Storms, M. A., Natland, J. H., et al., 1991
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8. DIAMOND CORING SYSTEM—ROLLER CONE BITS AND ASSOCIATED HARDWARE[1]

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EXECUTIVE SUMMARY

Design changes were made on conventional ODP rotary core barrel bits to allow deployment with the Diamond Coring System (DCS) hardware. Two of the more significant changes allowed for a latch-in center bit to be run. These changes included: (1) enlarging the throat diameter of the bit and (2) removing the core guide while still maintaining the same size roller cones. The center bit itself was a completely new design utilizing two small Tungsten Carbine Insert (TCI) cones. The position of the center bit within the primary bit was adjustable so that the center bit could be run ahead of the larger cones or behind them. This was accomplished by placing spacers between the latch and the center bit. The center bit was held in place with a modified Extended Core Barrel (XCB) latch which allowed recovery via a wireline.

The roller cone bits held up remarkably well against the young fractured basalt encountered at the Bonin back-arc location. Though not as abrasive as some locations investigated on previous hard rock legs, it still challenged the bits to penetrate and survive. All the holes were spudded with a Positive Displacement Coring Motor (PDCM). Several holes had the additional benefit of being confined within the diameter of a casing hanger and run in conjunction with spiral bladed stabilizers. There was no excessive wear or damage reported to any of the larger four-cone bits. Several of these bits were rerun on other holes at the Bonin back-arc location. One washout was reported on a center bit after 21 hr of rotation. Overall, the bit performance and quality was rated extremely high.

BACKGROUND

One of the primary objectives of Leg 132 was to provide a cased hole to isolate unstable formations in the upper portion of the hole and allow the smaller DCS to be deployed. This was accomplished by drilling-in and backing a Bottom Hole Assembly (BHA) composed of the larger API drill pipe and/or drill collars along with a modified version of ODP's rotary core barrel bit. In order to provide a greater degree of flexibility in the drilling program, two different sizes of core bits were designed to complement the two sizes of BHA also being developed. It had been learned on previous legs that the smaller the hole diameter drilled into fractured formations, the more likely the hole was to remain stable. However, this fact had to be balanced with the size of the roller cones themselves so that bit life could be preserved.

Two bit manufacturers were approached with the idea of redesigning ODP's roller cone bit in order to allow the DCS tubing and core bits to pass. After several discussions with each manufacturer and review of the preliminary concepts presented, Security was chosen to pursue the design to the final stage of development.

Since three locations were to be investigated on this leg, each with different types of formation, two cutting structures were incorporated in the roller bit cones. This allowed a total combination of four types of bits which could be run. It was felt that with this selection there was sufficient coverage for any of the formations expected during Leg 132. These formations ranged from young fractured basalt to reefal limestones. Figure 1 illustrates the different bit sizes and BHA combination that were available for Leg 132.

The conventional bits of this type used by ODP were normally run on a core barrel to catch the core cut by the four roller cones. However, for this application where tubing was to be run inside the API drill pipe and out the bottom of the bit, conventional core barrel hardware could not be run. Therefore, a whole new BHA and enlarged bit throat were required. To ensure that core would not enter the bit and BHA while drilling in the back-off assembly, the bits had to be further modified to accept a removable center bit.

DESIGN MODIFICATIONS

Two of the more significant design modifications to the bits manufactured for Leg 132 included removing the core guide and opening the throat of the bit to a diameter of 4.05 in. This modification was required so the diamond coring bits/core barrel and tubing string used with the DCS could pass freely out the bottom of the BHA. Several ideas pertaining to the center bit design were investigated prior to selecting a wireline retrievable center bit. These included: (1) drilling out a welded-in center bit, (2) retrieving a latched-in center bit, and (3) drilling through a tri-cone bit with the DCS diamond bit.

Before a decision was made as to the direction to pursue in the design of the center bit, several attempts were made to drill through a conventional core bit and a tri-cone bit with the DCS diamond bits. Full-scale field tests were performed in Salt Lake City, Utah, to determine the feasibility of the concept. The results were promising but not conclusive. Several diamond bits were needed to penetrate completely through existing ODP roller cone or tri-cone bits. It was also felt that the time taken to drill through the more conventional bits, coupled with the trip time for the DCS tubing and the possibility of leaving inserts, diamond matrix, and/or cones in the hole, was not in the best interest of testing the DCS. This scenario also involved sacrificing several diamond bits before even beginning a hole. Since manufacturing time was running out, it was decided to focus the design on adapting a retrievable center bit using a modified ODP downhole latch assembly.

The two sizes of bits manufactured were 11-5/8 and 9-7/8 in. with cutting structures designated as M84F and H87F. The M designation describes bits with tungsten carbide inserts for medium to hard formations. The inserts are shaped for moderate extension with a closely spaced chisel design. The H designates tungsten carbide inserts for hard to extra hard formations. Inserts selected for these bits used a short extension of closely spaced conical design. Both sizes used Securities patented sealed journal bearing and gauge inserts along the shirt-tails with hardfacing on

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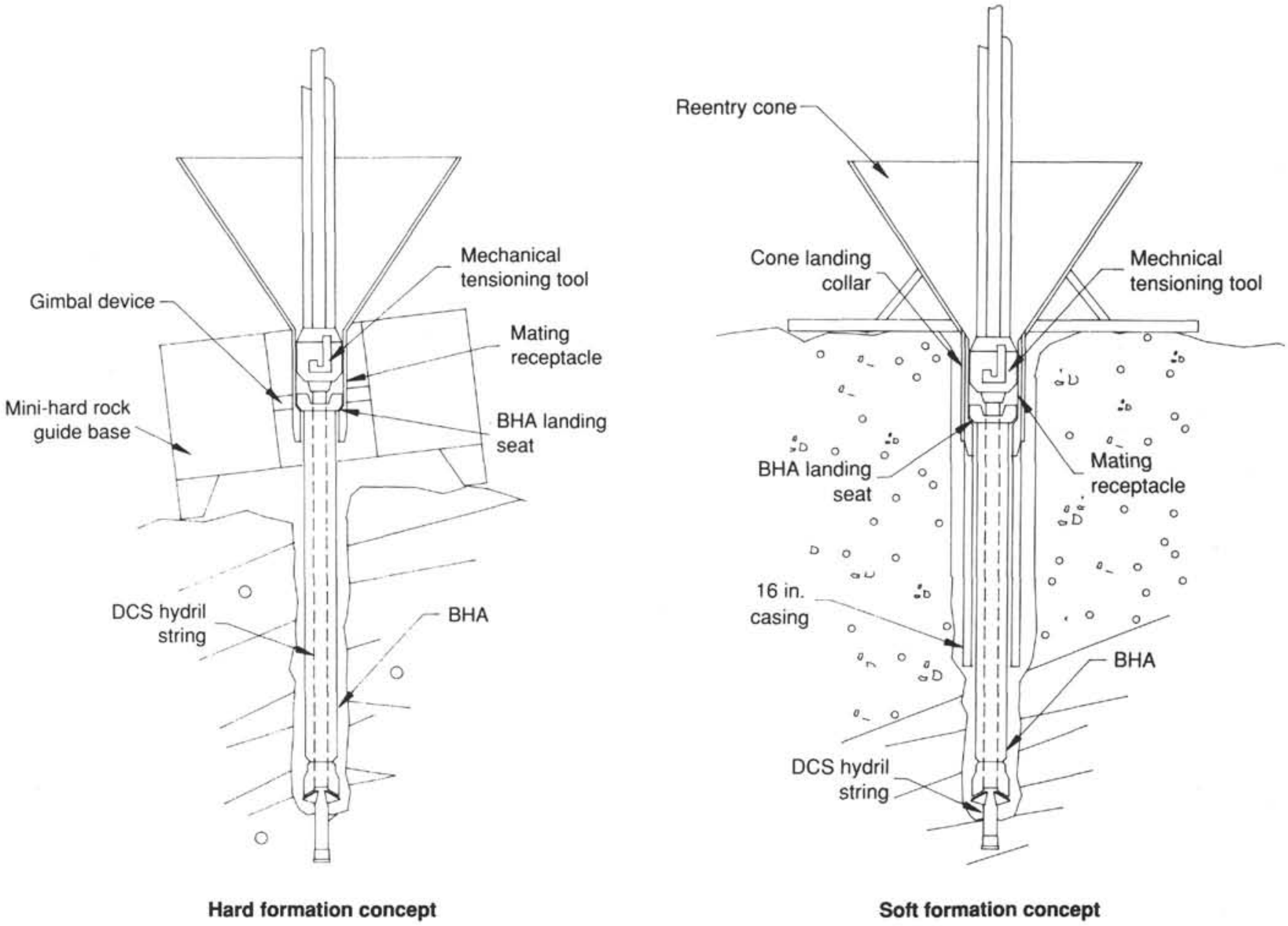

Figure 1. Bottom hole assembly options.

the leading edge. The journal bearing on the larger size bit used a 7-7/8 in. bearing with the smaller size bit using a 6-1/2 in. bearing. A schematic of this type of roller cone bit is presented in Figure 2.

