UNDERWATER PIPELINE CONSTRUCTION

USING THE B.B.T.

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ABSTRACT

On February 24, 1987, the Greater Vancouver Sewerage and Drainage District awarded an $8.5 million contract to Dillingham-Manson, A Joint Venture for construction of the Iona Outfall - Submarine Section. The work to be done under this contract involved the installation of approximately 10,500 ft.of twin 90 inch diameter steel outfall of which 1,640 ft.was twin 82 inch, 72 inch, and 64 inch diameter steel diffuser sections. The outfall extended from the end of the Iona Jetty into the Strait of Georgia near the mouth of the Fraser River. It was 350 ft. deep at the end of the diffusers.

The tender documents suggested a method of installation such that the pipe was fabricated full length on the jetty complete with flotation pipe and pulled into the water. Dillingham-Manson submitted an alternative method with their tender and were the successful low bidder. The proposed installation method was to assemble the pipe into nominal 1,000 ft.lengths in Dillingham's North Vancouver yard, launch them, tow them to the site, sink them and bolt together underwater.

One of the most interesting aspects of the project was the development of a remote controlled underwater bolting tool (affectionately called the BBT). This tool brought the flanges of the pipe strings together, aligned them in 3 dimensions, rotated one flange to line up the bolts, stabbed the bolts and tightened them. After completing the operation, the tool released itself from the pipe. The tool was operated from the surface using hydraulic controls. It contained five wide angle, high resolution video cameras complete with special underwater lights so the operator could observe the operation. The tool was designed to be used without the aid of divers and is believed to be one of the most sophisticated ever developed. The paper will describe the development and operation of this tool.

Dillingham Construction was awarded the Montgomery Medal for innovation in construction for this project.

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INTRODUCTION

The Iona Island Sewage Treatment Plant is owned and operated by the Greater Vancouver Sewerage and Drainage District. It is located south of the City of Vancouver near the airport (Figure 1). The Plant, which was constructed in 1962 provides primary treatment to wastewater flows from several parts of Greater Vancouver. Both sanitary sewage and stormwater runoff enter the same network of pipes and flow to the Plant.

The work to be performed under this contract was the installation of 10,500 ft. of twin steel outfall pipes of which 8,860 ft. was 90 in. diameter, and the remainder 82 in., 72 in., and 54 in. diameter steel diffuser sections. The pipe thickness was 0.375 in. The outfall extended from the end of an existing 2 mile long jetty into the Strait of Georgia near the mouth of the Fraser River. It was 350 ft. deep at the end of the diffuser.

The owner provided a "suggested method of construction" which involved fabricating the full length of twin steel outfall carrier pipes and floatation pipe on top of the recently constructed on shore twin concrete pipe. The outfall pipe and floatation pipe would be pulled through a 140 m long sheet piled trench in the existing jetty then a 10,000 ft. radius and continuing along a tangent alignment to the final location of the end diffusser.

The outfall pipe and floatation pipe were to be supplied by the owner and the value of floatation pipe used by the contractor would be considered in evaluating the low bidder.

CONSTRUCTION METHODS

During the tender period, Dillingham-Manson examined all the alternatives and decided that for this application a sectional placement method would be the most economical. Upon award, the construction team worked first to reduce the number of joints to be completed by maximizing the length of strings to be placed, then examined alternative methods of connecting these strings.

The estimate allowed for saturation diving to completed the deep water joints and divers to complete the joints in the shallower water. Due to the exposed nature of the site to rapid changes in weather and subsequent high risk of saturation diving in high tidal currents, Dillingham-Manson decided to develop a tool to simplify this operation.

Constructors Engineering had developed a bolt-up alignment tool for a prvious outfall and were invited to meet with the construction team to discuss equipment for this project. What evolved, was a result of the engineers' and diver's experience. It was a sophisticated purpose built tool which completed final alignment of the flanges, brought the flanges together, aligned the bolt holes, stabbed the bolts through the flanges, torqued the bolts up and released itself from the pipes. All functions were remotely controlled from the surface without diver assistance.

The bolt up - alignment tool (or BBT as it became affectionately known) performed 34 independent functions by electronically controlled hydraulic valve actuators. These were regulated to control the speed of each function to increase operator control. The BBT weighed 22 tons, was 43 ft. long, and was supported by a crane on a derrick scow (Figure 2). An umbilical cord on a hydraulically powered take up spool carried all the control lines as well as the hydraulic lines.

<u>Lowering and Connecting the Pipe</u>

Before the pipe was towed to the site, a trench had been excavated by clamshell derricks, checked for grade and bell holes dug where each flange joint would be located when the pipe arrived on site. Two derricks were positioned on anchor lines, one at each end of the pipe section. Lasers indicated where the pipe should be placed on line, and electronic distance measuring devices indicated the exact distance from shore.

