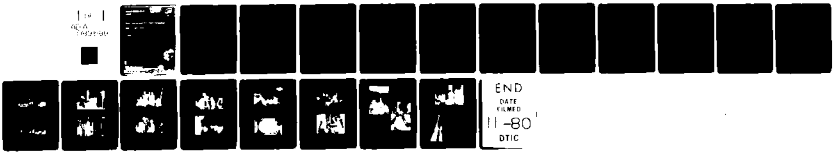
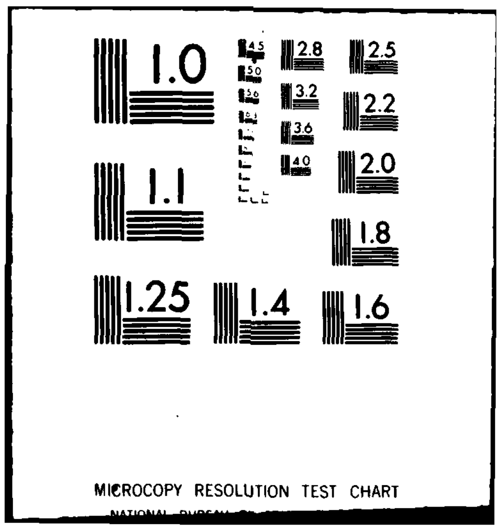
AD-A089 699 COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH F/G 8/12
GREENLAND ICE SHEET PROGRAM. 1979. PHASE 1. CASING OPERATION.(U)
JUN 80 J RAND
UNCLASSIFIED CRREL-SR-80-24 NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Special Report 80-24	2. GOVT ACCESSION NO. AD-A089	3. RECIPIENT'S CATALOG NUMBER 699
4. TITLE (and Subtitle) ~~1979~~ GREENLAND ICE SHEET PROGRAM, 1979, PHASE 1, CASING OPERATION		5. TYPE OF REPORT & PERIOD COVERED Special report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John Rand		8. CONTRACT OR GRANT NUMBER(s) NSF-DPP 78-17165
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Cold Regions Research and Engineering Laboratory Hanover, New Hampshire 03755		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS National Science Foundation Washington, D.C.		12. REPORT DATE Jun[redacted]80
		13. NUMBER OF PAGES 20
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) CRREL-SR-80-24		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Casing
Drilling
Drills
Glaciology
Greenland
Ice
Thermal drills

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A modified CRREL thermal drill was used at DYE-3 in Greenland to drill a 8.75-in.-diameter hole 251 ft deep for the installation of a steel casing. This activity was accomplished by a drill team from CRREL in preparation for the Danish deep drill tests. Included in this report is a description of both the drilling and casing operation as well as a description of the equipment used.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified 037100

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

This report was prepared by John Rand, Mechanical Engineer, Engineering and Measurement Services Branch, Technical Services Division, U.S. Army Cold Regions Research and Engineering Laboratory. The report covers work sponsored by the Division of Polar Programs of the National Science Foundation under Interagency Agreement NSF-DPP 78-17165.

The author expresses his personal thanks to the individuals who participated in this casing operation: the CRREL crew, Larry Gould, Frank Perron, and John Govoni, who did the work and kept the operation on schedule; Dave Johnsen and Chris Mumford of the University of Nebraska who pitched in and gave support as required; and the personnel at DYE-3 who were, as always, very helpful and understanding.

This report was technically reviewed by Larry Gould and Donald Garfield, Engineering and Measurement Services Branch, Technical Services Division, CRREL.

CONTENTS

ILLUSTRATIONS

TABLES

1979 GREENLAND ICE SHEET PROGRAM

PHASE 1: CASING OPERATION

John Rand

INTRODUCTION

This report describes Phase 1 of the Greenland Ice Sheet Program (GISP) 1979 field season, the casing operation at DYE-3. The primary objective was to drill a 251-ft hole through the firn and into the impermeable ice and line the hole with steel casing. This effort was the first phase in preparing a site for the University of Copenhagen's deep drill tests (Rand 1980).

Phase II of the GISP 1979 field season was the shelter preparation by the Danish arctic contractor over the cased hole. Phase III was the drilling tests conducted by the University of Copenhagen drill team.