CENTER BIT DESIGN

Security was again selected to pursue the manufacturing of the center bit option because of their innovative design, willingness to work with ODP, and the cost competitiveness of their product. Also, due to the time restraints of manufacturing, it was felt that a single bit manufacturer would be less apt to make dimensional mistakes or errors in compatibility between the two bit designs.

Therefore, along with the large roller cone bits, Security was to provide the center bits. These bits were to be positioned in the throat of the larger roller cone bits to provide a cutting structure to remove any material not broken up with the four outer cone rollers. Because of the small size required for the center bit, only two cones could be incorporated into this design. A schematic drawing of the center bit is presented in Figure 3.

These bits were made in an assembly which latched into the bladed spiral stabilizers attached immediately above the larger bits. A modified version of the XCB latch was adapted for holding the center bits in position (Fig. 4). Besides providing a positive locking mechanism, the latch also allowed three different lengths of spacers to be added so that the center bit elevation within the larger roller cone bits could be changed for the different formations encountered. This allowed for several different combinations of bits to be run until an optimum penetration rate could be established for the formation encountered. The elevations were: (1) 1.5 in. behind the roller cones, (2) flush with the roller cones, or (3) 1.5 in. beyond the roller cones. Figure 5 illustrates the different elevations at which the center bit could be positioned within the larger roller cone bits. The TCI's used on the small center bits were H100F. These inserts were for very hard to abrasive formations with a short 120° double conical shape. The center bit's body was slightly smaller than the cavity provided inside the large bit. Four centralizing tabs approximately one-eighth of the circumference were used to align and prevent wobble of the center bit inside the throat of the larger roller cone bit. These passageways provided additional flow paths to help in flushing the face of the center bits. Besides these flow paths, a single 3/16 in. hole was provided above each roller cone for the drilling fluid to cool and clean the individual cones.

SET-UP/FIELD ASSEMBLY

The assembly of the modified XCB latch and the adaptation to the two-cone center bits were not without some minor problems, as normally would be expected on any prototype design. These

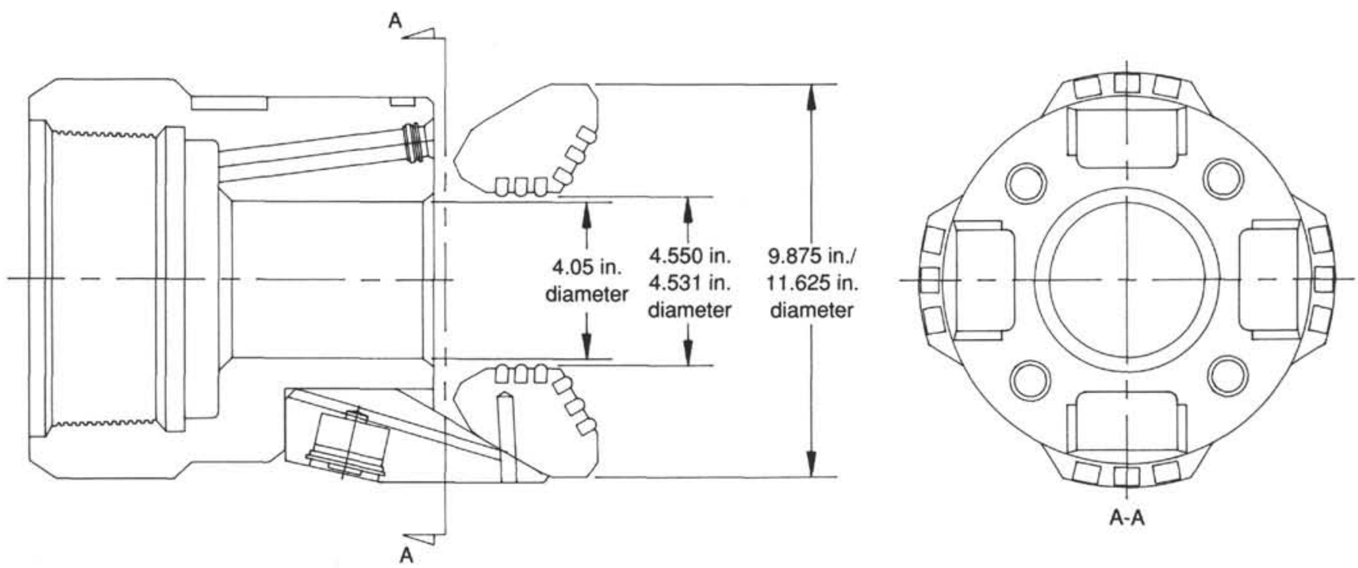

Figure 2. Roller cone bit design.

problems amounted to several small machining errors not checked before the parts were shipped. The first was that the length of the slots in the latch body for the latch dogs had to be increased by approximately 1 in. in order to latch properly. It was also discovered that the center bits were 3 in. longer than the design called for. This made the spacers provided to adjust the position of the center bit ineffective. Thus, the center bit without any spacers protruded from the end of the roller cone bit by approximately 1.75 in.

It was originally thought that the conditions at the Bonin site would necessitate the center bit be recessed. However, it was decided not to invest the time to remachine the center bits but to run them as they were originally manufactured. This decision proved to be correct at least for the unsupported spud-ins, in that the center bit acted as a pilot and eliminated the bit skating over the seafloor. It also provided a more severe test of the center bit latch assembly and center bit itself. Other than the small omissions mentioned above, the center bit latch assembly worked perfectly. Retrieval of the center bit was effortless on every attempt made with the overshot.

The XCB latch with the center bit attached was required to be loaded into the lower stabilizer before the bit was installed. This was necessary due to fact that the latch had been modified so that it could only operate in one direction. Loading the center bit was accomplished by tensioning the XCB latch first and locking the latch dogs down with a C-clamp. The bit could be pushed inside the cavity, oriented, and latched in. The C-clamp would be removed as soon as the latch dogs were held shut by the I.D. of the stabilizer.

PERFORMANCE

Boreholes 809A And -B

Two test holes were performed at the Bonin back-arc location to determine the performance of the different size bits. These tests were conducted to evaluate which type bit would provide the best penetration rate, hole cleaning characteristics, and stability, and also retain its integrity in the young fractured basalt expected at the first location. Both bits were rotated approximately the same length of time (7 hr for the 11-5/8 in. M84F and 8.25 hr for the 9-7/8 in. M84F). However, the actual penetration of the smaller bit nearly doubled that of the larger bit (13.4 m to 8.3 m). It was generally thought that the smaller size bit performed better since video inspection of the seafloor from the VIT revealed a cleaner hole. Also, the torque reported by the driller and stalling of the PDCM was less of a problem than on the first borehole. Results from the PDCM runs showing weight on bit, flow rate, and drilling times are presented in Tables 1 and 2. It should be noted, though, that the first borehole was stopped several times in order to view the spudding and to confirm that the bit was indeed penetrating the seafloor. This most likely contributed to some fill falling back into the borehole, confirmed by the amount of redrilling necessary on this borehole each time the PDCM was stopped for observation. Another factor is that the two boreholes were approximately 100 m apart and, consequently, material variability could have played a much larger role in the changed drilling characteristics than the size of the bits. However, it was generally felt that the material was consistent over the area.

Visual inspection of the roller cone bits and center bits revealed that both bits had very little wear. There were no chipped or broken inserts, all the cones were intact, and the bearings appeared to still be tight and functional. This was true for both the center cone bits and the larger roller cone bits despite the fact that the center bits took the majority of the wear by being run ahead of the roller cone bit.

Boreholes 809C, -D, -E, And -F

Boreholes 809C through 809F were all conducted through the mini-hard rock guide base (HRB) (Fig. 6) for spudding the DCS holes. All of these BHA's were restrained by the landing seat inside the lower section of the casing hanger (Fig. 7) attached to the HRB. Also, all the center bits run on these holes were recessed 1.5 in. behind the cones of the larger roller bits. Penetration rates averaged 10–12 m/hr for Holes 809D and 809F. The drilling rates for the two other sites (809C and 809E) were considerably greater and cannot be grouped into the same category as the other two locations. This was because a considerable amount of torque did not reach the bits but was lost by the BHA rotating against the side of the casing hanger. This occurred when attempting to spud and drill the boreholes at an angle greater than the reentry cones could compensate for.

