DISCLAIMER

This report was prepared by the Deep Sea Drilling Project, University of California, San Diego as an account of work sponsored by the United States Government's National Science Foundation. Neither the University nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.
New style "Dual Casing Hanger" Re-entry Cone is being deployed from the GLOMAR CHALLENGER in preparation for the keelhauling operation. The cone is designed to accept both 16" and 11-3/4" casing strings. Note the advanced design has a steel "mudskirt" for increased bearing resistance and diverter pipes for enhanced cuttings removal. The cones are routinely deployed in the sideways configuration to prevent rapid filling with seawater followed by ship's heave snapping the lifting slings. Photo taken on Leg 45 (December 1975)
Please note the following changes to

Table I - Re-entry Cone Deployment History

Technical Report No. 13, Page 28

(1) Map No. 1, Leg 15, Site 146. -
Water depth should be 3957 meters.

(2) Map No. 14, Leg 53, Site 418A -
Sonic/Caliper/Gamma Ray Logging tool with 300 m of cable
may be left in hole. Cable parted during drill string
trip. Tool may or may not be in hole. Caution should
be encouraged in future operations.

Revised: January 1984

M. A. Storms
<table>
<thead>
<tr>
<th>LEG NO.</th>
<th>SITE NO.</th>
<th>CONE LOCATION</th>
<th>WATER PENET.</th>
<th>CASING LENGTH (m)</th>
<th>NO. OF RE.</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LATITUDE</td>
<td>DEPTH (m)</td>
<td>16&quot;          11 3/4&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>146</td>
<td>15° 06.99'N</td>
<td>3957*</td>
<td>762</td>
<td>2</td>
<td>Hole open</td>
</tr>
<tr>
<td>30</td>
<td>288A</td>
<td>5° 58.35'S</td>
<td>3030</td>
<td>999</td>
<td>2</td>
<td>Hole bridged</td>
</tr>
<tr>
<td>34</td>
<td>319A</td>
<td>13° 01.04'S</td>
<td>4296</td>
<td>157</td>
<td>1</td>
<td>Hole open</td>
</tr>
<tr>
<td>34</td>
<td>320B</td>
<td>9° 00.40'S</td>
<td>4487</td>
<td>183</td>
<td>1</td>
<td>Hole open</td>
</tr>
<tr>
<td>37</td>
<td>332B</td>
<td>36° 52.76'N</td>
<td>1841</td>
<td>721</td>
<td>9</td>
<td>Sidetracked hole</td>
</tr>
<tr>
<td>37</td>
<td>333A</td>
<td>36° 50.45'N</td>
<td>1682</td>
<td>529</td>
<td>1</td>
<td>D.P. left in hole</td>
</tr>
<tr>
<td>45</td>
<td>395A</td>
<td>22° 45.35'E</td>
<td>4485</td>
<td>664</td>
<td>13</td>
<td>Sinker bar in hole</td>
</tr>
<tr>
<td>46</td>
<td>396B</td>
<td>22° 59.14'E</td>
<td>4465</td>
<td>406</td>
<td>7</td>
<td>Hole open</td>
</tr>
<tr>
<td>47</td>
<td>398D</td>
<td>40° 57.60'E</td>
<td>3900</td>
<td>1740</td>
<td>2</td>
<td>Hole open</td>
</tr>
<tr>
<td>48</td>
<td>400A</td>
<td>47° 22.90'E</td>
<td>4399</td>
<td>778</td>
<td>1</td>
<td>D.P. left in hole</td>
</tr>
<tr>
<td>50</td>
<td>415A</td>
<td>31° 01.65'E</td>
<td>2817</td>
<td>1080</td>
<td>3</td>
<td>Reflector obscured</td>
</tr>
<tr>
<td>50</td>
<td>416A</td>
<td>32° 50.18'E</td>
<td>4203</td>
<td>1605</td>
<td>9</td>
<td>Hole open</td>
</tr>
<tr>
<td>51B</td>
<td>417D</td>
<td>25° 06.69'E</td>
<td>5489</td>
<td>709</td>
<td>3</td>
<td>BHA left in hole</td>
</tr>
<tr>
<td>52</td>
<td>418A</td>
<td>25° 02.08'E</td>
<td>5519</td>
<td>868</td>
<td>4</td>
<td>Hole open</td>
</tr>
<tr>
<td>53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>433C</td>
<td>44° 46.63'E</td>
<td>1874</td>
<td>551</td>
<td>9</td>
<td>Sonic/CAL/GR Tool in hole?*</td>
</tr>
<tr>
<td>57</td>
<td>438B</td>
<td>40° 37.80'E</td>
<td>1575</td>
<td>1039</td>
<td>3</td>
<td>Hole open</td>
</tr>
<tr>
<td>58</td>
<td>442B</td>
<td>28° 59.04'E</td>
<td>4645</td>
<td>455</td>
<td>2</td>
<td>Hole open</td>
</tr>
<tr>
<td>61</td>
<td>462A</td>
<td>7° 14.50'E</td>
<td>5186</td>
<td>1206</td>
<td>15</td>
<td>Hole open</td>
</tr>
<tr>
<td>89</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>482D</td>
<td>22° 47.31'E</td>
<td>3012</td>
<td>187</td>
<td>4</td>
<td>D.P. left in hole</td>
</tr>
<tr>
<td>65</td>
<td>483B</td>
<td>22° 52.99'E</td>
<td>3084</td>
<td>267</td>
<td>7</td>
<td>Blocked at cone</td>
</tr>
<tr>
<td>69</td>
<td>504A</td>
<td>1° 13.61'N</td>
<td>3468</td>
<td>278</td>
<td>2</td>
<td>Bit cones in hole</td>
</tr>
<tr>
<td>69</td>
<td>504B</td>
<td>1° 13.61'N</td>
<td>3474</td>
<td>1350</td>
<td>6</td>
<td>Hole open</td>
</tr>
<tr>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>92</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>534A</td>
<td>28° 20.63'E</td>
<td>4976</td>
<td>1647</td>
<td>8</td>
<td>Hole open</td>
</tr>
<tr>
<td>79</td>
<td>547B</td>
<td>33° 46.84'E</td>
<td>3952</td>
<td>1030</td>
<td>3</td>
<td>Hole open</td>
</tr>
<tr>
<td>81</td>
<td>553A</td>
<td>56° 05.32'E</td>
<td>2339</td>
<td>683</td>
<td>2</td>
<td>Bit released in hole</td>
</tr>
<tr>
<td>88</td>
<td>581B</td>
<td>43° 55.66'E</td>
<td>5478</td>
<td>372</td>
<td>2</td>
<td>D.P. left in hole</td>
</tr>
<tr>
<td>91</td>
<td>595B</td>
<td>23° 49.30'E</td>
<td>5630</td>
<td>124</td>
<td>3</td>
<td>Hole open</td>
</tr>
<tr>
<td>92</td>
<td>597C</td>
<td>18° 48.39'E</td>
<td>4157</td>
<td>110</td>
<td>2</td>
<td>Hole open</td>
</tr>
<tr>
<td>93</td>
<td>603B</td>
<td>35° 27.70'E</td>
<td>4644</td>
<td>1585</td>
<td>4</td>
<td>D.P. left in hole</td>
</tr>
</tbody>
</table>

1. Refer to Reentry Cone Deployment Map (Figure 13)
2. Only 13 3/8 single casing string was available prior to Leg 45
3. Only 11 3/4 casing was run with special adapter to cone
INTRODUCTION

This Deep Sea Drilling Project Technical Report No. 13 includes a paper on the analysis, design and operation of the Re-entry Cone/Dual Casing Hanger System authored by M. A. Storms and J. H. Gerken. Operational details, a design review and an evaluation of soil support for the re-entry structure are included in an appendix.

The Re-entry Cone/Dual Casing Hanger System was developed to permit deeper penetrations into the ocean margins as well as significant penetrations into the volcanic basement underlying the ocean floor.

Scientific objectives required the drilling and coring of 500 to 1000 meters of unconsolidated sediments, clays, and chert stringers, before reaching basement rock. This deep water re-entry system, therefore, had to be capable of being set in water depths exceeding 6,000 meters, allow drilling through sedimentary layers 1000 meters thick, permit casing to be run and cemented, and provide for an unlimited number of re-entries. In association with Deep Oil Technology of Long Beach (now Fluor Subsea Systems), DSDP initiated a program to define and develop the required deep water re-entry hardware.

Modifications to the original re-entry system provided for an increased conductor casing diameter of 16" and an improved means for diverting the cuttings to the seafloor. In addition, the casing hanger assembly provided for the landing of an 11-3/4" protective string with provisions for cementing and conductor casing settling. All modifications were done so as to maintain compatibility with existing project running tools and consistent with past GLOMAR CHALLENGER operational procedures.

Having successfully passed sea trials during Leg 44A (November 1975), the Dual Casing Re-entry System was deployed for its first scientific mission on Leg 45 (December 1975). Since that time, re-entry cones have been set at 23 different sites and a total of 144 successful re-entries have been accomplished.

In the spring of 1978, a Triple Casing Hanger System was designed and tested. This system has the conductor string expanded to 20 inches in diameter and a surface protective string 16" in diameter. A third casing string 11-3/4" in diameter is available should additional protection be required downhole. This system has yet to be deployed from the CHALLENGER during a scientific mission.
ACKNOWLEDGEMENTS

The DSDP multiple casing hangar/re-entry cone systems may be used to case-off unstable hole at deep penetration sites. This development is an extension of the original single casing re-entry design which proved operational on Christmas Day 1970.

The dual casing design was developed by Mr. M. A. Storms of DSDP in collaboration with Mr. J. H. Gerken of Deep Oil Technology. The triple casing design was developed by Mr. Valdemar F. Larson, DSDP, and Mr. William Fischer, Consultant. Machine drawings for both systems were made by Deep Oil Technology (presently Fluor Sub Sea Systems). Mr. M. A. Storms also edited and compiled Technical Report No. 13 and is the principal author of the paper entitled "GLOMAR CHALLENGER'S DEEP WATER RE-ENTRY CONE/DUAL CASING HANGER SYSTEM" which is a part of this report.

Mr. Valdemar F. Larson's notable technical and operational contributions to re-entry systems since their inception is gratefully acknowledged.

The use of multiple casing hanger re-entry cone systems has led to a maximum penetration, to date, of 1740 meters in 3900 meters water depth off the west coast of Spain, during Leg 47. The longest casing string used with the new system was 533 meters of 29.85 cm O.D. (11-3/4 inch) casing used on Leg 76. The penetration at this site off the U. S. east coast is 1647 meters in a water depth of 4976 meters.

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

I. Dual Casing Hanger System
   A. Glomar Challenger's Deep Water Re-entry Cone/Dual Casing Hanger System .......................... 5
   B. System Description .................................................................................................................. 33
   C. System Operation ................................................................................................................... 51
   D. Parts List, Drawings & Specifications ..................................................................................... 89

II. Triple Casing Hanger System
   A. Triple Casing Hanger System Description ............................................................................. 163
   B. Parts List, Drawings & Specifications ..................................................................................... 169

III. Appendices
   A. Auxiliary Equipment ............................................................................................................. 197
   B. Acoustic Re-entry .................................................................................................................. 201
   C. Component Weights .............................................................................................................. 205
   D. Cementing Program .............................................................................................................. 207
   E. DOT Engineering Review and Design ..................................................................................... 213
   F. Dames & Moore Evaluation of Soil Support ........................................................................... 223
   G. Nugent Analysis of Mud Skirt Bearing Support .................................................................... 239
LIST OF FIGURES

1. D/V GLOMAR CHALLENGER .......................................................... 15
2. Keelhauling Original Re-entry Cone .......................................... 16
3. Vertical Load Capacity, Ft. of 11-4/5" 54 lb/ft casing .................. 17
4. Re-entry Cone/Dual Casing Hanger ........................................... 18
5. Assembling IPOD Re-entry Cone ............................................... 19
6. Keelhauling IPOD Re-entry Cone .............................................. 20
7. 16-Inch Casing Running Tool ................................................... 21
8. 11-3/4 Inch Casing Hanger/Running Tool .................................. 22
9. 11-3/4 Inch Casing Expansion Joint ......................................... 23
10. Diverter Packoff .................................................................. 24
11. Sonar Transducer ................................................................ 25
12. Plan Position Indicator (PPI) Scope ......................................... 26
13. Re-entry Cone Deployment Map ............................................... 27
14. IPOD Re-entry Concept ........................................................... 29
15. Re-entry Keelhauling Procedure .............................................. 53
16. Keelhauling Re-entry Guide Cone ............................................ 55
17. Making-up 16" Conductor Pipe ................................................ 59
18. Making-up 16" Casing Running Tool ........................................ 61
19. Landing Latch Sleeve in 16" Casing Hanger ............................... 63
20. Latching 16" Casing Hanger into Re-entry Cone....................... 65
21. Washing in 16" Conductor Pipe and Re-entry Cone ................... 67
22. Drill and Core 14-7/8" Hole ...................................................... 69
23. Make-up 11-3/4" Casing String ............................................... 73
24. Make-up BHA to 11-3/4" Casing String .................................... 75
25. Re-enter Cone with 11-3/4" Casing and Latch-in ........................ 77
26. Cleanout Holes and Verify Latching ........................................ 79
27. Release from 11-3/4" Casing Hanger ........................................ 81
28. Cementing 11-3/4" Casing ....................................................... 83
29. Re-enter Cone and Core Ahead with Standard Core Bit ............ 85
30. Re-entry Cone/Triple Casing Hanger ...................................... 165

LIST OF TABLES

I. Re-entry Cone Deployment History .............................................. 28

II. Casing String Specifications .................................................... 157
I. DUAL CASING HANGER SYSTEM
A. GLOMAR CHALLENGER'S DEEP WATER RE-ENTRY CONE
   DUAL CASING HANGER SYSTEM
GLOMAR CHALLENGER'S DEEP WATER RE-ENTRY
CONE/DUAL CASING HANGER SYSTEM

by

M. A. Storms
J. H. Gerken

ABSTRACT

Since 1968, when the Deep Sea Drilling Project (DSDP) began its worldwide scientific drilling and coring operations aboard the D/V GLOMAR CHALLENGER, the Project has been at the forefront of deep ocean technology exploring the geologic history of the earth.

In August, 1975, DSDP accepted a new challenge, the International Phase of Ocean Drilling (IPOD). Crucial to this new deep ocean challenge was the refinement of the Project's deep water re-entry hardware to permit penetration of the volcanic basement underlying the ocean floor. This paper covers the analysis, design, and operation of DSDP's deep water re-entry cone/dual casing hanger system developed in 1975.

DEEP SEA DRILLING PROJECT

The Deep Sea Drilling Project (DSDP) began coring in August, 1968, under the auspices of the National Science Foundation's (NSF) Ocean Sediment Coring Program to increase man's knowledge of the earth's development through the exploration of the ocean floor. The prime contract for the Project was executed in 1966 between NSF and the Board of Regents of the University of California (UC). Scripps Institution of Oceanography in La Jolla, California, which is part of the UC system, is responsible for the management and operation of the Project. Global Marine, Inc. (GMI) of Los Angeles, owner, designer, and builder of the GLOMAR CHALLENGER, subcontracts with Scripps to provide the drilling vessel for the drilling and coring program.

To plan the scientific objectives of the program, major oceanographic institutions in the United States (including Woods Hole Oceanographic Institution, Lamont-Doherty Geological Observatory of Columbia University, Rosenstiel School of Marine Sciences of the University of Miami, the University of Washington and Scripps), joined in an agreement to mutually support such a program of deep ocean drilling. This association is called the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) and provides scientific guidance for the Deep Sea Drilling Project. Recently the group has been enlarged and now includes nine American and five foreign institutions.
Scientific Achievements

During the Project's first seven years, DSDP and JOIDES have developed a priceless legacy of scientific achievements including:

1. Confirmation of the significant theories of seafloor spreading and continental drift through actual core samples of the continental margins.

2. Determination of the youth of the ocean basins—approximately 180 years young compared to the oldest known continental rock, 3.6 billion years old.

3. Performance of paleoceanography through the world's oceans and determination of the geologic history of such areas as the Mediterranean Sea, the Arctic and the Antarctic.


5. Development and refinement of the methods of fossil dating.

6. Discovery of the existence of oil in salt domes in deep subsea knolls in the Gulf of Mexico.

Technical Achievements

At the outset of the Project, DSDP realized it needed a unique platform to accomplish the scientific objectives of deep ocean drilling. As a result of competitive bidding, Global Marine designed and built the D/V GLOMAR CHALLENGER (Fig. 1) to perform the scientific drilling and coring program for the Project. The drillship, modified version of GMT's "Grand Isle" class, bears the respected name of the world's first full time oceanographic vessel, the H.M.S. CHALLENGER. The latter was a converted British warship, which was outfitted as a research vessel in 1872 and explored the oceans of the world in the first comprehensive attempt to survey the world underwater.

The GLOMAR CHALLENGER with its drilling systems and procedures has been recognized as a major technical achievement since drilling began in the Gulf of Mexico in 1968. The 10,500 metric ton drillship features an advanced on-board computer, dual bow and stern dual thrusters to dynamically position itself and maintain station in up to 30 knot winds and heavy seas, a 43 meter derrick amidships with a hook-load capacity of 450 metric tons and a capacity to drill in water depths in excess of 6,000 meters. The CHALLENGER uses an automatic pipe racker capable of handling 7,300 meters of 5-inch drill pipe, and an advanced drill pipe heave compensator. Well equipped shipboard scientific laboratories are utilized to conduct comprehensive core analyses.

The technical achievements of DSDP and the GLOMAR CHALLENGER over nine years, 53 cruises, are truly remarkable:

- 625 holes drilled in 418 sites
- 190,333 total meters (624,454 feet) drilled below seafloor
International Phase of Ocean Drilling

Scientific and technical successes of the Project's first decade of deep ocean drilling paved the way for a new challenge in August of 1975. Usually the coring program and scientific investigation focused on the unconstituted sedimentary surface of the ocean floor. In 1975 scientists felt it was necessary to drill even deeper into the ocean margins as well as penetrate the volcanic basement underlying the ocean sediments. This expanded program would require multiple bit runs and longer casing strings.

This, then, is the challenge of IPOD, the International Phase of Ocean Drilling; an initial three-year deep crustal drilling program supported financially and scientifically by the governments of France, Germany, Japan, England and Russia in addition to the American National Science Foundation. The first phase of IPOD involved exploration of the Atlantic Ocean. It began with Leg 45 in November of 1975 and ended with Leg 53 in April of 1977. The second, or Pacific phase of IPOD began with Leg 54 in May of this year at the Canal Zone; at least eight deep water re-entries are scheduled for the next year.
DEEP WATER RE-ENTRY SYSTEM

Critical to the success of the IPOD challenge is the refinement of the Project's deep water re-entry hardware, originally developed in the early 1970's. Based on earlier concepts for NSF's Project Mohole, DSDP developed and successfully tested the first operational re-entry system on Christmas Day, 1970 in 3,900 meters of water in the Caribbean's Venezuelan Basin (Fig. 2).

This early system consisted of a 4.5 meter diameter steel guide cone with three passive reflectors and an automatic, segment-type, spring-loaded casing hanger for suspending 13-3/8 inch conductor pipe, and a scanning sonar tool that was lowered through the 5-inch drill pipe on standard seven-conductor logging cable. Although this system proved effective, re-entry was performed infrequently during the next four years. The development of improved core bits allowed the relatively shallow coring objectives to be reached without re-entry.

Ipod Re-entry

The IPOD scientific objectives often require the drilling and coring of 500 to 1000 meters of unconsolidated sediments, clays, and chert stringers, before reaching basement rock. The DSDP deep water re-entry system, therefore, must be capable of being set in water depths exceeding 6,000 meters, allow drilling through sedimentary layers 1000 meters thick, permit casing to be run and cemented, and provide for re-entry an unlimited number of times. In association with Deep Oil Technology (DOT) of Long Beach, California, DSDP initiated a program to define and develop deep water re-entry hardware to meet the IPOD challenge.

