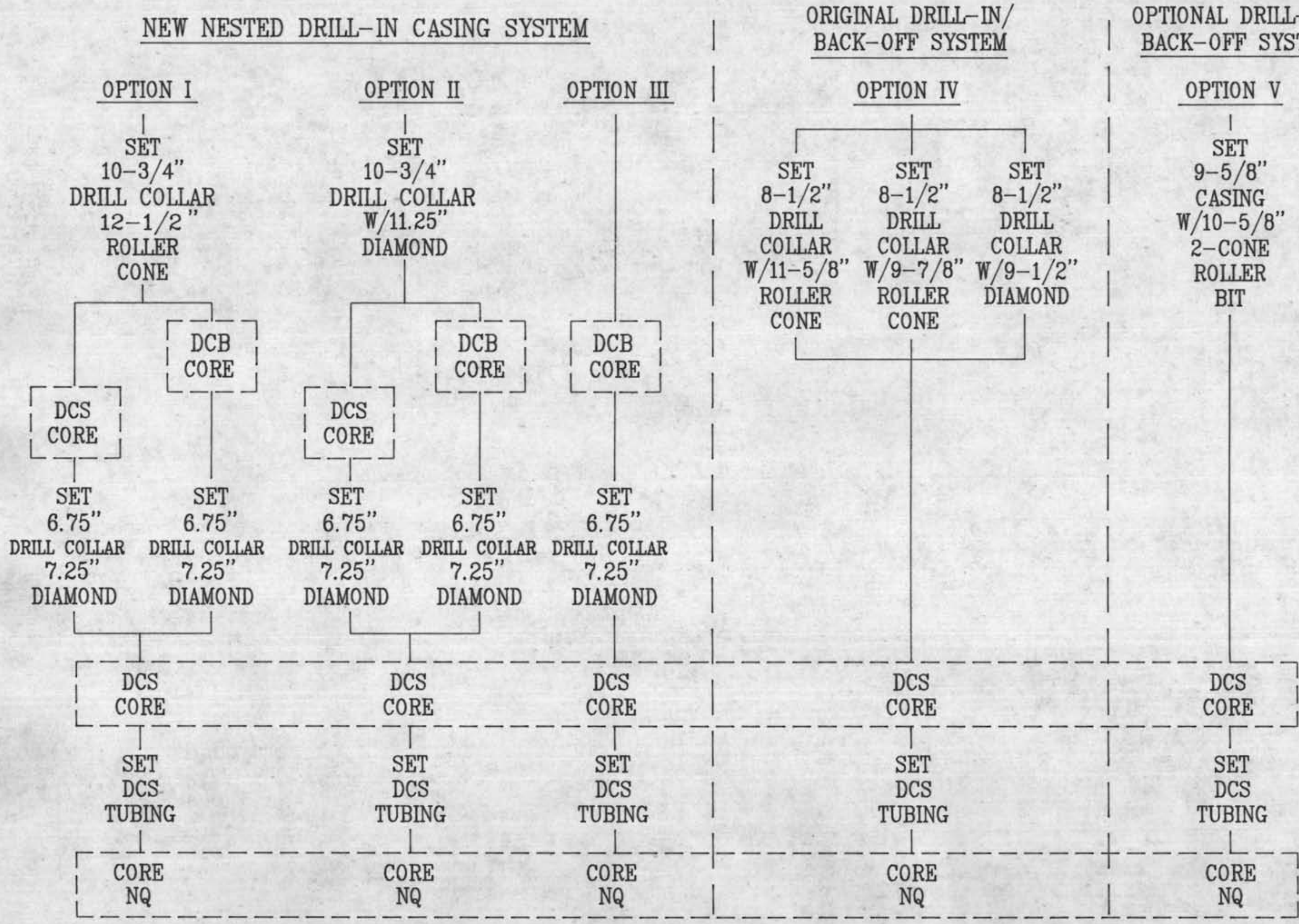
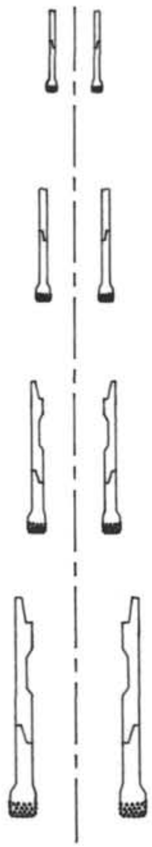


Figure D2

SEAFLOOR SPUDDING OPTIONS
FOR HARD ROCK LOCATIONS
NOTE: NQ CORE NOT AVAILABLE FOR LEG 142



CASING STAGE	CORING STAGE	DESCRIPTION	HOLE SIZE IN.	CORE SIZE IN.	TUBING SIZE I.D., IN.	TUBING SIZE O.D., IN.	WEIGHT LB./FT. (DRY)
N/A	Coring Stage 3	NCQ Rods (optional coring system not yet developed)	2.98	2.06	2.375	2.750	4.4
Casing Stage 3	Coring Stage 2	DCS – Coring String Hydril tubing	3.96	2.2	2.942	3.868	9.5
Casing Stage 2	Coring Stage 1	6.75'' Drill Collar	7.25	2.312 2.342	4.125	6.750	76.0
Casing Stage 1	N/A	10.75'' Drill Collar	11.25 12.50	N/A	7.375	10.750	160.0