The most notable difference between these holes (809C through 809F) and the unsupported spud-in holes (809A and 809B) was the penetration rate. Since two of the variables were changed in the spudding technique, it is not clear how much each

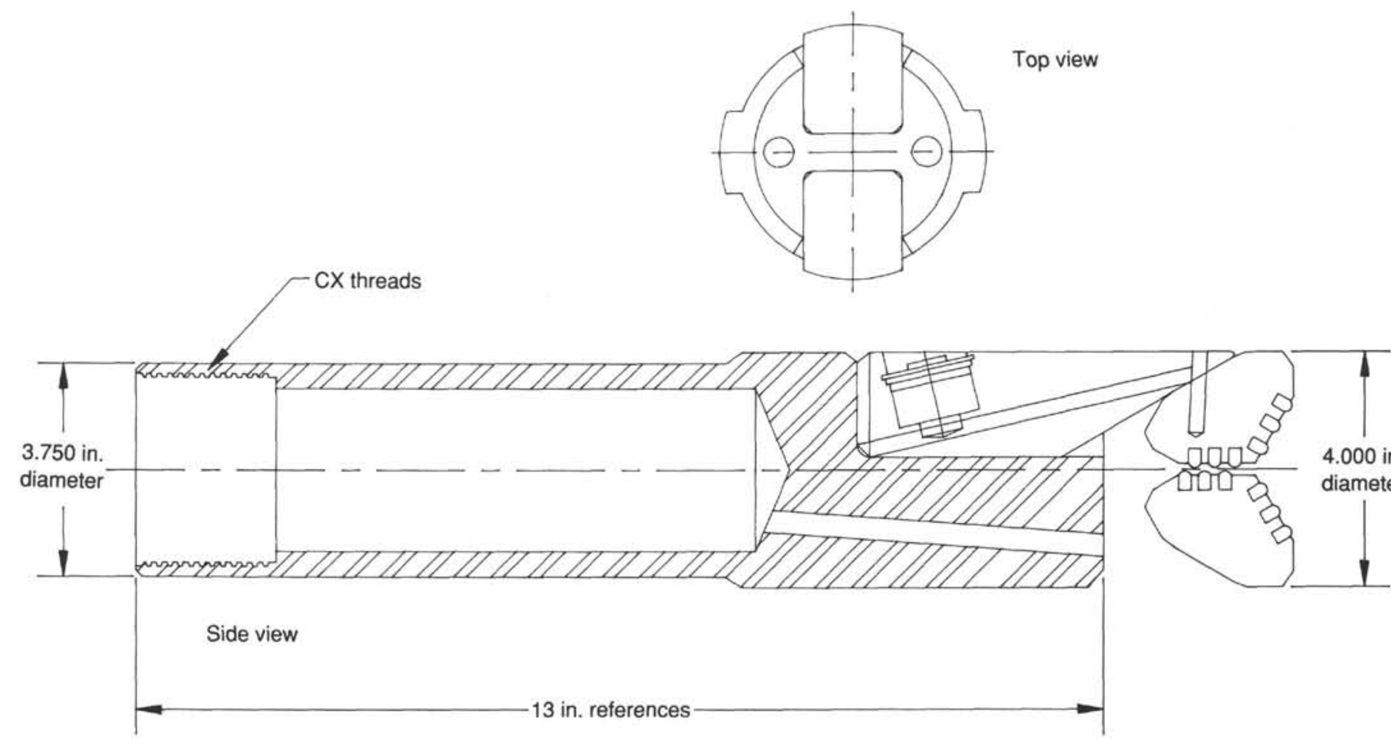

Figure 3. Center bit design.

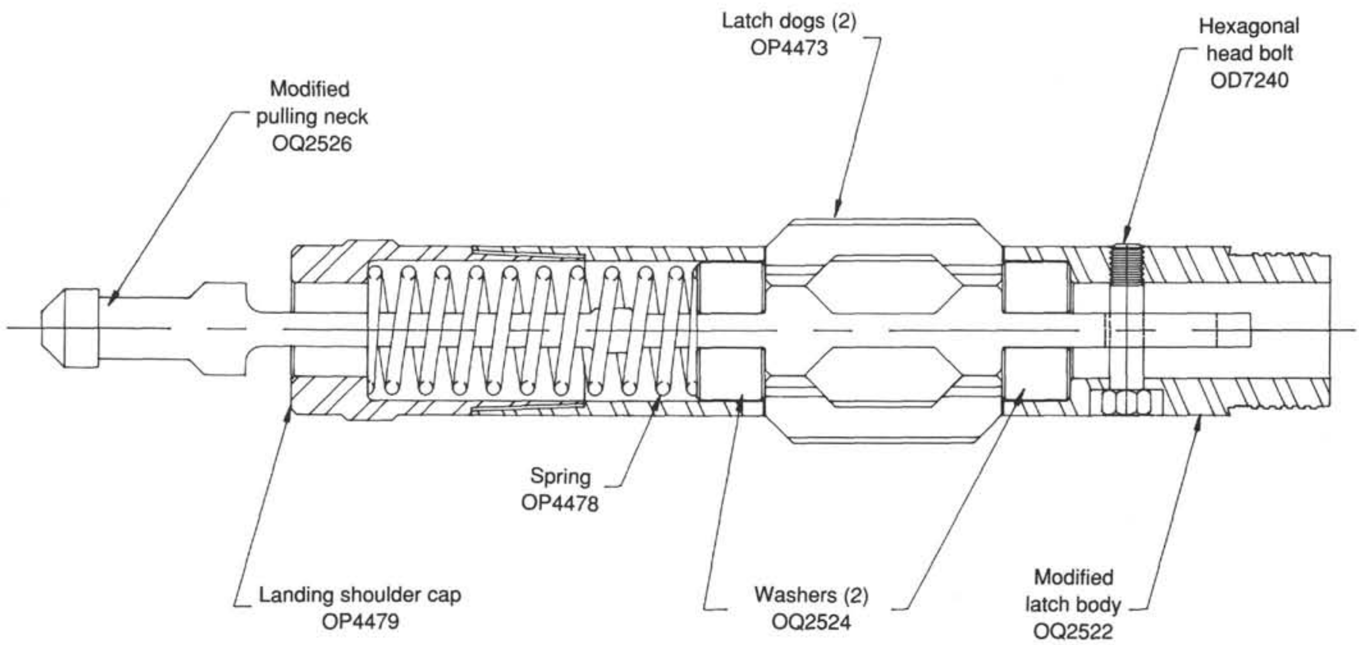

Figure 4. Modified XCB latch assembly.

contributed to the faster drilling. Good arguments can be made for both. However, it was felt that a significant improvement over bare rock spudding can be realized when the bit is restrained from rolling around/skating on the seafloor.

The two holes drilled at an angle (809C and 809E) and aborted prior to reaching the designated termination depth allowed better observation of bit wear. It was observed that material encountered at the Bonin location was not representative of that expected at East Pacific Rise or what was found at the Mid-Atlantic Ridge on Legs 106 and 109. However it is felt that improvements in these bits over those used previously are a step in the right direction.

One of the 11-5/8 in. bits rotated for 21 hr showed little sign of wear. However, the accompanying center bit with the same number of hours produced a wash out on one of its legs and loss of one insert on the gauge. The other 11-5/8 in. bit was rotated less than 2 hr and also showed relatively little wear. Typical weight on bit ranged between 2 and 8 kip. Tables 3 through 7 provide the bit record for flow rates, weight on bit, and penetra-

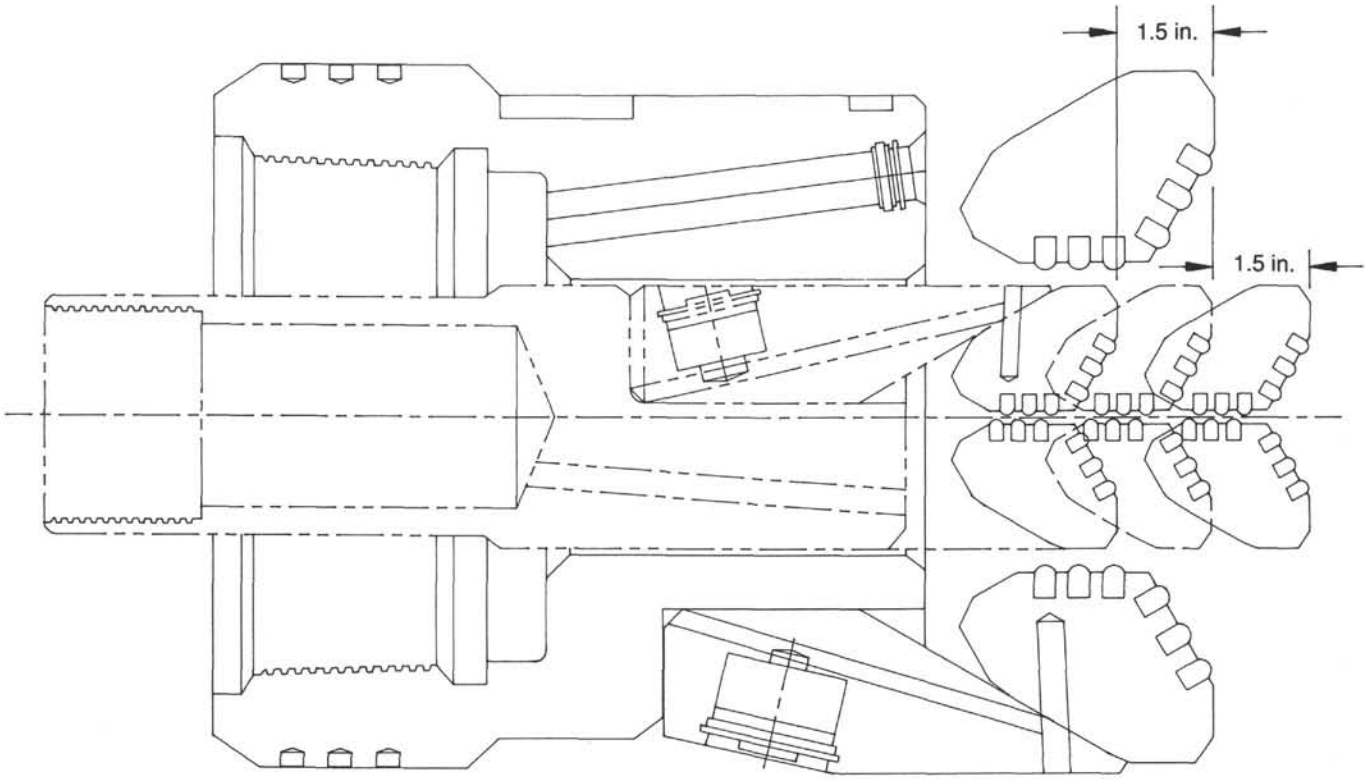

Figure 5. Center bit elevations.