Design Criteria

In the initial design analysis, the Project engineers believed several factors would effect the hardware design. These factors were:

1. Soil bearing capacity of the sediments
2. Mechanical strength required in the re-entry cone and casing hangers
3. Borehole casing required at various depths through unconsolidated sediments
4. Providing redundant passive reflectors in case of breakage during successive re-entries
5. Requirements for a cuttings removal system to dispose of drilled solids to keep the cone and wellbore clean of debris for re-entry.

The original re-entry system resulted in the development of a through drill pipe scanning sonar system and a suite of running tools and procedures. Since this auxiliary hardware was readily available, and the CHALLENGER's crew was familiar with its operation, it was desirable to incorporate this equipment into the IPOD re-entry system.
System Bearing Load

DSDP's experience in coring the shallow sediments in the deep ocean basins revealed the first design problem. That was, what type of footing was needed to support the anticipated cone and casing loads?

DSDP Scientists investigated core samples from the anticipated deep re-entry sites and observed that the ocean floors consisted predominantly of calcareous oozes, or muds, for 100 meters or more below the seafloor. The possibility of the re-entry cone settling into this subsea "quicksand" and preventing re-entry was a real concern. The services of a consulting firm specializing in solid analysis and oilfield platform piles was enlisted to assist in determining the bearing capacity of the ocean floors. The anticipated loads of the re-entry cone and dual casing system were reviewed and "typical" core samples from the proposed deep re-entry sites were analyzed to ascertain soil bearing and shear strengths.

Initially, a conventionally designed re-entry cone was considered with a flat bearing plate for support on the ocean floor. The soil analysts concluded that this was not feasible due to the poor bearing strength of the colloidal sediments. Instead, the soils study suggested that the sediments' reconstituted shear strength would be required to support the vertical casing load through skin friction.

After "jetting-in" the re-entry cone and 16-inch conductor, to a depth predetermined by a pilot core hole, the sediments, with the exception of clay, tend to reconsolidate around the casing. The skin friction between the pipe and the soil particles create an adhesion that effectively holds the re-entry system in place. A curve (Fig. 3), plotting vertical load of the 11-3/4 inch casing string, versus the depth of a 16-inch conductor supported by "skin friction" was developed for Operations to design their casing string at each unique re-entry site. This conclusion has a significant impact on the cone design.

Modified Re-entry Cone

Although the original cone design proved effective in the re-entries of the early 1970's, the IPOD objectives required several improvements.

Mechanical and structural features of the larger upper cone were considered sufficient for the new design. The CHALLENGER's design required any structure to be keelhauled. However, no significant increases in weight could be allowed due to the limited crane capacity. The demands of IPOD required a substantial modification of the lower cone in which the casing was landed. The principal design objectives were to increase the size of the lower cone to accept the anticipated dual casing hangers, strengthen the lower cone to support the heavier casing loads, and strengthen the transition zone to provide a greater resistance to bending. A failure in a re-entry cone structure occurred in 1974, apparently during re-entry operations.

Additional improvements in the re-entry cone design included provisions for redundant passive reflectors to assure successful re-entries throughout the long-term crustal drilling, and a cuttings removal system to dispose of the drilled solids. Both of these systems were subsequently integrated into the modified re-entry cone design.
Dual Casing Hangers

Because of the deep penetrations required to reach the IPOD objectives, a second casing string would be required to protect the borehole during drilling operations. This required not only a unique design to land two casing hangers in the lower cone but also required a full complement of running tools that could effectively set and release the casing in 6,000 meters of water and also allow use of the scanning sonar to direct the casing into the hole.

SYSTEM DESIGN

The re-entry cone dual casing hanger system designed for the IPOD phase of the Deep Sea Drilling Project (Fig. 4) is comprised of the following major components.

1. Upper Re-entry Cone
2. Lower Re-entry Cone
3. 16 Inch Casing Hanger and Running Tool
4. 11-3/4 Inch Casing Hanger and Running Tool
5. 11-3/4 Inch Casing Expansion Joint
6. Cuttings Disposal System

As discussed earlier, the IPOD re-entry system designed for deep penetrations maintains certain similarities to the original re-entry cone but incorporates several design improvements.

Re-entry Cone

The upper cone section (Fig. 5) is rolled mild steel with a 4.4 meter diameter, tapered at 30 degrees to a 1.2 meter mating flange. Angle and channel iron are used to structurally reinforce the outer perimeter of the cone; the interior remaining smooth to guide the core bit into the lower cone section. The upper section is split in half to facilitate shipping. Six semi-circular passive reflectors, one meter in diameter, are mounted on the upper rim of the cone to provide backup reflectors in case some are damaged during re-entry.

The lower cone section (Fig. 5) consists of a heavy wall transition section which provides greater resistance to bending moments and a landing collar for the 16-inch casing hanger. Integral to the lower cone is a 2.4 meter diameter mud skirt and three vertical transition fins; these provide bearing and permit the drilling to "feel" the ocean floor. Bearing can be increased by adding an optional 4.2 meter diameter mud skirt extension. In addition, three 8-inch discharge lines are incorporated into the lower cone as a part of the cuttings removal system to transport drilled solids away from the cone and borehole.

The cone sections are assembled in an inverted position with the inside greased to facilitate latching of the 16-inch casing hanger. The entire assembly is keelhauled (Fig. 6) over the port, or leeward, side of the CHALLENGER and secured into position below the drillship's centerwell.
16-Inch Casing Hanger and Running Tools

The original re-entry system used a single conductor string of 13-3/8 inch casing. For deeper penetration depths, the Project designed the IPOD re-entry system to include a dual casing string; a 16-inch, 75 pounds per foot buttress thread conductor and an 11-3/4 inch, 54 pounds per foot buttress thread surface string.

The 16-inch casing hanger assembly (Fig. 7) includes a 26-inch casing hanger welded to a heavy wall transition sub, and provided with a 16-inch buttress box down. A latch ring to capture the 11-3/4 inch casing hanger and a shoulder retaining ring nest in the 16-inch hanger. A special 16-inch landing tool was designed to handle the 16-inch casing hanger assembly, 16-inch conductor and re-entry cone. The 16-inch landing tool consists of a latch sleeve with three paddles mounted on paddle shafts and actuated by torsion springs recessed in the latch sleeve.

With the re-entry cone suspended below the centerwell, a length of 16-inch conductor predetermined by a pilot corehole is lowered through the cone. The 16-inch hanger assembly is threaded onto the top of the casing and the landing tool is lowered into the hanger. Engagement is achieved by manually rotating the paddles 90 degrees under the latch groove ring and running the DSDP release sub behind the paddles to lock them out. The entire assembly is then lowered into the cone where a conventional split latch ring engages the cone's landing collar. The slings are then removed from the re-entry cone and the cone with the casing attached is run in on the drill string.

Once on bottom, the 16-inch casing is "washed in" to the prescribed depth until the cone rests on the ocean floor. A release tool is lowered through the drill pipe on a sandline and engages in a sleeve in the running tool. Retrieving the sandline moves the sleeve up and releases the paddles. Drilling operations can then be resumed without tripping the drill pipe.

11-3/4 Inch Casing Hanger and Running Tools

The 11-3/4 inch casing hanger assembly (Fig. 8) consists of a flow-through hanger designed to permit circulation through the 16-inch x 11 3/4 inch annulus during cementing operations. Like the 16-inch hanger, a three meter long, heavy wall transition sub is welded to the hanger with an 11-3/4 inch buttress box down. A left hand modified buttress thread is provided in the hanger bore to run and land the assembly using an 11-3/4 inch hex-kelly running tool with a three meter stroke. The tapered flank of the buttress thread locks the hanger to the running tool as long as the casing is in tension.

After re-entering the cone, the 11-3/4 inch hanger is latched into the groove ring of the 16-inch hanger using a conventional split ring. Once an upward pull demonstrates that the casing is latched, the hex-kelly is placed in "neutral" and the left hand thread is disengaged from the flow through hanger. The casing is then cemented in place. A latch down plug is used to follow the cement.
11-3/4 Inch Casing Expansion Joint

As indicated earlier, possible settling of the re-entry system in unconsolidated sediments was a significant concern. Therefore, an 11-3/4 inch casing expansion joint (Fig. 9) was incorporated into the system to eliminate compressional loads on the 11-3/4 inch casing due to any differential settling of the re-entry cone and the 16-inch casing. The simple slip joint includes a mandrel with a three-meter stroke, a mandrel head, a honed outer barrel assembly and a packing retained. Braided asbestos packing is used in the expansion joint.

Cuttings Disposal System

Because the deep crustal sites would require several re-entries and the drilling would generate considerable drilled solids, it was essential to design a cuttings disposal system.

For IPOD, this system consisted of the 11-3/4 inch circulating casing hanger, three re-entry cone discharge lines and a diverter packoff assembly (Fig. 10). The diverter packoff serves to seal the annular area and divert the circulating fluids through the discharge lines and around the outside of the re-entry cone.

Primary sealing is provided by a drill pipe packer with a secondary cone packer to prevent cuttings from filling the lower cone and disrupting re-entry.
Designed to pass 7-1/4 inch tool joints, but shoulder on 8-1/4 inch drill collars, the diverter packoff is run after the last drill collar. After re-entry, the assembly nests in the lower cone transition section while the drill pipe is lowered to bottom. The packoff rides back on top of the drill collars when a bit change is made. The diverter packoff is held down by gravity with no attempt at latching.

Re-entry

Re-entry is accomplished by lowering the drill pipe until the core bit is 4 to 9 meters above the guide cone with a full stand of drill pipe up in the derrick. A wireline swivel is attached to the top of the drill pipe and the 3-3/4 inch EDO Western high resolution scanning sonar tool (Fig. 11) is run on an electric logging cable. The instrument is circulated to bottom through the tubing and seats in the core barrel with the sonar transducer extending below the core bit.

When the sonar tool is seated and scanning the ocean floor, the Plan Position Indicator (PPI) oscilloscope on the CHALLENGER’s bridge receives an acoustic response from the passive reflectors (Fig. 12). The drillship is maneuvered until the bit is directly above the cone and the drill string is lowered. Re-entry is verified if resistance is not encountered.

RESULTS: IPOD ATLANTIC PHASE

Prior to starting the first phase of IPOD, Engineering Leg 44A was scheduled off the east coast of Florida to conduct operational tests of the re-entry system. Although no re-entry was accomplished on this shakedown cruise, Operations personnel aboard the CHALLENGER gained valuable experience with the re-entry hardware.
The primary operational problem occurred with the 16-inch split latch ring. Because of its design, it was possible for the latch ring to move off center. This made it extremely difficult to stab the 16-inch hanger in the lower cone and engage the latch ring in the landing collar. Both the 16-inch and 11-3/4 inch latch rings were redesigned and provided with a retaining ring to capture and centralize them. The fine-threaded shoulder ring on the 16-inch casing hanger assembly was replaced with a coarse thread and moved externally to prevent damage during make-up. Additional lifting eyes were provided and the keelhaul slings were revised for improved handling. The passive reflectors were strengthened and excessive protective coating was eliminated from the bore of the cone's transition section. These modifications were accomplished prior to the CHALLENGER's departure from San Juan, Puerto Rico, on the first IPOD leg.

The first phase of IPOD commenced on Thanksgiving Day, 1975, with Leg 45 and involved a north-easterly excursion from San Juan through the North Atlantic eventually returning to the Caribbean. The Atlantic phase of IPOD ended 17 months later with the completion of Leg 53 on April 25, 1977 at Cristobal in the Canal Zone.

During the IPOD Atlantic phase, re-entry proved an unqualified success (Fig. 13), thereby extending the horizons for the scientific community. On seven of the Project's nine legs, seven re-entry cones were successfully landed on the ocean floor and a total of 52 re-entries were achieved. Only once, on Leg 51, was a re-entry cone lost. This was due to a failure of a pin on the lower bumper sub when subjected to excessive bending. Total penetration of the ocean sediments and basalts was 6127 meters ranging from 406 meters on Leg 46 to 1624 meters on Leg 50B. Average water depth was 4600 meters with the deepest water of 5519 meters encountered at the Bermuda rise on Legs 52B and 53. During Leg 53, a fatigue failure caused the drill pipe to part and fall in the borehole. A standard oilfield overshot was guided into the re-entry hole and a 365 meter section of drill pipe was successfully recovered.

FUTURE: IPOD PACIFIC PHASE

During the first 15 months of IPOD, the improved re-entry system (Fig. 14) permitted the DSDP scientists to reach the volcanic basement and investigate deep geology in such areas as the mid-Atlantic Ridge, the Bay of Biscay and the Rockall Plateau, the continental margins off the North Atlantic Coast and the Bermuda Rise.

No significant mechanical design problem has developed since the redesign of the latch rings. Only the particular hole conditions at each deep crustal re-entry site seem to limit the drilling and coring operations. DSDP is, in fact, considering a third generation re-entry system that would include a third casing string to permit even deeper penetration attempts.

Because of the success of the Atlantic phase, the IPOD participants have extended the original three year project an additional 14 months. During the next phase of IPOD, the GLOMAR CHALLENGER will crisscross the Pacific twice setting re-entry cones at at least eight deep crustal sites. Through a combination of improved drilling systems and the efforts of the Project's scientists and engineers, the Deep Sea Drilling Project is continuing its remarkable development of man's understanding of his planet.
D/V GLOMAR CHALLENGER

Fig. 1
Fig. 3

"SETTING - UP" PERIOD OF AT LEAST 24 HOURS

VERTICAL LOAD CAPACITY, FT OF 11-3/4 in. 54# CASING
ASSEMBLING IPOD REENTRY CONE

Fig. 5

-19-
KEELHAULING IPOD REENTRY CONE

Fig. 6
TORSION SPRING
LATCH SLEEVE
PADDLE SHAFT
PADDLE
INDEX SUB
RELEASE SUB
SHIFTING SLEEVE
STOP BOLTS

16 in. CASING RUNNING TOOL
Fig. 7
-21-
NC-61 API THD.

11 3/4 in. CASING HANGER BODY
HEX KELLY LANDING TOOL

11 3/4 in. LATCH RING
D.O.T. MOD. BUTTRESS BOX THD.

11 3/4 HEX. MANDREL

11 3/4 in. TRANSITION SUB
12 3/4 in. O. DO. X 11.06 in. I. D.
X 10 ft.

NC-61 THD.

11 3/4 in. CASING

11 3/4 in. CASING HANGER / RUNNING TOOL
Fig. 8
11 3/4 in. CASING EXPANSION JOINT

Fig. 9

-23-
Fig. 10

- CONE PACKER
- DIVERTER PACKOFF BODY
- BOLT RING
- DRILL PIPE PACKER

DIVERGER PACKOFF
SONAR TRANSDUCER

Fig. 11
RE-ENTRY CONE DEPLOYMENT MAP
FIG. 13
SEE DEPLOYMENT HISTORY, TABLE I
### TABLE I

**REENTRY CONE DEPLOYMENT HISTORY**

<table>
<thead>
<tr>
<th>MAP NO</th>
<th>LEG NO</th>
<th>SITE NO</th>
<th>CONE LOCATION</th>
<th>...</th>
<th>PENET. DEPTH (m)</th>
<th>CASING LENGTH (m)</th>
<th>NO. OF RE.</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>146</td>
<td>15° 06.99'N 69° 22.67'W</td>
<td>3939</td>
<td>762</td>
<td>50° 2</td>
<td>2</td>
<td>Hole open</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>288A</td>
<td>5° 58.35'S 161° 49.53'E</td>
<td>3030</td>
<td>999</td>
<td>56° 2</td>
<td>2</td>
<td>Hole bridged</td>
</tr>
<tr>
<td>3</td>
<td>34</td>
<td>319A</td>
<td>13° 01.04'N 101° 31.46'W</td>
<td>4296</td>
<td>157</td>
<td>65° 2</td>
<td>1</td>
<td>Hole open</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
<td>320B</td>
<td>9° 00.40'S 83° 31.80'W</td>
<td>4487</td>
<td>183</td>
<td>65° 2</td>
<td>1</td>
<td>Hole open</td>
</tr>
<tr>
<td>5</td>
<td>37</td>
<td>332B</td>
<td>36° 52.76'N 33° 38.57'W</td>
<td>1841</td>
<td>721</td>
<td>68° 2</td>
<td>9</td>
<td>Sidetracked hole</td>
</tr>
<tr>
<td>6</td>
<td>37</td>
<td>333A</td>
<td>36° 50.45'N 33° 40.05'W</td>
<td>1682</td>
<td>529</td>
<td>70° 2</td>
<td>1</td>
<td>D.P. left in hole</td>
</tr>
<tr>
<td>7</td>
<td>45</td>
<td>395A</td>
<td>22° 45.35'N 46° 04.90'W</td>
<td>4485</td>
<td>664</td>
<td>62° 109</td>
<td>13</td>
<td>Sinker bar in hole</td>
</tr>
<tr>
<td>8</td>
<td>46</td>
<td>396B</td>
<td>22° 59.14'N 43° 30.90'W</td>
<td>4465</td>
<td>406</td>
<td>120° 163</td>
<td>7</td>
<td>Hole open</td>
</tr>
<tr>
<td>9</td>
<td>47</td>
<td>398D</td>
<td>40° 57.60'N 10° 43.10'W</td>
<td>3900</td>
<td>1740</td>
<td>80°</td>
<td>2</td>
<td>Hole open</td>
</tr>
<tr>
<td>10</td>
<td>48</td>
<td>400A</td>
<td>47° 22.90'N 9° 11.90'W</td>
<td>4399</td>
<td>778</td>
<td>75°</td>
<td>1</td>
<td>D.P. left in hole</td>
</tr>
<tr>
<td>11</td>
<td>50</td>
<td>415A</td>
<td>31° 01.65'N 11° 39.97'W</td>
<td>2817</td>
<td>1080</td>
<td>68° 331</td>
<td>3</td>
<td>Reflector obscured</td>
</tr>
<tr>
<td>12</td>
<td>50</td>
<td>416A</td>
<td>32° 50.18'N 10° 48.06'W</td>
<td>4203</td>
<td>1605</td>
<td>40°</td>
<td>9</td>
<td>Hole open</td>
</tr>
<tr>
<td>13</td>
<td>51B</td>
<td>417D</td>
<td>25° 06.69'N 68° 02.82'W</td>
<td>5489</td>
<td>709</td>
<td>113°</td>
<td>3</td>
<td>BHA left in hole</td>
</tr>
<tr>
<td>14</td>
<td>52</td>
<td>418A</td>
<td>25° 02.08'N 68° 03.45'W</td>
<td>5519</td>
<td>868</td>
<td>71°</td>
<td>4</td>
<td>Hole open</td>
</tr>
<tr>
<td>15</td>
<td>55</td>
<td>433C</td>
<td>44° 46.63'N 170° 01.23'E</td>
<td>1874</td>
<td>551</td>
<td>45°</td>
<td>3</td>
<td>Hole open</td>
</tr>
<tr>
<td>16</td>
<td>57</td>
<td>438B</td>
<td>40° 37.80'N 143° 14.80'E</td>
<td>1575</td>
<td>1039</td>
<td>41°</td>
<td>1</td>
<td>D.P. left in hole</td>
</tr>
<tr>
<td>17</td>
<td>58</td>
<td>442B</td>
<td>28° 59.04'N 136° 03.43'W</td>
<td>4645</td>
<td>455</td>
<td>65°</td>
<td>2</td>
<td>Hole open</td>
</tr>
<tr>
<td>18</td>
<td>61</td>
<td>462A</td>
<td>7° 14.50'N 165° 01.90'E</td>
<td>5186</td>
<td>1206</td>
<td>75°</td>
<td>15</td>
<td>Hole open</td>
</tr>
<tr>
<td>19</td>
<td>65</td>
<td>482D</td>
<td>22° 47.31'N 107° 59.51'W</td>
<td>3012</td>
<td>187</td>
<td>60°</td>
<td>4</td>
<td>Hole open</td>
</tr>
<tr>
<td>20</td>
<td>65</td>
<td>483B</td>
<td>22° 52.99'N 108° 14.84'W</td>
<td>3084</td>
<td>267</td>
<td>123°</td>
<td>7</td>
<td>Blocked at cone</td>
</tr>
<tr>
<td>21</td>
<td>69</td>
<td>504A</td>
<td>1° 13.61'N 83° 43.95'W</td>
<td>3468</td>
<td>278</td>
<td>90°</td>
<td>2</td>
<td>Bit cones in hole</td>
</tr>
<tr>
<td>22</td>
<td>69</td>
<td>504B</td>
<td>1° 13.61'N 83° 43.81'W</td>
<td>3474</td>
<td>1350</td>
<td>90°</td>
<td>6</td>
<td>Hole open</td>
</tr>
<tr>
<td>23</td>
<td>76</td>
<td>534A</td>
<td>28° 20.63'N 75° 22.89'W</td>
<td>4976</td>
<td>1647</td>
<td>86° 533</td>
<td>8</td>
<td>Hole open</td>
</tr>
<tr>
<td>24</td>
<td>79</td>
<td>547B</td>
<td>33° 46.84'N 9° 20.98'W</td>
<td>3952</td>
<td>1030</td>
<td>28°</td>
<td>3</td>
<td>Hole open</td>
</tr>
<tr>
<td>25</td>
<td>81</td>
<td>553A</td>
<td>56° 05.32'N 23° 20.61'W</td>
<td>2339</td>
<td>683</td>
<td>60°</td>
<td>2</td>
<td>Bit released in hole</td>
</tr>
<tr>
<td>26</td>
<td>88</td>
<td>581B</td>
<td>43° 55.66'N 159° 47.77'E</td>
<td>5478</td>
<td>372</td>
<td>364</td>
<td>2</td>
<td>D.P. left in hole</td>
</tr>
<tr>
<td>27</td>
<td>91</td>
<td>595B</td>
<td>23° 49.30'S 165° 31.60'W</td>
<td>5630</td>
<td>124</td>
<td>34° 74</td>
<td>3</td>
<td>Hole open</td>
</tr>
<tr>
<td>28</td>
<td>92</td>
<td>597C</td>
<td>18° 48.39'S 129° 46.23'W</td>
<td>4157</td>
<td>110</td>
<td>40°</td>
<td>2</td>
<td>Hole open</td>
</tr>
<tr>
<td>29</td>
<td>93</td>
<td>603B</td>
<td>35° 27.70'N 70° 01.90'W</td>
<td>4644</td>
<td>1585</td>
<td>72° 500</td>
<td>4</td>
<td>D.P. left in hole</td>
</tr>
</tbody>
</table>