EQUIPMENT DESCRIPTION

Thermal drill

A modified version of the CRREL thermal drill (Ueda and Garfield 1969) was used to drill the casing hole. The modified thermal drill is 14 ft 3 in. long and weighs 155 lb. At the lower end of the drill an aluminum shoe, 8 5/8 in. outside diameter by 7 1/8 in. inside diameter, is electrically heated by 18 cartridge heaters. The individual heaters are 0.375 in. in diameter by 4 in. long and rated at 625 W with an internal resistance of 70 ohms. The cartridge heaters are electrically connected in parallel series and have an equivalent resistance of 18 ohms. Figure 1 shows a schematic of the system. The heater shoe melts a hole with a diameter of 8.75 in. and leaves a core with a diameter of 6.75 in. The electrical power dissipated by the heater shoes was adjusted by varying the voltage output from the generator. The effects of the applied voltage on the watt densities for the large heater shoe (5/8 in. outside diameter x 7 in. inside diameter) and the small heater shoe (6-3/8 in. outside diameter x 4 7/8 in. inside diameter), as well as the total power dissipated are shown in Table 1. These dimensions vary slightly depending upon drilling speed, which in turn depends upon the density and temperature of the firn or ice, as well as degree of contamination. Actual drilling rates experienced during this operation varied from 2.6 to 1.5 in./min.

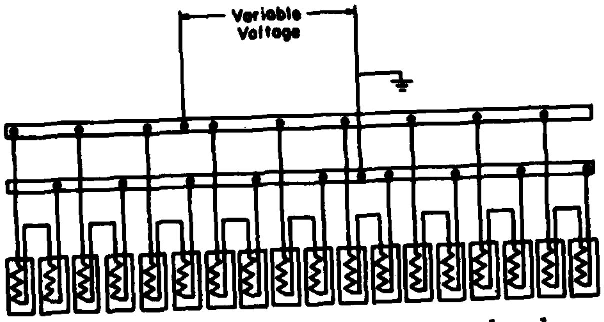


Fig. 1. Schematic of heater heads.

The meltwater produced by the drill is pumped up from the heater shoe through electrically heated nichrome tubes that are embedded in the core barrel wall to a cylindrical, laminated plastic storage container above the core barrel. The tank's capacity is 5 gal. or approximately 40 lb of water.

Table 1. Effect of the applied voltage on the watt densities for the small and large heaters.

Generator output (V)	Current (A)	Power (W)	Watt density Small heater ($W/in.^2$)	Watt density Large heater ($W/in.^2$)
208	13.4	2787	228	139
220	14.2	3122	255	156
240	15.5	3716	303	185
260	16.7	4361	356	218
280	18	5058	412	252

Two diaphragm vacuum pumps connected in parallel are housed above the melt tank. The pumps are rated at 115 V ac, 1.5 A. A vacuum line extends from the pumps down into the top of the melt tank. The vacuum developed sucks the water from the shoe up into the melt tank.

The core passes through the heater shoe into an aluminum core barrel. The maximum possible length of core is 68 in. Six spring-loaded core catchers at the bottom of the core barrel grip and retain the core.

Ice core drilling is a cyclic operation. Upon completion of a run, the drill is hoisted to the surface. The hoist is halted when the bottom of the melt tank is about 5 ft above the snow surface. A drainage tube is inserted into a valve assembly at the bottom of the melt tank, the water is drained into a plastic container, and the quantity collected is measured and recorded. The drill is then hoisted to the top of the tower.

The core is removed after each of the six core catchers is manually retracted and locked. Core length and characteristics are logged. The heater shoe is cleaned and the core catchers released. Before the drill is lowered a suction test is performed by immersing the aluminum shoe in a bucket of alcohol and actuating the vacuum pumps. The drill is lowered until the vacuum pumps are accessible and the pumps lubricated with ethyl alcohol to ensure both the pumps and lines are free from ice. The drill is lowered to the bottom and the next cycle starts.

Drill penetration is monitored by a weight indicator located at the top of the drill. This spring suspension system keeps the drill suspended during drilling, allowing a maximum of 30% of the drill's weight to rest on the ice. The suspended condition is necessary to ensure that a plumb hole is drilled.