Figure D3

DCS/DCB DRILL-IN CASING/CORING OPTIONS

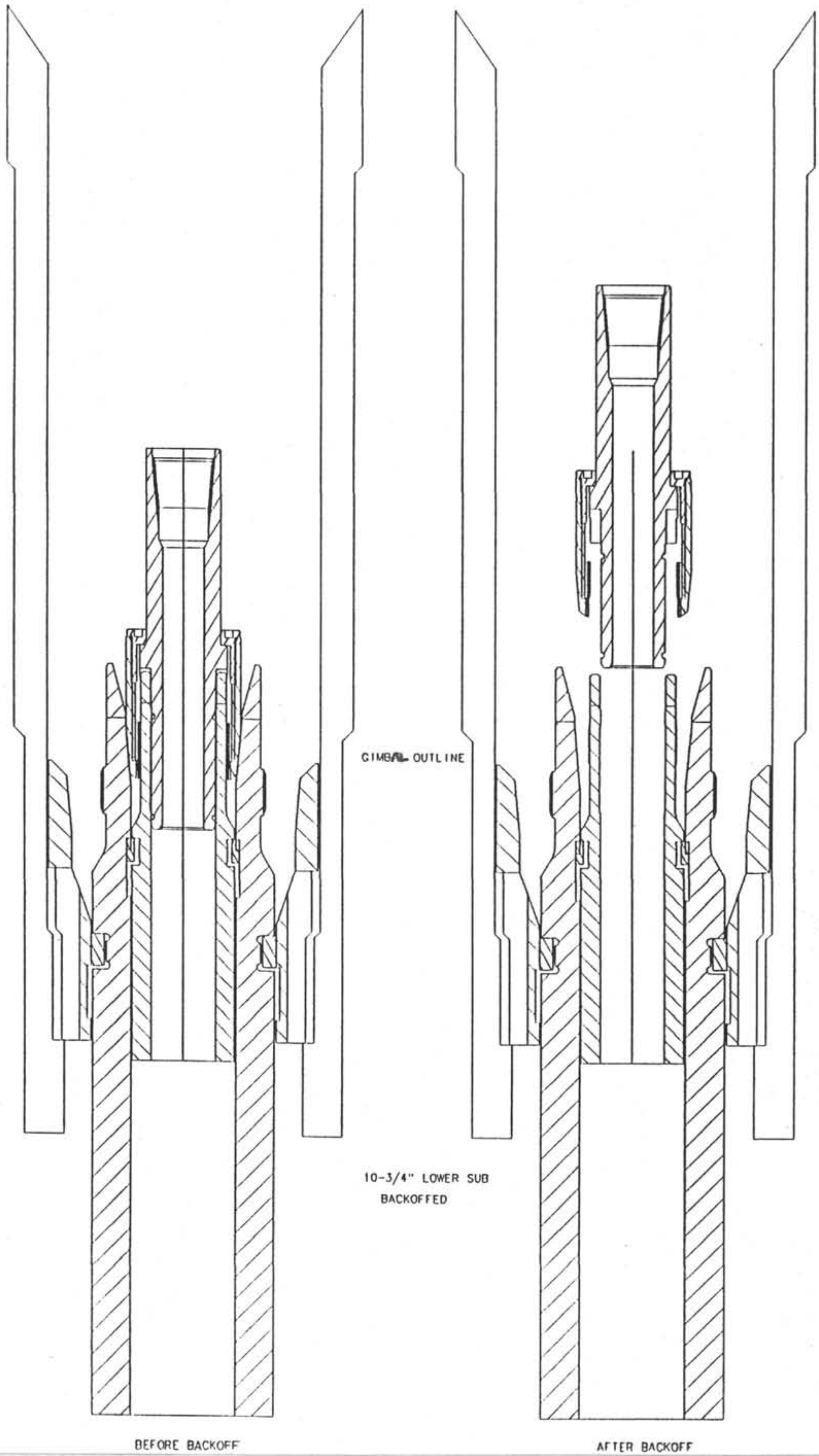


Figure D4

INTERMEDIATE BACK-OFF SUB

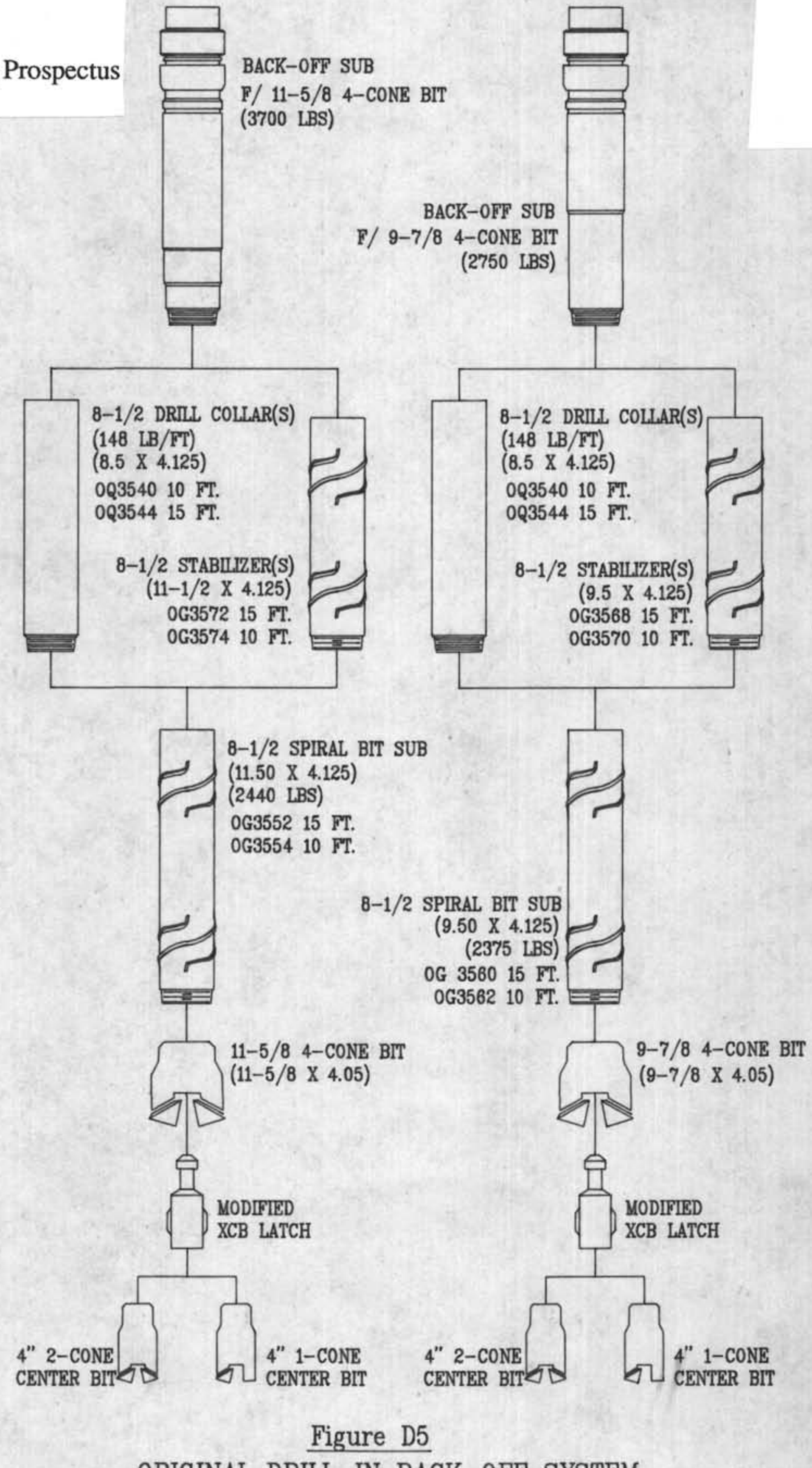


Figure D5

ORIGINAL DRILL-IN BACK-OFF SYSTEM

(LEG 132 SYSTEM)

NOTE: ALL WEIGHTS ARE REPORTED AS DRY.

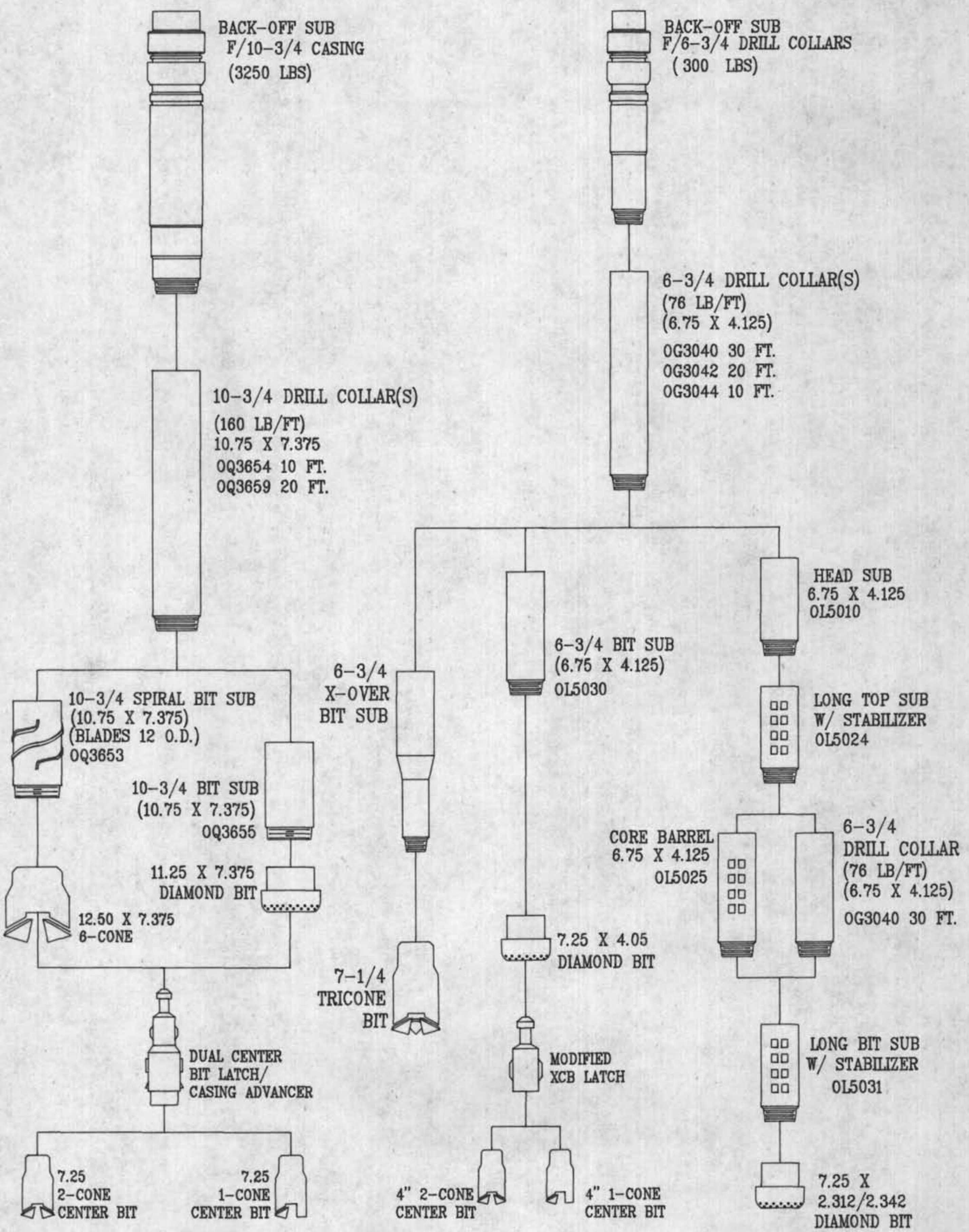


Figure D6

NESTED DRILL-IN CASING SYSTEM

APPENDIX E

ODP DIAMOND CORING SYSTEM PHASE IIB

MINI RISER COMPONENTS

Introduction

The introduction of the nested drill-in-BHA concept has increased the complexity of the hardware required for deployment prior to initiating DCS coring operations. The mini-riser hardware originally designed for Leg 132 worked quite well, with the exception of the tensioning tool (j-tool). All of the original mini-riser hardware has been retained for Leg 142, and the tensioning tool has been strengthened in the modified version.

The majority of new hardware has centered around the addition of the 6-3/4-in. intermediate string. The different options available with the nested drill-in-BHA have resulted in requirements of centralization of the DCS coring string inside 10-3/4-in. drill collars, retrieval of a large-diameter center bit (7-1/4 in.), and deployment of a bit guide for reentry with the intermediate string. These options are illustrated in Fig. E1.

Tapered Stress Joint

The tapered stress joint (Fig. E2) is designed to serve two primary functions for use with the DCS mini-riser system. First, it provides a smooth transition in bending stiffness from the bottom of the riser (5-in. drill pipe) to the seafloor template. Second, it provides a mechanical fuse to release the riser from the seafloor template in an emergency.

The stress joint is 33 ft long, with a 5-1/2 F.H. box connection on one end and a 16-bolt flanged connection on the other end. The flanged connection is grooved for an API BX-156 stainless steel gasket.

Tensioning Tool

The tensioning tool designed for Leg 132 had two mechanical release systems built into it. The first allowed the dogs to shear and ramp down to the same diameter as the body of the tool itself. The second was to shear 16 bolts, placed between the top of the tensioning tool and the flanged connection on the tapered stress joint.

The new tensioning tool has been designed with only one break-away device to allow for rapid disconnect between it and the seafloor template. This method uses the same sheer bolt concept (which connected the stress joint to the tensioning tool) employed on the earlier version. A combination of both lateral and vertical force must be applied for the connection to separate. The same basic tool shape was retained in the new design, but the body has been strengthened and the dogs permanently welded to the body. A schematic of the modified tensioning tool is shown in Fig. E2.

Bit Guide/Retrieval Tool

The introduction of the 6-3/4-in., second-stage string is the primary reason for the bit guide. With the 10-3/4-in. drill-in BHA set, there is no longer a landing seat to guide the bit into the center of the casing hanger. This is illustrated in Fig. E3. A second bit guide for the 6-3/4-in. string is needed if it is deployed after the 10-3/4-in. drill collars. Since the intermediate string uses only diamond bits, this bit guide is made of a weighted plastic material to reduce the chance of bit damage during reentry.

The bit guide is deployed in conjunction with the retrieval of the primary drill-in-BHA 7-1/4-in. center bit. The bit guide rides on four mechanical dogs, which are held out with a bit guide holder positioned inside the upper sub. Once the tensioning tool is in place, the wireline overshot is sent down the API drill string to retrieve the latch/bit guide holder. With the removal of the bit guide holder, the dogs are allowed to rotate inward, releasing the bit guide and allowing it to fall into place.