1. Refer to Reentry Cone Deployment Map (Figure 13)
2. Only 13 3/8 single casing string was available prior to Leg 45
3. Only 11 3/4 casing was run with special adapter to cone
DYNAMIC POSITIONING AND RE-ENTRY

FORWARD / THRUSTERS

HYDROPHONES

WATER DEPTH AS DEEP AS 20,500 FEET

DRILL RE-ENTRY CONE-SONAR BEACON (To Position Ship)

DRILL STRING LIMITS OF DRILL STRING PLAY 3% OF WATER DEPTH

UPPER MEAN EXCURSION RADIUS - 100 FEET

PIECE DERRICK PILOT HOUSE

DRILL STRING POSITION INDICATOR

PIPE RACKS

FORWARD THRUSTERS

AFT THRUSTERS

SHIP HYDROPHONES

FLEXIBLE DRILL STRING

LIMITS OF DRILL STRING PLAY 3% OF WATER DEPTH

SONAR REFLECTORS

SONAR BEACON

SONAR SCANNER

BEAM AND ECHOES

WATER DEPTH AS DEEP AS 20,500 FEET

PENETRATION AS DEEP AS 4,300 FEET

IPOD REENTRY CONCEPT

Fig. 14

-29-
B. RE-ENTRY CONE/DUAL CASING HANGER SYSTEM DESCRIPTION
REENTRY CONE/DUAL CASING HANGER
SYSTEM DESCRIPTION

The Reentry Cone/Dual Casing Hanger System designed for future reentries and deep crustal penetrations maintains certain similarities to the original reentry cone and incorporates several new features.

1. Upper cone section - retains the same physical dimensions of the original cone incorporating additional passive reflectors and a modified cuttings disposal system.

2. Lower cone section - modified to include additional structural support and provide the means to land an increase conductor casing diameter (16").

3. Dual casing hangers - provisions to run and land 300' of 16", 75# conductor and 3000' of 11 3/4", 54# protective casing.

4. Cuttings disposal system - integral to the reentry cone with an internal diverter packoff assembly to disburse cuttings away from the cone.

5. Casing expansion joint - incorporated to minimize compressional loads on the 11 3/4" casing due to differential settling of the reentry cone in the deep ocean sediments.

6. Casing landing tools - modified to run the 16" and 11 3/4" dual casing hangars.
A. Reentry Cone (Dwg. 101914)

The reentry cone consists of an upper cone section (P/N 102027) fabricated in two halves and a lower cone assembly (P/N 102028). Prior to keelhauling, assemble the reentry cone in an inverted position as follows:

1. Flange the upper cone halves together per the attached bolting specification in Appendix I. Cone halves are match-marked (e.g. 1-1, 1A-LA, 2-2, 2A-2A) and should be so assembled to assure flange alignment.

2. Flange the lower cone to the assembled upper cone, making sure that the bolted side flanges on the upper cone are in line with the lifting eyes on the lower cone. This is required for keelhauling operations.

3. Pickup an upper discharge line (P/N 102037) and stab into the connecting collar on the lower cone. Bolt the top flange of the discharge line to the 3 1/2" angle on the upper cone. Continue until all three discharge lines are in place.

4. Install the desired number of reflector support brackets (P/N 102039-3 max.), bolting to the top and side angles of the upper cone.

5. Install the desired number of passive reflectors (P/N 102038-6 max.) by bolting to the upper discharge lines (3 req'd) and support brackets (3 max.).

6. If seafloor conditions warrant, install the mud skirt extension (P/N 102040) a half section at a time, bolting to the lower cone assembly. After both sections are in place, flange the half-sections together and install the three 3" OD mud skirt stiffeners.

7. Before keelhauling the cone assembly, thoroughly coat the inside of the lower cone with grease to facilitate landing of the 16" hanger. NOTE: Lifting eyes with shackles are provided on the upper cone at the side flange, and on the lower cone at the base of the landing collar.
B. **Dual Casing Hanger (Dwg. 101915)**

The casing hangers include provisions to run and land multiple strings of casing, 16" and 11 3/4". The 16" running tool assembly (P/N 102196) used to run the 16" conductor and reentry cone allows the use of existing DSDP lowering and index subs and is released by either the Baker or Rotary shifting tools. A 11 3/4" hex-kelly running tool (P/N 102026) was developed to run and land the 11 3/4" casing hanger in the 16" hanger. This tool utilizes a modified buttress left hand thread to land the 11 3/4" hanger and incorporates a 10' stroke hex-kelly to facilitate disengagement.

The 16" casing hanger assembly (P/N 102012) includes the 16" hanger (P/N 102013) welded to a 16" heavy wall transition sub (P/N 102014) provided with a 16" buttress box down. A shoulder ring (P/N 102015), latch groove ring (P/N 102016) to land the 11 3/4" hanger, a 16" latch ring (P/N 102017), and a set of retaining rings (P/N 102636 & 102637) complete the assembly. The 16" casing hanger is landed on a heavy-wall landing collar in the base of the reentry cone and engaged with the 16" latch ring.

The 11 3/4" casing hanger assembly (P/N 102000) includes the 11 3/4" hanger (P/N 102001) welded to a 11 3/4" heavy wall transition sub (P/N 102002) provided with an 11 3/4" buttress box down. A left hand modified buttress thread is provided to run and land the 11 3/4" hanger using an 11 3/4" hex-kelly landing tool (P/N 102026). The 11 3/4" flow through hanger is designed to permit circulation through the 16" by 11 3/4" annulus during cementing operations. The 11 3/4" latch ring (P/N 102003) and a set of retaining rings (P/N 102638 & 102639) complete the assembly.
C. 16" Casing Landing Tool Assembly (P/N 102196)

A casing landing tool is provided to handle the 16" hanger, conductor and reentry cone using existing casing lowering tools. The 16" landing tool includes: the 16" latch sleeve (P/N 102018) run on the lowering sub, three paddles (P/N 102020), paddle shafts (P/N 102021) and torsion springs (P/N 102022).

Assembly of the tool is accomplished by engaging the torsion springs in their pockets and placing the paddles in the lower windows. Make certain the square paddle corner is at the top. The paddle shafts are now inserted through the springs and paddles and the shaft head engaged with the torsion spring. Paddles and shafts are match-marked and should be so assembled. Using a pipe wrench, rotate the shaft head clockwise approximately 90°, thereby aligning the holes in the paddles and shafts. Secure with 5/16" x 1 5/8" stainless steel roll pins and release the shaft head. The torsion springs will act to keep the paddles in a closed position when released. Remove the three lifting eyes (3/4") provided in each latch sleeve for handling purposes before landing in the 16" hanger.
D. **11 3/4" Casing Landing Tool (P/N 102026)**

An 11 3/4" hex-kelly landing tool is provided to run and land the 11 3/4" casing hanger in the 16" latch groove ring. This landing tool consists of a 10 foot stroke hex-kelly landing mandrel (P/N 102025) provided with API NC-61 rotary shouldered connections, a landing tool with a modified buttress left-hand thread (P/N 102024) to land and release the 11-3/4" hanger, and a bottom sleeve (P/N 102023) that permits kelly repairs. Dress the landing tool by installing an ARP-452 O-Ring trash seal as provided. Holding the mandrel in neutral, the buttress landing tool is threaded into the 11 3/4" hanger and made up hand tight. The assembly is then picked up on a drill collar and run in to bottom on the drill-pipe. After the casing is landed in the 16" hanger, the hex-kelly mandrel is put in neutral and the landing tool released from the hanger by turning to the right.

Disassembly of the landing tool is accomplished by drilling out the three one inch plug welds in the bottom sleeve (center punched for locating) and the alloy steel retaining plugs removed. The bottom sleeve can be backed off and the landing tool slid off the kelly mandrel for repairs. To reassemble, reverse the procedure making certain alloy steel (AISI 4130) retaining plugs are inserted before plug welding.
NOTE: MACHINE SURFACE TO BE TRUE AS T.I.R.
E. 11 3/4" Casing Expansion Joint (P/N 101924)

An 11 3/4" casing expansion joint is incorporated into the system to minimize the compressional loads on the 11 3/4" due to differential settling of the reentry cone and 16" casing. The expansion joint is provided with 11 3/4" buttress thread and includes a ten foot stroke inner mandrel (P/N 102009), a mandrel head (P/N 102010), an outer barrel assembly (P/N 102005) and a packing retainer (P/N 102011). Conventional asbestos rope packing (Garlock Marine Packing #5862 or equivalent) is used in the slip joint.
TOP COLLAR
11-3/4", 54 LB, K55
BUTTRESS THO CASING

MANDREL
P/N 102009

PACKING RETAINER
P/N 102011

GARLOCK MARINE PACKING "5662"

13-3/8" BARREL ASS'Y
P/N 102005

MANDREL HEAD
P/N 102010

11-3/4", 54 LB, K55
BUTTRESS THO
F. Diverter Packoff Assembly (P/N 102041)

The cuttings disposal system consists of the 11 3/4" circulating casing hanger, the reentry cone discharge lines and the diverter packoff assembly. The diverter packoff serves to seal the annular area and divert the circulating fluids through the cone discharge line.

The primary seal is provided by the drillpipe packer (P/N 102044) with the cone packer (P/N 102043) preventing cuttings from filling the lower cone and disrupting reentry. The diverter packoff will pass 7 1/4" tool joints but will shoulder on 8 1/4" drill collars. The assembly is, therefore, to be run after the last drill collar. A 5 1/2" API FH starting mandrel is provided to assist in stripping the assembly over the first tool joint. Depending upon the drillpipe packer wear during drilling or cementing operations, the diverter packoff should ride out on the first stand of drill collars.
INSTALLATION OF 16" and 11-3/4" LATCH RINGS

A special tool to be used for installation of the 16" and 11-3/4" latch rings is currently being developed. In the interim period, the latch rings can be installed utilizing the following procedure:

1) Slip ring over transition sub and onto casing hanger body. Ring will have to be slightly spread and jarred onto body. The ring can then be driven with brass mallets until it comes in contact with shoulder directly beneath latch ring groove.

2) Using No. 3 Armstrong C-clamps, place lower clamp surface beneath ring and upper clamp surface on bottom of latch ring groove. First clamp should be placed near 3" gap in ring.

3) Slowly ease latch ring up onto O.D. of shoulder beneath latch ring groove using C-clamps approximately 6" apart on circumference. Begin at one end and work around circumference.

4) After ring is fully expanded around maximum O.D. hanger, all C-clamps should be removed. Now ring can be "popped" into groove by using brass mallets.

5) Latch ring retainer can now be installed to centralize the ring in the groove.

6) Installation procedure should require approximately one half hour to complete.

NOTE: Should it be necessary to test the 11-3/4" casing hanger aboard ship with the latch ring installed, it is recommended that the "shoulder ring" be left off of the 16" casing hanger. This will allow the latch ring to be released after testing. If the "shoulder ring" is installed prior to the test, then removal of the 11-3/4" latch ring from the latch groove will be necessary in order to separate the "shoulder ring" from the 11-3/4" casing hanger body. This is not advised as it subjects the ring to possible damage during removal.
C. RE-ENTRY CONE/DUAL CASING HANGER SYSTEM OPERATION
II. OPERATIONAL PROCEDURES FOR DEEP CRUSTAL PENETRATIONS

A. Keelhaul Reentry Cone

1. Assemble reentry cone in an inverted position. Turn cone on its side and install reflectors. Rig reentry cone for keelhauling by placing 1" doubled slings (each 66' or 33' doubled) around the lifting bars on the upper cone and store inside cone. Make-up short bridle (13'6" and 10' slings) on upper and lower cone padeyes to doubled 3/4" line and shackle into crane whipline (Figure 15). In addition, shackle into crane block using a short 1" sling.

2. Pickup cone with crane block and swing cone onto port side of main deck with open end facing towards the starboard bow. Use air tuggers to restrain cone (use tuggers both from rig floor and main deck).

3. Hook up keelhaul lines to main doubled keelhaul slings. Use at least one inch keelhaul lines (120' long each) rigged up to derrick travelling blocks (Figure 15).

NOTE: Keelhaul lines should be run prior to these operations. Small diameter manila pull lines have been installed without the aid of divers by positioning the Glomar Challenger so that the ocean current is running thwart ship from the starboard. The manila line is lowered along with a small diameter rubber air hot hose attached through the proper openings in the moon pool. A fabric bag (pillow case) secured to the end is then inflated and floats alongside on the port side where it is retrieved.

4. Remove crane block and short sling from short bridle and transfer load to crane whipline.

5. Using crane whipline swing cone over the side with open end facing the moon pool. Take up slack on keelhaul lines with derrick travelling blocks. These lines will act to keep the cone in proper orientation (Figure 6).
**KEELHAUL SKETCH**

1. **TRAVELING BLOCK**
2. **WHIPLINE-SOTON CRANE**
3. **CRANE BALL & HOOK**
4. **3/4" x 50' WIRE ROPE DOUBLED WITH BOTH EYES IN HOOK**

**MODIFIED AFTER TRAVIS 12.14.70**  

**KEELHAUL PROCEDURE:**

1. ASSEMBLE CONE IN A VERTICAL POSITION.
2. RIG SHORT BRIDLE A & B TO CONE PADEYES TEMPORARILY CONNECT TO BLOCK WITH SHORT 1" SLING.
3. SECURE LINES (1) & (6) INSIDE CONE & MOVE CONE TO PORT SIDE & LAND ON PIPE RACK, DECK, & PORT RAIL.
4. SHACKLE LINES (7) & (8) CONNECTED TO BAILS OF TRAVELLING BLOCKS TO LINES (1) & (6).
5. REDRIG SHORT BRIDLE A & B WITH LINE (1) AND CONNECT TO WHIPLINE. SWING CONE TO MIDSHIP & LOWER INTO WATER TO WHERE "WHIPLINE" HOOK IS AT RAIL ON MAIN DECK. KEEP CONE BELOW WAVE ACTION.
6. PICK-UP ON LINES (1) & (6) WITH TRAVELLING BLOCK UNTIL ALL SLACK IS OUT OF LINES.
7. WITH CUTTING TORCH, CUT ONE EYE OFF LINE (6) AT "WHIPLINE" HOOK TO LET LINE (6) STRIP THRU RING ON LINES (1) & (6).
8. PICK-UP ON LINES (1) & (6) UNTIL LINES (7) & (8) MAKE UP WITH LINES (1) & (6).
9. REMOVE LINES (1) & (6).

**FIGURE #15**
6. Assure lines are not fouled on reflectors. Lower cone quickly while hauling in on keelhaul lines. When ball on whip line is even with bulwark, cut one 3/4" line below eye with cutting torch and retrieve entire line.

7. Pick up on keelhaul line carefully and shackle doubled lifting slings from cone onto sling prepared to receive same in moon pool.

8. Secure reentry cone in moon pool (Fig. 16).
KEELHAUL RE-ENTRY
GUIDE CONE

MUDLINE

SEDIMENT

FIGURE 16
B. Running 16" Casing

The length of the 16" casing string is affected by two factors:
1) the condition of the ocean floor as determined by an exploratory core hole (i.e. the depth of penetration possible without rotation), and 2) the anticipated length of the 11 3/4" surface casing. The amount of 16" conductor recommended to effectively support (through skin-friction) the 11 3/4" casing will be based on the corehole depth and Figure #4.

NOTE: Casing aboard the Challenger is usually rusted due to exposure in storage. The casing should be thoroughly cleaned in the elevator area prior to running.

1. After the casing length is determined, the lower joint is cut to fit keeping in mind that the bit should be spaced out to be at the casing shoe.

2. The casing shoe is welded on the lower joint.

3. All threaded casing connections will be glued and/or tack-welded.

   a. Mill made up collars are to be tack welded before beginning to run casing (2" passes in three places). Any casing tack welded should not be run into the water until it is cool (200 F.±).

   b. Baker-Lok must be applied on a completely clean and dry thread.

4. Remove the collar from the last casing joint and weld a false collar (stop ring) 12" below the threads to prevent the casing string from passing through the slips set in the rotary table.

5. Prior to installing the 16" casing hanger, grease the 16" latch ring and the entire hanger to facilitate landing in the reentry cone. With the 30° taper down, slip the latch ring over the 16" transition sub and engage in the hanger groove. Install the 16" outer and inner retaining rings, P/N 102636 & 102637, per the matchmarks and fasten together with the 3/8" X 5/8" long UNF cap screws.

NOTE: Refer to the special operating procedure for installing the latch rings.
6. Makeup the 16" casing hanger on the last joint of 16" casing using the casing clamp and doubled one inch slings provided (10' minimum) and land the hanger on top of the support plate situated in the lower horn section (Figure 17).
MAKE-UP 16" CONDUCTOR PIPE TO CASING HANGER AND HANG OFF ON ELEVATORS IN MOON POOL.
C. Bottomhole Assembly

1. The bottomhole assembly is made up including a 15" bit and the 16" casing running tool (Figure 18). The casing running tool is made up in the bottomhole assembly so that when engaged in the 16" casing hanger, the core bit will be at the casing shoe (Figure 19). This usually requires that the casing length be fitted to the bottomhole assembly and the shoe joint cut to proper length prior to running the casing.