Dillingham had available 12 - 8 x 8 x 40 ft. pontoon scow sections in which to make 6 catamarans. A winch was mounted on each catamaran to support and lower the pipe. A detailed analysis of the pipe was done to determine the optimum span between catamarans and subsequently string length. The resulting 1,000 ft. strings were fabricated in Dillingham's North Vancouver yard and were stored floating until the trench was ready. The catamarans were floated over the pipe string and the straps connected before the pipe was flooded. The pipe and catamarans were towed to site submerged just below the surface.

The pipe section and catamarans were landed alongside the two derricks (Figure 3). Deck lines from the derricks were attached to the front and rear catamarans and one anchor line from each derrick was placed over top of the pipe to complete each derrick's 5-point anchoring system. The pipe was then lifted by the catamarans so that the top was just above the water.

The BBT was then clamped onto the pipe (Figure 3). Once it was attached to the pipe, the bolts were installed in the rotating ring and the pipe was lowered so that it was even with the water surface.

Everyone involved with the lowering operation had portable radios. The lowering was done in 2 ft. intervals, i.e. letting out 10 ft. of line, since there were five parts to the rigging. Where the pipe had to be sloped to match the bottom contour, the pipe had to be pivoted around the first catamaran by letting out 0 ft. at this one, 2 ft. at the second, 4 ft. at the third and so on till 10 ft. at the last (Figure 4). The superintendent would order the line to be let out and each winch operator would acknowledge over his radio when he had done so. This procedure was repeated until the pipe section was close to the bottom. The distance of the pipe below the surface was checked by electronic depth sounders mounted on each catamaran. The load on the individual catamarans was checked by reading the still well markers and adjustments were made to keep the loads equal. The derrick with the aid of an electronic load cell in its 2-part hoisting line, was able to maintain the load of the BBT in water.

When the ends of the pipes were close together the landing of the alignment yoke of the BBT on the pipe in place had to be monitored by divers due to the reduced visibility in the silt laden water. The divers used hard hat gear or rode in a small submarine for the deeper dives. Initial alignment of the flange faces was accomplished by adjusting the rigging, e.g. lowering the pipe with the winches; rotating the pipe with the winches; moving the derrick north or south; moving the catamarans east or west; lifting the end of the last pipe and the BBT with the derrick; sagging the pipe, etc. Five video cameras (with corresponding high intensity lights) on the BBT were used as the operator's eyes in the alignment and bolt up procedures.

The BBT then mated the flanges using a combination of its landing gear and its flange together rams. The flanges had been especially designed so that one could be rotated relative to the other to line up the bolt holes. The nuts were attached to the fixed flange by a wooden retaining ring so they would not rotate with the bolts.

Once the flanges were mated the BBT rotated one flange to line up the bolt holes, the bolts were then stabbed and tightened by impact wrenches. Each joint contained 44 bolts so two impact wrenches were operated independently to save time.

When the bolts were tight, the pipe was lowered to the bottom in 2 ft. intervals as described above. The lowering lines from the catamarans were slackened off and a hydraulic pump was activated to pump hydraulic oil to the pin release cylinders that held one end of the nylon slings that supported the pipe. The slings were pulled out from under the pipe and then the blocks and slings were hoisted to the surface. The BBT's grippers and bolting ring were released and it was hoisted to the surface and stored on the deck of a derrick. The entire connecting operations was typically accomplished in three to six hours versus twenty-four hours for similar operations not using this sophisticated tool.

CONCLUSION

The project was substantially completed by November 1987 about 8 months after contract award. The contractor used several innovative construction methods during its execution. These methods contributed to the award of the project, its safe execution and completion within schedule. One of the most innovative was the development of the BBT, a purpose built, sophisticated tool incorporating advanced robotic systems. With better visibility, this tool would be able to connect pipes under water without diver assistance.

ACKNOWLEDGMENTS

The project could not have been completed so successfully without the dedication and hard work of the supervisors and crews of the Dillingham-Manson, Joint Venture. The Greater Vancouver Regional District through their Project Manager, Mr. D. A. Gillis, P.Eng. were very helpful and supportive throughout. Additional construction engineering was supplied by Buckland and Taylor Ltd. and Constructors Engineering Co., Inc. Their assistance was greatly appreciated. Finally many subcontractors helped on the project, in particular Can Pac Divers, Inc. and Martech International provided key personnel.