Table 1. Coring motor runs, Hole 809A.

Run no.	WOB (1000 lb)	Flow rate[a] (gpm)	Operating pressure (psi)	Stalling pressure (psi)	Penetration (m)	Time (hr)
1	0–5	250	250	500	0.00	0430
2	0–5	325	300	550	0.00	0435
3	0–5	325	300	550	1.00	0445
4	2–5	325	400	800	1.80	0545
5	2–5	370	500	800	2.00	0600
6	2–5	315	500	800	2.20	0615
7	2–5	310	450	800	3.00	0650
8	2–5	310	450	800	3.50	0730
9	2–5	320	500	800	4.00	0750
10	2–5	340	500	800	4.50	0815
11	2–5	345	500	800	5.00	0830
12	2–5	350	500	800	5.80	0910
13	2–5	350	500	800	6.00	0915
14	2–5	370	500	800	6.10	0925
15	2–5	370	500	800	6.10	0945
16	2–5	370	500	800	6.50	1030
17	2–5	420	550	1000	7.00	1045
18	2–5	410	550	1100	7.50	1105
19	2–5	415	550	1100	8.30	1145
20	2–5	415	550	1100	8.30	1215

[a] Gallons per minute divided by 5 equals strokes per minute.

Table 2. Coring motor runs, Hole 809B.

Run no.	WOB (1000 lb)	Flow rate[a] (gpm)	Operating pressure (psi)	Stalling pressure (psi)	Penetration (m)	Time (hr)
1	0–5	325	300	500	0.00	2345
2	0–5	210	200	—	1.00	2350
3	0–5	210	200	—	2.00	2400
4	0–5	260	300	700	3.00	0020
5	0–5	270	300	—	3.00	0030
6	0–5	320	350	700	4.00	0100
7	0–5	330	250	700	4.50	0120
8	0–5	335	350	—	5.00	0145
9	0–5	370	350	—	5.30	0200
10	0–5	360	700	—	5.50	0210
11	0–5	360	250	—	6.00	0230
12	0–5	360	400	—	6.00	0240
13	0–5	360	700	—	6.00	0255
14	0–5	410	450	—	6.00	0300
15	0–5	420	400	—	7.00	0345
16	0–5	420	400	—	7.60	0400
17	0–5	415	500	—	7.60	0400
18	0–5	420	500	—	8.00	0420
19	0–5	420	450	—	9.00	0435
20	0–5	420	400	—	10.00	0445
21	0–5	420	800	1200	10.30	0520
22	0–5	450	500	—	11.00	0550
23	0–5	450	500	—	12.00	0610
24	0–5	455	475	—	13.00	0655
25	0–5	450	500	—	13.40	0705
26	0–5	450	500	—	13.40	0710

[a] Gallons per minute divided by 5 equals strokes per minute.

tion. A complete summary of the bits run and their performance in terms of hours run and meters drilled is presented in Table 8.

Another important point is that all the bits were manufactured with a consistent quality control. Threads were all cut to gauge on both the larger Hycalog threads and the smaller and more difficult ODP CX thread on the center bits. There were no reported bearing failures on any of the bits other than the center bit, which experienced a wash out and all the welds held up without losing any arms.

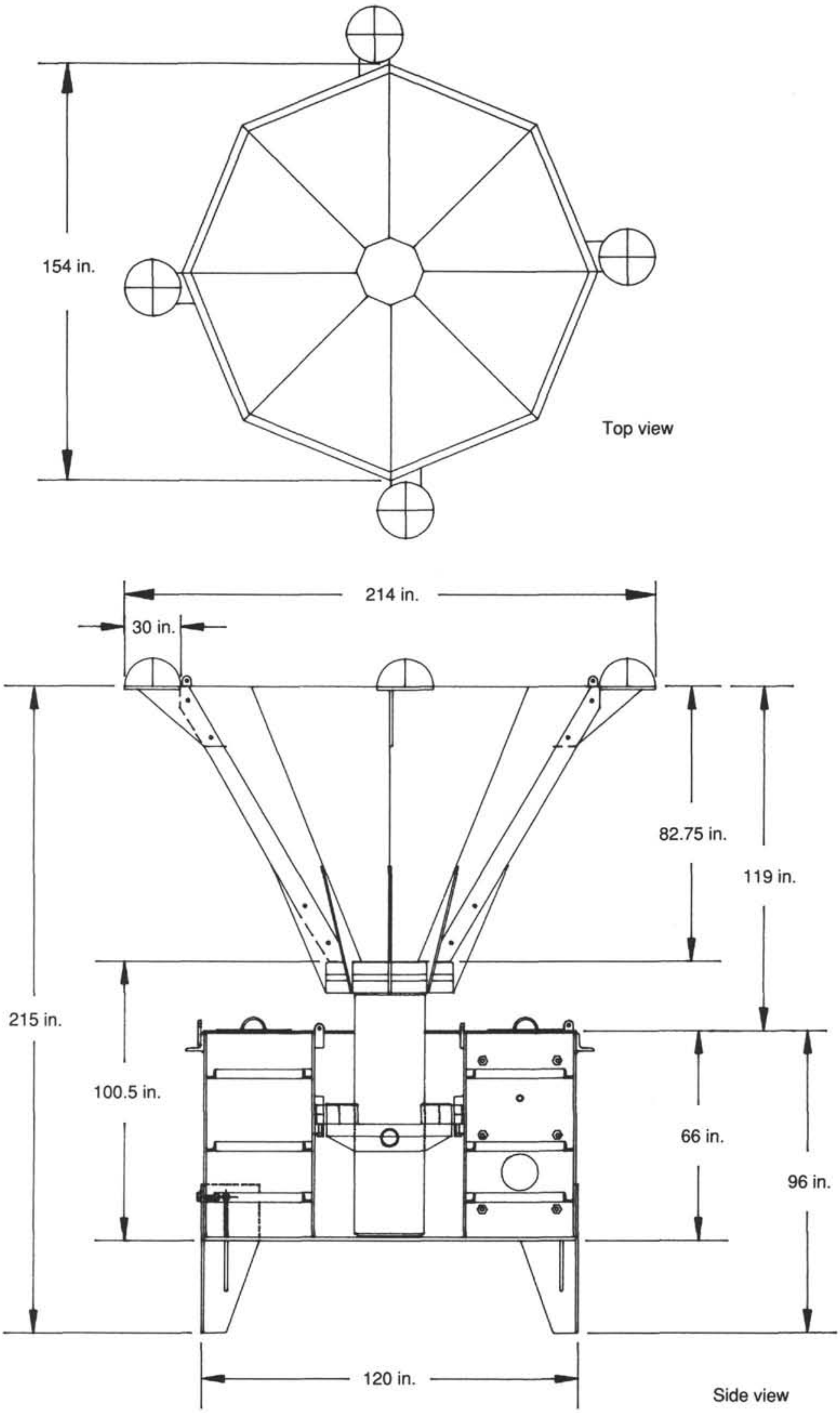

Figure 6. Mini-hard rock guide base.