2. Makeup the lowering and index subs on the assembly plate provided (consisting of an NC-61 thread protector welded to a 24" square plate). Lower the latch groove ring over the subs and rest on the plate. Place the latch sleeve over the assembled running tool and shoulder on the index sub. Lift the latch groove ring up to shoulder on the latch sleeve and hold in place with 7/8" NC bolts provided. The latch sleeve is rotated until the windows in the latch sleeve and the slots in the lowering sub line up.

3. The sliding sleeve is raised until the three spring clips lock and hold it in the up position. After the rollers are aligned correctly, release two of the spring clips simultaneously. Turn the paddles to the in or latched position verifying that the rollers remain correctly aligned. The third spring clip holding the sliding sleeve is released allowing sleeve to slide down locking the paddles in place (Drawing DOT 102196). At times, the sleeve may have to be forced down.

4. Releasing is checked by lowering the shifting tool into place with the sandline and shifting the sleeve to release the paddles.

5. The paddles are reengaged and checked for latching by attempting to rotate the lowering sub in the latch sleeve. Disengage and remove all the 7/8" bolts holding the latch groove ring.

6. Lift the shoulder ring over the assembly and lower onto the top of the latch sleeve.

NOTE: Steps #2 through #6 are to be accomplished before picking up drill collars.
MAKE-UP 16" CASING RUNNING TOOL IN BHA. ENGAGE LATCH SLEEVE WITH RUNNING TOOL.

GUIDE CONE

16" CASING RUNNING TOOL

16" CSG. HANGER

16" CONDUCTOR PIPE

MUD LINE

SEDIMENT

FIGURE 18
7. A drill collar is added to the bottomhole assembly and the lowering and index subs are made up to a bumper sub. The assembly is lowered through the table until the latch sleeve is just above the 16" casing hanger.

8. The latch sleeve is now eased into the 16" casing hanger until it is seated. The shoulder ring is made up using the two 3/4" holes and tack welded (Dwg. DOT 102196, Figure 19).

9. The 16" casing assembly is then lowered slowly into the reentry cone and latched (Figure 20). On the earlier (1975) cone design, a significant frictional drag occurs as the latch ring is lowered through the lower cone section. This condition has been basically eliminated in the new (1976) cones in that the cone bore and the latch ring OD will come into contact only in the last three inches of travel. Verify the engagement by lifting the entire assembly. Before proceeding shake the assembly several times.

NOTE: In case of current, allow ship to drift off station to assure proper alignment.

10. When ready to lower cone, one side of each doubled keelhaul sling is cut below the eye and the wire retrieved.
ANDING LATCH SLEEVE
16" CASING HANGER
MAKE-UP SHOULDER
RING AND TACK WELD.

GUIDE CONE

16" CONDUCTOR PIPE

MUD LINE

SEDIMENT

FIGURE 19
LOWER 16” CONDUCTOR PIPE & HANGER INTO CONE & ENGAGE LATCH.

GUIDE CONE

16” CONDUCTOR PIPE

MUD LINE

SEDIMENT

FIGURE 20
D. Running to Bottom

The remainder of the bottomhole assembly is picked up and the reentry cone run to bottom in normal manner, care being exercised not to lower the cone too rapidly. The lowering can be watched on the PDR to 6000 feet plus.

NOTE: After running to last 8 1/4" drill collar, pick up the diverter packoff assembly on the first 7 1/4" drill collar and run in on the drill string, using the 5 1/2" starter mandrel to install the diverter on the drill collar.

E. Washing in Casing

When the casing shoe is a few meters off bottom, the swivel and Bowen sub is picked up. Circulation is started and the casing string is washed in until the base of the reentry cone is resting on the ocean floor (Figure 21).

F. Release Reentry Cone and Casing

The shifting tool is run in on the 1/2" coring line with the normal retrieving hook up (refer to Appendix II for complete description of shifting tools). It is lowered until the drag blocks engage the index sub and the dogs are below the sliding sleeve. The coring line is pulled:

(1) The line pulls tight and released indicating the sliding sleeve moved to the released position.

(2) The line pulls tight and holds, indicating the sliding sleeve is in a bind. Normally, rotating the pipe left and right and raising and lowering the drill string will free the sleeve. As soon as the sleeve has been moved up, rotating the drill string to the right will force the paddles to rotate, releasing the drill string from the cone and the base.

G. Coring

Normal coring operations continue until dull bit forces first "tripping" operation or the desired casing depth has been reached. (Fig. 22). Fill hole with gel mud.

NOTE: With roller bits due regard to bearing life is required to avoid loss of hole gauge.
WASH-IN 16" CONDUCTOR PIPE W/ GUIDE BASE.

MUD LINE

SEDIMENT

1/6" CONDUCTOR

FIGURE 21
H. Tripping

Conduct normal "tripping" operations. Diverter packoff assembly is designed to be carried out on the first stand of drill collars. The latch sleeve should be allowed to ride to the rig floor on top of the lowering sub. The casing running tools are broken out of the bottomhole assembly at this time.

NOTE: Casing running tool and latch sleeve must be completely disassembled, washed with fresh water, oiled and wrapped in polyethylene.

I. Reentry

1. The drillpipe is run until the 15" bit is approximately 4-9 meters above the cone with a full stand up. A poor boy swivel is attached to the top of the drillpipe and fitted with a wireline stripper. It is necessary to circulate while running the scanning sonar tool. The large diameter (3 3/4") of the scanning sonar tool causes the tool to drop very slowly in the drillpipe without circulation and the wireline can easily be overrun.

2. The EDO high resolution scanning sonar instrument is attached to a Schlumberger cable head. The instrument and surface electronic gear are checked per the EDO Instruction Manual. The instrument is run to bottom and seated in the core barrel. Care must be exercised while running in so that the conductor cable does not overrun the instrument.

3. When the instrument is seated and scanning, the bit is guided over the cone by maneuvering the vessel. The bit height above the cone should be three to four meters. When the bit is directly over the cone, the drill string is slacked off allowing the bit to slide down the cone and be guided into the casing. Hold tension on Schlumberger line.

NOTE: If the drillpipe stops and verification of reentry is required, run collar locator or sidewall sampler.

4. Continue with normal coring operations until a 15" diameter hole has penetrated at least 50' into the basalt (or indurated sediment) or a dull bit forces second tripping operation.
J. Surface Casing String (11 3/4")

1. After making required penetration into basalt or indurated sediment, trip out of hole.

2. Make up and run on drillpipe sufficient 11 3/4" casing to place Halliburton cementing shoe within 50" of total depth. This will require approximately 1200" of casing (3000" maximum). Run casing centralizers 10" above the shoe and on the first collar. 
   NOTE: Make up and run the 11 3/4" casing expansion joint two joints below the last casing joint (Figures 23 and 24).

3. Remove the collar from the last casing joint and weld a false collar (stop ring) 12" below the threads.

4. Prior to installing the 11 3/4" casing hanger, grease the 11 3/4" latch ring to facilitate engagement with the latch groove ring. With the 30° taper down, slip the latch ring over the 11 3/4" transition sub and engage in the hanger groove. Install the 11 3/4" outer and inner retaining rings, P/N 102638 & 102639 per the matchmarks and fasten together with the 3/8" X 5/8" long UNF cap screws.

5. Make up the 11 3/4" casing hanger on the last joint of 11 3/4" casing (transition sub is provided with a 11 3/4" buttress box down).

6. Make up the 11 3/4" hex-kelly casing running tool in the 11 3/4" hanger by turning to the left until fully engaged (shouldered hand tight). Run 11 3/4" casing hanger to bottom and reenter cone by scanning sonar. Latch into the latch groove ring (Figure 25, DWG. DOT 101915). Pull up and verify that casing is latched.

7. Clean out to bottom of hole and check that hanger is all the way down (Figure 26).

8. Release from the 11 3/4" casing hanger by turning to the right with the hex-kelly in neutral (Figure 27).
-11\frac{3}{4}" CASING HANGER W/DOT. LEFT HAND THD.-

-2 JOINTS 11\frac{3}{4}" CASING-

-EXPANSION JOINT-

-HALLIBURTON GUIDE SHOE-

MAKE UP CASING
RUN DRILL PIPE, LOCATE SHOE AND MAKE UP LINER HANGER NUT.

FXURE 24
Run casing to immediately above re-entry cone, run sonar and re-enter hole.
CLEAN OUT TO BOTTOM AND CHECK THAT HANGER IS ALL THE WAY DOWN.

FIGURE 26
HANGER REMOVED

HALIBURTON LATCH DOWN PLUG

RELEASE FROM CAS'ING, CEMENT CAS'ING, BUMP PLUG.

FIGURE 27
9. Cement the casing in place through drillpipe with sufficient gel cement to fill annulus to the ocean floor. Last 100 sacks to be neat cement (refer to Appendix III-D).

NOTE: Wiper lock-down plug to be inserted in drillpipe 25 sacks prior to completing mixing.

10. Pull drillpipe, circulate residual cement out of drillpipe. Run 10" bit and reenter hole. Drill out cement and 11 3/4" casing shoe with standard core bit (Figure 28).

11. Core 10" diameter hole to depth as determined by shipboard scientists (Figure 29).
SONAR GUIDED DRILL BIT FOR RE-ENTER'Y

HALLIBURTON PLUG LATCH

PULL DRILL PIPE, CIRCULATE RESIDUAL CEMENT OUT OF PIPE AND RUN 'BIT.
MAKE-UP BHA WITH 10" CORE BIT RE-ENTER HOLE, CORE AND/OR DRILL TO DESIRED DEPTH.
D. RE-ENTRY CONE/DUAL CASING HANGER
PARTS LIST, DRAWINGS, SPECIFICATIONS
<table>
<thead>
<tr>
<th>DSDP</th>
<th>DOT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>OH 3000(D)</td>
<td>10219B</td>
<td>16&quot; Casing Landing Tool Assembly</td>
</tr>
<tr>
<td>OH 3001(D)</td>
<td>102018B</td>
<td>Latch Sleeve - 16&quot; Casing Landing Tool</td>
</tr>
<tr>
<td>OH 3002(C)</td>
<td>102019</td>
<td>Paddle Actuation</td>
</tr>
<tr>
<td>OH 3110(C)</td>
<td>102020B</td>
<td>Paddle</td>
</tr>
<tr>
<td>OH 3111(A)</td>
<td>102047</td>
<td>Roll Pin - 16&quot; &amp; 20&quot; Landing Tool</td>
</tr>
<tr>
<td>OH 3113(B)</td>
<td>102021B</td>
<td>Paddle Shaft</td>
</tr>
<tr>
<td>OH 3117(A)</td>
<td>102022A</td>
<td>Torsion Springs</td>
</tr>
<tr>
<td>OH 3300(D)</td>
<td>102026A</td>
<td>11-3/4&quot; Hex-Kelly Landing Tool Assembly</td>
</tr>
<tr>
<td>OH 3301(D)</td>
<td>101923C</td>
<td>11-3/4&quot; Hex-Kelly Landing Tool - Conceptual</td>
</tr>
<tr>
<td>OH 3305(C)</td>
<td>102024A</td>
<td>11-3/4&quot; Hex-Kelly Type Landing Tool</td>
</tr>
<tr>
<td>OH 3306(D)</td>
<td>102025A</td>
<td>11-3/4&quot; Landing Mandrel</td>
</tr>
<tr>
<td>OH 3307(B)</td>
<td>102023A</td>
<td>Bottom Sleeve</td>
</tr>
<tr>
<td>OH 4000(D)</td>
<td>101914B</td>
<td>Re-entry Guide Cone Assembly</td>
</tr>
<tr>
<td>OH 4005(D)</td>
<td>102027A</td>
<td>Re-entry Guide Cone - Upper Section</td>
</tr>
<tr>
<td>OH 4010(D)</td>
<td>102028A</td>
<td>Re-entry Guide Cone - Lower Section Assembly</td>
</tr>
<tr>
<td>OH 4011(C)</td>
<td>102029A</td>
<td>Re-entry Guide Cone - Lower Section</td>
</tr>
<tr>
<td>OH 4012(C)</td>
<td>102030</td>
<td>Cone Mud Skirt</td>
</tr>
<tr>
<td>OH 4013(B)</td>
<td>102031A</td>
<td>Lower Cone Reinforcing Web</td>
</tr>
<tr>
<td>OH 4014(B)</td>
<td>102032</td>
<td>Discharge Line Reinforcing Web</td>
</tr>
<tr>
<td>OH 4015(B)</td>
<td>102033A</td>
<td>24&quot; Cone Transition Section</td>
</tr>
<tr>
<td>OH 4016(C)</td>
<td>102034B</td>
<td>Cone Landing Collar</td>
</tr>
<tr>
<td>OH 4017(B)</td>
<td>102035A</td>
<td>Discharge Line - Lower Section</td>
</tr>
<tr>
<td>OH 4018(B)</td>
<td>102036A</td>
<td>Discharge Line - Connecting Collar</td>
</tr>
<tr>
<td>OH 4020(C)</td>
<td>102040A</td>
<td>Mud Skirt Extension</td>
</tr>
<tr>
<td>OH 4021(B)</td>
<td>102049</td>
<td>Mud Skirt Extension Stiffeners</td>
</tr>
<tr>
<td>OH 4030(C)</td>
<td>102037</td>
<td>Discharge Line - Upper Section</td>
</tr>
<tr>
<td>OH 4040(C)</td>
<td>102038</td>
<td>Passive Reflector, 3'</td>
</tr>
<tr>
<td>OH 4042(C)</td>
<td>102039</td>
<td>Reflector Support Bracket</td>
</tr>
<tr>
<td>OH 4043(A)</td>
<td>101914S</td>
<td>Bolting Specification - DSDP Re-entry Cone</td>
</tr>
<tr>
<td>OH 4190(D)</td>
<td>101915(C)</td>
<td>11-3/4&quot; x 16&quot; Casing Hanger Assembly - Conceptual</td>
</tr>
<tr>
<td>OH 4200(D)</td>
<td>102012B</td>
<td>16&quot; Casing Hanger Assembly</td>
</tr>
<tr>
<td>OH 4201(D)</td>
<td>102013F</td>
<td>16&quot; Casing Hanger Body</td>
</tr>
<tr>
<td>OH 4202(C)</td>
<td>102014</td>
<td>16&quot; Casing Transition Sub</td>
</tr>
<tr>
<td>OH 4210(C)</td>
<td>102015C</td>
<td>Shoulder Ring, 16&quot; &amp; 20&quot; Casing Hangers</td>
</tr>
<tr>
<td>OH 4215(C)</td>
<td>102016C</td>
<td>Latch Groove Ring</td>
</tr>
<tr>
<td>OH 4220(C)</td>
<td>102017C</td>
<td>Latch Ring, 16&quot; &amp; 20&quot; Casing Hangers</td>
</tr>
<tr>
<td>OH 4221(C)</td>
<td>102636</td>
<td>Outer Retaining Ring, 16&quot; &amp; 20&quot; Casing Hangers</td>
</tr>
<tr>
<td>OH 4222(D)</td>
<td>102227</td>
<td>Casing Elevators, 16&quot; &amp; 20&quot; Casing Hangers</td>
</tr>
<tr>
<td>OH 4300(D)</td>
<td>102000C</td>
<td>11-3/4&quot; Casing Hanger Assembly - 11-3/4&quot; X 16&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH 4301(D)</td>
<td>102001D</td>
<td>11-3/4&quot; Casing Hanger Body</td>
</tr>
<tr>
<td>OH 4302(D)</td>
<td>102002</td>
<td>11-3/4&quot; Casing Hanger Transition Sub</td>
</tr>
<tr>
<td>OH 4303(A)</td>
<td>102004A</td>
<td>Transition Sub Fins</td>
</tr>
<tr>
<td>OH 4320(C)</td>
<td>102033C</td>
<td>11-3/4&quot; Latch Ring</td>
</tr>
<tr>
<td>OH 4321(C)</td>
<td>102638</td>
<td>11-3/4&quot; Outer Retaining Ring</td>
</tr>
<tr>
<td>OH 4400(D)</td>
<td>101924A</td>
<td>11-3/4&quot; Casing Expansion Joint</td>
</tr>
<tr>
<td>OH 4401(C)</td>
<td>102005A</td>
<td>13-3/8&quot; Barrel Assembly</td>
</tr>
<tr>
<td>OH 4402(C)</td>
<td>102006B</td>
<td>13-3/8&quot; Barrel</td>
</tr>
<tr>
<td>OH 4403(B)</td>
<td>102007</td>
<td>Barrel Insert</td>
</tr>
<tr>
<td>OH 4404(C)</td>
<td>102008</td>
<td>Bottom Sub</td>
</tr>
<tr>
<td>OH 4405(C)</td>
<td>102009A</td>
<td>11-3/4&quot; Mandrel</td>
</tr>
<tr>
<td>OH 4406(C)</td>
<td>102010A</td>
<td>11-3/4&quot; Mandrel Head</td>
</tr>
<tr>
<td>OH 4407(C)</td>
<td>102011B</td>
<td>Packing Retainer</td>
</tr>
<tr>
<td>OH 4408(A)</td>
<td>101924S</td>
<td>Packing Specification - 11 3/4&quot; Casing Expansion Joint</td>
</tr>
<tr>
<td>OH 4500(D)</td>
<td>102041</td>
<td>Diverter Packoff Assembly</td>
</tr>
<tr>
<td>OH 4501(D)</td>
<td>102042B</td>
<td>Diverter Packoff Body</td>
</tr>
<tr>
<td>OH 4505(D)</td>
<td>102044</td>
<td>Drill Pipe Packer</td>
</tr>
<tr>
<td>OH 4506(D)</td>
<td>101993</td>
<td>Bolt Ring</td>
</tr>
<tr>
<td>OH 4507(D)</td>
<td>102043A</td>
<td>Packer Molding Ring</td>
</tr>
<tr>
<td>OH 4508(A)</td>
<td>102041S</td>
<td>Packer Specification - Diverter Packoff Assembly</td>
</tr>
<tr>
<td>OH 4509(B)</td>
<td>102226</td>
<td>Starting Mandrel - Diverter Packoff Assembly</td>
</tr>
<tr>
<td>OH 4600(C)</td>
<td>102046</td>
<td>Ring/Plug Gauge #159 (DOT Safety Thread)</td>
</tr>
<tr>
<td>OH 4601(C)</td>
<td>102266</td>
<td>Ring/Plug Gauge #168 (Shoulder Ring)</td>
</tr>
</tbody>
</table>
RECOVERABLE LATCH
CASING HANGER ASSEMBLY
FOR USE WITH 27/64" CASING ROLLING TOOL
AND 1-1/4" O.D. 75 LBS/FT. 3/16" WALL CASING
1. PRE-HEAT TO 600°F.
2. ARC WELD STOOGY 3/6 x 3/4 THK AND GRIND (1/6). 
3. REHEAT TO 1510°F AND OIL QUENCH.
\[
\frac{1}{32} \times 45^\circ \text{ CHAMFER (TYP)}
\]

*FOR PRESS FIT W/P/N OH 3110*
PART NO. OH 3115

- 9/32 DRILL-THRU

1/8" BLIND HEAVY HEX. NUT

2.093 (REF.)

SHAFT - 11/2" CSG. LANDLUG TOOL
U.C. S.A. DEEP SEA DRILLING PROJECT

REV. MILLIUM

DRAFTED BY
J. HUMPHREYS
3-14-75

CHECKED BY
J. HERKEN
3-14-75

SCALE 1"=1'-0"
SPECIFICATION - HELICAL TORSION SPRING

Wire Diameter: 1/4" Ø
Spring O.D. (Free): 1.900"
Active Coils: 7
Free Height: 2.000
Torque @ 180°: 408 in/#
To work in 2.000" dia. hole
To work over 1.125" dia. shaft
All Tolerances: Commercial
Straight offset ends, 3/4" Long, squared and ground smooth.
Left-Hand Wind

DO NOT SCALE DWG

PART NO. OH 3117

DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
TORSION SPRING
16" Casing Hanger Landing Tool Ass'y.