The overshot is again deployed to latch onto the large 7-1/4-in. center bit. Due to the size of the center bit, it cannot be pulled back through the API drill pipe. Therefore, it must be captured and held outside the API string while being retrieved back to the ship. This operation requires a lower sub with an internal circumferential groove matched to a smaller latch located on top of the driver latch. The first latch is used to drive the large center inside the 7-3/8 I.D., and the second latch acts as a retrieval mechanism for capturing the center bit. This small latch is pulled into the cavity where the latch dogs lock it in place. The overshot is jarred off before pulling the string back to the ship. This sequence of operations is illustrated in Figs. E4 through E6.

Centralization of DCS Tubing

Centralization and stabilization of the DCS coring string is one of the most important aspects of diamond coring. With the deployment of the large 10-3/4-in. drill-in BHA as the primary stage, the DCS string must not only be stabilized, but centralized, inside the 7-3/8-in. internal diameter of the string. This is accomplished using 6-3/4-in. drill collars deployed beneath the tensioning tool. These drill collars are used to reduce the effective diameter from 7-3/8 to 4-1/8 in. A tapered cross-over sub allows this transition to occur between the tensioning tool and drill collars.

A slip joint was added for two reasons. The first was to eliminate any unsupported length that the DCS string might see while beginning a hole. The second was to ensure complete centralization of the DCS string inside the 10-3/4-in. drill collar. The slip joint allows 48 in. of stroke. It was designed so that it will span the gap created with any length of primary drill collars which might be deployed. This minimal gap can be maintained by the addition of 6-3/4-in. drill collars one-for-one to the number of 10-3/4-in. drill collars used in the primary drill-in BHA.

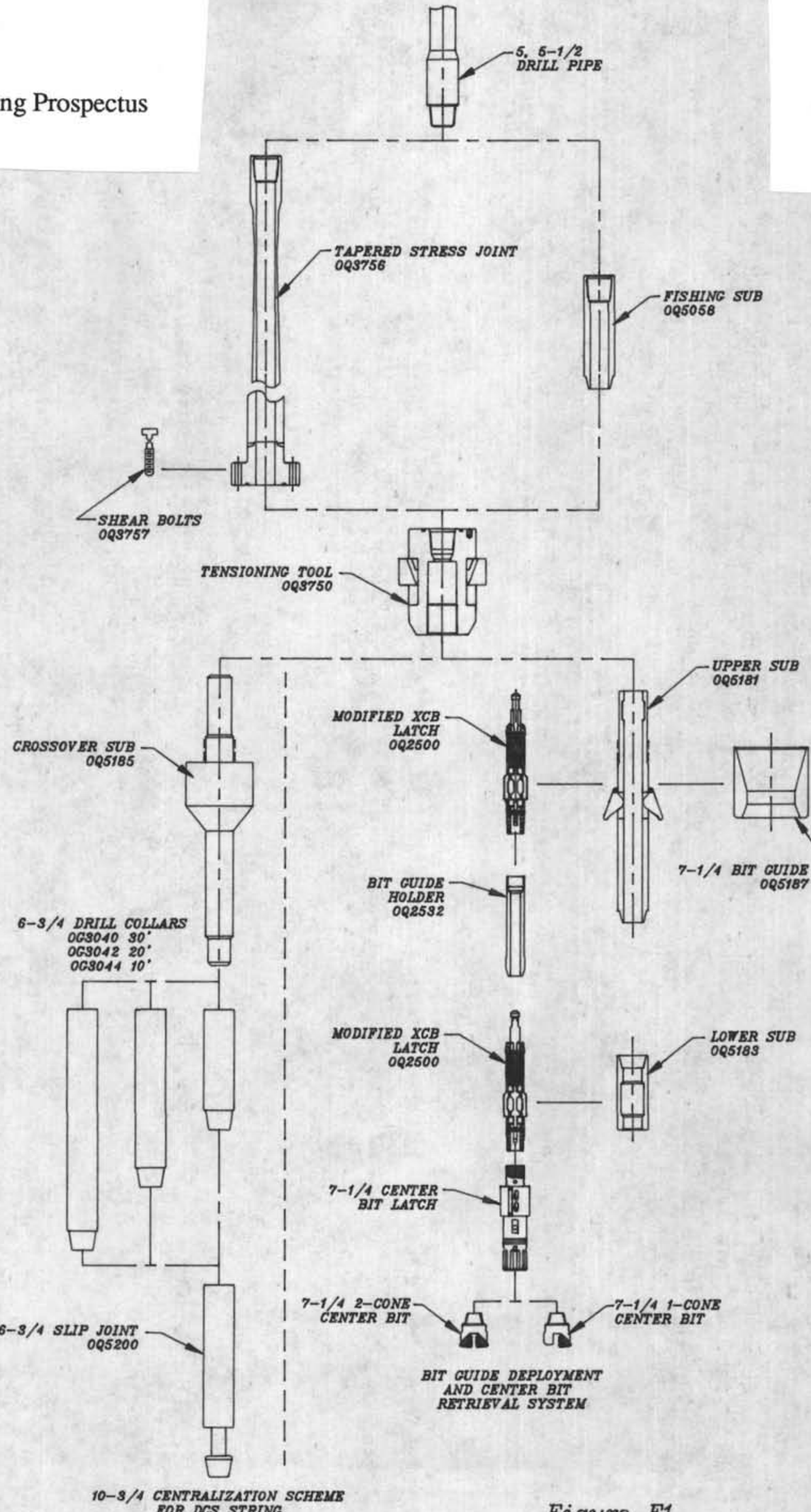
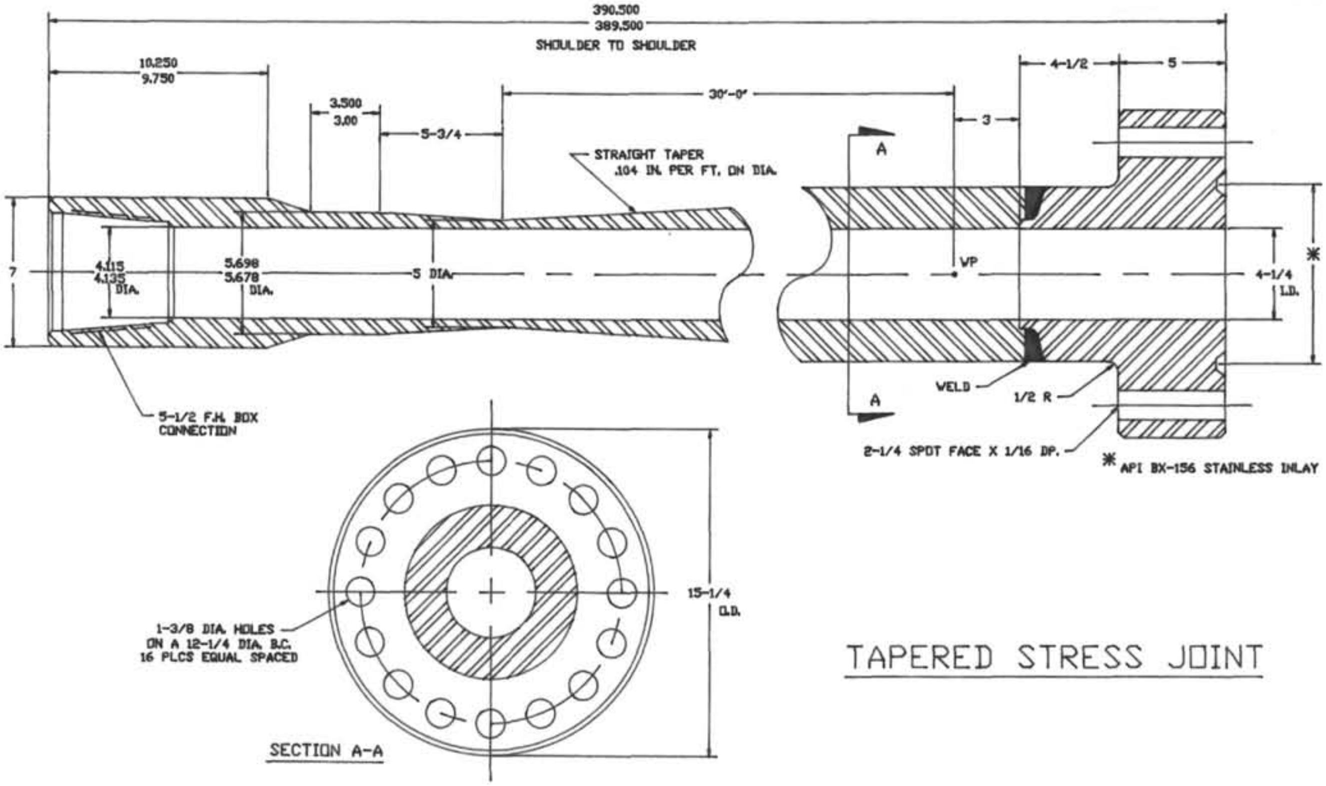
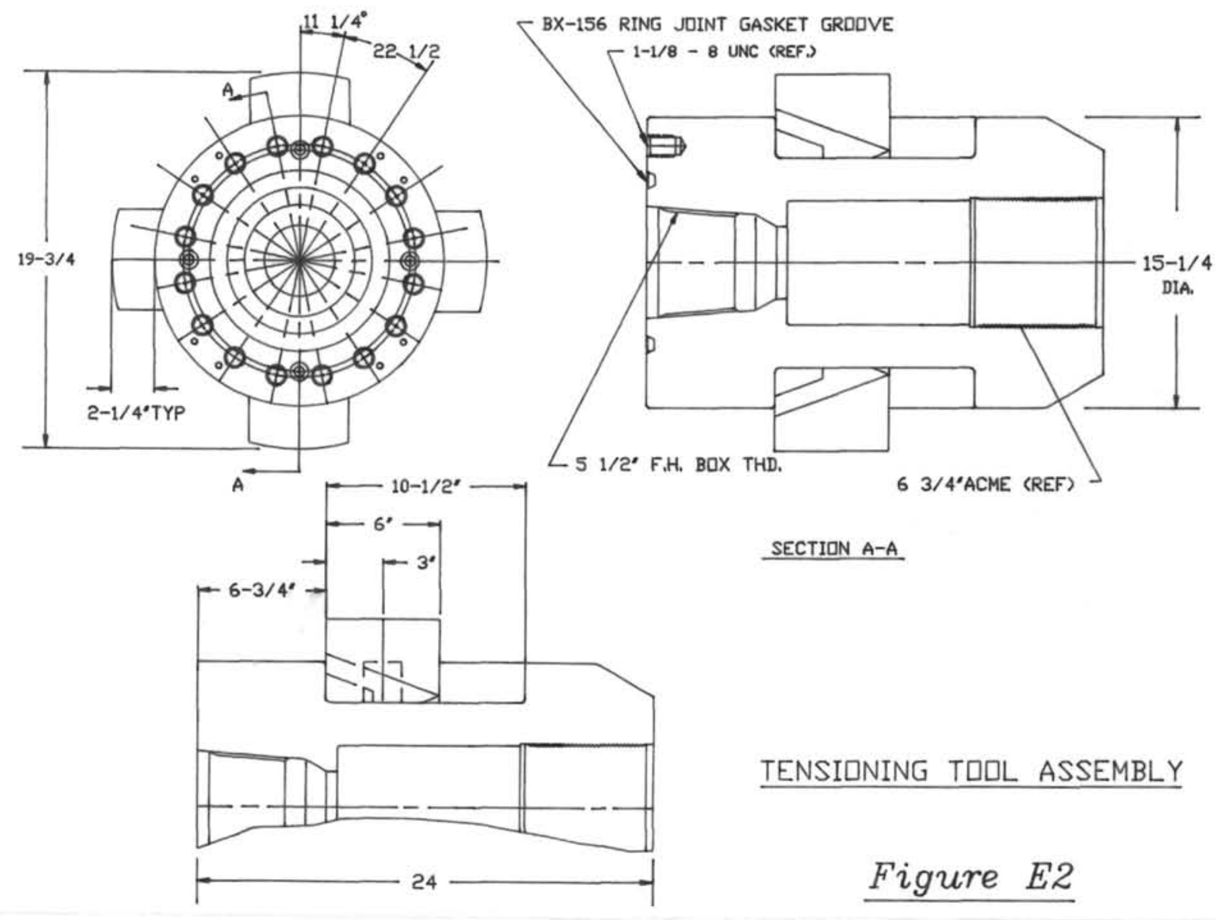