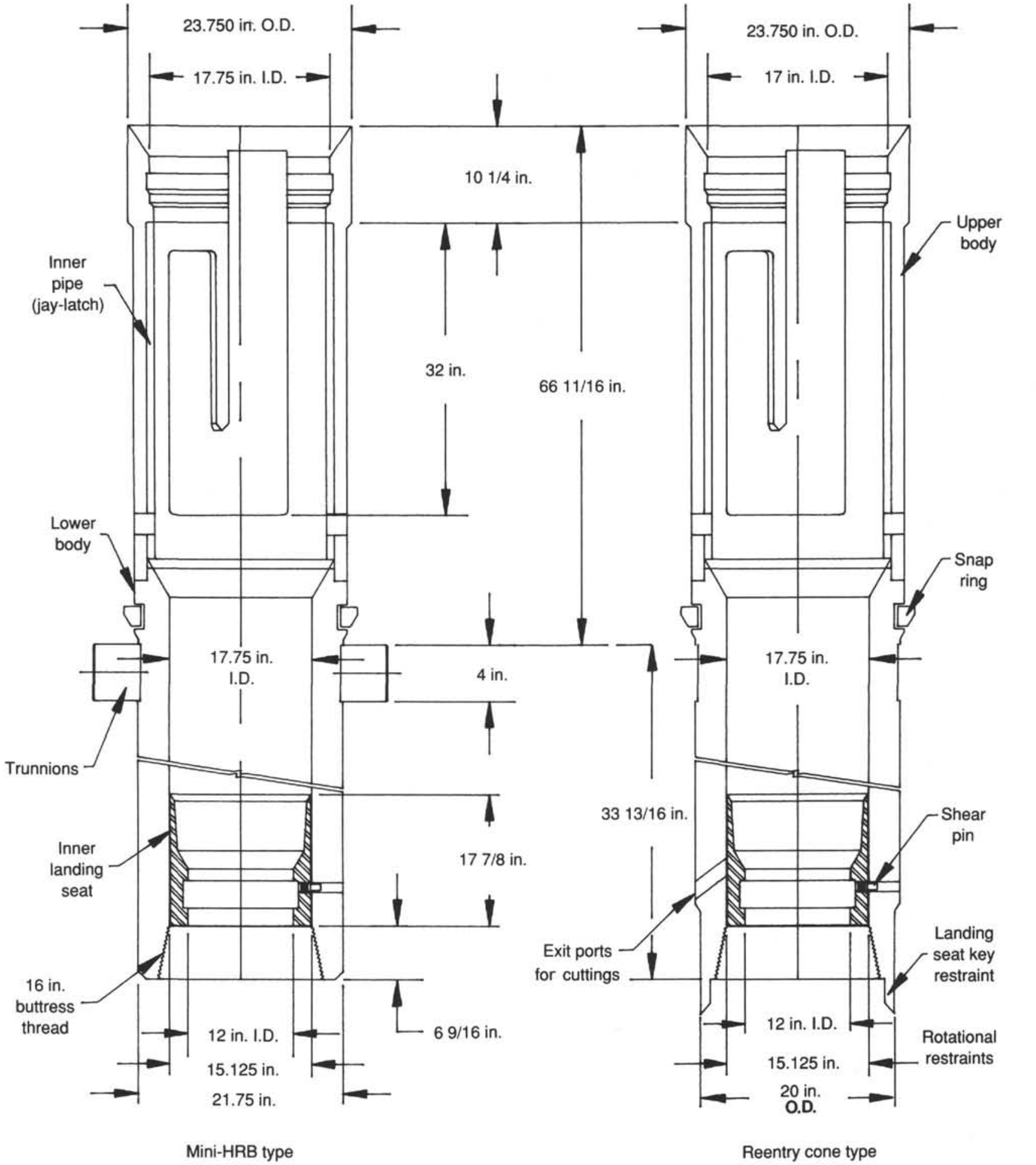

Figure 7. Modified casing hanger.

HOLE 810D

A 9-7/8 in. H87F bit was run at this location. The formation consisted of soft calcarious oozes to firmer chalk down to a depth of 127.1 mbsf (417 ft). A hard chert layer was located at this depth. This was confirmed by a wash-in test (no rotation) conducted earlier at this site to determine the depth to which it would be physically practical to set 16 in. casing. The test, which limited the weight on bit to only 5000–10,000 lb, produced a penetration of 60 m (197 ft) in a little less than an hour. A reentry cone was then deployed at this site to establish a conduit for the BHA to be drilled through (Fig. 8). However, due to a problem with the casing hanger itself, casing was not run. Since casing was not run, it was decided to drill the BHA (consisting only of drill collars) to 112.63 mbsf (369 ft). This was accomplished in a little less than 3 hr with the PDCM. However, because the BHA did not back off

Table 3. Coring motor runs, Hole 809C.

Run no.	WOB (1000 lb)	Flow rate[a] (gpm)	Operating pressure (psi)	Stalling pressure (psi)	Pene-tration (m)	Time (hr)
1	2–5	210	300	500	0.00	1220
2	2–5	350	350	600–700	—	1230
3	2–5	400	400	600–700	2.00	1235
4	2–5	400	400	600	—	1250
5	2–5	410	300	—	3.00	1300
6	2–5	405	300	—	—	1330
7	2–5	410	300	—	4.00	1345
8	2–5	410	300	—	4.10	1410

[a] Gallons per minute divided by 5 equals strokes per minute.

Table 4. Coring motor runs, Hole 809D.

Run no.	WOB (1000 lb)	Flow rate[a] (gpm)	Operating pressure (psi)	Stalling pressure (psi)	Pene-tration (m)	Time (hr)
1	5	225	200–250	—	0,00	0610
2	2–5	300	250–350	—	0.50	0617
3	2–5	300	250–350	—	1.00	0622
4	2–5	300	275–350	—	1.50	0624
5	2–5	350	325–400	—	2.00	0625
6	2–5	350	325–400	—	2.50	0627
7	2–5	350	350	—	3.00	0628
8	2–5	350	350	—	3.50	0629
9	2–5	350	350–450	—	4.00	0631
10	2–5	350	425–600	—	4.50	0633
11	2–5	350	425–600	—	5.00	0637
12	2–5	350	400–500	—	5.50	0639
13	2–5	350	450–500	—	6.00	0644
14	2–5	350	375–400	—	6.30	0647
15	2–5	350	200–250	—	6.30	0649
16	2–5	250	100–125	—	6.30	0651
17			shut down pumps			0657
18			pull out of cone			0708

Comments: Good run, drilled to total depth, and backed off as designed.
[a] Gallons per minute divided by 5 equals strokes per minute.

as it was suppose to, it was retrieved for inspection. This scenario occurred two more times before actually leaving the BHA in the seafloor.

As would be expected for this soft of material, the bit still looked new after being retrieved. There was no damage to the inserts or cones, even though some small stringers of chert may have been encountered during the drilling. The center bit, though having been run twice before in basalt, did not show any additional wear after drilling/washing another 119.3 m (391 ft). The bit was redeployed a third time and drilled another 13.72 m (45.65 ft) where the BHA was finally backed off. However, due to a problem with the C-ring on the back-off sub, the BHA did not latch-in but continued downward approximately 26 m (85 ft) deeper than it was supposed to land. This necessitated a fishing trip to retrieve the BHA. Upon recovery to the rig floor, it was observed that the bit was totally destroyed after falling onto the hard chert layer with 50,000 lb of BHA behind it. The weld on one arm had broken and allowed it to be pulled from its original socket. The other three arms were broken at the bit body. The impact was so severe that even the throat of the bit was deformed and slightly flattened on one side. What was surprising was that the center bit again came out without any appreciable additional wear over the previous run. It is speculated that due to its position within the larger bit (1.5 in. behind the larger cones), the majority of the impact was taken by the four cones/arms. A record of bit performance while using the PDCM is provided in Table 7.

Table 5. Coring motor runs, Hole 809E.

Run no.	WOB (1000 lb)	Flow rate[a] (gpm)	Operating pressure (psi)	Stalling pressure (psi)	Pene-tration (m)	Time (hr)
1	2–5	225	—	—	0.00	0644
2	2–5	225	—	—	0.50	0645
3	2–5	225	200–250	—	1.00	0646
4	2–5	225	200–250	—	1.50	0648
5	2–5	300	375–400	—	2.00	0650
6	2–5	300	300	—	2.50	0651
7	2–5	350	400	—	3.00	0653
8	2–5	350	400–525	1000	3.50	0655
9	2–5	350	450–500	—[b]	4.00	0657
10	2–5	350	400–475		4.50	0701
11	5–8	350	425–475	—	5.00	0706
12	5–8	350	475–550	700[c]	5.00	0712
13	5–8	350	525–600		6.00	0713
14	5–8	400	475–550	—[d]	6.50	0718
15	5–8	450	525–700		7.00	0748
16	5–8	450	800–1000	[e]	—	—
17	8–10	350	600–675	—	7.50	0827
18	8–10	350	675–750	—	8.00	0845
19	8–10	350	700–750	—	8.50	0920
20	5–10	350	700–800	1000[f]	8.75	0921
21	—	500	1000–1200		8.75	—
22	—	—	625–850	—[g]	8.75	1006
23	—	—	800–1000		8.75	1014
24	—	—	1000–1100	—[h]	8.75	1026
25	0–5	365	500–600		3.00	1120
26	0–5	350	650–750	[i]	2.5–3	1123
27	0–5	350	650–700	—	2.5–3	1130
28	0–2	350	600–650	750	2.5–3	1140
29	0–2	400	700–800	950	2.00	1141
30	0–2	400	650–750	—	2.00	1147
31	0–2	400	650–750	—	1.50	1153
32	0–2	400	700–850	900	2.00	1155
33	0–2	450	850–950	—[j]	2.75	1200
34	0–2	450	850–900		3.00	1212
35	2–5	460	800–1000	—[k]	3.00	1215
36	2–5	550			3.50	1230
37	2–5	450	800–900	1500	3.50	1245
38	0–5	470	800–900	—	4.00	1300
39	0–5	475	800–900	1200[l]	4.25	1301
40	0–5	475			4.50	1315
41	0–5	500		[m]	4.00	1320
42	0–5	500	1000	—	5.00	1332
43	0–5	530	900–1000	—	5.50	1334
44	0–5	500	900–1000	—	5.50	1340
45	10–15pull	450		1200[n]	5.50	1410
46	0–5	535	1000		5.50	1420
47	2–8	620	1400	[o]	6.00	1425
48	4–8	620	1300–1400	—	6.00	1435
49	4–8	610	1400	1600[p]	6.50	1455
50	0–5	595	1400		7.00	1525
51	0–5	590	1300–1400		7.10	1545
52	2–4	585	1400		7.20	1550
53	2–4	580	1300–1400	[q]	7.25	1700
54	2–8	575–600	1300–1550	good rotation	7.30	1730
55	4–10	575–600	1300–1550	rotation ok	7.40	1743
56	4–10	575–600	1300–1500	1600	7.50	1800
57	4–10	575–600	1300–1550	—	7.70	1820
58	4–10	575–600	1200–1500	—	7.70	1830
59	4–10	575–600	1350–1550	1600	7.75	1845
60	4–10	575–600	1350–1550	1600[r]	7.80	1900
61	4–10	600	1350–1550		7.85	1915
62	4–10	585	1300–1400	—	7.90	1930
63	4–10	585	1300–1400	—	8.00	1945
64	4–8	450	900–950	1050	8.00	2030