SURFACE TREATMENT
Cad. Plate
HEAT TREATMENT
ASTM A-228

DRAWN BY J.H. GERKEN 8/22/75
CHECKED BY W. GERKEN 8/22/75

SCALE 102196

REV 2
Torch cut
9 1/2" dia. hole
on 86" B.C.
3 holes @ 120°

7/8" dia. hole
12 places
on 86" B.C.
Stringed

Weld detail "W"
Full scale
TORCH CUT HOLES TO MATCH I.D. OF DISCHARGE LINE: LOWER SECTION PAU OH 4017.
3 HOLES, TYPICAL
NOTE: MACHINE SURFACES TO BE TRUE WITHIN .003 T.I.R.
NOTE:
THIS PIECE
SAME AS PART ON
"REFLECTOR SUPPORT
PLATE" PN OH 4642

GUSSET
2 REQ'D PER
UPPER SECT.

1/8 DIA. HOLE
B PLCS, TYP.

3 REQ'D PER CONE.

O H 4030-1

DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
DISCHARGE LINE UPPER SECTION
UC, SAN DIEGO-DEEP SEA DRILLING PROJ.

DIMENTION
L. J. CARDINAL 3-8-76
J. H. LEREN 3-4-76
NOTED B C-OH4050 1
BOLTING SPECIFICATION
DSDP Reentry Cone System (1976)

A. 3/4"-10NC x 2" Long Hex-Head Cap Screws, SAE Grade 5 (4140 Quenched and tempered steel) with heavy hex nuts and lockwashers; T.S. = 120,000#, P.L. = 85,000#.

<table>
<thead>
<tr>
<th>#</th>
<th>Fastener Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Upper Cone Flange Fastener</td>
</tr>
<tr>
<td>12</td>
<td>Upper-Lower Cone Fastener</td>
</tr>
<tr>
<td>12</td>
<td>Mud Skirt Extension</td>
</tr>
<tr>
<td>10</td>
<td>Mud Skirt Flange Fastener</td>
</tr>
<tr>
<td>24</td>
<td>(6) Passive Reflector Fasteners</td>
</tr>
<tr>
<td>24</td>
<td>(6) Reflector Brackets to Upper Cone Flange</td>
</tr>
<tr>
<td>9</td>
<td>(3) Reflector Brackets to Side Flange</td>
</tr>
</tbody>
</table>

B. 5/8"-11 NC x 5" Long Alloy Stud Bolts, (ASTM 193-87 Steel) with heavy hex nuts and lockwashers; T.S. = 125,000#, Y.S. = 105,000#.

<table>
<thead>
<tr>
<th>#</th>
<th>Fastener Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Drillpipe Packer to Diverter Body</td>
</tr>
</tbody>
</table>

C. 5/8"-11 NC x 1 1/2" Long Hex-Head Cap Screws, SAE Grade 2 (ASTM 307-B steel) with finished hex nuts and lockwashers; T.S. = 64,000#, P.L. = 52,000#.

<table>
<thead>
<tr>
<th>#</th>
<th>Fastener Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Cone Packer to Diverter Body</td>
</tr>
</tbody>
</table>

D. 3/4"-10 NC x 5" Long Hex-Head Cap Screws, SAE Grade 5 with heavy hex nuts and lockwashers; T.S. = 120,000#, P.L. = 85,000#.

<table>
<thead>
<tr>
<th>#</th>
<th>Fastener Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>(3) Mud Skirt Extension Stiffeners</td>
</tr>
</tbody>
</table>

E. 7/8"-9 NC x 1 3/16" Long Hex-Head Cap Screws, SAE Grade 5; T.S. = 115,000#, P.L. = 78,000#.

<table>
<thead>
<tr>
<th>#</th>
<th>Fastener Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>a. Retains latch groove ring on latch sleeve while engaging paddles beneath ring.</td>
</tr>
<tr>
<td></td>
<td>b. Disengages 16&quot; casing hanger from cone landing collar during testing.</td>
</tr>
<tr>
<td></td>
<td>c. Disengages 11 3/4&quot; casing hanger from latch groove ring during testing.</td>
</tr>
</tbody>
</table>

F. 3/8"-24 NF X 5/8" Long Unbrako Socket-Head Cap Screws, Series 1960; Tensile Strength = 190,000#.

<table>
<thead>
<tr>
<th>#</th>
<th>Fastener Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>(2) Latch Retaining Rings</td>
</tr>
</tbody>
</table>
WELDING PROCEDURE:

PROVIDING TO WELDING, A MINIMUM DISTANCE OF 8" EACH SIDE OF THE WELD SHALL BE PREHEATED TO A TEMPERATURE OF 400°F - 600°F. THE PREHEAT TEMPERATURE SHALL BE MAINTAINED UNTIL WELDING IS COMPLETE. AFTER COMPLETING THE WELD, THE WELD AND ADJACENT AREA, 1" EACH SIDE OF THE WELD, SHALL BE SLOWLY COOLED IMMEDIATELY BY NEUTRAL TO A TEMPERATURE OF 1100°F - 1200°F. THE STRESS RELIEVING TEMPERATURE SHALL BE MAINTAINED FOR A PERIOD OF 24 HOURS, TEMPERATURE TO BE WATERTAKEN BY "TEMPERATURE".

IN ALL CASES, ALLOW TO COOL SLOWLY IN AIR UNTIL HEAVIEST PART HAS REACHED A TEMPERATURE LESS THAN 300°F BEFORE PERMITTING ANY LOAD TO BE APPLIED AND BELOW 300°F BEFORE PERMITTING ANY LOAD TO BE APPLIED AND BELOW 300°F BEFORE PERMITTING ANY QUENCHING.

WELDING ELECTRODE: E-7018

NOTE: WELD AS SHOWN
NOTE: MACHINE SURFACES TO BE TRUE AS T.I.R.
NOTE: MACHINE SURFACE TO BE TRUE .005 T.I.R.
FABRICATION INSTRUCTIONS

1. BALL 1" MILD STEEL, B 2" 1" 6" 7.25 8" 9" 10"
2. FLANGE CUT ELEVATOR WELDS, DRILL & COUNTERSINK
3. BOLT ELEVATOR WELDS TOGETHER, USE 2" BOLTS & WASHERS FOR STABILITIES
4. WELD WELDS TO CEMENTEX - EXTERNAL WELDS ONLY
5. FINISH CUT CYLINDER TO HOLE AS SHOWN, INSIDE INTERNAL WELDS & SMOOTH
6. ASSEMBLE TAIL (WITHOUT 2" WASHERS) & MACHINE T.D. TO 17.15"
LET A TAP GROSS: 40 DP
BY: K. LIP THD: 16 OA
8 PLACES AS SHOWN

REMOVE IMPERFECT THD.
BY GRINDING

DEEP DR. MODIFIED BETWEEN THD. Cuts
Left Hs: 15.7" Thd: 1.123 Pitch: 18°-55°
Used Gage: +303
Anvil: Material

Thickness Map
NOTE:
WELD TO 12 3/4" O.D. & TURN 14.94 O.D.

PART NO. OH 4303-1

DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY

11 3/4"-CSG.. TRANSITION SUB FIN.
U.C. SAN DIEGO DEEP SEA DRILLING PROJ.

MATERIAL: MILD STEEL

DRAWN BY: J. MURPHY 3/10/75
CHECKED BY: J. GERKEN 8-12-75
SCALE: HALF-1/2'-1"

REV

Heat Treatment

Material: Mild Steel

Revision: A-0H4303-1
WELDING PROCEDURE

Previous to welding, a minimum distance of 2" each side of the weld shall be preheated to a temperature of 400°F - 500°F. The preheat temperature shall be maintained until welding is complete. After completing the weld, the weld and adjacent area, 4" each side of the weld, shall be stress relieved immediately by heating to a temperature of 1100°F - 1250°F. The stress relieving temperature shall be maintained for a minimum of one-half hour. Temperature to be indicated by "Tempilstiks". If unusual conditions make it impossible to attain the minimum temperature listed, the highest temperature attainable should be held for one-half hour. In all cases, allow to cool slowly in air until heaviest part has reached a temperature less than 500°F before permitting any load to be applied and below 300°F before permitting any quenching.

Welding electrode E-7018

NOTE:
Bottom sub (PN OH4404) to be welded on after insertion of mandrel (PN OH4405) and mandrel head (PN OH4406) assy. Into barrel assy. (PN OH4401) see thru. OH4400. OH4401-2
NOTE: TO FIT 13 3/8 BARREL
(PART NO. OH 4402)

PART NO. OH 4403-1

DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
BARREL TUBING - 11 3/4 x 13 3/4 EXP. JOINT
U.C. SAN DIEGO - DEEP SEA DRILLING PROJ.
R. BLACK 3-1275
R. H. GERKEN 3-475
MILD STL.

SCALE 1/2" = 1'-0"
△ Note: To fit 13 3/8 barrel (Part No. OH 4402)

Note: Machine surfaces to be true .003 T.I.R.

Note: All buttress casing threads to be cut in a shop licensed to use the API monogram or other Univ. of Calif. at San Diego (DSDP) approved shop.

Deep Sea Drilling Project
Scripps Institution of Oceanography

Part No. OH 4404-1

Nominal 2 1/4\nParcolubrite
AISI A-4130 STL
COH C4404-1
NOTE:
ALL BUTTRESS CASING THDS TO BE CUT IN A
SHOP LICENSED TO USE THE API MONOGRAM OR
OTHER. UNIV. OF CALIF. AT SAN DIEGO (DSDP)
APPROVED SHOP.

11.75" BUTTRESS
O.D. THD.
TYR BOTH ENDS

STAMP CIRCUMFERENTIALLY:
OH-4405-1

11.75"
O.D.

10.88A
I.D.

4.76"

15.5"

4.76"

1/8 + 45"
TYR BOTH ENDS

1) POLISH O.D. OF CASING AFTER MACHINING THREADS
NOTES:

PART NO. OH-4405-1

DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY
11.75" N.A.
11.75" EXPANSION WING
U.C. SAN DIEGO-DEEP SEA DRILLING PROJ

10.88A I.D.

11.75", 54" K.S.S. CASING
X C-OH-4405-1
NOTE:
ALL BUTTRESS CASING THREADS TO BE CUT IN A SHOP LICENSED TO USE THE A.R.I. MONOGRAM OR OTHER UNIV. OF CALIF. AT SAN DIEGO (DSDP) APPROVED SHOP.

NOTE: MACHINE SURFACES TO BE TRUE .003 T.I.R.
PACKING SPECIFICATION

11-3/4" Casing Expansion Joint

Manufacturer: Garlock
Packing Type: 3/0" Rope
Packing Style: #5862
Composition: Long-fiber asbestos yarn with TFE impregnation and white lubricant.
Max. Temp: 500° F
PART No. OH 4506

DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY

BOLT RING - DRILL PIPE PACKER
U.C. SAN DIEGO - DEEP SEA DRILLING PROJECT

DIMETCOTE 94

MATERIAL: MILD STEEL

REV. B - OH 4506
DIVERTER PACKOFF ASSEMBLY

Packer Specifications

A. Cone Packer (P/N 102043)

General Electric RTV-664 (or RTV 630) Silicone Liquid Rubber Molding Compound with mild steel molding ring. SS-4155 Primer required.

Typical cured properties:

Physical Strength, 48 hours at room temperature:
- Tensile, psi: 750
- Elongation, %: 280
- Durometer, Shore A: 60
- Tear, Die B, #/in.: 100

B. Drillpipe Packer (P/N 102044)

Shaffer Type RS 55-66 Stripper Rubber, or equal. Natural rubber composition (Shaffer P/N 143232).

Size of drillpipe: 5 1/2" thru 6 5/8"
Stripper rubber expands to 8" OD.
L.H. 12". 3/4 THD. - 1.333 PITCH - 15° MOD. BUTT. STRT.

4 1/4 DR. - 4 1/4 DEEP. 4 HOLE @ 90°

9/16 x 45° TYP.

11 1/4 DIA.

4 1/2 THD. 45°

STAMP:
DEEP OIL GA 159
L.H. 12". 3/4 THD. - 1.333 PITCH - 15° MOD. BUTT. STRT.

NOTE:
RILEB GAGE TO FIT PLUG WITH 1/4 AXIAL MOVEMENT

PART No OH4600-0

DEEP SEA DRILLING PROJECT
SCRIPPS INSTITUTION OF OCEANOGRAPHY

GAGE 159 MOD. BUTT.
L.H. 12". 3/4 THD. - 1.333 PITCH - 15° STRT.

scale: 1/4" = 1"
### TABLE II

**CASING SPECIFICATIONS**  
OG - 0320  
September 29, 1983

<table>
<thead>
<tr>
<th>Size</th>
<th>Weight/lb/ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 3/4&quot;</td>
<td>54</td>
</tr>
<tr>
<td>16&quot;</td>
<td>75</td>
</tr>
<tr>
<td>20&quot;</td>
<td>94</td>
</tr>
</tbody>
</table>

K-55 or J-55, Range 2 Casing w/Buttress Threads

Manufactured in accordance with API Specification 5A.

Couplings to be locked w/Baker-Lok epoxy.

Maximum permissible length for each joint 32' OAL.

Vendor to supply thread protectors.
II. TRIPLE CASING HANGER SYSTEM
A. RE-ENTRY CONE/TRIPLE CASING HANGER SYSTEM DESCRIPTION
RE-ENTRY CONE/TRIPLE CASING STRING DESCRIPTION

The Triple Casing Re-entry System builds on the highly successful Dual Casing System in operation since December 1975 (Leg 45). Whereas the Dual Casing System is limited to a 16" Conductor string and a single 11-3/4" string of surface casing, the Triple Casing System utilizes a 20" conductor allowing the use of two protective strings of casing; 11-3/4" and 16" (Figure 30). The need for this second protective string became apparent on earlier sites where intervals of unstable hole were encountered deeper in the sediment column, below the already cemented 11-3/4" casing string. The Triple Casing String System now allows an additional string of protective casing to be emplaced when more than one unstable area exists in the formation.

The Deep Sea Drilling Project, aided by Mr. William Fischer (Independent Consultant), developed concepts for the Triple Casing Hanger Re-entry System late in 1976. In 1977, the concept was finalized and Deep Oil Technology (now Fluor Subsea Systems) was commissioned to prepare machine drawings suitable for use in the fabrication of the prototype assembly.

Upon completion of the drawings and specifications, a prototype assembly was fabricated and Latch-In clearance tests were conducted at the DSDP facility. Having successfully completed these shore based tests, the system was approved for sea trials aboard the GLOMAR CHALLENGER. Since no re-entry location appropriate for the sea trials testing of the system was forthcoming, the testing was not completed. Therefore, the operational readiness of the Triple Casing String System awaits further shipboard deployment and testing.
SEAFLOOR

DRILL STRING

SONAR REFLECTORS

RE-ENTRY CONE

MUD SKIRT

RE-ENTRY CONE & 20" CASING "JETTED-IN" 10-50 meters

16" CASING CEMENTED 50-300 meters

11 3/4" CASING CEMENTED 300-1000 meters

18 7/8" HOLE

14 7/8" HOLE

9 7/8" HOLE

REENTRY CONE/TRIPLE CASING HANGER ASSEMBLY

FIG. 30

-165-
B. RE-ENTRY CONE/TRIPLE CASING HANGER
PARTS LIST, DRAWINGS, SPECIFICATIONS
# RE-ENTRY CONE/TRIPLE CASING HANGER SYSTEM

## PARTS, DRAWINGS AND SPECIFICATIONS

### I. TRIPLE CASING HANGER SYSTEM

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OH D4700</td>
<td>Assembly - Re-entry Cone &amp; 20&quot; x 16&quot; x 11-3/4&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH D4701</td>
<td>Assembly - 20&quot; x 16&quot; x 11-3/4&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH D4702</td>
<td>Landing Assembly - Re-entry Cone &amp; 20&quot; Casing</td>
</tr>
<tr>
<td>OH D4703</td>
<td>Assembly - 20&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH D4704</td>
<td>Body - 20&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH D4705</td>
<td>Transition Sub - 20&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH C4706</td>
<td>Latch Groove Ring - 20&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH D4707</td>
<td>Landing Assembly - 16&quot; Casing</td>
</tr>
<tr>
<td>OH D4708</td>
<td>Assembly - 16&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH D4709</td>
<td>Body - 16&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH C4710</td>
<td>Transition Sub - 16&quot; Casing Hanger</td>
</tr>
<tr>
<td>OH C4711</td>
<td>16&quot; Latch Retaining Ring (20&quot; x 16&quot; Assembly)</td>
</tr>
<tr>
<td>OH D4712</td>
<td>Landing Assembly - 11-3/4&quot; Casing</td>
</tr>
<tr>
<td>OH D4713</td>
<td>16&quot; Hex - Kelly Landing Tool Assembly</td>
</tr>
<tr>
<td>OH D4714</td>
<td>16&quot; Bushing for 11-3/4&quot; Hex-Kelly</td>
</tr>
<tr>
<td>OH D4715</td>
<td>Assembly - 20&quot; Paddle Type Landing Tool</td>
</tr>
<tr>
<td>OH D4716</td>
<td>Latch Sleeve - 20&quot; Paddle Type Landing Tool</td>
</tr>
<tr>
<td>OH D4717</td>
<td>20&quot; Paddle Actuation</td>
</tr>
<tr>
<td>OH C4718</td>
<td>Paddle - 20&quot; Paddle Type Landing Tool</td>
</tr>
<tr>
<td>OH D4719</td>
<td>15-7/8&quot; O.D. Modified Buttress Thread Gauge</td>
</tr>
<tr>
<td>OH B4720</td>
<td>Ribs - 16&quot; Casing Hanger Assembly</td>
</tr>
<tr>
<td>OH D4721</td>
<td>Re-entry/Triple Casing String System</td>
</tr>
</tbody>
</table>