Figure E1

SEAFLOOR HARDWARE OPTIONS FOR DCS CORING SET UP

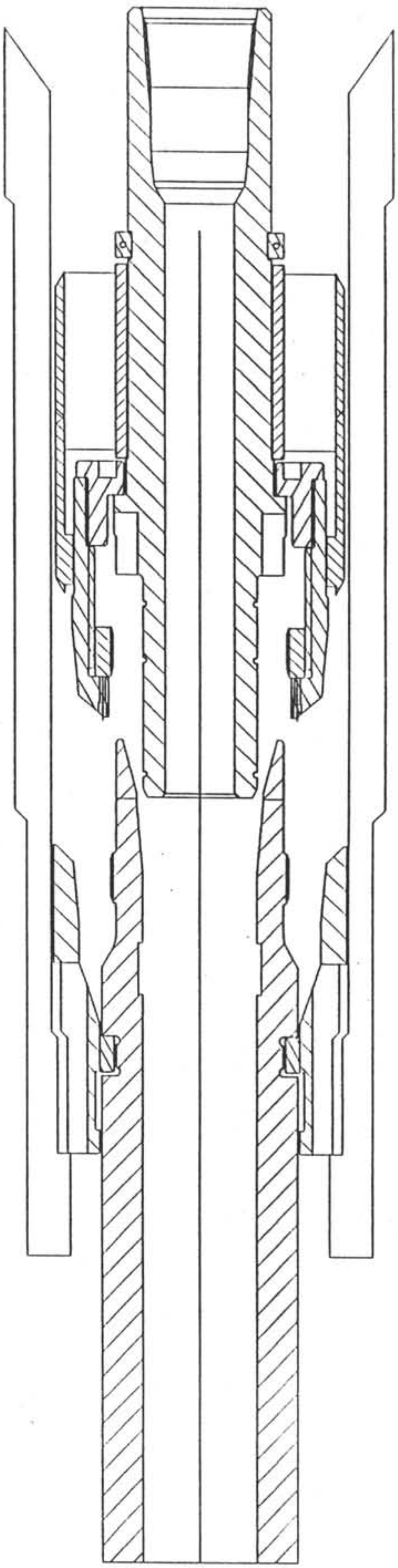


TAPERED STRESS JOINT

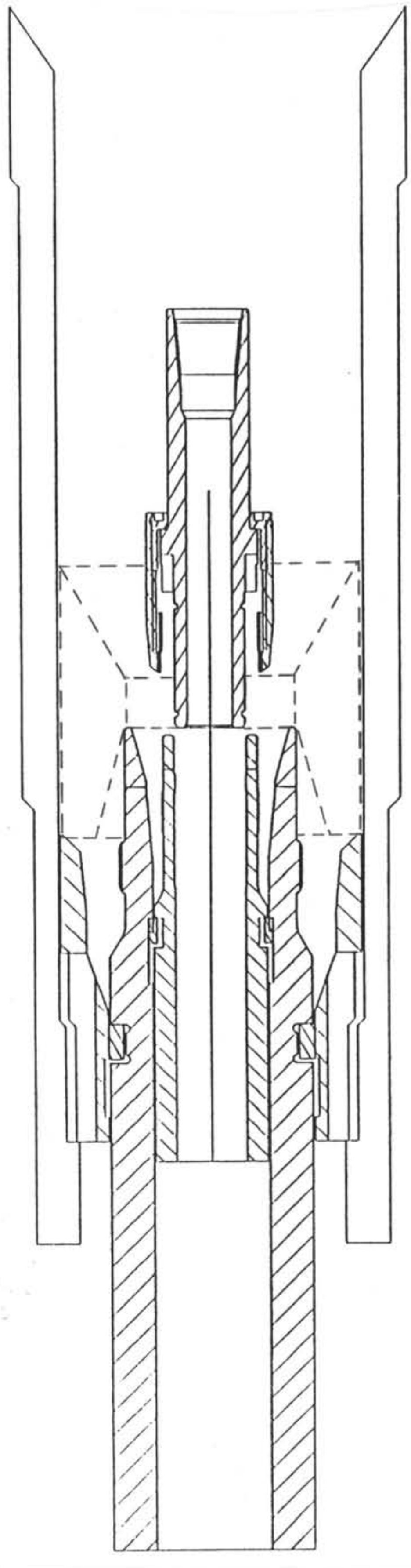


TENSIONING TOOL ASSEMBLY

Figure E2



10-3/4 STRING
DEPLOYED THROUGH
LANDING SEAT



6-3/4 STRING
DEPLOYED W/
INTERMEDIATE
BIT GUIDE

Figure E3

DEPLOYMENT
OF DRILL-IN
SYSTEMS
THROUGH
CASING HANGER

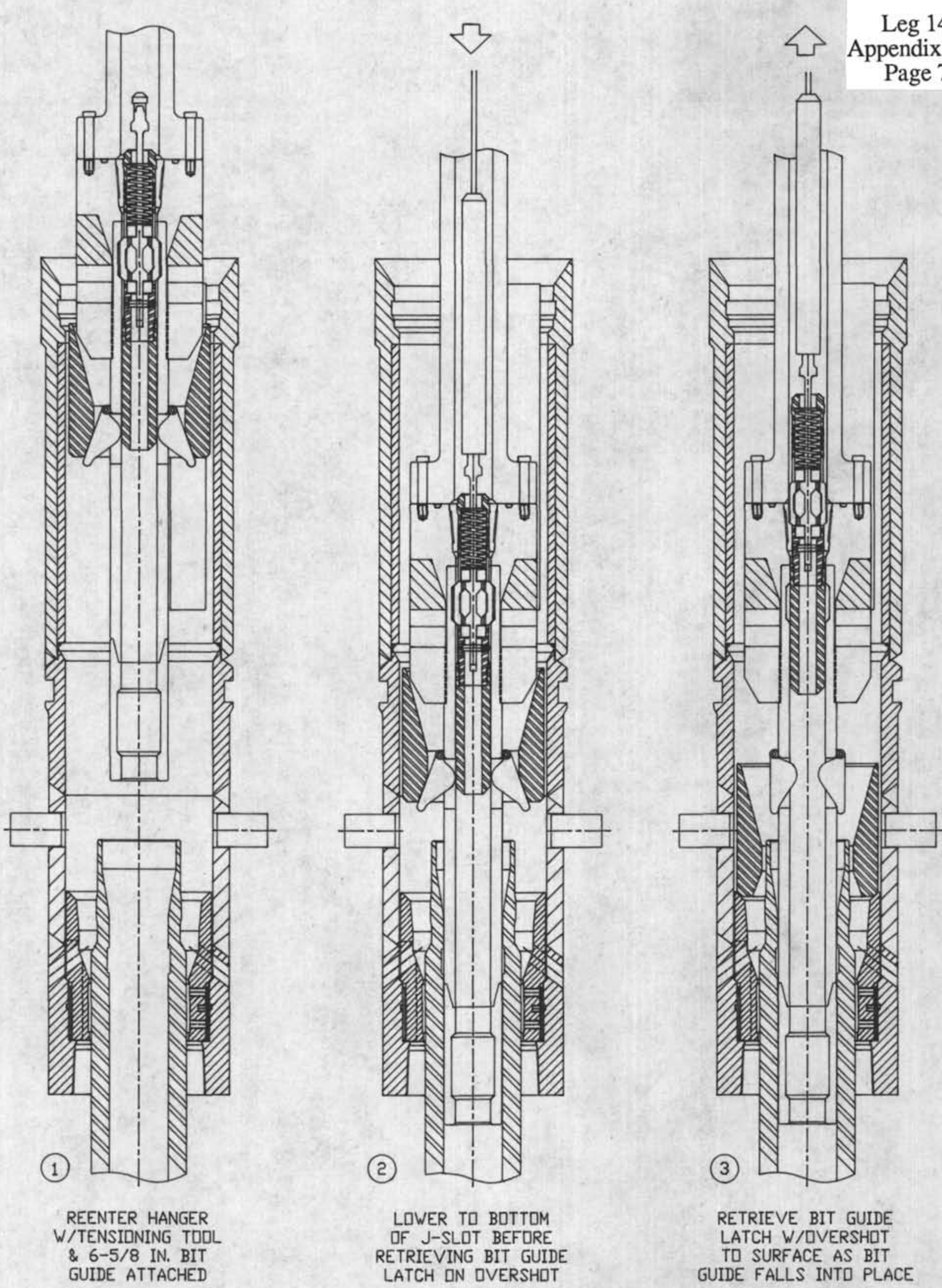


Figure E4

BIT GUIDE DEPLOYMENT/CENTER BIT RETRIEVAL

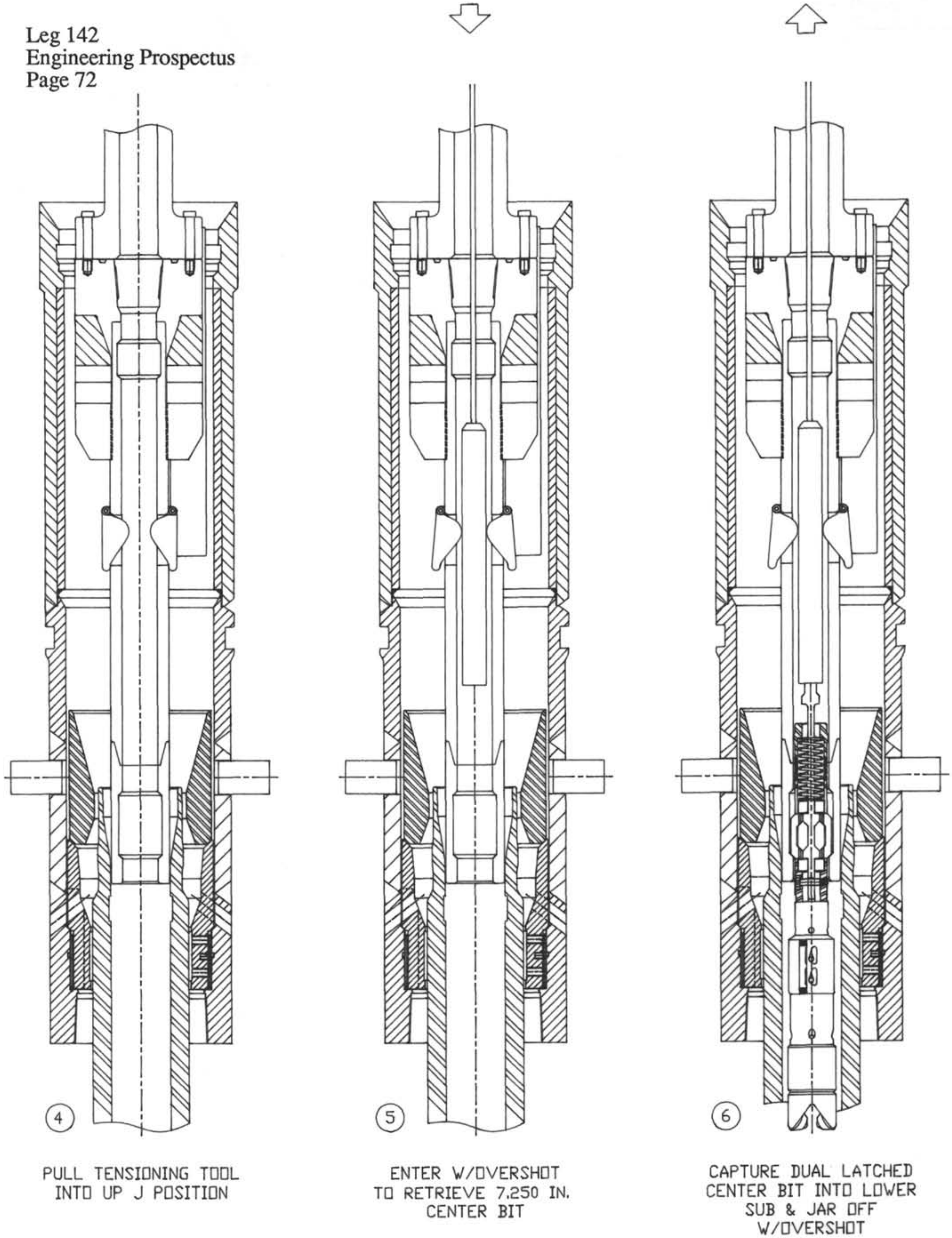
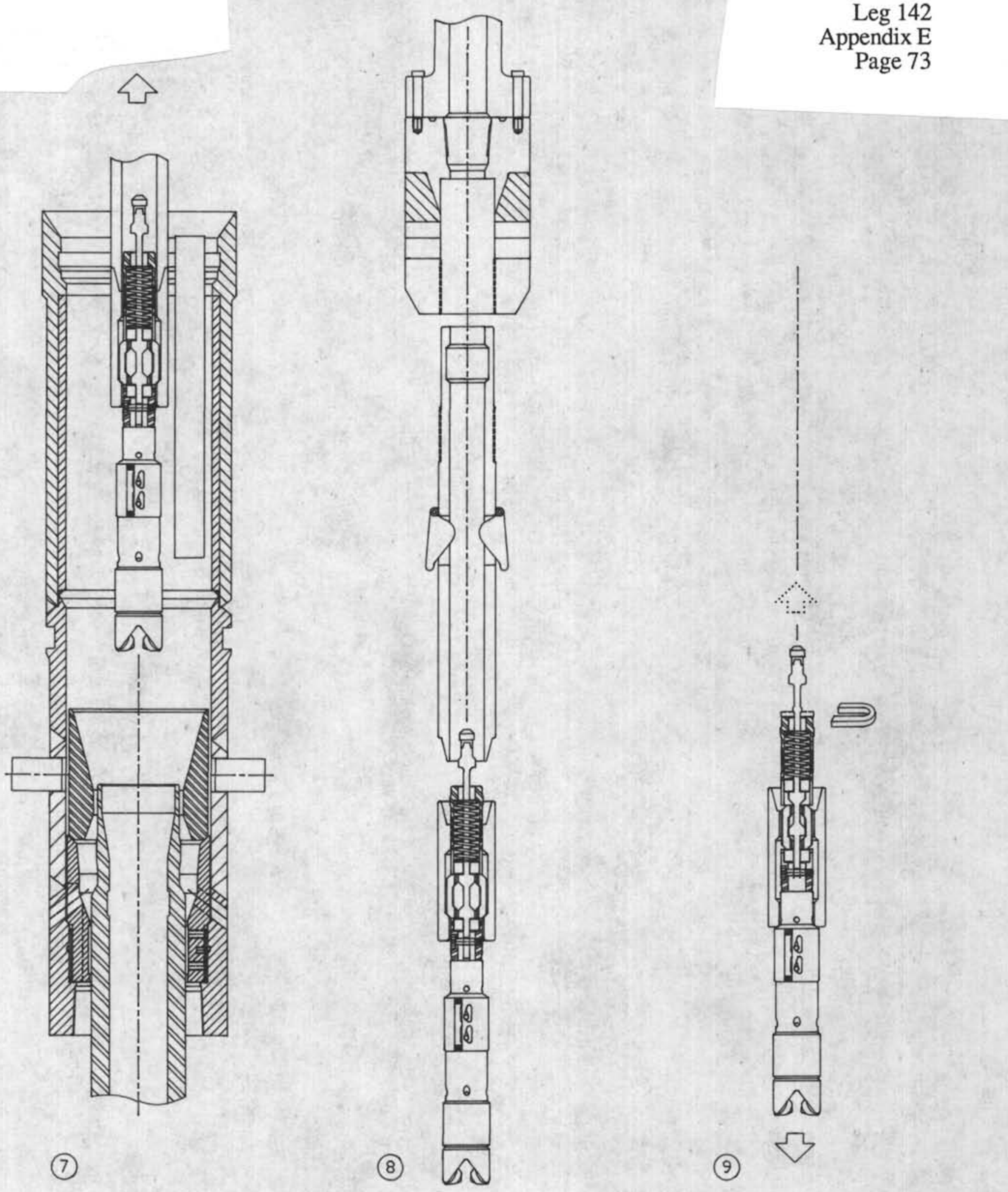

4
PULL TENSIONING TOOL INTO UP J POSITION
5
ENTER W/OVERSHOT TO RETRIEVE 7.250 IN. CENTER BIT
6
CAPTURE DUAL LATCHED CENTER BIT INTO LOWER SUB & JAR OFF W/OVERSHOT

Figure E5



UN-J AND RETRIEVE TENSIONING TOOL

REMOVE LOWER SUBS FROM TENSIONING TOOL

RETRACT XCB LATCH W/C-RING CLAMP BEFORE PUSHING CENTER BIT ASSEMBLY THROUGH LOWER SUB

Figure E6

APPENDIX F

ODP DIAMOND CORING SYSTEM PHASE IIB

DRILLING/CORING BIT OPTIONS

Introduction

One of the primary objectives of Leg 132 was to provide a cased hole to isolate unstable formations in the upper portion of the borehole so that the DCS could be deployed as soon as possible. This was accomplished by drilling-in and backing-off a bottom hole assembly (BHA). The drill bits required to perform this operation were similar to ODP's conventional roller cone coring bits, but with the throat enlarged to a diameter of 4.05 in. to allow the DCS core bit/tubing to pass. To ensure that core would not enter the bit and pass into the BHA while drilling in the assembly, the bits were modified to accept a removable center bit.