LIST OF FIGURES

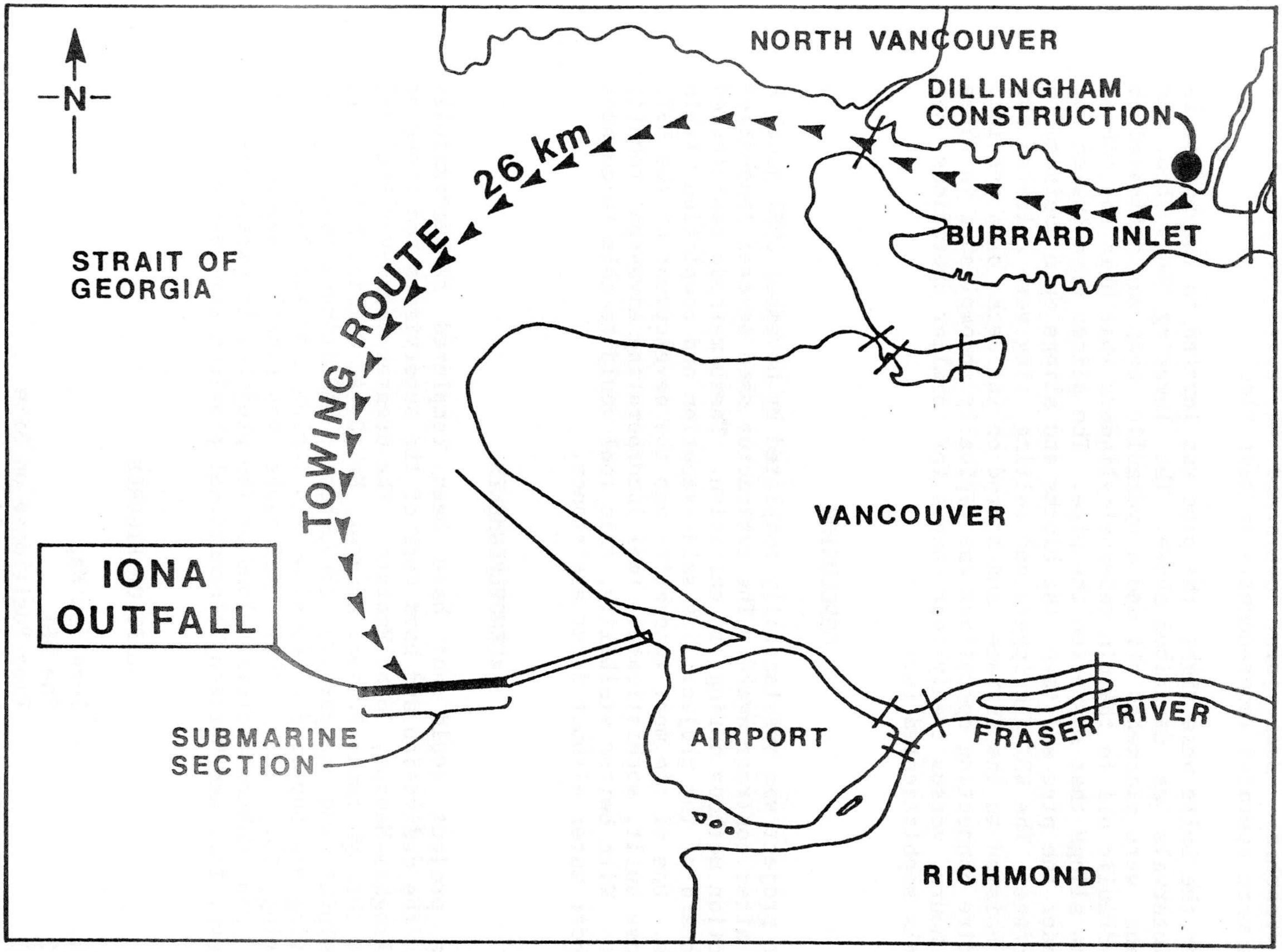

FIG. 1. – LOCATION MAP