Comments: Penetration rate decreased to almost nothing, decision made to pull out BHA and check bits.
[a] Gallons per minute divided by 5 equals strokes per minute.
[b] 10 bbl high viscosity mud pumped down.
[c] 10 bbl high viscosity mud pumped down.
[d] 15 bbl high viscosity mud pumped down.
[e] Penetration rate decreased significantly.
[f] Problems with stalling out and drag (over pull).
[g] 15 bbl high viscosity mud pumped down.
[h] Pulling back to keep motor running.
[i] Pulling back to keep motor running.
[j] Motor stalls out with very little WOB.
[k] Reestablish rotation.
[l] Stall out at 5 gpm, pull back to restore rotation.
[m] Reestablish rotation.
[n] 50 kip overpull to free BHA.
[o] Good rotation.
[p] Motor stalling out.
[q] 10 bbl high viscosity mud pumped down.
[r] Motor stalling out, pick up BHA 0.2 m.

Table 6. Coring motor runs, Hole 809F.

Run no.	WOB (1000 lb)	Flow rate[a] (gpm)	Operating pressure (psi)	Stalling pressure (psi)	Pene-tration (m)	Time (hr)
1	2–5	225	200–300	500	0.00	2222
2	2–5	225	250–325	—	0.50	2223
3	2–5	225	300–450	—	1.00	2226
4	2–5	300	450–575	—	1.50	2228
5	2–5	300	400–525	700	2.00	2229
6	2–5	300	375–475	—	2.50	2235
7	2–5	350	475–600	700	3.00	2238
8	2–5	350	400–500	700	3.50	2239
9	2–5	350	425–500	—	4.00	2240
10	2–5	350	450–650	—	4.50	2243
11	0–5	350	450–600	—	5.00	2245
12	2–5	350	475–550	—	5.50	2247
13	0–5	350	450–525	—	5.90	2250
14	0–5	350	300	—	5.90	2252

Comments: Pressure spikes not real obvious, but dropped off to 300 psi after back off.
[a] Gallons per minute divided by 5 equals strokes per minute.

Table 7. Coring motor runs, Hole 810D.

Run no.	WOB (1000 lb)	Flow rate[a] (gpm)	Operating pressure (psi)	Stalling pressure (psi)	Pene-tration (m)	Time (hr)
1	0–2	75–100	—	—	0.00	0410
2	0–2	75–100	—	—	3.00	0411
3	0–2	75–100	—	—	6.00	0415
4	from 0427 to 0431 made up pipe connection				?	0427
5	0–2	75	150–250	—	9.00	0431
6	0–2	100–125	150–200	—	12.00	0433
7	0–5	125	100–200	—	15.00	0435
8	0–5	100–125	100–200	—	18.00	0436
9	0–5	100–125	150–250	—	20.00	0437
10	from 0414 to 0448 made up pipe connection					0438
11	0–5	?	—	—	24.00	0450
12	0–5	125	200–225	—	27.00	0451
13	0–5	125	—	—	30.00	0452
14	0–5	125	150–225	—	33.00	0454
15	0–5	125	300	—	36.00	0455
16	0–5	140–150	250–300	—	39.00	0457
17	from 0457 to 0503 made up pipe connection					0503
18	2–6	165	250–300	—	42.00	0506
19	2–6	170	250–300	—	45.00	0508
20	2–6	170	215–425	—	49.00	0511
21	from 0511 to 0524 made up pipe connection					0524
22	6–10	150	225–300	—	51.00	0527
23	6–10	150	300–400	—	54.00	0530
24	6–10	165	300–350	—	57.00	0532/
25	6–10	210	400–450	—	60.00	0534
26	6–10	210	300–400	—	63.00	0536
27	6–10	200	300–375	—	67.00	0538
28	6–10	200	300–400	—	69.00	0540
29	from 0540 to 0545 made up pipe connection					0545
30	6–10	200	300–400	—	73.00	0549
31	6–10	200–210	275–400	—	76.00	0551
32	6–10	215	300–400	—	79.00	0553
33	from 0553 to 0610 made up pipe connection					0610
34	6–10	210	300–350	—	82.00	0613
35	6–10	230	300–400	—	85.00	0614
36	0–6	220	300–400	—	88.00	0616
37	0–6	225	300–400	—	91.00	0618
38	2–8	225	300–400	—	94.00	0620
39	6–8	225	300–450	—	97.00	0622
40	6–8	225	325–450	—	99.00	0623
41	from 0623 to 0632 made up pipe connection					0632
42	from 0632 to 0635 made up pipe connection					0635
43	6–10	235	325–450	—	103.00	0638
44	6–10	225	300–400	—	106.00	0640
45	6–10	225	500–550	—	107.00	0641
46	—	—	shut down	—	107.50	—

[a] Gallons per minute divided by 5 equals strokes per minute.

RECOMMENDATIONS/CONCLUSIONS

Performance of the roller cone bits, center bits, and latch assemblies illustrated that the concept of a removable center bit was a viable alternative when an additional tubing string was to be deployed through the initial drilled-in BHA. Though possibly not as demanding as some young fractured basalt formations, the Bonin site did provide several instances where total rotating hours exceeded that accomplished during Legs 106 and 109. It was reported not uncommon for bit failure to occur within 6 hr in unsupported bare rock spud-in on Leg 106 and up to 12 hr for the bits used on Leg 109. Designs incorporated from those bits were used as the basis for the bits manufactured for Leg 132. Better bit life could also possibly be attributed to overall bit and bearing assembly design, better control of the PDCM, less weight on the bit, better stabilization/centralization, and/or manufacturer/vendor quality control.

It was felt that the reduced hole diameter and annulus with the 9-7/8 in. bit improved hole stability and hole cleaning characteristics over that of the larger 11-5/8 in. bit. However, with only two tests for comparison, definitive answers can not be claimed at this time. It is recommended that additional testing of the bits in a similar material be performed so that conclusive evidence can support this premise.

The two-cone center bits provided a prototype design which may be improved after further studying their performance. Since these small bearing bits are more apt to wear out sooner than the larger cone bearings, a more robust design should be investigated along with a possible wireline replaceable version, when the hole is not initially drilled with the PDCM. Using the center bit as a pilot for bare rock spud-in appeared to prevent the bit from walking on the seafloor and may possibly have reduced the wear on the larger cones by removing the initial core. However, prolonged use in this mode could result in the complete failure and possible loss of the smaller cones.

The fact that the BHA was somewhat supported and centralized by the hard rock guide base on Leg 109 was cited as reason for longer bit life and performance over what was experienced on Leg 106. This concept was taken a step further using the technique of continual centralization and stabilization of the bit until borehole termination depth was reached on the hard rock sites. The restrained bit movement due to the tight diameter of the landing seat inside the casing hanger, coupled with the centralization from the spiral-bladed stabilizers, is felt to have added significantly to the bit life and performance. A schematic of the spudding technique is illustrated in Figure 9. Annular clearance through the 12 in. landing seat between it and the BHA was typically less than 1/2 in. throughout the drilling process. Annular clearances for the HRB used on Leg 109 were much larger due to the 31 in. diameter opening in the guide base despite the fact that a 24 in. diameter guide bushing was run when spudding the hole.

Another possible reason for better bit performance was the different design philosophy used to establish the hole. Leg 109 attempted to use the more conventional oilfield approach of drilling a larger hole and setting surface casing strings, whereas a drill-in type BHA was used on Leg 132. This concept of the

Table 8. Summary of bit performance.