The location where these bits were to be deployed mandated that they be protected as much as possible to ensure that the highly abrasive formations would not prematurely limit the life of the bits. Short bit life has a significant impact on how the drill-in-BHA system performs. Two sizes of bits were manufactured for Leg 132. These included 11-5/8- and 9-7/8-in. 4-cone bits. Besides the two sizes of bits provided, two different types of cutting structures were used on the bits. A schematic of the original drill-in BHA hardware is presented in Fig. F1.

Upon completion of Leg 132, it was felt that a dual- or nested-casing concept should be developed to enhance the depth capabilities of the DCS when encountering unstable formations at depth. The original DI-BHA developed for Leg 132 would still be retained as a back-up system to be used if the larger hole size of the nested system proved unfeasible or too difficult to drill-in.

To develop this nested system, new drill bits also had to be designed to allow the two larger strings to be drilled-in and backed-off prior to initiating DCS coring. Two sizes of DI-BHA's were selected. They included 10-3/4 x 7-3/8 in. and 6-3/4 coring x 4-1/8 in. To prevent core from entering the BHA, the removable center bit concept was retained. Hardware developed for this nested system is illustrated in Fig. F2.

Besides developing bits for the nested DI-BHA concept, the original drill-in bits (11-5/8 and 9-7/8-in. O.D.) were enhanced with a hybrid designed body to enhance bit life. The nested system required development of a new 7-1/4-in. center bit for the 10-3/4 in. drill collars. Improvements to the 4-in. center bit used for both the original system (11-5/8 and 9-7/8 in.) and the nested 6-3/4-in. system were also made.

Primary Nested BHA Drill Bits for 10-3/4-in. Drill Collars

Two types of bits were designed for drilling in the primary 10-3/4-in. drill collars. These included a 12-1/2-in.-diameter roller cone bit and an 11-1/4-in. diamond bit. The large roller cone has six 4-3/4-in. journal bearing style cones placed in pairs between three integral pads. Three junk slots are positioned between each of the three groups of cones/pads. Due to the size of the hole required through the center of the bit (7.30 in.), the six cones are actually positioned to cut a 7.92-in. gauge. The bit is protected on the shirt tail with hard facing and tungsten carbide shirt tail compacts. In addition, compacts are placed on the hybrid pads and along the O.D. of the bit body for wear protection. The roller cone bit does not have any circulation holes, but relies on the ports in the 7-1/4-in. center bit and the 8-1/4-in. flutes milled around the O.D. of the center. Table F1 contains information pertaining to the large roller cone bits.

The large diamond bits are designed as a back-up to the roller cone bits, in case cone performance is less than desired. Two types of diamond bit (impregnated and surface set) were built. A total of five 11-1/4-in. x 7-3/10-in. diamond bits were manufactured. Two of the bits have surface-set carbonado diamonds; the remaining three are impregnated-style bits. Semi-round crown profiles were used for both. Different numbers and sizes of water ways were also used on the bits. Table F2 presents the diamond bit data. These bits use the same center bits as those designed for the roller-cone bits.

Secondary Nested BHA Drill Bits for 6-3/4-in. Drill Collars

Only diamond bits are available for the second stage of the nested drill-in-BHA system. Since rotary speeds will be less than 150 rpm, two styles of diamond bits were again designed. Both surface-set and impregnated bits were manufactured. These bits, along with appropriate design parameters, are listed in Table F3. Center bits used with these 7-1/4-in. diamond bits are the same as those used with the original back-off system.

9-7/8-in. and 11-5/8-in. Drill Bit Options

The two sizes of roller cone bits designed for the original DI-BHA were modified from the design used on Leg 132. The new design incorporates four integral hybrid pads placed between the four cones. These pads are similar to the integral pads developed for the 12-1/4-in. roller cone bits. Protection on the bit and pads uses both hard facing and short conical tungsten carbide inserts. These bits have four 7/16-in. face discharge circulation holes. Additional flow is provided through 6 fluted ports on the O.D. of the 4.00 in. center bit. In addition, two 1/2-in.-diameter ports are located on the center bits themselves. Two bits of each size were manufactured to serve as back-up in case the nested system proved unsuccessful. Six bits built for Leg 132 were not used and are still available for use on Leg 142. All of the bits available for Leg 142 are listed in Table F1.

Center Bit Options

Center bits were designed in two sizes (7-1/4 and 4 in.). Both of the center bits use roller cones as the cutting medium. Two styles of centers bits (1 cone and 2 cone) for each size have been manufactured. The center bits can be run in a variety of locations with respect to the outer bits. The positions range from 1-1/2 in. behind the cutting structure to 3 in. beyond the primary bit face. The two-cone 7-1/4-in. bits use 6-1/2-in. premium journal bearings with an M89TF cutting structure. The 7-1/4-in. one-cone bit uses 12-1/4-in. journal bearings with 411 style inserts. Both center bits use flat and domed compacts as protection for the arms and O.D. gage. The center bits may be run ahead of the primary drill-in-BHA bit for some applications and/or material types. The larger one-cone bearing bit was designed to withstand the higher bit weights it might encounter when run out in front of the main bit.

The same design philosophy was used for the smaller 4-in. center bits. The two-cone bits use a 4-in. premium journal bearing with H110F cutting structure, while the one-cone bits use 7-1/4-in. journal bearings. Both sizes of two-cone bits use a combination of two flow ports and milled flutes on the O.D. The one-cone bit provides a combination of flow ports and junk slots to expel the cuttings. Several of the original 4-in. center bits designed for Leg 132 are still available and can be used if required. Table F4 provides a description of the center bit options for Leg 142.

DCB Coring Bit Options

One option which became apparent when designing the nested drill-in BHA was that the intermediate string (6-3/4 in.) could be used as a core barrel. Since the 6-3/4-in. drill collars would have the same bore as conventional hardware, the standard Rotary Core Barrel (RCB) wireline tools could be used to retrieve core. Thus the diamond core barrel (DCB) was developed as a smaller, diamond version of the standard RCB system. Diamond bits were manufactured for this core barrel in two styles. These include both surface-set and impregnated type bits. Matrix hardness, profile, stones per carat, set weight, and other information are presented in Table F3.

Special Bits

Two special-application bits were developed for use with the secondary string (6-3/4 in.) of the nested drill-in-BHA system. These bits include a 7-1/4-in. reaming bit with 3.93-in. stringer bit assembly and a conventional tri-cone designed for a 7-1/4-in. drill-ahead application. The reaming bit is an impregnated v-ring style bit with 6 face discharge ports in addition to 6 flow ports. The face discharge ports are funneled through an internal manifold set up through the introduction of a fluted stinger. The reaming bit was designed as a hole opener for the DCS hole so that a more conventional suite of logging tools could be run. The stinger bit is set ahead of the reaming bit by 18 in. so that it will stay as concentric to the DCS hole as possible. A schematic of this bit arrangement is presented in Fig. F3.

The 7-1/4-in. tri-cone bit was manufactured as a rugged, full face, drill-ahead bit for the secondary stage BHA. This would be used if the diamond bits wear excessively. This bit can operate only in formations where conditions allow the string to be removed and a throated bit drilled-in and backed-off. This 7-1/4-in. tri-cone bit is a non-standard size for the oil industry. Extra gauge protection, hard facing, and wear pads, placed over the grease reservoirs, are all included on this bit.

DCS Coring Bit Options

Diamond bits for the DCS core barrel have a special hard matrix with both I.D. and O.D. gage protection using geosets. The face profiles of the different bits are relatively the same, with different sizes, numbers, and configurations of water way paths. All of the bits use a v-ringed flat face profile with 100A grade of stones. Set weight varies with matrix hardness from 121 to 191 carats. All of these bits were built with a taller-than-normal matrix in order to enhance bit life.

Only six new bits were designed for Leg 142. The remainder of the bits presented in Table F2 were purchased as part of the original DCS coring hardware developed for Leg 132. All of these bits will be available should the new design prove inefficient or the new bits be consumed at a faster rate than expected.

TABLE F1 - ROLLER CONE BITS FOR DRILL-IN BHA HARDWARE

ITEM	SIZE	I.D.	LENGTH	MFR	DECSRIPTION	# CONES	COMPACT	IADC	FLOW PORTS	SIZE	BEARING SIZE
1	12.5	7.92	15.82	SECURITY	HYBRID DI-BHA	6	M89TF	627X	NONE	N/A	4 3/4
2	12.5	7.92	15.82	SECURITY	HYBRID DI-BHA	6	M89TF	627X	NONE	N/A	4 3/4
3	12.5	7.92	15.82	SECURITY	HYBRID DI-BHA	6	M89TF	627X	NONE	N/A	4 3/4
4	11.625	4.05	13.5	SECURITY	DI-BHA	4	H87F	737X	4 STD NB	N/A	7 7/8
5	11.625	4.05	13.5	SECURITY	DI-BHA	4	H87F	737X	4 STD NB	N/A	7 7/8
6	11.625	4.05	13.5	SECURITY	DI-BHA	4	H87F	737X	4 STD NB	N/A	7 7/8
7	11.625	4.05	13.5	SECURITY	DI-BHA	4	M84F	617X	4 STD NB	N/A	7 7/8
8	11.625	4.05	14.25	SECURITY	HYBRID DI-BHA	4	M84F	617X	4	7/16	7 7/8
9	11.625	4.05	14.25	SECURITY	HYBRID DI-BHA	4	M84F	617X	4	7/16	7 7/8
10	9.875	4.05	12.63	SECURITY	DI-BHA	4	M84F	617X	4 STD NB	N/A	6 1/2
11	9.875	4.05	12.63	SECURITY	DI-BHA	4	H87F	737X	4 STD NB	N/A	6 1/2
12	9.875	4.05	14.25	SECURITY	HYBRID DI-BHA	4	M84F	617X	4	7/16	6 1/2
13	9.875	4.05	14.25	SECURITY	HYBRID DI-BHA	4	M84F	617X	4	7/16	6 1/2