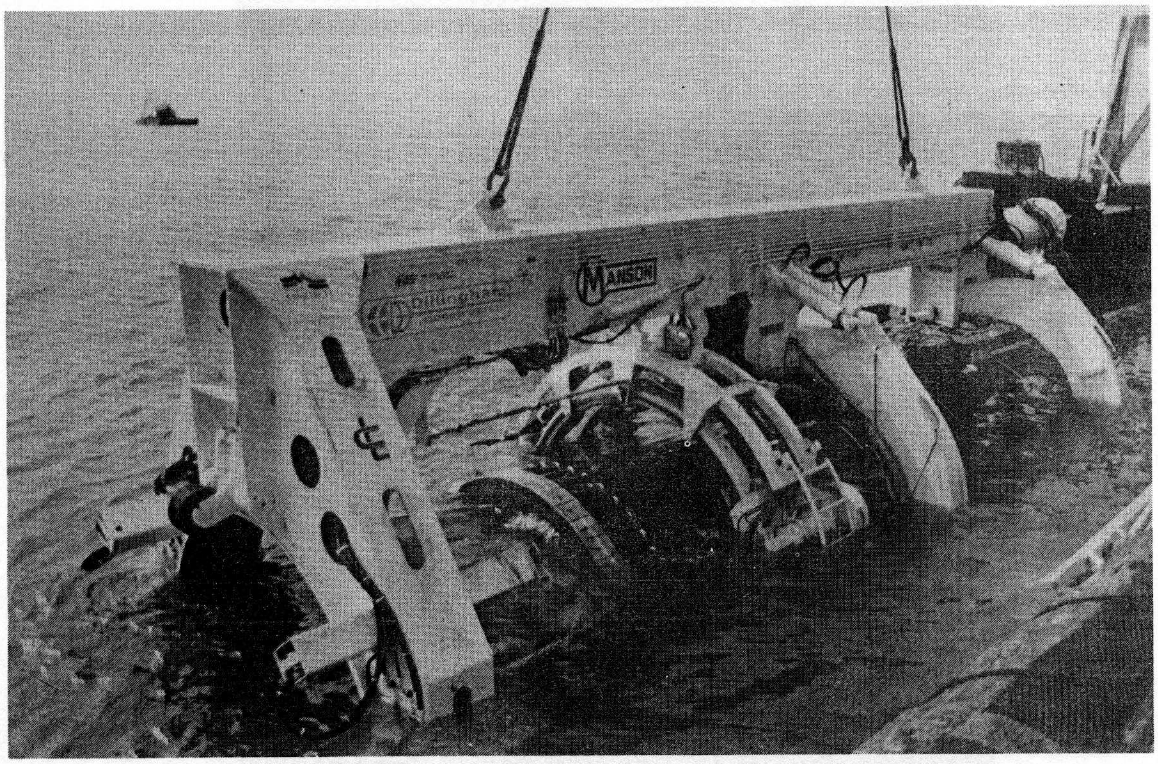

FIG. 2. – THE B.B.T.