### II. TRIPLE/DUAL CASING HANGER SYSTEM (Common)

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OH A3111</td>
<td>Roll Pin - 20&quot; &amp; 16&quot; Landing Tools</td>
</tr>
<tr>
<td>OH B3115</td>
<td>Paddle Shaft</td>
</tr>
<tr>
<td>OH A3117</td>
<td>Torsion Springs</td>
</tr>
<tr>
<td>OH D3300</td>
<td>11-3/4&quot; Hex-Kelly Landing Tool Assembly</td>
</tr>
<tr>
<td>OH C3305</td>
<td>11-3/4&quot; Hex-Kelly Type Landing Tool</td>
</tr>
<tr>
<td>OH D3306</td>
<td>11-3/4&quot; Landing Mandrel</td>
</tr>
<tr>
<td>OH B3307</td>
<td>Bottom Sleeve</td>
</tr>
<tr>
<td>OH D4005</td>
<td>Re-entry Guide Cone - Upper Section</td>
</tr>
<tr>
<td>OH D4010</td>
<td>Re-entry Guide Cone - Lower Section</td>
</tr>
<tr>
<td>OH C4011</td>
<td>Re-entry Guide Cone - Lower Section</td>
</tr>
<tr>
<td>OH C4012</td>
<td>Cone Mud Skirt</td>
</tr>
<tr>
<td>OH B4013</td>
<td>Lower Cone Reinforcing Web</td>
</tr>
<tr>
<td>OH B4014</td>
<td>Discharge Line Reinforcing Web</td>
</tr>
<tr>
<td>OH B4015</td>
<td>24&quot; Cone Transition Section</td>
</tr>
<tr>
<td>OH C4016</td>
<td>Cone Landing Collar</td>
</tr>
<tr>
<td>OH B4017</td>
<td>Discharge Line - Lower Section</td>
</tr>
<tr>
<td>OH B4018</td>
<td>Discharge Line - Connecting Collar</td>
</tr>
<tr>
<td>OH C4020</td>
<td>Mud Skirt Extension</td>
</tr>
<tr>
<td>OH B4021</td>
<td>Mud Skirt Extension - Stiffeners</td>
</tr>
<tr>
<td>OH C4030</td>
<td>Discharge Line - Upper Section</td>
</tr>
<tr>
<td>OH C4040</td>
<td>Passive Reflector, 3'</td>
</tr>
<tr>
<td>OH C4042</td>
<td>Reflector Support Bracket</td>
</tr>
<tr>
<td>OH A4043</td>
<td>Bolting Specification - DSDP Re-entry Cone</td>
</tr>
<tr>
<td>OH C4210</td>
<td>Shoulder Ring, 16&quot; &amp; 20&quot; Casing Hangers</td>
</tr>
<tr>
<td>OH C4220</td>
<td>Latch Ring, 16&quot; &amp; 20&quot; Casing Hangers</td>
</tr>
<tr>
<td>OH C4221</td>
<td>Outer Retaining Ring, 16&quot; &amp; 20&quot; Casing Hangers</td>
</tr>
<tr>
<td>OH D4222</td>
<td>Casing Elevators, 16&quot; &amp; 20&quot; Casing Hangers</td>
</tr>
<tr>
<td>OH D4301</td>
<td>11-3/4&quot; Casing Hanger Body</td>
</tr>
<tr>
<td>OH D4302</td>
<td>11-3/4&quot; Casing Hanger Transition Sub</td>
</tr>
<tr>
<td>OH A4303</td>
<td>Transition Sub Pins</td>
</tr>
<tr>
<td>OH C4320</td>
<td>11-3/4&quot; Latch Ring</td>
</tr>
<tr>
<td>OH D4400</td>
<td>11-3/4&quot; Casing Expansion Joint</td>
</tr>
<tr>
<td>OH C4401</td>
<td>13-3/8&quot; Barrel Assembly</td>
</tr>
<tr>
<td>OH C4402</td>
<td>13-3/8&quot; Barrel</td>
</tr>
<tr>
<td>OH B4403</td>
<td>Barrel Insert</td>
</tr>
<tr>
<td>OH C4404</td>
<td>Bottom Sub</td>
</tr>
<tr>
<td>OH C4405</td>
<td>11-3/4&quot; Mandrel</td>
</tr>
<tr>
<td>OH C4406</td>
<td>11-3/4&quot; Mandrel Head</td>
</tr>
<tr>
<td>OH C4407</td>
<td>Packing Retainer</td>
</tr>
<tr>
<td>OH A4408</td>
<td>Packing Specification - 11-3/4&quot; Casing Expansion Joint</td>
</tr>
<tr>
<td>OH C4600</td>
<td>Ring/Plug Guage #159 (DOT Safety Thread)</td>
</tr>
<tr>
<td>OH C4601</td>
<td>Ring/Plug Guage #168 (Shoulder Ring)</td>
</tr>
</tbody>
</table>
1) Hardface with Stoody #6 or Equivalent 1/8 thick.
Grind to finished dimensions 1/4 surface finish.
3) 20° i. 0°. 0°.

STEEL SONAR REFLECTORS
3 FEET AT 120°

STANDARD CORR SEA TAILING
3 FEET AT 120°

MUD SHIRT

MUD SHIRT EXTENSION

CUTTINGS

9.5% CHA DISCHARGE PIPE
3 FEET AT 120°

1. 11 3/4" BUTTRESS STAB-IN FLOAT SHOE.
2. 16.5" BUTTRESS STAB-IN FLOAT SHOE.
3. 20" S.D.W. OPEN GUIDE SHOE.

Casing Hanger Assembly
Drawing No. D-OH4721

54" - 65" BUTTRESS CASING
SYNTHETIC PACE/4.0CEMENT
11 3/4" - 12" BUTTRESS CASING
CEMENTED IN 14 7/8" HOLE

11 3/4" EXPANSION JOINT

14 7/8" HOLE SIZE
CEMENT

14 7/8" HOLE SIZE
CEMENTED

11 3/4" - 24" BUTTRESS CASING
CEMENTED IN 14 7/8" HOLE

14 7/8" HOLE SIZE
CEMENTED

STANDARD 4 1/2" - 4 1/2" DRILL COLLAR ASSEMBLY
1 7/8" - 2 1/2" CORE BIT

RE-ENTRY/TRIPLE CASING STRING SYSTEM
DRAWING NO. D-OH4721
III. APPENDICES
A. Release Sub
The release sub, DSDP Dwg. RE-010, is placed (spaced out) in the bottom hole assembly so that the core bit will be at the casing shoe, preferably immediately below a bumper sub. This sub has three pockets on the outside into which the paddles of the casing hanger are rotated into. The paddles are locked in place by moving stop bolts alongside the paddles. These stop bolts are screwed into a sleeve in the bore of sub. The sleeve is shifted (moved up) by a special tool run on the 1/2 inch wire coring line. When the sleeve is up the paddles are free to rotate out of the pockets and when the sleeve is down, the paddles are locked in the pockets. Catches on the sleeve hold it in the up position after shifting.

B. Shifting Tools
A shifting tool, similar to those used to open and close sleeves in oil field production tubing, is used to release the downhole assembly from the base. The shifting sleeve (with stop bolts) is machined so that either the Rotary Oil Tool or the Baker Oil Tool shifting tool, will engage, shift, and release.

The tool is run in and retrieved with the same wireline used to retrieve cores. The Baker shifting tool has had a history of broken profile keys, and should only be considered as a backup to the Rotary tool.

1. Baker Oil Tool Company Equipment
The Baker Shifting Tool, Ref. Baker Oil Tool Dwgs. 204/865, DSDP Dwg. RE-12, is designed to move the shifting sleeve in the release sub to release the bottom hole assembly from the reentry cone.

A positioning groove is machined in the crossover sub on top of the release sub. Spring loaded profile keys in the Baker shifting tool expand into this groove when the tool is run in on the sand line. This stops downward motion of the tool and positions the shifting fingers slightly below the shifting sleeve in the release sub to
engage the sleeve. An upward pull on the sand line moves the sleeve to the release position and then collapses the fingers so the tool can be retrieved.

CAUTION: The spacing of the positioning groove, shifting sleeve, and profile keys and fingers on the tool are very critical. If the shifting tool jams the keys, ride up the taper in the positioning groove. Jarring action releases the fingers by shearing pivot pins.

2. Rotary Oil Tool Company Equipment
The Rotary Oil Tool sleeve shifting tool, DSDP Dwg. RE-019, is assembled as follows:

a. Place dog spring (3) in spring cavity in shifting dog (2). Insert dog and spring in slot in shifting tool body (1). Push forward until end of dog is under retainer lip of slot. The pin holes in the body and dog should now line up.

b. The dog pivot pins are next driven through the body and dog. If it is desired to have the pivot pins shear and release the dogs before parting the coring line, pins with reduced shear areas can be selected. The pin is retained by a 1/4" NC socket head cap screw. Drift holes are continued through one boss, so sheared section of the pivot pin can be removed with a drift.

C. Edo Western Model 516 High Resolution Scanning Sonar consists of the following units:

1. Surface Control Unit
2. Power Supply
3. Remote Display
4. Downhole Scanner-Transceiver
This equipment will locate and range underwater targets at ranges from two feet to 500 feet. The scanner-transducer must see the target and will operate through a 2 7/16 inch core bit. The signal is transmitted to the surface through a standard 7-conductor logging cable.

Edo Western's instruction manual No.13096, complete with blue line prints, covers the operation and maintenance of this equipment. A copy is onboard the Glomar Challenger.

D. Logging Cable and Logging Unit

The logging cable is standard 7-conductor double armour 15/32 inch diameter. The logging unit is the special unit designed by Schlumberger for Project Mohole. Instruction manuals for this unit are onboard the Glomar Challenger.
APPENDIX B

ACOUSTIC REENTRY

A. Method for Reentry Using Vessel's Positioning Equipment Only

1. Leave vessel in automatic mode of operation during all operations and leave vessel on same heading.

2. During all observations, make frequent notation of blip heading on sonar oscilloscope to assure that Edo Tool has not slipped in azimuth. Also, be certain that all observations or range and bearings are taken with the vessel centered over beacon display of computer oscilloscope. Observations on range and bearing should be made only after the drillpipe motion due to vessel excursion is minimal. (Normally this requires a minimum of 15 minutes without a major change in position).

3. All movements of vessel, range and bearing of target should be plotte on U.S. Navy maneuvering board HO 2665-20 with original positioning beacon plotted as center and the vessel's position in relation to this beacon plotted using any offsets previously put into computer. This must be done so that the final movements of the vessel by use of depth changes will be along a path angle in direct relation to the true position of the positioning beacon.

4. While using 500 foot scan on sonar oscilloscope locate target. With vessel directly centered over positioning beacon display on computer take initial range and bearing of reentry cone target. Plot the circle of observed range from the vessel's plotted position.

5. Make an arbitrary move of vessel by using offsets in one direction only, preferably as near as possible to the vessel's heading. (Vessel's heading will of necessity be determined by existing elements and has no significant effect upon the operation).

6. Observe whether offset move has increased or decreased the range of reentry cone target. If vessel's move has increased range, the arbitrary move was in the wrong direction. In this case, the offsets should be removed and opposite direction offsets should be put into...
computer. Offsets of 200 to 400 feet should be used depending upon the distance of the original observed range of the target. If there has been a substantial decrease in range of target, allow sufficient time for vessel and drill pipe to settle (minimum of 15 minutes) and then, by an average of new ranges on target, draw another circle of range from the vessel's newly plotted position. This circle will intersect the original plotted range circle at two locations either of which could be the potentially true position of reentry cone.

7. The approximate true position of the reentry cone target may now be ascertained by observing the apparent relative motion of the reentry target either to the right or left. The correct position is now selected.

8. After ascertaining the true position of the reentry cone, draw a line from the center of the plotting sheet (i.e., true position of the beacon) through the true position of the reentry cone.

9. Before any further movement of the vessel, plot three or more alternate coordinates of 100 foot offsets adjacent to the position of the reentry cone. Draw dotted lines from the center of the plotting sheet to the outer edge of the plotting sheet which passes through these coordinates. (It is along these lines that the vessel may be moved by altering depth settings).

10. If desired, at this point the drillpipe may be rotated to display azimuth as follows:

a. Plot the true position of the reentry cone target.

b. Calculate the relative bearing.

c. Rotate the drillpipe with chain tongs until the relative azimuth of the reentry cone is displayed in its proper position on the sonar oscilloscope.
NOTE: The above procedure may be desirable, however, in our present stage of evaluation of reentry capabilities, it is not a requisite.

11. By visual inspection of the plotted alternate coordinates, select that set of coordinates whose azimuth through the center of the plotting board most closely approaches the target. The vessel can be made to move in and out along these lines of azimuth by adjustment of water depth selections (approximately).

12. Now, move the vessel in 100 foot increments by "offsets" to your selected coordinates.

NOTE: A study is in process to modify the positioning system so that offsets as small as 10 feet can be used.

13. A brief exploration of the movements of the vessel by depth adjustments follows:

NOTE: This formula is approximate, but sufficiently accurate when used with small offsets in deep water.

a. To decrease range along plotted azimuth to beacon "increase" water depth.

b. To increase range from beacon "decrease" water depth.

c. The following formula may be used to pre-compute "closest point of approach" of reentry cone target.

\[
\text{Depth Setting Required} = \text{True Depth} \times \frac{\text{Range from Beacon}}{\text{New Range Desired}}
\]

or

\[
\text{Depth Setting Required} = \text{True Water Depth} \times \frac{\text{Coordinate Selected-Range from Beacon}}{\text{Desired Range (Over Cone) from Beacon}}
\]
EXAMPLE

In attached "example plot" the water depth is 13,000 feet. The coordinate selected range from beacon is 590 feet, the position of reentry cone target from beacon is 450 feet.

\[ X = 13,000 \text{ feet} \times \frac{590}{450} = 16,900 \text{ feet} \]

16,900 feet = required depth setting to place vessel over sonar reentry cone within 10 feet in example.

14. Now, after the vessel and bottom hole assembly has settled over new offset coordinates, increase or decrease depth settings as required to approach "CPA" of reentry cone target.

15. A third alternate should always be borne in mind and that is our capability of moving "forward" or "aft" along a line of azimuth with our heading a distance of approximately 54 feet by making alternate hydrophone selections.

16. The above explained method of reentry using vessel positioning only, does not preclude the future possibilities of movement in semi-automatic or manual modes of operation as our evaluation of ideas and techniques develop. However, at our present stage of development the automatic mode of operation appear by fare the most expeditious.

17. Please refer to attached plotting sheets for a graphic display of vessel and target movements.
## APPENDIX C
### COMPONENT WEIGHTS
DEEP SEA DRILLING PROJECT
REENTRY CONE/DUAL CASING HANGER SYSTEM

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th>Weights in Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>101924</td>
<td>11 3/4&quot; Casing Expansion Joint</td>
<td>1655</td>
</tr>
<tr>
<td>102000</td>
<td>11 3/4&quot; Circulating Casing Hanger</td>
<td>2125</td>
</tr>
<tr>
<td>102003</td>
<td>11 3/4&quot; Latch Ring</td>
<td>20</td>
</tr>
<tr>
<td>102012</td>
<td>16&quot; Casing Hanger Assembly</td>
<td>2700</td>
</tr>
<tr>
<td>102015</td>
<td>Shoulder Ring</td>
<td>150</td>
</tr>
<tr>
<td>102016</td>
<td>Latch Groove Ring</td>
<td>125</td>
</tr>
<tr>
<td>102017</td>
<td>16&quot; Latch Ring</td>
<td>25</td>
</tr>
<tr>
<td>102026</td>
<td>11 3/4&quot; Hex-Kelly Landing Tool Assembly</td>
<td>1625</td>
</tr>
<tr>
<td>102027</td>
<td>Reentry Guide Cone-Upper Section</td>
<td>3900</td>
</tr>
<tr>
<td>102028</td>
<td>Reentry Guide Cone-Lower Assembly</td>
<td>4000</td>
</tr>
<tr>
<td>102037</td>
<td>Discharge Line-Upper Section, 3 @ 350# ea.</td>
<td>1050</td>
</tr>
<tr>
<td>102038</td>
<td>Passive Reflector, 6 @ 175# ea.</td>
<td>1050</td>
</tr>
<tr>
<td>102039</td>
<td>Reflector Brackets, 3 @ 75# ea.</td>
<td>225</td>
</tr>
<tr>
<td>102040</td>
<td>Mud Skirt - Extension &amp; Stiffeners</td>
<td>2475</td>
</tr>
<tr>
<td>102041</td>
<td>Diverter Packoff Assembly</td>
<td>1500</td>
</tr>
<tr>
<td>102196</td>
<td>16&quot; Casing Landing Tool Assembly</td>
<td>1450</td>
</tr>
</tbody>
</table>

*Fully-Equipped Keel-Haul Weight*
APPENDIX D

CEMENTING PROGRAM

GLOMAR CHALLENGER

4% PRE-HYDRATED GEL-CEMENT

(Equivalent to 12% Dry Blend)

MIXING FLUID - GEL/WATER

Requires 31.46# of bentonite/100 gal fresh water or 13.21# bentonite/barrel of fresh water.

Weight of gel/water mix 8.5 PPG or 63.5 PCF

*To test fluid property take gel/water and add cement 7.85#/gal) and weigh the resultant slurry. It should be approximately 90-94 PCF or 12.0-12.4 PPG and a pumpable consistency. If this weight is low add water. If high, add bentonite.

TO MIX ONE CU. FT. OF SLURRY

5.7 gal gel/water
44.8 lbs cement

On the GLOMAR CHALLENGER, it is necessary to measure the mixing water as it is impractical to measure the amount of dry cement mixed.

EXAMPLE CALCULATION

Cement 700 ft of 11 3/4" of 54# casing in 15" hole through 15.095' of 5" 19.50# drill pipe with sufficient 4% pre-hydrated gel cement followed with 100 sx. API Class "H" cement to fill to the ocean floor and leave 80' of cement inside the casing.

HOLE-CASING ANNULUS VOLUME

11 3/4" x 15" = 0.4742 cu ft/lin ft

Theoretical Volume = 700 x 0.4742 = 332 cu ft

Excess 20% for wash outs = 66

Total = 398 cu ft
CASING VOLUME:

11 3/4" 54# = 0.6456 w. ft/lin ft

Volume = 0.6456 x 80 = 52 cu ft

REQUIRED VOLUME OF SLURRY

398 + 52 = 450 cu ft

NEAT CEMENT VOLUME

1.2 cu ft/sack = 120 cu ft

GEL CEMENT SLURRY

450-120 = 330 cu ft

GEL-WATER REQUIRED FOR MIXING

5.7 gal x 330 = 1881 gal

= 45 bbls

FRESH WATER REQUIRED FOR MIXING

5.4 gal x 100 sx = 540 gal

= 13 bbls

DISPLACEMENT VOLUME OF DRILL PIPE

0.01776 bbls/lin ft x 15.095' = 268 bbls
SCHEMATIC - CEMENTING EQUIPMENT
GLOMAR CHALLENGER
OPERATIONAL PROCEDURES

STEP #1

Mix 200 barrels of a gel - fresh water mix weighing 63.5 PCF (8.5 PPG) in 500 barrel storage tank. Test mixture with cement as shown on Page 1 of instructions.

STEP #2

Hook-up transfer line to valve #12 and fill measuring tanks with gel-water.

STEP #3

Check operation of unit by circulating measuring tanks set valves as follows:

Valve #1 - Open
Valve #2 - Open
Valve #3 - Closed
Valve #4 - Closed
Valve #5 - Open
Valve #6 - Closed
Valve #7 - Open
Valve #8 - Closed
Valve #9 - Open
Valve #10 - Open
Valve #11 - Closed
Valve #12 - Closed
Valve #13 - Open
Valve #14 - Closed

STEP #4

Close jet line valve #9 to hopper and adjust throttle on Detroit diesel so that centrifugal pump discharge reads 100 psi.

STEP #5

Shut master Valve #7 to hopper control stand. Open hopper jet line Valve #9 and open hopper density control Valve #8 to one half.

STEP #6

Open master control Valve #7 and circulate tanks. Leave throttle setting fixed and change gears as required to keep mixing pan one-half full.

STEP #7

Hook-up pneumatic cement shipping line to surge hopper. Fill hopper.

STEP #8

Close master control Valve #7. Open Valve #14 and close Valve #13. Open Valve #7 and fill hopper with cement.
STEP #9

Weigh slurry and adjust density with density control Valve #8. Open to lower density and close to increase density.

STEP #10

When fluid level in first tank has gone down 5 barrels (15 barrels remaining) switch to #2 tank. Open Valve #3 and close #2.

STEP #11

Refill #1 measuring tank. Continue mixing gel-cement. After using fluid in #2 tank switch to #1 tank. Refill #2 tank with fresh water.

STEP #12

After completion of mixing gel-cement slurry, switch to fresh water tank and adjust density to 116-118 PCF (15.5 - 15.7 PPG). After mixing with 6.0 barrels close master control Valve #7 and put pacemaker in neutral. Fill #1 tank with sea water.

STEP #13

Remove cementing head from drill pipe and insert wiper/latch down plug. Reinstall cement head.

STEP #14

Open Valve #7 and complete mixing of neat cement (7 barrels) and follow cement with remaining fresh water (7 barrels).

STEP #15

Switch valves to displace directly with pacemaker pump. Open Valve #4 and close #5. Open #2 and close #3.