Bit no.[a]	Manu-facturer	Type	Number of cones	Size (in.)	Serial no.	Hole	Depth drilled (m)	Cumulative depth drilled (m)	Hours	Cumulative hours	Jet size (in.)	Remarks
1.0	Security	M84F	4	11⅝	489656	809A	8.3	8.3	7	7	4–14	Basalt
1.1	Security	M84F	4	11⅝	489656	809E	9	17.3	14	21	4–14	Basalt
2.0	Security	M84F	4	11⅝	489657	809C	4.1	4.1	1.75	1.75	4–14	Basalt
3.0	Security	M84F	4	11⅝	489658	809D	6.2	6.2	0.58	0.58	4–14	Basalt
4.0	Security	H87F	4	11⅝	489659	New						Not run
5.0	Security	H87F	4	11⅝	489660	New						Not run
6.0	Security	H87F	4	11⅝	489661	New						Not run
7.0	Security	H87F	4	11⅝	489662	809F	6	6	0.5	0.5	4–14	Basalt
8.0	Security	M84F	4	9⅞	489663	809B	13.4	13.4	9	9	4–14	Basalt
9.0	Security	H87F	4	9⅞	489664	New						Not run
10.0	Security	H87F	4	9⅞	489665	810D	119.3	119.3	2.5	2.5	4–16	Soft chalk
11.0	Security	M100F	2	4	489713	809A	8.3	8.3	7	7	7/16	Without spacers–1.75 in. stick out
11.1	Security	M100F	2	4	489713	809E	9	17.3	14	21	7/16	Washed out
12.0	Security	M100F	2	4	489712	809B	13.4	13.4	9	9	7/16	Without spacers–1.75 in. stick out
13.0	Security	M100F	2	4	489711	809C	4.1	4.1	1.75	7/16	Basalt	
13.1	Security	M100F	2	4	489711	809F	6	10.1	0.5	2.25	7/16	Basalt
13.2	Security	M100F	2	4	489711	810D	119.3	129.4	2.5	4.75	7/16	Soft chalk
14.0	Security	M100F	2	4	489709	809D	6.2	6.2	0.58	7/16	Basalt	
15.0	Security	M100F	2	4	489710	New					7/16	Not run
16.0	Security	M100F	2	4	489714	New					7/16	Not run
17.0	Security	M100F	2	4	489715	New					7/16	Not run

[a] Bits 1 and 8 were bare-rock spud-ins, Bits 1.1 and 2.0 were drilled at reduced torque due to contact with the hanger; all center bits run after Hole 809B were spaced 1.5 in. behind large roller cones.

drill-in BHA allowed the hole to be drilled down only once without retracting the drill string. This lead not only to a more stable hole but also did not require the bits to drill out rubble created when the drill string and bit were removed.

It is recommended that ODP continue a dialogue with Security in order to upgrade and/or modify the bits once Security has reviewed the dull bits. Additional information and insight as to the bit's performance and failure mode might be gained from Security which could allow all bits designed in the future to benefit from the information learned on this leg.

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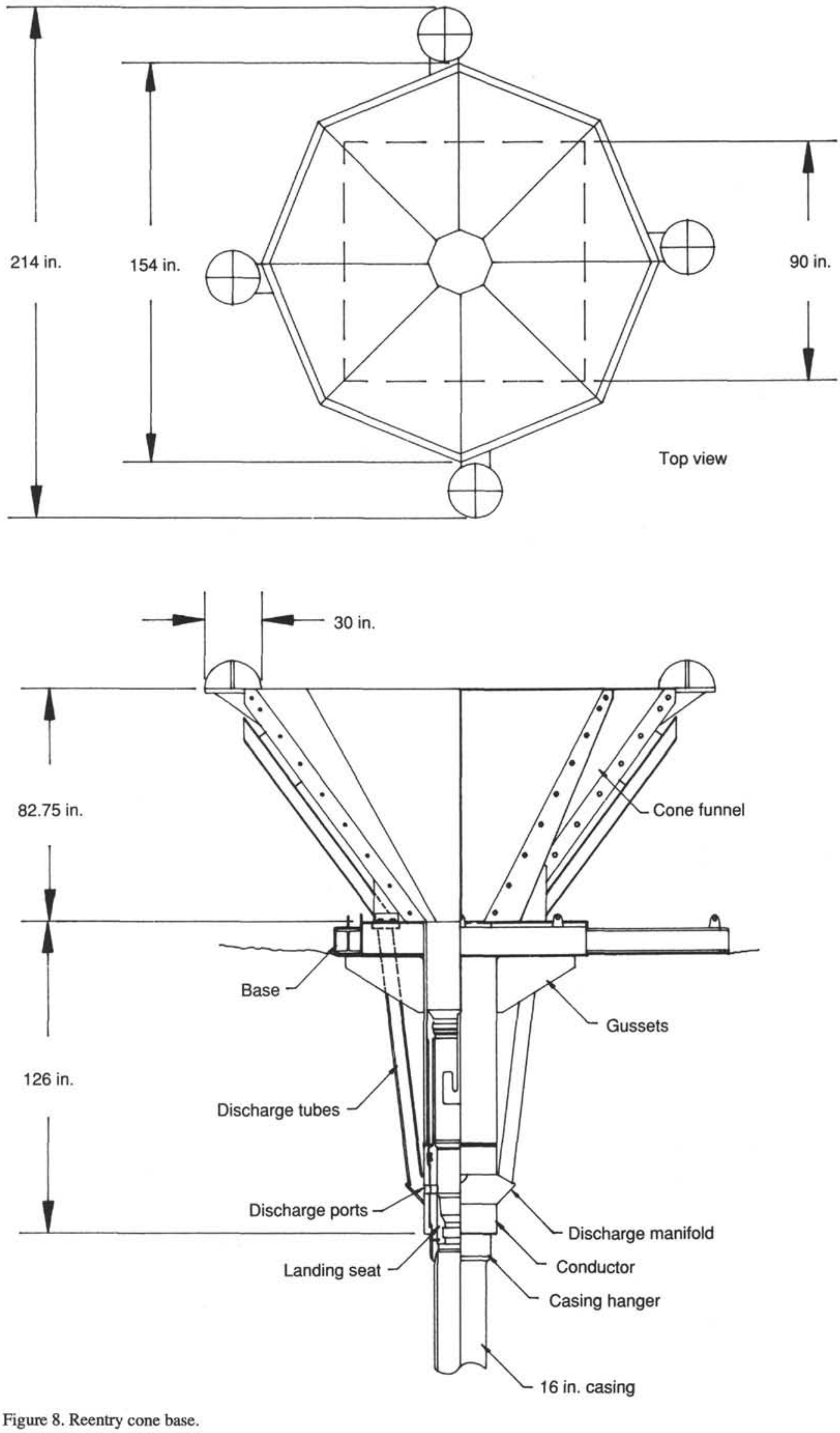

Figure 8. Reentry cone base.