Winch assembly

The thermal drill also incorporates a cable, a winch, a tower, and a generator. The electromechanical cable is 0.467 in. in diameter and has seven number 16 AWG signal conductors, one number 6 AWG power conductor, and two outer armor layers of high-strength, improved-plow-steel galvanized wire. The cable specifications and mechanical characteristics are listed in Appendix A.

The electromechanical cable is spooled on an aluminum drum that is capable of storing 1800 ft of 0.467-in.-diameter cable. A single cross-over orthocyclic winding (Aamot 1969, Lebus 1958) is used to provide proper cable spooling without the use of a mechanical level winding device. The cable is clamped inside the core of the drum. The electrical leads are connected to a slip-ring assembly located on one side of the drum to provide continuous electrical contact while the drum is rotating.

Power to the drum is provided by a 3-hp, 3-phase, 208-V ac motor. The motor is coupled to a clutch assembly that provides the hoisting control. From the clutch, power is transmitted to a gear reducer, and finally through a chain and sprocket assembly to the drum. The hoisting speed is approximately 100 ft/min.

The drill requires 208-V ac, 3-phase electricity for the winch motor and 208- to 280-V ac, single-phase electricity for the thermal drill. In addition, 110-V ac power is required for the device that controls the drill penetration rate and for miscellaneous equipment used around the drill site. Normally a 5- or 6-kW generator is adequate for this operation; however, we were welding on site, so a 35-kW diesel generator was used.

A control panel allows the operator to monitor the voltage and current to the drill, to activate the pump motors and heater, to monitor the weight indicator lights, to control drill penetration rates, and to switch the hoist motor for the lifting or lowering operation.

The 18-ft tower, which is mounted near the front of the winch, consists of two aluminum containers. Each container serves as a shipping container for the thermal drill. A sheave assembly is mounted on top of the tower.

Casing equipment

The GISP-79 casing placement operation also required the following: 30 10-ft sections of 7-in. schedule 10 steel pipe, a tower assembly, a Caterpillar model 931 track loader, and welding supplies.

A steel collar was welded to one end of each casing section as shown in Appendix B. The casing sections were sequentially numbered. Each collar was checked to assure it would fit over its mating section. The casing was shipped to Greenland in June 1978 and stored outside the GISP warehouse during the winter.

The tower assembly was manufactured at CRREL after a set of design drawings (Perkins unpublished). A hydraulic winch attached to the tower base lifted and lowered the casing. Hydraulic lines connected the hydraulic winch to the existing hydraulic lines on the track loader. Two casing lengths were welded together to form a 20-ft tower assembly. The base of the tower assembly was designed to attach to the forks of the track loader.

The casing lengths were welded together as the string was lowered into the hole. The welds had to be liquid tight and the casing had to be vertical. This operation was accomplished on site and is described in the performance section of this report.

Table 2. Sequence of events

10 May	Military Airlift Command C141 charter flight from Pease AFB to Sondrestrom, Greenland.
14 May	N.Y. Air National Guard 190th shuttle flights, Sondrestrom to DYE-3.
15 May	Establishment of drill site, cargo moved to site.
16 May	Final site preparation, drill assembly, tests.
17 May	Start of thermal drilling.
20 May	Completion of drilling (final depth 251 ft).
21 May	Move of thermal drill off site, begin casing hole.
22 May	Completion of casing operation; water into hole.
24 May	Ice plug frozen; start of drilling to remove plug.
25 May	Completion of starter hole; removal of drill; top 34 ft of casing lifted out of hole. Casing sealed. Departure for Sondrestrom.
26 May	Departure from Sondrestrom for McGuire AFB.

PERFORMANCE

The modified CRREL thermal drill was used for the casing operation at DYE-3. It drilled a 251-ft hole 8-3/4 in. in diameter while obtaining a 6-3/4 in. diameter core. The drilling performance is summarized in Table 3.