NOTES:
1.0 STD NB REFERS TO STANDARD NOZZLE BORE

TABLE F2 - DCS CORING BITS FOR LONGYEAR CORE BARREL

ITEM	SIZE	I.D.	LENGTH	MFR	MATRIX TYPE	GRADE	SPC/SET WT	PROFILE	WATER WAYS	SIZE
1	3.96	2.20		LONGYEAR	SERIES 2	100A	25/35 - 145	FLAT	10	1/8 X .438
2	3.96	2.20		LONGYEAR	SERIES ID	100A	25/35 -191.25	FLAT	10	1/8 X .438
3	3.96	2.20	6.94	DIMATEC	VIX6(MED/HARD	100A	30/50 - 121	FLAT	8	.31 X .65
4	3.96	2.20	6.94	DIMATEC	VIX6(MED/HARD	100A	30/50 - 121	FLAT	8	.31 X .65
5	3.96	2.20		HOBIC	SERIES 1	100S	20/25 - 100	FLAT	8	.125 X .46
6	3.96	2.20		HOBIC	SERIES 2	100S	20/25 - 100	FLAT	8	.125 X .46
7	3.96	2.20		HUDDY	SILVER/BLUE			FLAT	5	.197 X .29
8	3.96	2.20		HUDDY	YELLOW			FLAT	5	.197 X .29
9	3.96	2.20		HUDDY	YELLOW			FLAT	5	.197 X .29
10	3.96	2.20		HUDDY	GOLD			FLAT	5	.197 X .29
11	3.96	2.20		HUDDY	SURFACE SET	AA	18-20/43	MODX		
12	3.96	2.20		HUDDY	SURFACE SET	AA	25-40/37	MODX		
13	3.96	2.20		HUDDY	SURFACE SET	AA	25-40/37	MODX		
14	3.96	2.20	6.31	LONGYEAR	SERIES 2	100A	25/35 - 80.75	FLAT	10	1/8 X 1/4
15	3.96	2.20	6.31	LONGYEAR	SERIES 2	100A	25/35 - 80.75	FLAT	10	1/8 X 1/4
16	3.96	2.20	6.31	LONGYEAR	SERIES 2	100A	25/35 - 80.75	FLAT	10	1/8 X 1/4
17	3.96	2.20	6.31	LONGYEAR	SERIES 6	100A	30/40 - 72	FLAT	12	1/8 X .313
18	3.96	2.20	6.31	LONGYEAR	SERIES 6	100A	30/40 - 72	FLAT	12	1/8 X .313
19	3.96	2.20	6.31	LONGYEAR	SERIES 6	100A	30/40 - 72	FLAT	12	1/8 X .313
20	3.96	2.20	6.31	LONGYEAR	SERIES 6	100A	30/40 - 72	FLAT	12	1/8 X .313
21	3.96	2.20	6.31	DIAMETIC	M7HP	100A	30/50 -79.8	V-RING	10/10	3/16 X .44
22	3.96	2.20	6.31	DIAMETIC	M6HP	100A	30/50 -79.8	V-RING	10/10	3/16 X .44
23	3.96	2.20	6.31	HOBLE	GEOSET	GEOSET	130 GEOSETS	W		
24	3.96	2.20	6.31	HUDDY	SURFACE SET	AA	18/20 - 43	MODX		
25	3.96	2.20	6.43	LONGYEAR	SURFACE SET	PREM.	35/45 -37.25	X	8	3/16 X 3/32
26	3.96	2.20	6.43	LONGYEAR	SURFACE SET	PREM.	35/45 -37.25	X	8	3/16 X 3/32
26	3.96	2.20	6.43	LONGYEAR	SURFACE SET	PREM.	15/25 - 38.25	X	8	3/16 X 3/32
28	3.96	2.20	6.31	LONGYEAR	SERIES 6	100A	30/40 - 72	FLAT	12	1/8 X .313
29	3.96	2.20	6.31	LONGYEAR	SERIES 6	100A	30/40 - 72	FLAT	12	1/8 X .313
30	3.96	2.20	6.31	LONGYEAR	SERIES 6	100A	30/40 - 72	FLAT	12	1/8 X .313

NOTES:
HUDDY BITS HAVE 5 FACE DISCHARGE PORTS OF 5MM

TABLE F3 - DIAMOND BITS (IMPREGNATED/SURFACE SET)

ITEM	SIZE	I.D.	LENGTH	MFR	DESCRIPTION	GRADE	SPC/SET WT	PROFILE	WATER WAYS	SIZE
1	11.25	7.30	15.813	HOBIC	DI-BHA	100S	20-25/1300	H403	18	0.2x0.35
2	11.25	7.30	15.813	HOBIC	DI-BHA	100S	20-25/1300	H403	18	0.2x0.35
3	11.25	7.30	15.813	HOBIC	DI-BHA	100S	20-25/1300	H403	18	0.2x0.35
4	11.25	7.30	15.813	LONGYEAR	DI-BHA	CARB	4-6/490	SEMI-ROUND	30	1/8x3/16
5	11.25	7.30	15.813	LONGYEAR	DI-BHA	CARB	4-6/490	SEMI-ROUND	30	1/8x3/16
6	7.25	4.05	14.50	CHRISTENSEN	REAMING	SYNTHETIC	25/35 - 692	7C	6/6	1/4 X .625
7	7.25	4.05	14.50	CHRISTENSEN	REAMING	SYNTHETIC	25/35 - 692	7C	6/6	1/4 X .625
8	7.25	4.05	14.25	HOBIC	DI-BHA	100S	20-25/575	H403	15	0.2x0.35
9	7.25	4.05	14.25	HOBIC	DI-BHA	100S	20-25/575	H403	15	0.2x0.35
10	7.25	4.05	14.25	HOBIC	DI-BHA(HARD)	100S	20-25/600	H403	15	0.2x0.35
11	7.25	4.05	14.25	HOBIC	DI-BHA(EXTRA HARD)	100S	20-25/650	H403	15	0.2x0.35
12	7.25	4.05	14.25	LONGYEAR	DI-BHA	CARB	4-6/230.4	SEMI-ROUND	18	1/8x3/16
13	7.25	4.05	14.25	LONGYEAR	DI-BHA	CARB	4-6/230.4	SEMI-ROUND	18	1/8x3/16
14	7.25	2.33	12.123	LONGYEAR	DCB	CARB	4-6/245	SEMI-ROUND	10	1/8x3/16
15	7.25	2.33	12.123	LONGYEAR	DCB	CARB	4-6/245	SEMI-ROUND	10	1/8x3/16
16	7.25	2.33	12.123	LONGYEAR	DCB	CARB	4-6/245	SEMI-ROUND	10	1/8x3/16
17	7.25	2.33	12.11	HOBIC	DCB	100S	20-25/700	H403	15	0.2x0.35
18	7.25	2.33	12.11	HOBIC	DCB	100S	20-25/700	H403	15	0.2x0.35
19	7.25	2.33	12.11	HOBIC	DCB(EXTRA HARD)	100S	20-25/800	H403	15	0.2x0.35
20	3.94	N/A	3.74*	CHRISTENSEN	STINGER BIT	PREMIUM	15 - 73.58	CONCAVE	12	3/16 X 3/16
21	3.94	N/A	3.74*	CHRISTENSEN	STINGER BIT	PREMIUM	15 - 73.58	CONCAVE	12	3/16 X 3/16

NOTE:
1.0 REAMING BIT HAS 6 X 3/8 FACE DISCHARGE PORTS IN ADDITION TO 6 WATER WAYS

TABLE F4 - ROLLER CONE CENTER BITS FOR DRILL-IN BHA HARDWARE

ITEM	SIZE	I.D.	LENGTH	MFR	DECSRIPTION	# CONES	COMPACT	IADC	FLOW PORTS	SIZE
1	7.25	N/A	15.1	SECURITY	MOD. CB	2	M89TF	627X	2	5/8
2	7.25	N/A	15.1	SECURITY	MOD. CB	2	M89TF	627X	2	5/8
3	7.25	N/A	15.1	SECURITY	MOD. CB	2	M89TF	627X	2	5/8
4	7.25	N/A	15.1	SECURITY	MOD. CB	2	M89TF	627X	2	5/8
5	7.25	N/A	15.1	ROCK BIT	MOD. CB	1	411	637	2	1/2
6	7.25	N/A	15.1	ROCK BIT	MOD. CB	1	411	637	2	1/2
7	7.25	N/A	7.5	ROCK BIT	TRICONE	3	231	637	3	8-18 JETS
8	7.25	N/A	7.5	ROCK BIT	TRICONE	3	231	637	3	8-18 JETS
9	4.00	N/A	19-3/32	SECURITY	CENTERBIT	2	M100F	837Y	2	7/16
10	4.00	N/A	19-3/32	SECURITY	CENTERBIT	2	M100F	837Y	2	7/16
11	4.00	N/A	19-3/32	SECURITY	CENTERBIT	2	M100F	837Y	2	7/16
12	4.00	N/A	19-3/32	SECURITY	CENTERBIT	2	M100F	837Y	2	7/16
13	4.00	N/A	19-3/32	SECURITY	CENTERBIT	2	M100F	837Y	2	7/16
14	4.00	N/A	16.089	SECURITY	MOD. CB	2	H100F	837Y	2	1/2
15	4.00	N/A	16.089	SECURITY	MOD. CB	2	H100F	837Y	2	1/2
16	4.00	N/A	16.089	SECURITY	MOD. CB	2	H100F	837Y	2	1/2
17	4.00	N/A	16.24	ROCK BIT	MOD. CB	1	231	637	1	1/2
18	4.00	N/A	16.24	ROCK BIT	MOD. CB	1	231	637	1	1/2

NOTE:

1.0 SECURITY MOD. CB HAS 8 1/4 FLUTES MILLED ON O.D.
2.0 TRICONE BIT IS MEASURED SHOULDER TO TIP OF CONES

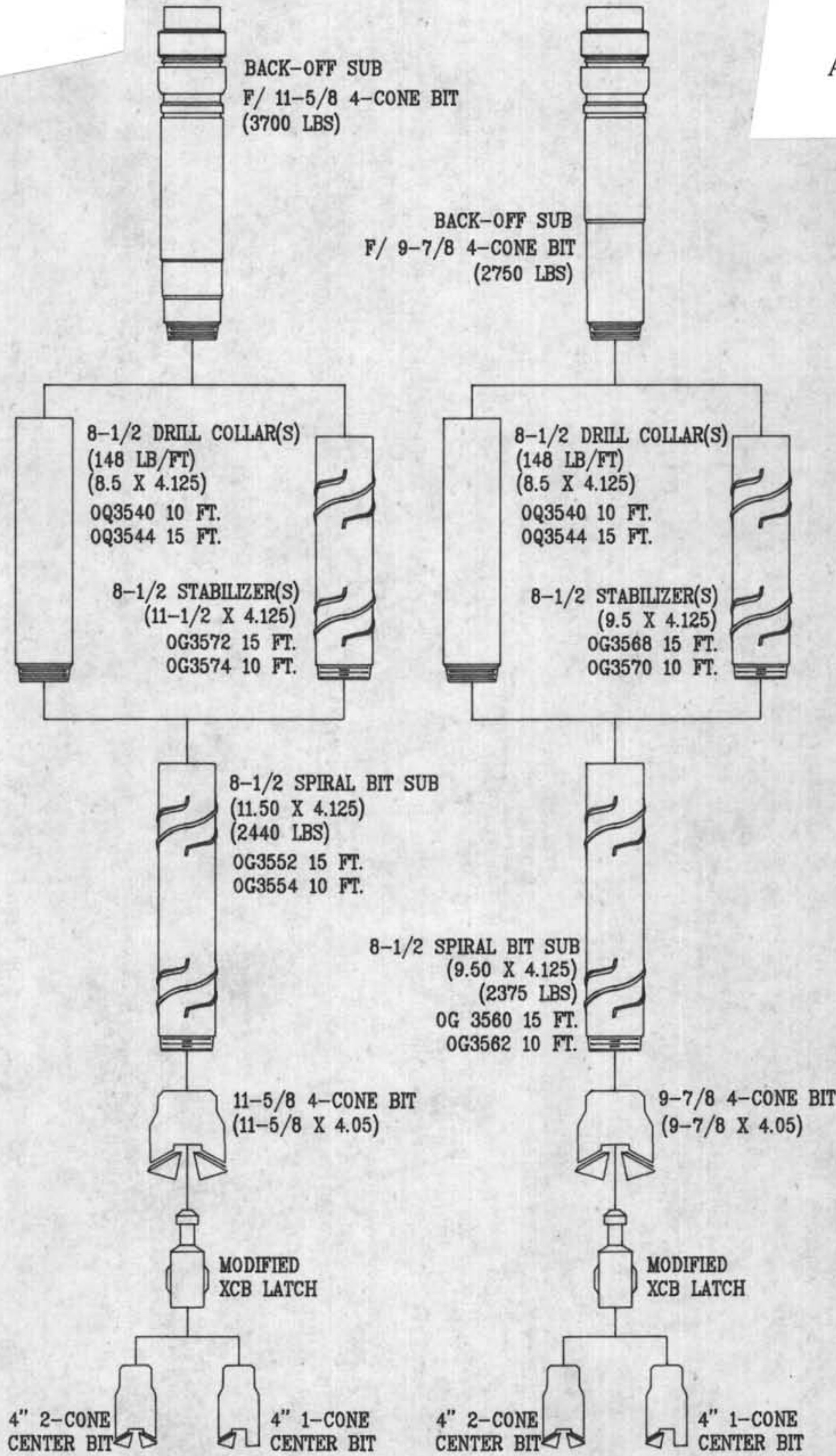


Figure F1

ORIGINAL DRILL-IN BACK-OFF SYSTEM

(LEG 132 SYSTEM)

NOTE: ALL WEIGHTS ARE REPORTED AS DRY.

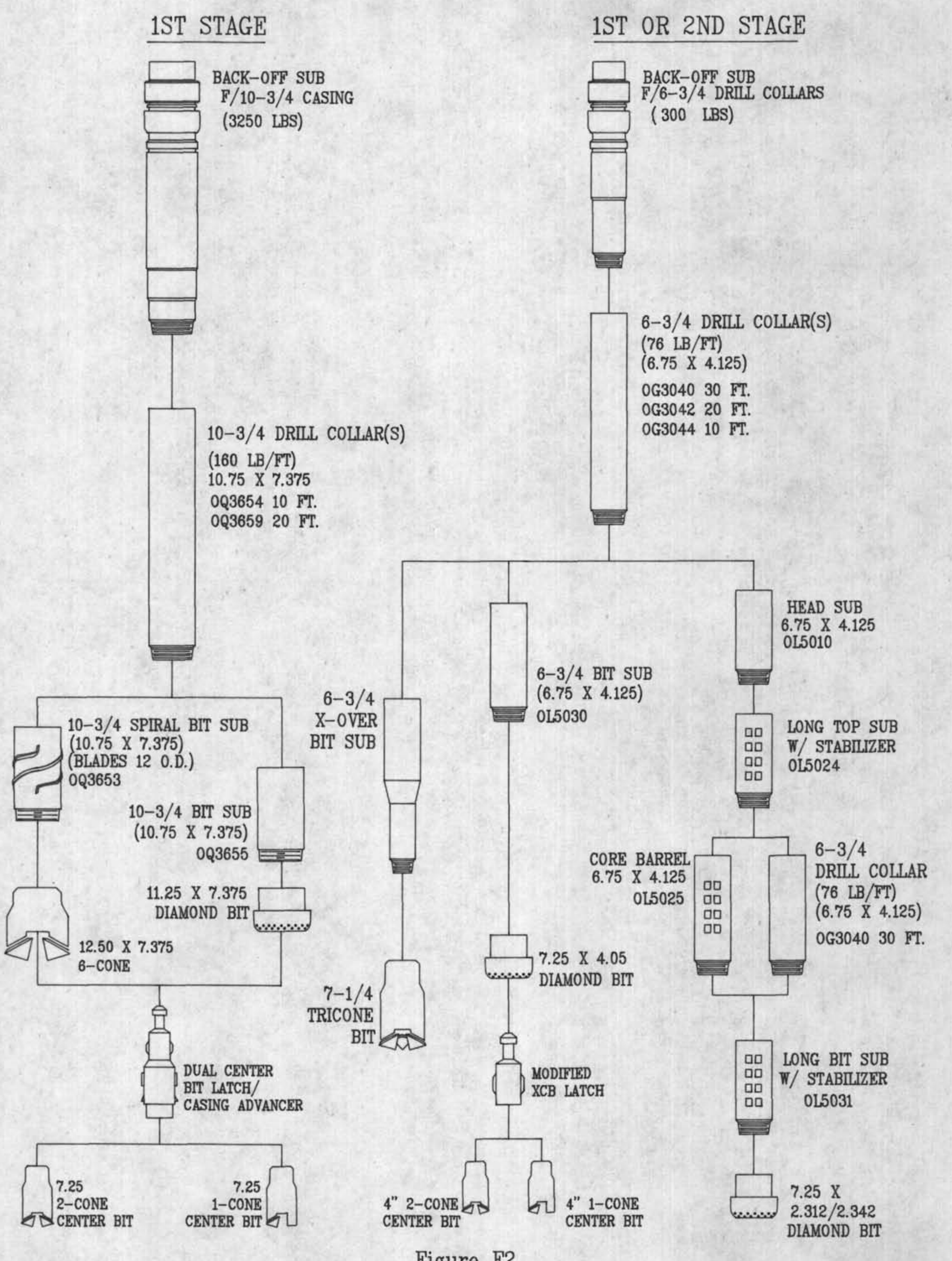


Figure F2

NESTED DRILL-IN CASING SYSTEM

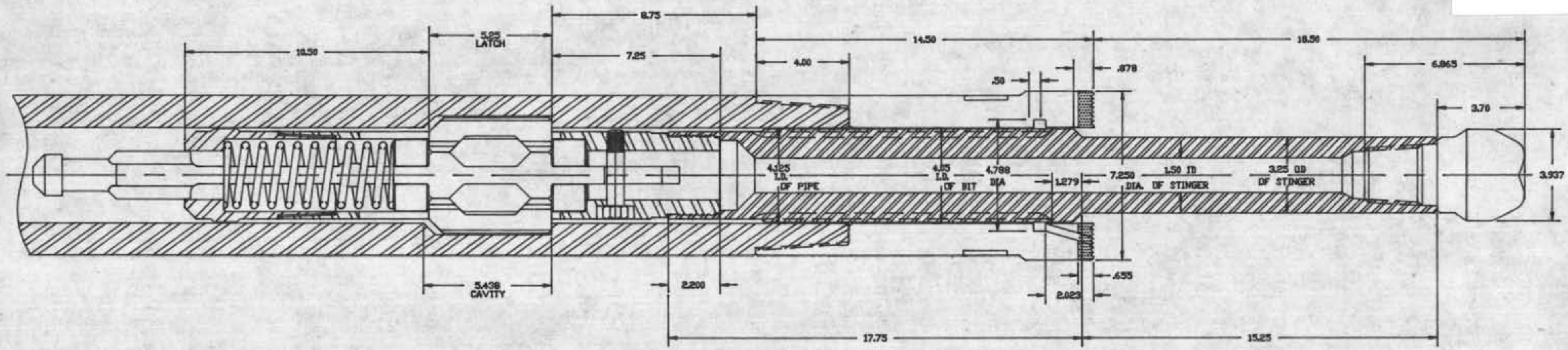


Figure F3

REAMING BIT SPACE OUT
W/ STINGER & LATCH ATTACHMENTS