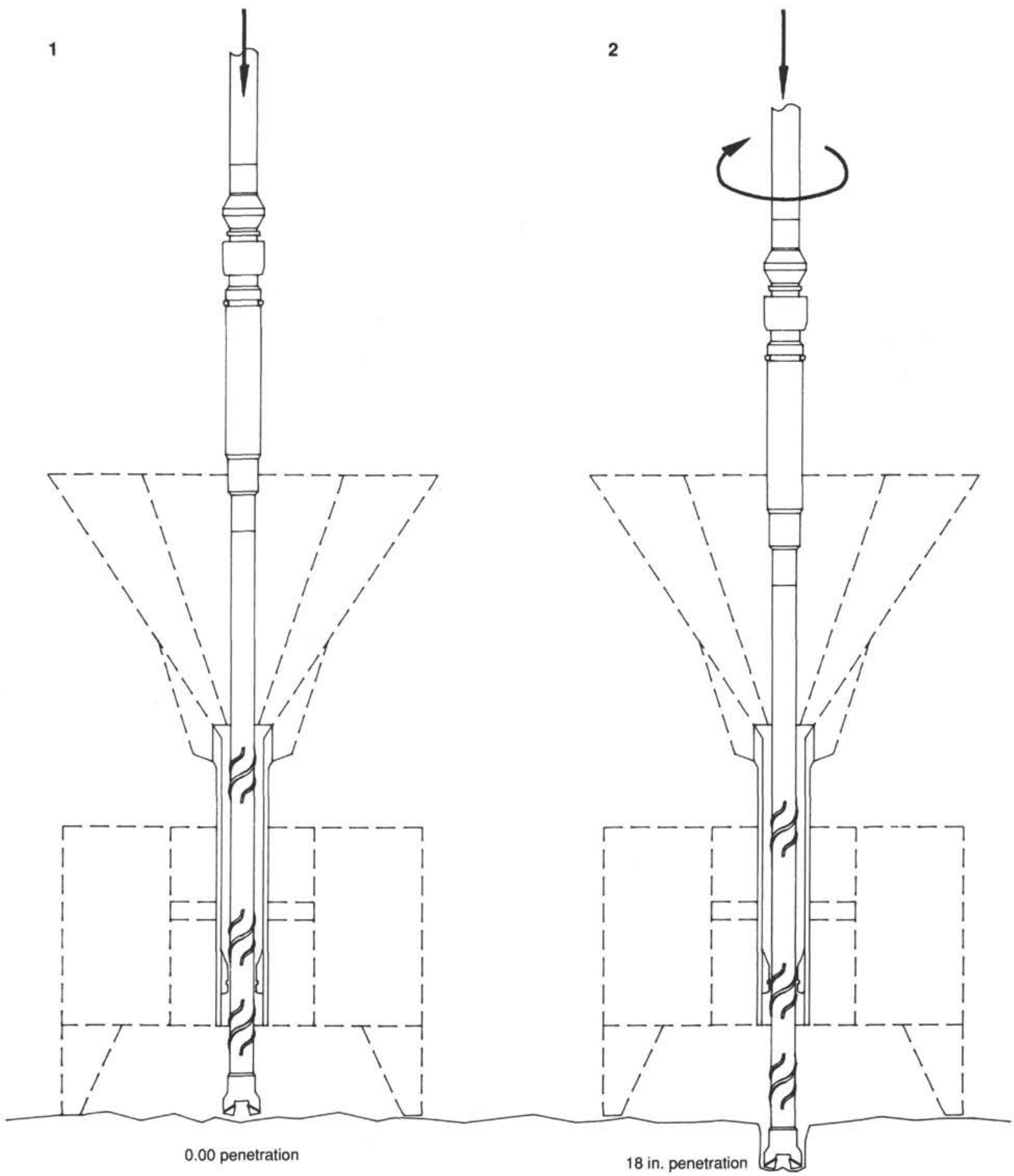

Figure 9. DCS borehole spudding techniques.

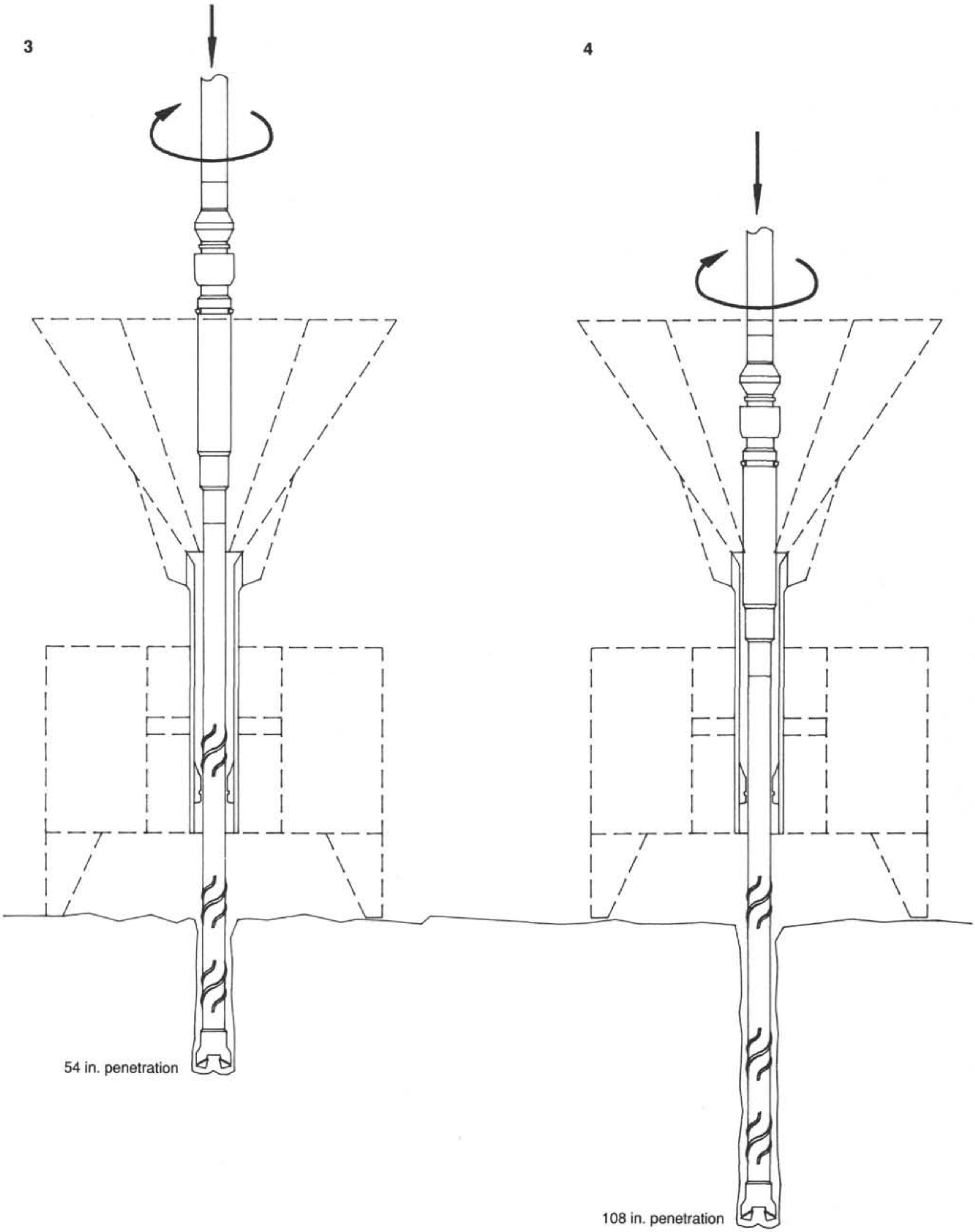

Figure 9 (continued).

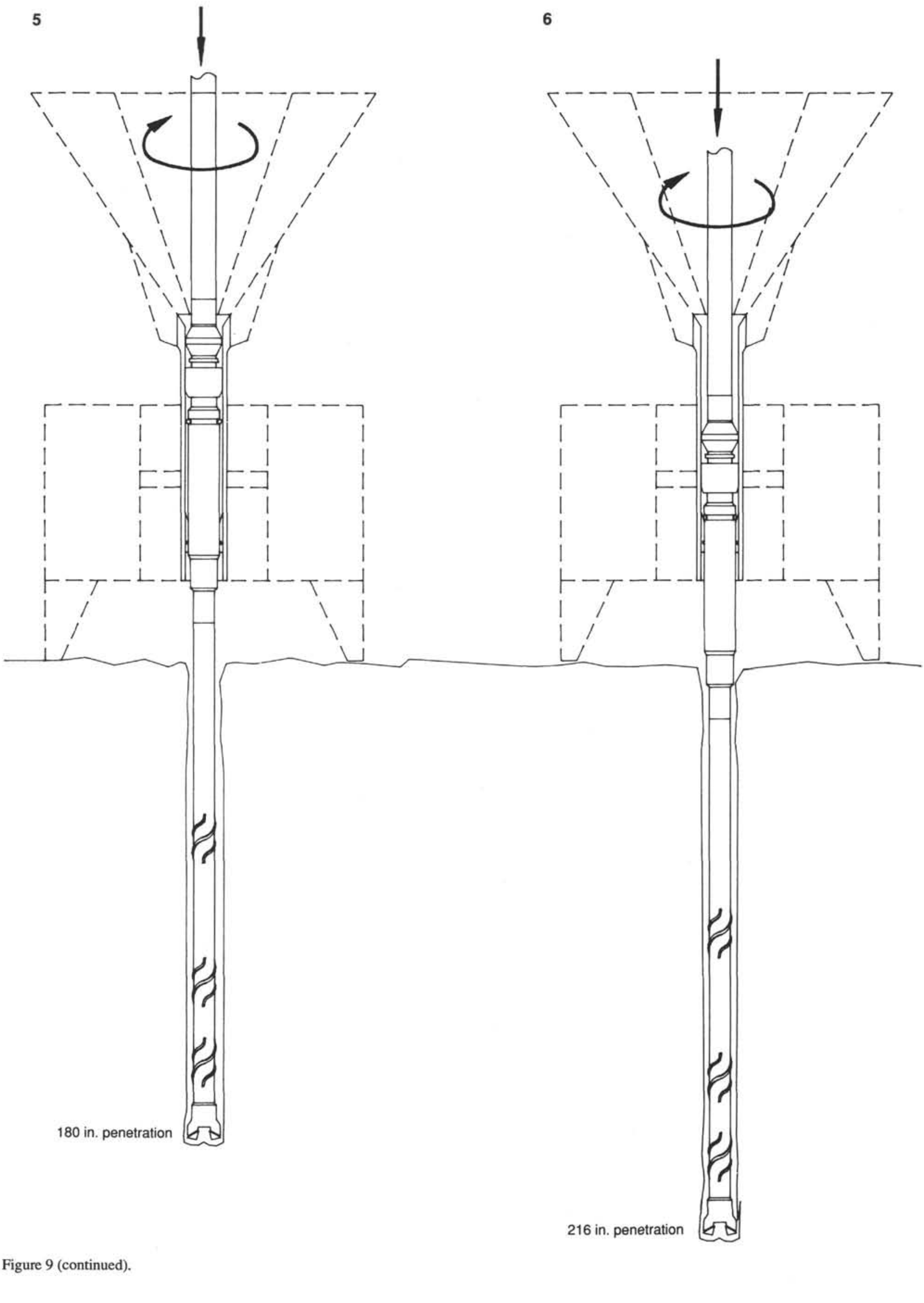

Figure 9 (continued).