Table 3. Drilling Summary

Date	No. runs	Duration	Actual drilling time (hr)	Core drilled (ft)	Avg core length/run (ft)	Avg penetration rate for the day (in./min)
17 May	13	0828-1649	5.4	75	4.7	2.8
18 May	12	0956-2034	5.3	53	4.4	2.1
19 May	16	0758-2151	7.7	71	4.4	1.8
20 May	14	0831-2100	6.0	52	3.7	1.6
Total	55	45.2 hr	24.4	251	4.3	2.1

Photographs of the operation are shown in Appendix B.

Factors that directly affected the drilling performance were the melt tank capacity, the length of core obtained per run, the power available at the heating element, and the reliability of the core catchers.

The amount of meltwater collected and stored in the melt tank depends upon the density of the firn or ice, the length of run, and the permeability of the firn. The tank used on the modified drill was originally designed for the 6-3/8-in.-OD core barrel and had a 5-gal. capacity. As the firn's density increased and its permeability decreased with depth, the volume of meltwater collected per run increased. The amount of meltwater collected on each run was carefully measured to ensure that the tank did not overflow. As the amount collected approached the melt tank capacity, the depth drilled per run was reduced.

As drilling progressed the heater voltage was gradually increased from the inital 240 V to 280 V at the 251-ft maximum depth.

If the Danish deep drill is to operate correctly, its starter hole must be deep enough that the drilling fluid cannot leak out of the hole. Leakage will not occur when the pores between the ice grains are discontinuous, which generally occurs at an ice density of about 0.83 g/cm^3. The drilling fluid is used to prevent ice creep from closing the hole and to transport chips away from the bit. The fluid to be used in the Danish drill is Jet-A fuel and tetrachlorethyene mixed to a density approximately the same as that of ice, 0.92 g/cm^3. The final depth required for this operation was determined by sampling the core obtained during the drilling. A 1-in.-diameter hole was bored in the center of the core and a quantity of arctic-grade diesel fuel (DFA) poured into the hole. If the level of fluid in the hole remained constant the core was not permeable. Every core was sampled from 216.5 ft to the final depth. All the samples measured and, with the exception of the samples at 232 ft and 235 ft, held the DFA level constant. Finally at 251 ft the drilling was stopped.

Once the drilling was stopped, the winch and drill were removed from the site and preparations were made to install the casing.

Casing

The 30 lengths of 7-in. schedule 10 steel pipe were cleaned with a steel brush on the inside and with brushes and rags on the outside. The bottom three lengths were completely cleaned to ensure a good ice seal when the pipe was frozen in the hole. The special tower assembly was attached to the loader forks and moved into position over the hole. The tower was approximately 25 ft tall to allow the casing to be lifted over the previous casing and held in position for welding. The weld had to be liquid tight to prevent drill fluid from leaking to the outside. One length of casing could easily be assembled and lowered each hour.

The top three casing lengths were removed once the bottom was frozen to allow room for the Danish drill to swing into place. A special bayonet fitting was made and placed on the top of casing number 22 to allow these lengths to be pulled. Mating pins were added to the bottom of casing number 23 (see Figs. B-14 and B-15 in Appendix B). The adapter was welded on and casing number 23 attached and lowered. The next two casing lengths were tack welded.

Once the full length of casing was in place, it was suspended approximately 1 ft off the bottom of the drilled hole. This clearance was necessary to allow the water, when added, to flow around the bottom of the casing until the water level was equal inside and outside the casing. Eighty gallons of water was poured down the inside of the casing through a plastic tube that prevented water from splashing against the side walls and freezing. This tube was nearly lost downhole because the frictional drag of the water along its walls added to its effective weight. The eighty gallons of water was added in about 30 minutes and frozen completely in 36 hours. During this time the casing tower was removed and the thermal drill winch replaced over the hole.

Starter hole operation

The standard CRREL thermal drill was used to drill a starter hole for the Danish drill. This operation was started once the water was frozen at the bottom of the casing. A total of 42 ft was drilled during a 9-hour period. Drilling was very slow because the hole was contaminated with the casing dirt. When the starter hole was completed the winch and drills were packaged for return shipment.