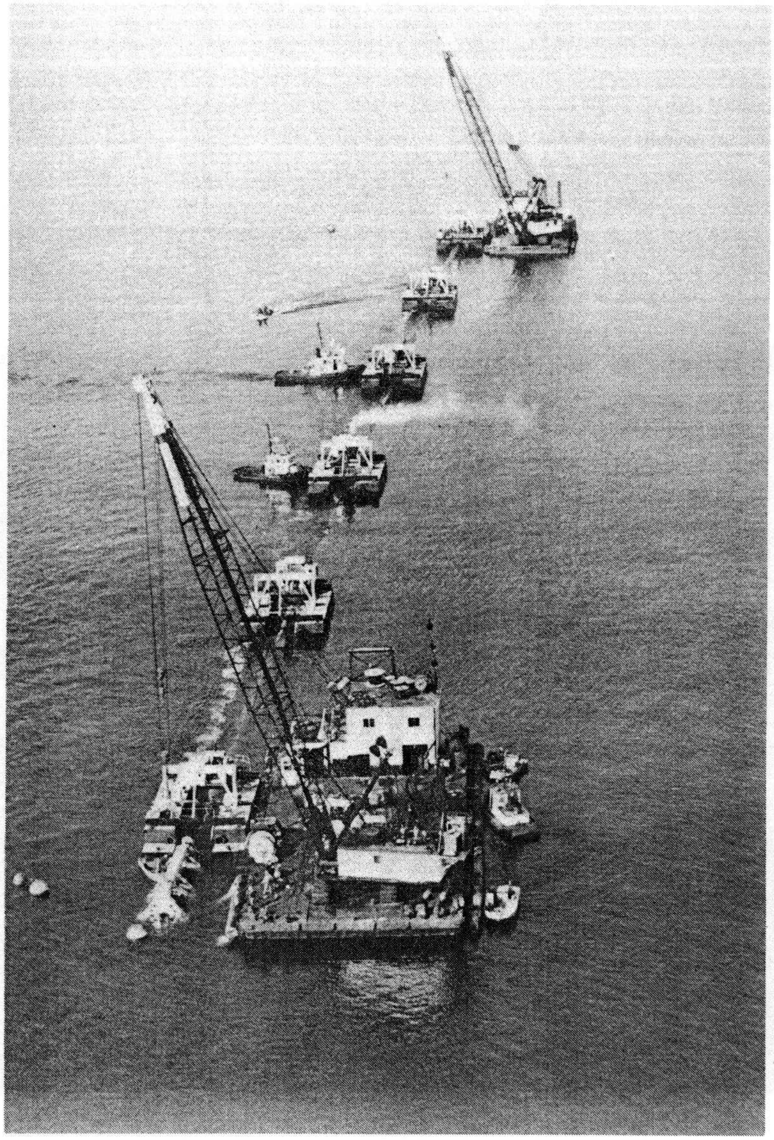

FIG. 3. – POSITIONING THE PIPE

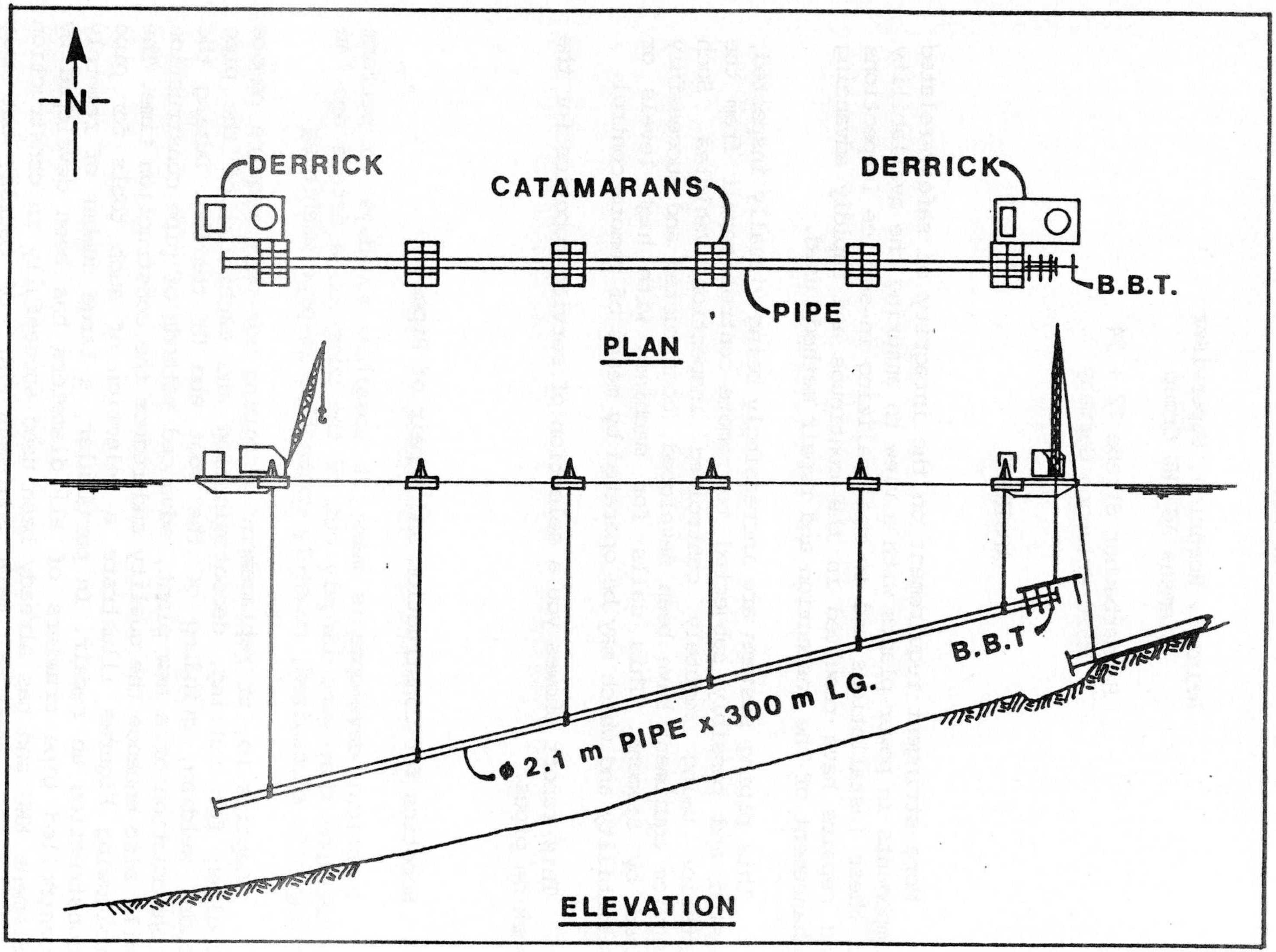

FIG. 4. — LOWERING THE PIPE