STEP #16

Displace cement with theoretical volume (254 barrels) of sea water and slow pump down and watch for pressure increase. An excess of 1-3% is normal to allow for air in displacing fluid. Bump plug with 1000 psi and check for back-flow by opening Valve #13.
STEP #17

Fill tank #1 with fresh water and circulate system. Use hose on Valve #6 to thoroughly wash down equipment.

STEP #18

Break all lines exposed to cement. Wash lines, hopper and pan. Remove cement shipping line. Remove suction line adjacent to Valve #5 and clean and replace.
APPENDIX E

PHASE I - ENGINEERING REVIEW & DESIGN

STATEMENT OF WORK

I SUMMARY

The scope of Phase I work as proposed below is to design and prepare final machine drawings for fabrication of a complete prototype Re-entry Cone/Casing Hanger System as per conceptual drawings No.'s D-0212-03, C-0208-01 and C-0213-02. This system is to be used in lowering conical re-entry base (guide cone) and conductor casing to seafloor, jetting in this assembly and then releasing from drill pipe using existing Project running tools. The system is to be capable of suspending 500' of 16" O.D. 65 lbs./ft. casing (conductor pipe) and provide casing head for 3,000' of 11-3/4" O.D. 54 lbs./ft. casing (surface string).

A provision for removal of cuttings from the re-entry cone area will be included in Phase I. A previous concept will be reviewed as well as other designs based on proven drilling techniques currently being used in other areas.

To insure that the re-entry cone assembly will have the ability to support the 11-3/4" surface string weight (162,000 lbs. in air - 139,320 lbs. in water), Phase I will include a review of soil data, furnished by the Project from previous drilling operations.

Work to be accomplished in Phase I is described in detail below. The resultant system is to be consistent with and accompanied by appropriate operational procedures.
Upon acceptance of Phase I, a prototype system will be fabricated and tested (Phase II). The Project is to retain all rights to completed machine drawings and has the right to review all drawings prior to fabrication of the prototype. Additional units will be fabricated as the result of competitive bidding (Phase III).

II DESIGN CONCEPT

The proposed design will utilize a present design which will be modified through this Statement of Work to provide for an increased conductor casing diameter and a means of landing a second (surface) casing string with provisions for cementing. The proposed design will be based on the following concepts.

To accommodate varying seafloor conditions, a modification to the supporting structure of the re-entry cone will be required. This modification will be based upon the analysis of soil data previously developed by the Project. A consulting firm specializing in soil studies will be used as a subcontractor to aid in this analysis. Criteria will be developed to determine those seafloor conditions requiring special preparations for distributing the weight of the re-entry cone and casing over a greater area.

Phase I will include recommendations for a method of determining seafloor integrity, either by penetrating with the drill string or by more formal penetrometer techniques. These recommendations will be intended for use in determining the need for the soft bottom adapter assembly.

A casing running tool will be made up as part of the drill string from which a re-entry cone, 16" casing hanger and
conductor casing are to be lowered to the seafloor, washed-in and released. A second 11-3/4" surface casing string will then be lowered on a duplex cementing shoe, landed and automatically latched into the 16" casing hanger assembly.

During lowering operations, the 16" casing hanger assembly (including re-entry cone) will be suspended on three spring loaded paddles in the latch sleeve. These paddles are to be locked in the open or running position with a sleeve and stop bolt assembly contained within the casing running tool and made-up in the drill string. To release the 16" casing hanger assembly (including re-entry cone) from the drill string, a shifting tool will be run inside the drill pipe on a sandline and positioned in by an indexing sub. By pulling up on the shifting tool, the sleeve and stop bolt assembly are to be moved upwards allowing the spring loaded paddles to swing out and free the 16" casing hanger from the drill string.

NOTE: The design is to allow the paddles to be released by drill string rotation if necessary after sleeve has been shifted up.

The 11-3/4" surface casing and hanger will be run on a duplex cementing shoe, latched into the 16" casing hanger assembly and cemented in place with swab cups.

The design should incorporate an adequate safety factor allowing for dynamic loads commonly experienced during operations from a floating vessel. Heaves of up to 10' roll and pitch of 8° (1/2 amplitude) may be experienced.

The maximum water depth to which the assembly will be used is approximately 25,000 feet.
III DESCRIPTION OF PHASE I REVIEW AND DESIGN TASKS

A. 16" O.D. Casing Hanger Assembly - The proposed work will result in final machine drawings for use in fabrication of the 16" casing hanger assembly as per conceptual drawing No.'s. D-0212-03 and C-0208-01 and to be compatible with present 9 7/8" casing running tools drawing No.'s RE-010 (release sub), R-068-01 (index sub, D-0079-02 (shifting sleeve), A-0081-02 (stop bolt assembly), A-0080-03 (stop bolt sleeve) and RE-28 (stop bolt). These drawings are to include the following:

1. 16" casing hanger body
2. shoulder ring
3. latch groove ring
4. latch sleeve
5. shaft (3 required assemblies)
6. paddle (3 required assemblies)
7. torsion spring (3 required assemblies)
8. roll pin (6 required assemblies)
9. transition sub (16" casing hanger to 16" O.D. 65 lbs./ft. casing pup).

B. 11 3/4" O.D. Casing Hanger Assembly - The proposed work will result in final machine drawings for use in fabrication of the 11-3/4" O.D. casing hanger and latch assembly as per conceptual drawing No. C-0213-02 and to be compatible with 16" casing hanger assembly as described in A. above. These drawings are to include the following:

1. 11-3/4" O.D. casing hanger
2. latch ring
NOTE: Stabilizing lugs may be welded to slightly oversized tubing that can be slipped over 11-3/4" casing joint tack welded in place and clamped at the base (Drawing No. C-0213-01).

C. 16" Diameter Conical Re-entry Base (Guide Cone) -
The proposed work will include modifying existing machine drawings No. RE-020, 10285 sheet No. 1, 1028t sheet No. 2, 10285 sheet No. 3 (conical re-entry base), B-0084-00 (cone, guide base, re-entry), A-RE-030 (guide base latch installation), A-RE-31 (guide base latch), A-RE-32 (latch rod), A-RE-35 (stop washer), A-RE-33 (latch spring) and A-RE-34 (latch spring retainer), to be compatible with the 16" O.D. casing hanger assembly and the 11 3/4" O.D. casing hanger assembly described in A. and B. above and consistent with conceptual drawing No.C-0213-01.

The proposed work will also include modifying of the existing re-entry base to accept the required soft-bottom adapter assembly. This equipment would be used only if required, as indicated by seafloor integrity.

D. Cuttings Removal System - The proposed work will include developing of an acceptable design for a cuttings removal system to insure that cuttings returning to the
top of the hole will not build up in the re-entry cone but will be discharged to the seafloor.

**PHASE II PROTOTYPE FABRICATION AND TEST**

Although Phase II is outside the scope of this proposal, the following statement of work is included for clarification. If awarded Phase I, Deep Oil is prepared to undertake Phase II subject to estimates which will be prepared based on Phase I designs.

The designs and construction drawings developed in Phase I will be used in the fabrication of a complete prototype unit. Upon completion of the prototype components a test program will be conducted to demonstrate proper clearances, mechanical actuation, and reliability of latching and locking devices. Phase II will also include modification of production drawings and preparation of bid specifications for use by the Project for the fabrication of production units (Phase III).

The various components will be tested as follows:

**16" Casing Hanger Test**

1. Rotate paddles to support position under latch groove ring and cock by sliding shifting sleeve to down position. This will check paddles clearance and compatibility with running tool.

2. Lower casing running tool and latch sleeve into 16" casing hanger with shoulder and latch groove rings riding on upper paddle surface. Make up shoulder ring to casing hanger.

3. Pick-up assembly. Rotate and/or shake 16" casing hanger assembly through horizontal and vertical angle to test for premature release.
4. Pull shifting sleeve up allowing paddles to rotate and release latch assembly from 16" casing hanger assembly.

5. Repeat cycle five times.

6. Latch 16" casing hanger assembly into conical re-entry base and lift to verify latching action. Set down and release latch segments.

7. Repeat cycle five times.

8. Latch 16" casing hanger assembly into conical re-entry base. Pick up off bottom and repeat steps one through five.

9. A 50,000 lb. static load pull test should be performed on latch sleeve assembly.

11 3/4" Casing Hanger Test

1. Latch in 16" casing hanger assembly with transition sub to conical re-entry base- Retrieve latch sleeve assembly.

2. Land and latch-in 11 3/4" casing hanger and one joint of heavy wall casing with stabilizing lugs in 16" casing hanger. Pick up to test latching ring.

   NOTE: Latch groove ring to be equipped with threaded holes around circumference for release screws.

3. Rotate and/or shake assembly through horizontal and vertical angles to test for failure of latch ring.
4. Repeat three times.

5. A 200,000 lbs. static load pull test should be performed on the 11 3/4" casing hanger assembly.

Cuttings Disposal System Test

Test of this unit will be limited to assembly for the purposes of verifying clearances and mechanical actuation only. It is not within the scope of this test to verify actual cuttings disposal capability.

Foundation Support Equipment

Test of the Foundation Support Equipment will be limited to the assembling of the "soft bottom adapter" with the re-entry base to verify the alignment of the connections.

Dynamic Testing

All dynamic testing will be limited to the safe handling capacity of the existing 10 Ton bridge crane in Deep Oil's test facility. This program, as presently written, does not include any special handling or dynamic test equipment for developing operational type accelerations that may be considered as representative of at-sea conditions.

Production Drawings and Specifications

At the completion of Phase II prototype test and acceptance, a production bid package will be compiled including production drawings, assembly drawings, bills of materials, and specifications for use by the Project in procuring subsequent units.
PHASE III  FABRICATION OF PRODUCTION UNITS

Although outside the scope of this proposal, it is understood that following the fabrication of the prototype unit, additional units required by the Project will be procured by competitive bids from qualified manufacturers. Deep Oil Technology requests to be regarded as a qualified source for these units.
APPENDIX F

REPORT
EVALUATION OF SOIL SUPPORT
DRILLING REENTRY SYSTEM
DEEP OCEAN SITES
FOR DEEP SEA DRILLING PROJECT

DAMES & MOORE JOB NO. 3607-001-02
LOS ANGELES, CALIFORNIA
February 26, 1975
February 27, 1975

Deep Oil Technology
1280 Windham Avenue (Pier G)
Long Beach, California 90802

Attention: Mr. Ed Horton, President

Gentlemen:

We are transmitting herewith five copies of our report, "Evaluation of Soil Support, Drilling Reentry System, Deep Ocean Sites, for Deep Sea Drilling Project."

This work was commenced following our December 2 and 18, 1974 meetings in your offices. Our initial steps are discussed in our December 18, 1974 letter to you, and subsequent steps toward solution were identified and planned during further technical meetings.

We have recommended that the reentry system be supported by jetting-in at least 300 feet of 16-inch casing, and have described conditions representing exceptions to our assumptions. We believe recommended single system configuration and utilization of a familiar and simple installation method represents the most economical solution to the problem.

This has been an exceptionally interesting and challenging problem for which there was no soils engineering precedent. Hence, we drew upon the combined offshore experience of a number of Dames & Moore staff members in addition to the technical team members represented in our meetings.

We wish to express our appreciation for the excellent assistance and cooperation we received from your project team and from the Deep Sea Drilling Project staff. This
was especially helpful to us in identifying and defining the practical soil mechanics problems to be addressed.

It has been a pleasure to assist you in this unique project. Please contact us if you have any questions regarding this report.

Very truly yours,

DAMES & MOORE

Vernon A. Smoots
Partner

Jerry C. Wilson
Associate
INTRODUCTION

Deep Oil Technology has been contracted by the Deep Sea Drilling Project (DSDP) to design a complete prototype drilling reentry cone/casing hanger system. This system is to be installed in thesea floor in both the Atlantic and Pacific Ocean basins and must be supported by the deep ocean sediments. The system must be operational for a period of several months and provide for multiple reentries at deep crustal drilling sites. Provisions for sonar tracking and cuttings removal must be compatible with the concept for support of the system.

Deep Oil Technology (DOT) has authorized Dames & Moore to assess the supporting concept for this new system and the capacity of the deep ocean sediments to carry the imposed loading. Total load of the system may be up to 180,000 pounds. This will consist of the reentry cone/casing hanger system, 16-inch surface conductor and 11-3/4 inch casing. The lower end of the casing must be cemented into oceanic basalt. Dames & Moore also reviewed the methods of installation of the system as this is a critical influence on the strength of the supporting sediments. There is no basis of engineering experience regarding the potential behavior of these soils.
SCOPE OF WORK

The work tasks performed by Dames & Moore included the following:

1. Assess the supporting concept to be designed into the system, including surface bearing, skin friction, end bearing, or combinations of these.

2. Review available physical property information and other published data provided by DSDP and DOT to extract geotechnical engineering data.

3. Use these to make general assumptions and choose soil parameters for use in computations on the basis of our past experience and judgment.

4. Perform computations to analyze load carrying capacities.

5. Provide recommendations for comparison of various methods of placement.

6. Define work needed before and during drilling at reentry sites to confirm applicability of our assumptions and computational approach.

SUPPORT CONCEPT

Dames & Moore reviewed general unreduced sedimentary data and discussed results of previous reentry operations using a lighter system. On the basis of this initial information we provided the recommendation that the system
support should be evaluated in terms of skin friction. DOT acknowledged that this was feasible in terms of their design considerations.

The problem was then defined as support capacity of a single pipe pile. Following this, our work was directed toward collecting sedimentary data appropriate to this type of soil mechanics analysis.

**SOIL DATA**

Previous borings made by DSDP have revealed that unconsolidated surface sediments of ooze and clay are characteristic of both the Atlantic and the Pacific Ocean sites, typically to depths on the order of 300 meters (1,000 feet) below ocean bottom. This generalization was concluded in conjunction with DSDP staff on the basis of boring data in the vicinity of the five reentry sites specified for this project. Eighty to ninety percent of all these surface sediments were found to be calcareous or siliceous ooze, which is primarily fine grained sediment. One sample selected as typical by DSDP was provided to us for visual inspection and appeared to have the characteristics of a silt soil. Differences in engineering characteristics between samples, especially strength properties, may be overshadowed by the large amount of disturbance during this type of sampling. However, certain baseline engineering information can be assumed from the scattered data.

Shear strength data are available for a limited number of ocean sites. These data do not show a significant variation from site to site. A laboratory vane or a torvane was used to perform these tests. This is not the best testing method for silty materials. Therefore, the shear strength information
must be utilized only with caution. A review of density, porosity, and water content data from DSDP samples indicates that these materials are fairly uniform. Limited data are available on the plasticity and grain specific gravity of the ooze. These latter properties are not affected by soil disturbance.

These data are directly related to soil behavior and indirectly related to strength characteristics. To make a selection of soil parameters for use in computations, considerable judgment was needed in utilizing the limited available data. This was augmented somewhat by a visual inspection of one typical sample of ooze selected by DSDP. Our judgments were based on comparing our past experience with similar structures and various offshore installation procedures.

In view of this discussion it is apparent that a relatively low degree of confidence can be placed on the input data. However, our calculations do serve to demonstrate orders of magnitude and allow comparison of various installation techniques.

**CALCULATIONS**

Three methods of installation for the casing pipe were considered: jetting, drilling-and-grouting, and driving. Computations were made for load-carrying capacities of the casing if it were installed by each of these three methods. The results of the computations are shown on Plate 1, Recommended Vertical Load Capacity of 16-Inch Casing in Deep
Ocean Ooze Assumed Typical of Reentry Sites. It was assumed that the casing is embedded entirely in ooze. A discussion of the assumptions and choice of soil parameters is presented in the appendix.

The computations were performed using two approaches. In the first approach all soil parameters used in the computation were chosen as conservative numbers that would yield low vertical load capacities with no factor of safety applied. In the second method, numbers that in our judgment were realistically applicable were used to develop vertical load capacities, and a factor of safety of 3 was applied. The use of the safety factor of 3 for vertical pile capacities after having chosen realistic soil parameters is not uncommon in the practice of geotechnical engineering. A comparison of the capacities calculated by these methods showed that the first method generally yielded lower capacities.

We also took into account the effect of liquefaction which may occur in the ooze material due to cyclic lateral loading on the casing pipe during drilling. We calculated the hypothetical maximum depth of liquefaction to be on the order of 70 feet. This reduction of strength was included in both methods of analysis.

CONCLUSIONS

Our computations indicate that although jetting would yield lower ultimate vertical capacities, it would still be the most desirable method of implacement. This is in view of simplicity and previous experience in field installation and the relatively short length (300 feet) of casing needed for generating the design capacity. We understand from DOT that jetting-in to penetration of 300 feet is feasible and practical with the GLOMAR CHALLENGER.
We believe that upon initial installation with jetting, the casing will have only a small fraction of the capacity that it will ultimately reach after "setting-up." It is difficult to estimate the time required for the setting-up process to reach equilibrium. However, we understand that the casing will not be loaded to its full capacity immediately after installation. A time lapse of at least 24 hours should be allowed for the casing to set up.

**VERIFICATION**

In order to assure that the material in which the casing is being installed is of the same type as assumed, we recommend that plasticity tests (Atterberg Limits test) be performed aboard the drilling ship on cores recovered from sediments at the site. These are relatively simple tests. They may be performed by a technician in a reasonably short period of time. The test methods are described in the American Society for Testing and Materials, Test Procedure Designations D-423 and D-424. These tests are used to classify fine grained soils. If the results of these tests on the drilling ship indicate an ML or MH type soil (using the Unified System of Soil Classification) having a plasticity index of less than 20 the curves and data provided by us may be used. We anticipate that all ooze material will be found to be of the above type. If large proportions of the cored material are not of these types (say more than 25 percent) a revision of our recommendations may be needed.

The following items should be observed in the field. These are indicators of possible problem areas.

1. If it is found that the material of the surface sediment plots soil type as CL or CH and in addition to that, the second method of jetting
described below under "Recommendations," is essential for lowering the casing to the required depths, there is a serious problem.

2. We understand that experience indicates that if jetting is stopped for about 2 hours or more, then the casing "sets up" and further jetting is not possible. If at any time it is found that this is not true and that jetting may be continued even after allowing several hours of setting up time, then the minimum set-up time recommended should be increased. Further, this indicates that the material is not behaving in accordance with our assumptions.

3. If the casing is jetted through zones of hard material (hard material includes anything of the consistency of soft rock) then friction cannot be relied on in this zone. This reduces the vertical capacity of the pipe. Such a condition is not common in the ooze, but if hard layers of significant thickness are encountered, the length of the casing should be increased by the thickness of such layers.

4. The density of the ooze material has been assumed at 94 pounds per cubic foot (1.51 gm/cc), yielding a submerged unit weight of 30 pounds per cubic foot (0.51 gm/cc). If it is found at any time that the in situ density of the ooze material is less than this number, a correction should be made in the required length of the 16-inch casing. For example, if the density of the ooze is found to be as low as 84 pounds per cubic foot (1.35 gm/cc), which yields a submerged density of 20 pounds per cubic foot (0.35 gm/cc) then the required length of the
casing should be increased in proportion to the submerged densities. In this example the length of the casing required would be 1-1/2 times our initial recommendation (that is, 450 feet).

RECOMMENDATIONS

We recommend that for all sites where the surface material is composed primarily of calcareous ooze the 16-inch casing be placed to a depth of 300 feet or more. We understand that this is not an unrealistic depth by current field procedures, and such a length will be sufficient to provide lateral support for the drill string. If the casing is installed by jetting, at least 24 hours should be allowed to elapse before the casing is loaded to its full capacity. A longer length of time to allow setting up is preferable.

To better define the coefficient of friction between ooze material and casing pipe, we recommend that laboratory tests be performed on already obtained samples of ooze. This is an inexpensive process which will lend further confidence to our analysis.