Removal of top casing

Because of the design of the Danish drill, a 10-m deep trench was to be excavated at the drill site to enable the Danish drill and tower to pivot into position. This required that the upper 30 ft of steel casing be removed. As tension was released from the casing, pins in the bayonet connection dropped 3/4 in. The top three casing sections were rotated 30° counterclockwise and lifted out (see Figs. B-14 and B-15 in Appendix B). Grinding at the welded joints separated the pieces.

The final step of the operation was to plug the top of the casing, 30 ft below the snow surface, to keep foreign material out of the casing. The hole location was marked, and the casing operation was over.

CONCLUSION

The entire phase went very well, with only minor problems developing along the way. Installing steel casing for this type of operation is a very delicate task, especially with only 0.312 in. clearance between the drilled hole and the largest diameter of the casing.

The initial hole had to be vertical. The casing, when welded together, also had to be vertical. With welded joints every 10 ft apart, even the slightest error would have prevented the casing from entering the hole. The hole at DYE-3 had an inclination of 1 in. in 250 ft. The casing passed through the hole without being forced down from the surface.

The starter hole drilling was slower than expected because of dirty ice. Cleaning of the casing was not good enough to ensure clean ice. More attention should be concentrated on this area in the next casing operation.

LITERATURE CITED

Aamot, H.W.C. (1969) Winding long slender coils by the orthocyclic method. U.S. Army Cold Regions Research and Engineering Laboratory Special Report 128.

Lebus International Engineering Inc. (1958) Wire line spooling handbook, 5th ed., Lebus International Engineers, Inc., Longview, Texas.

Perkins, E. (unpublished) USACRREL shop drawing TS 78-8, sheet 2 and sheet 5, Specifications for CRREL thermal drill tower and casing for 1979 GISP casing operation.

Rand, J.H. (1980) Danish deep drill progress report: February - March 1979, CRREL SR 80-3.

Ueda, H.T. and D.E. Garfield (1969) 1968 USACRREL drill for thermal coring in ice. Journal of Glaciology, vol. 8, no. 53.

Appendix A: SPECIFICATIONS OF DOUBLE ARMORED CABLE

Construction

Seven stranded conductors, 7 wire plain copper .009 in., with .0085-in. nylon insulation, 3 Mylar tapes, 12 wired. .0465-in. plain copper, .030-in. polyethylene Dacron braid, inner armor 12 wired .39 in. galvanized steel and 12 wires. 039-in. hard tinned copper, outer armor wired 24 wired .049 in. galvanized steel to 0.467 in. O.D.

Armor: The armor shall consist of 2 layers, right hand lay on inner armor and left hand lay on outer armor, at an angles of about 20° to the axis of the cable and shall be preformed so that the height of helix (O.D. ratio) is in the range 75%-85% on the steel wires in the inner armor and 80%-90% on the outer armor. The percent cover of the armor shall not be less than 95% nor more than 98 1/2%. The steel wires comprising the armor shall be high strength improved plow steel, galvanized with 1/2 oz. of zinc per sq. ft. The wire shall have a minimum of 200,000 psi ultimate tensile strength. The copper wires on the inner armor shall be tinned.

Insulation: The insulation on all conductors shall stand on a test of 100 volts per mil prior to armoring and 80 volts per mil after the cable is completed.

Test certification: Contractor will be required to furnish in triplicate, Test Certificate, evidencing the fact that cable meets all specifications set forth herein and specifically the following:

Armor for both inner and outer layers:

A. Wire size
B. Percent of elongation
C. Diameter over layer
D. Height of helix
E. Length of helix
F. Length of lay and percent of cover
G. Load at break

Electrical:

A. Insulation resistance (megohms/1000 ft at 500 V dc
B. Voltage test and copper resistance (ohms/1000 ft on all conductors

NOTE: The resistance of the signal conductors (#23AWG) is 20 ohms per 1000 ft, the resistance of the copper power conductor (12 wires 0.0465 in. dia) is 0.399 ohm per 1000 ft and the resistance of the armor is 0.428 ohms per 1000 ft. The cable weights 400 lb per 1000 ft and has a breaking strength of over 11,000 lb.

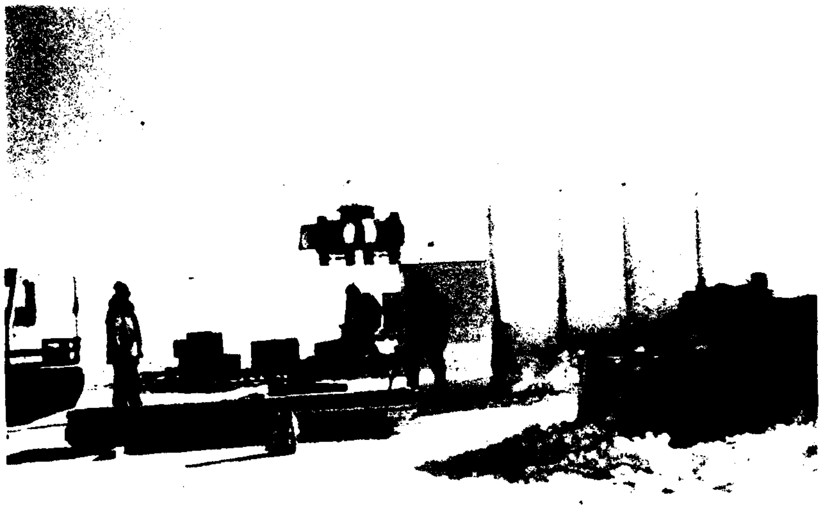


Fig. B-1. Drill site preparations. This picture also shows the DYE-3 "nose" in relation to the drill site.

Fig. B-2. Thermal drill in operation.

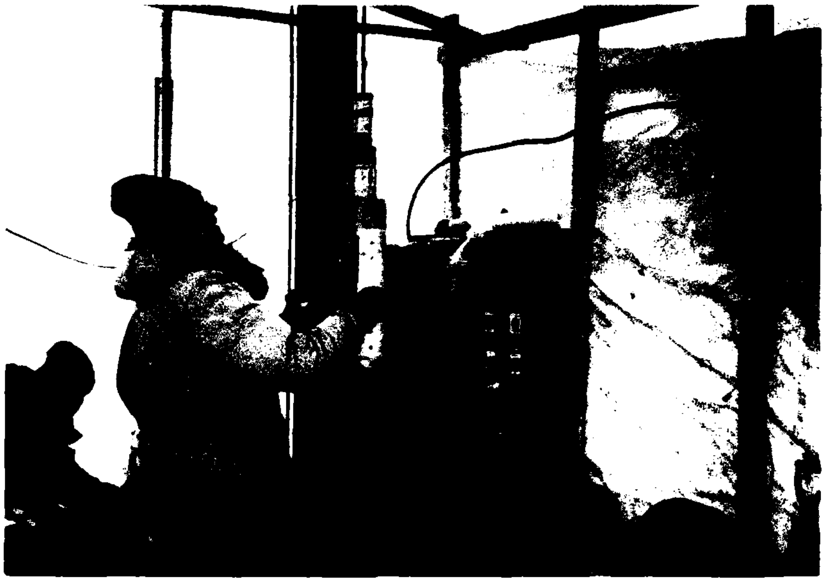


Fig. B-3. Alcohol being drawn through the vacuum pump to clear moisture and ice from lines.

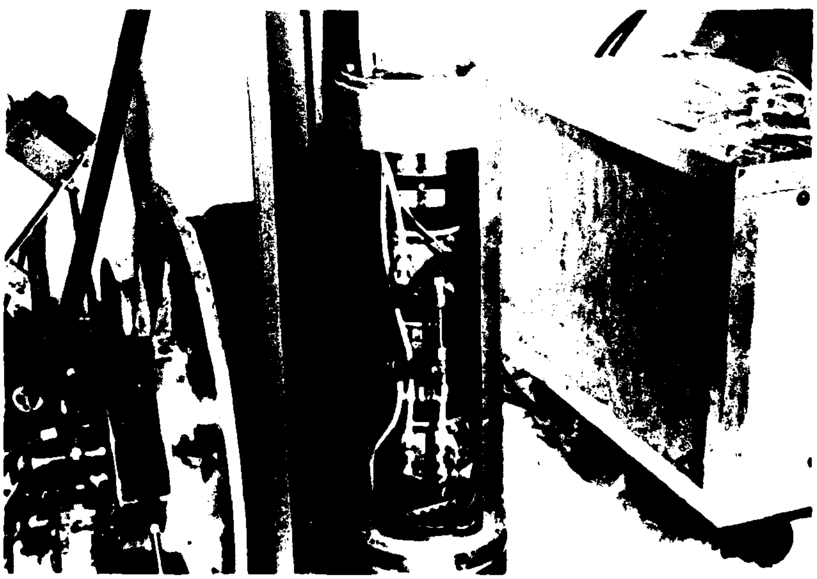


Fig. B-4. Top section of the drill, vacuum pump suction lines connected in parallel.