We are informed that the jetting process may be performed by two methods. In the first method, a pipe is lowered inside the 16-inch casing and material is cleaned by jetting from inside the casing only. In the second method, this pipe is extended about 1 foot below the bottom of the 16-inch casing and a seal provided in the annulus between this pipe and the 16-inch casing so that the drilling fluid is forced to return upward along the outside of the 16-inch casing. The second method results in considerably greater disturbance to the in situ soils. This reduces vertical capacity in general. Therefore, we recommend that if the casing can possibly be lowered to the recommended depth of 300 feet using the first
method of jetting, then this method should be used. If this method has to be supplemented with the second method the use of the second method should be minimized and jetting pressures should be kept as low as feasible.

We recommend consideration of including a procedure to "rattle" or vibrate the system after the design depth is reached. This might be done by an eccentric attachment that could be rotated by the drill string. This would tend to augment the setup of the pipe. In addition, it would provide the advantage of causing any soil strength reductions related to liquefaction by cyclic loadings to occur prior to actual drilling and reentry operations. Some of this loss will be recovered during the set up period.

The following plate and appendix are attached and complete this report:

Plate 1 - Recommended Vertical Load Capacity of 16-Inch Casing in Deep Ocean Ooze Assumed Typical of Reentry Sites

Appendix: Assumptions and Choice of Soil Parameters

DAMES & MOORE

Vernon A. Smoots
Partner

Jerry C. Wilson
Marine Geologist

Iskandar Khan
Soils Engineer

February 27, 1975
Los Angeles, California
RECOMMENDED VERTICAL LOAD CAPACITY
OF 16 INCH CASING IN DEEP OCEAN OOZE
ASSUMED TYPICAL OF REENTRY SITES
APPENDIX
ASSUMPTIONS AND CHOICE OF SOIL PARAMETERS

GENERAL ASSUMPTIONS

1. The casing is embedded throughout its length in ooze. This assumption is reasonable in the sense that the depths (of sediments) we are considering are less than 600 feet (approximately 200 meters). The ooze and clay at Site 146/149 were found to exist to twice that depth. Also, the clay has a higher strength than the ooze, based on available data, in its undisturbed condition.

2. The three methods of placement have the following essential features:

   a. Jetting: A jet of drilling fluid scours material at the bottom of and ahead of the casing. The drilling fluid returns inside the casing. Some water may be lost in the sediment while jetting ahead. The casing is advanced by some method to the required depth.

   b. Drilling-and-Grouting: The casing is provided with drilling teeth. It is rotated into the ocean bottom with slight over-coring. A jet cleans the inside of the casing but stays well above the bottom during drilling. At the required depth grout is injected under pressure at the bottom and joints of the casing.

   c. Driving: The casing is driven ahead. The soil inside is removed by jetting making sure that the jet stays well within the casing. This procedure is repeated until the required casing depth is reached.
3. The choice of soil parameters used in these computations has been based on information available from tests on highly disturbed samples. No strength data were available for Site 146/149. Information from other sites was reviewed to estimate strength parameters. There is considerable scatter in shear strength data generated at any particular location. However, the overall trend is the same for all ooze material studied.

**CHOICE OF SOIL PARAMETERS**

The following parameters were chosen after a review of available soil information.

<table>
<thead>
<tr>
<th>Description of Parameter</th>
<th>Symbol</th>
<th>Chosen Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average total unit weight</td>
<td>( \gamma_t )</td>
<td>94 pcf</td>
<td>104 pcf</td>
</tr>
<tr>
<td>Average submerged unit weight</td>
<td>( \gamma_b )</td>
<td>30 pcf</td>
<td>40 pcf</td>
</tr>
<tr>
<td>Effective cohesion</td>
<td>( c' )</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Effective angle of internal friction</td>
<td>( \phi' )</td>
<td>35°</td>
<td>25°</td>
</tr>
<tr>
<td>Remolded undrained strength</td>
<td>( c_{ur} )</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>Angle of friction between ooze and casing</td>
<td>( \delta )</td>
<td>10°</td>
<td>20°</td>
</tr>
<tr>
<td>Ratio of horizontal effective stress to vertical effective stress</td>
<td>( K )</td>
<td>( \frac{1-\sin \phi'}{1+\sin \phi'} )</td>
<td>0.35, 0.6, 0.7</td>
</tr>
<tr>
<td>a. Jetting</td>
<td>( K_j )</td>
<td>( \frac{1-\sin \phi'}{1+\sin \phi'} )</td>
<td>0.35</td>
</tr>
<tr>
<td>b. Drilling and Grouting</td>
<td>( K_g )</td>
<td>( 1-\sin \phi' )</td>
<td>0.6</td>
</tr>
<tr>
<td>c. Driving</td>
<td>( K_d )</td>
<td>0.7</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Used to compute lateral pressures only.

Used Elsewhere.
To: Mr. S. T. Serocki  
Chief Engineer  
Deep Sea Drilling Project  
Scripps Institution of Oceanography  
University of California at San Diego.

Subject: Progress Report- Re entry Guide Cone Drilling Assembly  
Reference: F.O. No 7B-02172-0

STAFF STUDY REPORT

1.0 Introduction and Problem Statement:

The subject assembly is exposed to a variation of environmental and physical conditions which interact and contribute to possible malfunction. This thirty hour study will review and outline the mechanics of some of the probable failure causes.

2.0 Assumptions

The results of "Bearing Capacity Study of Seafloor Soils Mid-Atlantic Ridge Atlantic Ocean" by Mc Clelland Engineers, Inc. Houston Texas, Dated April 1976, is used as the baseline.

2.1 Particular reference is made to the following:

Maximum load on the cone without skirt extension 125,000 lbs. at a penetration depth of 12 feet below the ocean floor on a friction angle of 20°.

Maximum load on the cone with the skirt extension 200,000 lbs. at a penetration depth of 4 feet below the ocean floor based on a friction angle of 20°.

Density of the calcareous ooze 35 lb/ft³.

3.0 Facts Bearing upon the Problem:

An increase in the base area of the cone skirt produces a significant increase in the supporting capacity of the re entry guide cone for a given penetration. Reference is made to Plates 5 and 6. The change in slope of the load versus penetration relationship curve Plate 6 at 4 feet indicates a sudden change in the stress-strain relationship of the foundation material.

4.0 Discussion

The primary objective of this study is to analyze the structural integrity of the subject assembly particularly the skirt extension. An intuitive approach is taken to analyze the mechanism. Consider a thin membrane structure with a light weight rim. Reference Figure 2.
4.0 Discussion (continued)
The Guide Cone Assembly skirt is considered to be loaded at P and supported uniformly at its base. Reference Figure 1. A static condition will be analyzed with the load P = 200,000 lb. The contribution of the struts will be neglected. Results of a preliminary analysis will be presented in Appendix A to this report.

5.0 Observations
The foundation material on the ocean floor is reported to be subject to liquification due in part to vibratory motion during the drilling process. This "pumping action" tends to reduce the foundation bearing pressure, and coupled with the predicted sudden change in the load versus penetration relationship Plate 6, the assembly may experience relatively high acceleration and high rates of change in acceleration (snatch loads).

6.0 Recommendations
1) The assembly be analyzed for factual operating weights and predicted vibration and acceleration spectra.
2) Investigate the application of buoyancy material to reduce the submerged weight of the installation.

7.0 Proposed Study Items for the next Phase:
1) Methods for reinforcing the skirt and skirt extension for exposure to 25,000 lb. casing hanger systems in 10, 20, 50g acceleration environments.
2) Methods for load alleviation viz. buoyancy material application.

8.0 Time Used for this Phase:
1) Conference and Familiarization 3 hours
2) Report Reading and Digest 2.5 hours
3) Data Search (references) 2.5 hours
4) Analysis 8.0 hours
5) Report Preparation 2.0 hours
6) Travel 40 miles.
IF THE RIM IS "STIFF" "NON-YIELDING", THE BASE MORE NEARLY RETAINS ITS "CIRCULAR" FORM & THE CONICAL SHELL DEFLECTS.

INCREASING THE MOMENT OF INERTIA OF THE CONICAL SHELL BY STIFFENERS RADIAL TO THE CONICAL SURFACE REDUCES THE DEFLECTION & INCREASES THE LOAD SUPPORTING CAPACITY.

THEN THE STRUTS, WHILE PROVIDING A DEGREE OF STABILITY, ARE REDUNDANT.
Progress Report on
Re entry Guide Cone Study
P. O No 7B-02172-0

Date November 9, 1976

W. Nugent
CONDITIONS
A TRUNCATED THIN WALL CONE SUPPORTED AT ITS BASE
WALL THICKNESS 0.25
MODULUS OF ELASTICITY $29.5 \times 10^6$ lb/m²
USE POISONS RATIO $= 0.25$

PROCEDURE: A MEMBRANE ANALYSIS WILL BE USED TO OBTAIN REASONABLE RESULTS, IN A FIRST ORDER OF MAGNITUDE ANALYSIS TO DETERMINE THE SPECIFIC STRESS LEVEL ON THE MUD CONE AND SKIRT EXTENSION.

\[ \begin{align*}
2N_\theta &= P \cdot D \\
N_\theta &= P \cdot \frac{D}{2} = \frac{P r}{2} \\
N_\phi &= P \left( \frac{\pi r^2}{2} \right) = \frac{P r}{2}
\end{align*} \]

FROM THE CLASSICAL STUDY THE MERIDIAN FORCE IS HALF THE HOOP FORCE.
FOR A CONE $\frac{r_1}{r_2}$ IS INFINITY AND
\[ \begin{align*}
N_\phi &= \frac{P r_2}{2} = \frac{P r}{2 \cos \theta} \\
N_\theta &= \frac{P r_2}{2}
\end{align*} \]
\[
\frac{N_1}{r_1} + \frac{N_2}{r_2} = P
\]

For the condition of loading \( P = 0 \)

\[
\therefore \frac{N_1}{r_1} + \frac{N_2}{r_2} = 0
\]

AND

\[
\frac{P}{\sin \theta} = N_0 \cdot 2\pi R
\]

OR

\[
N_0 = \frac{P}{2\pi R \sin \theta}
\]

\[
= \frac{200,000}{2\pi (84) (\sin 60^\circ)} = 437 \text{ lb/in}
\]

\[
= 1748 \text{ psi} \quad \text{LIMIT LOAD}
\]

This is the intensity of stress in the meridional direction acting on the conical skirt, no safety factors have been applied.

If a 10g acceleration is applicable, and the skirt is manufactured in 'AISI 12XX' materials care must be taken in finishing & processing, to achieve the desired working stress,
\[ S = \sqrt{(R-1)^2 + \theta^2} \]
\[ = 62.35 \text{ inches} \]

**Surface Area of Truncated Cone**

\[ A = 1.5708(62.35)(114) = 11,165.775 \text{ in}^2 \]

**Equivalent Reaction at the Base to a Hypothetical Density of the Cone Ref Rock**

Then \[ S = 200,000 / A = 17.91 \text{ lb/in}^3 \]

\[ \rho = \frac{-17.91(84)}{2 \sin 60^\circ \cos 60^\circ} = 1737 \text{ psi} \]

\[ \Delta R = \frac{-17.91(84)^2}{29.5 \times 10^6 \cos 60^\circ (\sin 60^\circ - 0.25)} = 0.00629 \text{ inches} \]

\[ \Delta \gamma = \frac{-17.91(84)^2}{29.5 \times 10^6 \cos 60^\circ (4 \sin^2 60^\circ - \sin^2 60^\circ)} = -0.00357 \text{ inches} \]

**Vertical Deflection of the Truncated Cone**

\[ \Delta \gamma_{ke} = -0.00357 \left( \frac{30}{84} \right)^2 = -0.0004553 \text{ inches} \]

**The Volume of Surface Material Removed by 17.32 in**

\[ \frac{30}{\sin 60^\circ} \left( \frac{30}{2} \right)^2 \times 0.25 = 816 \text{ in}^3 \]

**Weight of Vertex Section**

\[ 816 \times 17.91 = 14618.31 \text{ lb} \]
EQUILIBRATING THE UNIFORM LOAD REACTED AT THE BASE OF THE CONE TO THE EFFECTIVE WEIGHT THE RELATIVE DENSITY $\delta = 19.22 \text{ lb/in}^3$

STRESS IN CONICAL SKIRT

$$\sigma = \frac{-19.22 (84)}{2 \sin 60^\circ \cos 60^\circ} = -1864.155 \text{ psi}$$

CHANGE IN BASE RADIUS

$$\Delta R = \frac{19.22 (84)^2}{29.5 \times 10^6 \cos 60^\circ} \left( \frac{\sin 60^\circ - 0.25}{2 \sin 60^\circ} \right) = 0.00636 \text{ inches}$$

$$\Delta y = \frac{19.22 (84)^2}{29.5 \times 10^6 \cos 60^\circ} \left( \frac{1}{4 \sin^2 60^\circ - \sin 60^\circ} \right) = -0.0038131 \text{ inches}$$

VERTICAL DEFLECTION OF THE TRUNCATED CONE

$$\Delta y_{tc} = -0.0038131 \left( \frac{30}{84} \right)^2 = -0.0048$$

THE VOLUME OF SURFACES MATERIAL REMOVED

$$\frac{30}{\sin 60^\circ} \left[ \frac{30 \pi}{0.25} \right] = 816 \text{ ins}^3$$

WEIGHT OF VERTEX REMOVED: $816 \times 19.22 = 15683.52 \text{ lbs}$

$$\sigma_{tc} = \frac{15683.52}{2 \pi (84)(0.25) \cos 60^\circ} = 237.724 \text{ psi}$$

$$\Delta R_{tc} = \frac{-0.25 (15683.52)}{2 \pi (84)(0.25) \cos 60^\circ (29.5 \times 10^6)} = -2.01 \times 10^{-6} \text{ inches}$$

$$\Delta A_{tc} = 4.02 \times 10^{-4}$$

THEORETICALLY THE TRUNCATED SECTION OF THE CONE

$$\sigma = -1864 + 237 = -1627 \text{ psi}$$

$$\Delta R = 0.00636 - 2.0 \times 10^{-2} = -0.00358 \text{ inches}$$

$$\Delta R = -0.00381 + 0.00413 + (4.02 \times 10^{-4}) = -0.002493 \text{ inches}$$
SUMMARY OF DISCUSSION  NOV 18 1976
MR. J.T. SEROCKI  CHIEF ENGINEER
W. NEWENT  CONSULTANT

SUBJECT  MUD SKIRT ATTACHMENT FOR
THE RE ENTRY CONE.

EXAMINATION OF THE DESIGN FOR THE
SUBJECT EQUIPMENT POINTED OUT AREAS
OF IMPROVEMENT FOR THE ATTACHMENT
OF THE MUD SKIRT & MUD SKIRT
EXTENSION AS FOLLOW:

PROVIDE WELDS AT THE INTERSECTION
OF THE MUD SKIRT AND MUD SKIRT
EXTENSION

INTERMITTENT WELDS 3 INCHES LONG
1/4 INCH AROUND THE CONICAL INTERSECT.
This action is recommend on the basis of the shear load developed in the conical surface of the plate.

**Meridinal Shear = 437 lb/in**

**Hoop Shear = 874 lb/in**

The combined effect yields a shear stress of \( \sigma = 24,758 \text{ psi} \), say \( \frac{\sigma}{S} = 25,000 \text{ psi} \).

The allowable \( \frac{\sigma}{S} \) of material = 75000 psi.

Safety factors:
- Allow 1.5 for load factor
- 1.5 for alignment & fitting factor
- 3.0 factor total

Applying a factor of 3 to 25,000 psi shows that the bolt in the skirt are loaded to the maximum capacity. Furthermore, the \( \frac{3}{4} \) inch diameter holes in the skirt and the \( \frac{3}{8} \) inch diameter bolts do not insure that the bolts are uniformly loaded.

As a consequence, the chain weld 3 inch weld 3 inch gap is recommended to provide uniform shear distribution around the attachment.
The structural design of the mud skirt will be significantly improved if the bolting arrangement of the two halves of the skirt extension, and the bolt attachment at the 8 ft diameter skirt & the skirt extension are increased in number.

The 7/8 inch diameter holes with 3/4 inch diameter bolts do not insure that each bolt in the attachment carries its share of the load. Progressive failure of the bolts in the attachment could lead to a structural failure.

W. Nugent
CONDITIONS:

FLOW VELOCITY ~ 15 ft/sec  

DRAG COEFFICIENT ~ 2  

$D = \frac{1}{2} \rho V^2 C_D$  

$C_D = \frac{1}{2} (64) / 32.2$  

Then: DRAG FORCE = \( \frac{1}{2} \rho V^2 C_D \)  

= (225)(2)(1.099373) = 447.2

CONICAL SURFACE AREA = \([8.5(7.5)] + [3.5(7.1)]\) = 33.25 ft²

ESTIMATED CP, $CP = \frac{63.75 \times 2 + (24.5 \times 1.5)}{98.25}$  

= 5 ft
MUD SKIRT EXTENSION BOLT ATTACHMENTS (FLANGE)

5 - 3/4 in. dia. bolts -
LENGTH = 41.88 in.
SHEAR = 211 lb/in.
LOAD/BOLT = 41.88 × 211 = 17,67 lb
5
F₄ = Bolts = 4001 p.s.i.

CONSIDER HYDRODYNAMIC FORCES ON THE GUIDE CONE
ACTING SIMULTANEOUSLY WITH A VERTICAL FORCE
REF APPENDIX (A2) 437 lb/in. MERIDIANAL FORCE
874 lb/in. HOOP FORCE
LOAD/BOLT = 41.88 × 437 = 3,660 lb.
5
F₅/BOLT = 3,660/4417 = 828.6 p.s.i.

F₆/BOLT = 41.88 × 874 = [16,573 p.s.i.]
5 (4417)
SHEAR/BOLT = F₆ = 12,285 p.s.i.

MUD SKIRT EXTENSION BOLT ATTACHMENT (SKIRT CONE)

A MERIDIAN = 437 + 211 = 648 lb/in.
Δ HOOP = 874 + 211 = 1085 lb/in.
RESULTANT = 1263 lb/in.

F₀ = 64,378 p.s.i.

RECOMMEND MORE FASTENERS IN THE SKIRT ATTACHMENT.
SUMMARY OF DISCUSSION

NOV 18 1976

MR J.T. SERIOCKI CHIEF ENGINEER
W. NUGENT CONSULTANT

SUBJECT: MUD SKIRT ATTACHMENT FOR THE RG ENTRY CONE.

EXAMINATION OF THE DESIGN FOR THE SUBJECT EQUIPMENT POINTED OUT AREAS OF IMPROVEMENT FOR THE ATTACHMENT OF THE MUD SKIRT & MUD SKIRT EXTENSION AS FOLLOWS:

PROVIDE WELDS AT THE INTERSECTION OF THE MUD SKIRT AND MUD SKIRT EXTENSION

INTERMITTENT WELDS 3 IN. LONG 1/4 INCH AROUND THE CONICAL INTERSECTION

\[\frac{1}{4}\ \frac{3}{4}\]\n
3/4" DIA BOLT
This action is recommended on the basis of the shear load developed in the conical surface of the plate.

Meridional shear = 437 lb/in

Hoop shear = 874 lb/in

The combined effect yields a shear stress of 24,758 psi. Say \( f = 25,000 \) psi.

The allowable \( f \) of material = 75,000 psi

Safety factors

Allow 1.5 for load factor

1.5 for alignment & fitting factor

3.0 factor total

Applying a factor of 3 to 25,500 psi shows that the bolt in the skirt are loaded to the maximum capacity.

Furthermore, the 7/8 inch diameter holes in the skirt and the 3/4 inch diameter bolts do not insure that the bolts are uniformly loaded.

As a consequence, the chain weld 3 inch weld 3 inch gap is recommended to provide uniform shear distribution around the attachment.

[Signature]

-255-