Fig. B-5. Once the operational checks have been made the drill is ready to be lowered downhole again.

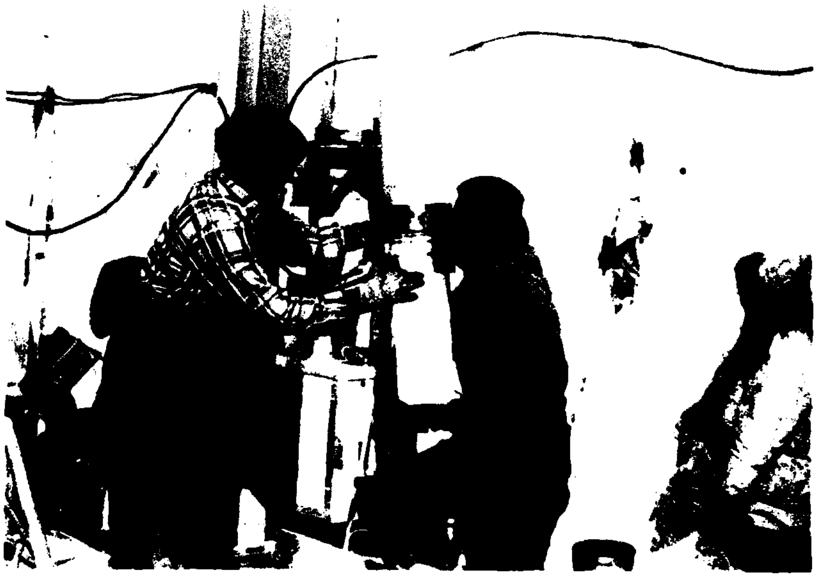


Fig. B-6. Core removal.

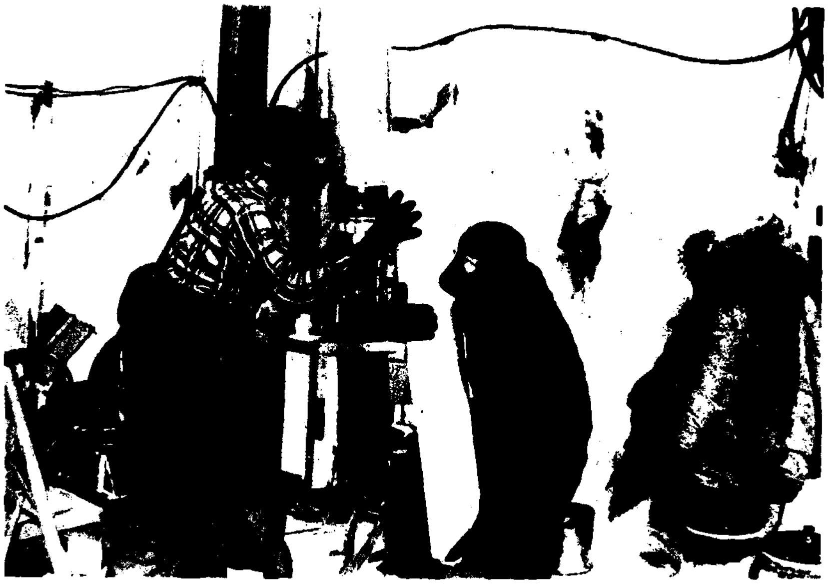


Fig. B-7. Core removal, sometimes a two-man job.

Fig. B-8. Sections of core are split apart and 1 in. holes drilled in the center. DFA is poured in the holes to determine the permeability of the ice.

Fig. B-9. Cores being taken to the pile, note upper left of picture.

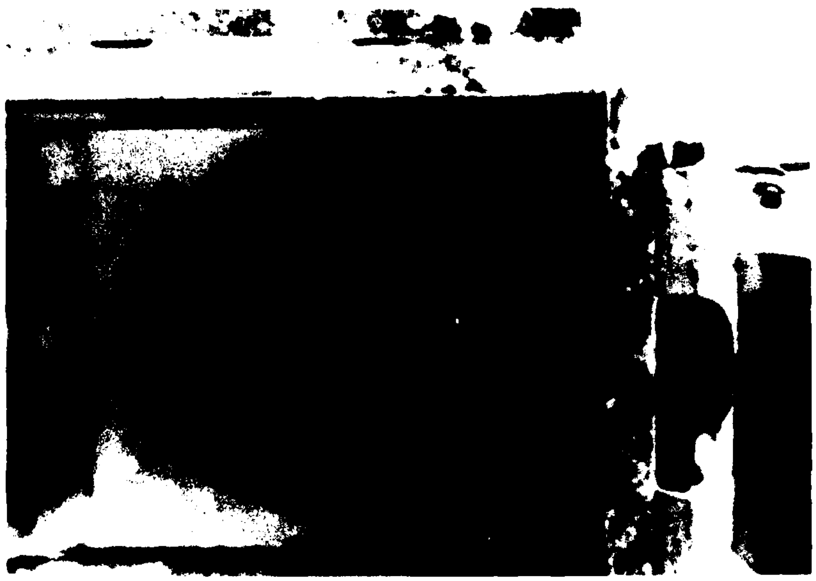


Fig. B-10. The finished hole, 8 3/4 in. diameter and 251 ft deep.

Fig. B-11. Casing being lifted into position.

Fig. B-12. Each casing length had to have a continous weld at each end. Note asbestos blanket around casing.

Fig. B-13. Prior to raising the casing into position each pipe was cleaned as thoroughly as possible.

Fig. B-14 Because of the Danish winch design, the top 30 ft of casing had to be removed after freeze-in. A special adapter allowed the top lengths to be separated from the rest of the casing.

Fig. B-15. As long as a tensile pull was applied to top section the joint could not come apart. Once the bottom three lengths of casing were frozen- in, weight was released. The pins dropped down, and the top lengths were rotated counterclockwise 30 degrees and lifted out.

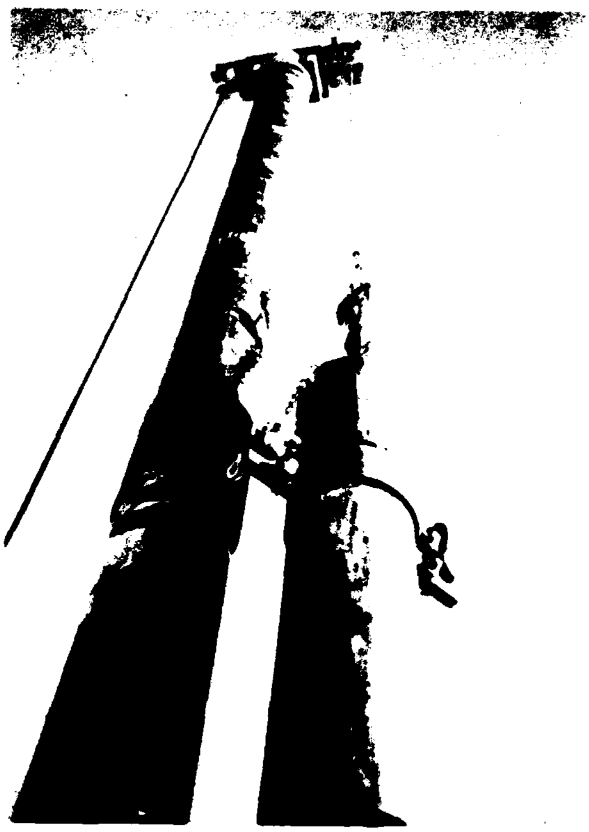


Fig. B-16. Top section of casing being removed.

☆U.S. GOVERNMENT PRINTING OFFICE: 1980—601-023/102