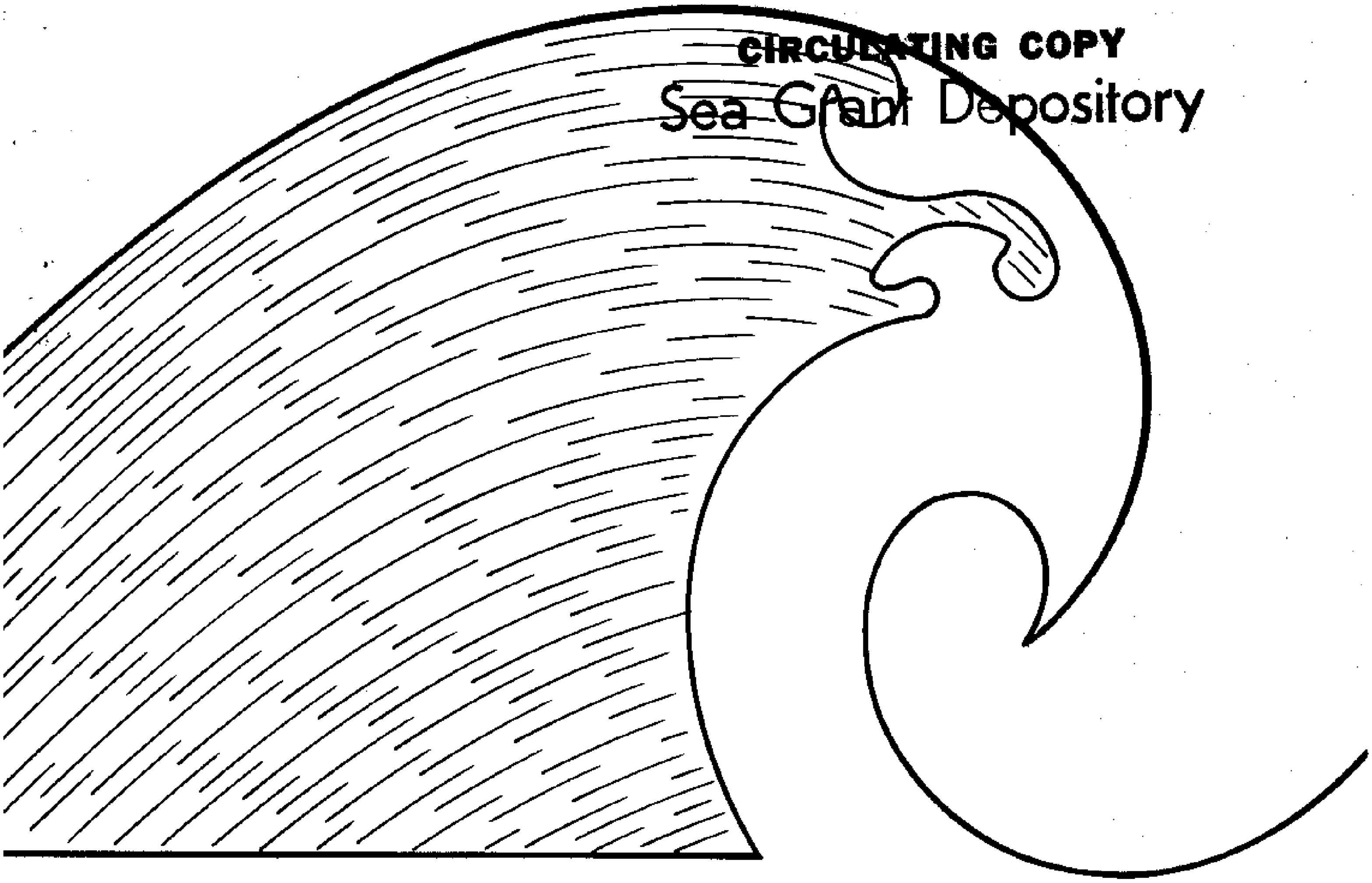
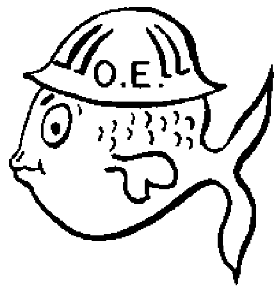


DEPARTMENT OF OCEAN ENGINEERING

SEA GRANT PUBLICATIONS

COLLEGE OF ENGINEERING UNIVERSITY OF RHODE ISLAND

Memorandum Number 10M



A SHALLOW WATER SUB – BOTTOM PROFILER

BY
F. H. MIDDLETON
M. G. FAGOT

15 SEPTEMBER 1970

MEMORANDUM NUMBER 10M

A SHALLOW WATER SUB-BOTTOM PROFILER

by

F. H. Middleton
M. G. Fagot

Prepared for

National Science Foundation

Under

Sea Grant Contract Number GH-99

by

Department of Ocean Engineering

University of Rhode Island

15 September 1970

ACKNOWLEDGMENT

This memorandum was prepared as part of the BAY WATCH Program under the direction of Professor F. H. Middleton. The data presented is a brief summary of some of the effort leading to M. G. Fagot's Ocean Engineering MS Thesis entitled, "A High Resolution Sub-Bottom Profiling System for Shallow Water".

TABLE OF CONTENTS

SHALLOW WATER SUB-BOTTOM PROFILING

1.0 Introduction

Starting in 1964, several faculty and graduate students in the College of Engineering have been involved in sediment studies of various types. This report is concerned with one specific part of this activity--the shallow water profiling capability as it relates to the BAY WATCH Program of Sea Grant.

Two MS and one PhD theses in Ocean Engineering have been generated to date. This report summarizes the main features of a 3rd MS thesis wherein the emphasis is on shallow water, small boat operations. In BAY WATCH work, an important requirement is to develop and continuously improve the profiling system for shallow penetration, and high vertical and horizontal resolution.

There is an important, though little understood, relationship between the bay sediments and the water column above them. The coring capabilities are on hand in the Ocean Engineering Department and the ultimate goal is to be able to profile the entire floor of Narragansett Bay. It is important to map the floor to a depth of perhaps 30 feet in terms of the material on the bottom of the bay, the thickness, and the properties of various underlying sediment layers.

Typical sub-bottom profiling systems involve great weight, large size, high power, and sometimes high pressure, which are necessary for deep ocean work. However, they present serious problems in shallow water on small vessels. Instead of an air gun, sparker, explosive, or boomer of some kind, the present system employs a small commercial transducer, in this case an Edo Pinger, operating in the frequency band 10 KHz to 12 KHz. Power is supplied by a battery operated amplifier, which obviates the need for an AC generator on board. No precision graphic recorder (PGR) is used but system behavior is monitored by a small battery powered oscilloscope. Synchronization pulses and returning echos are recorded on a small portable battery powered ¼-inch tape recorder. The final profile is produced in the laboratory by means of a moving film photo-display system which has been in use at the University for several years. The system will be briefly described.

2.0 System Configuration

The acoustic source is an 8-inch diameter transducer, mounted in a metal structure on which are mounted stabilizing fins. The source structure is normally towed over the stern of the vessel, 2 to 5 feet below the surface. Being a circular piston source operating at about 10 KHz, it produces a nominal circular pattern, directed toward the sea floor, having a nominal beam width of 30 degrees. The input electrical power to the source transducer is from 50 to 100 watts.

The receiving array is approximately 5 feet long. It was fabricated from a surplus Navy sonar array. The acoustic wavelength in water at 10 KHz is about ½ foot and thus the array is 10 wavelengths long. The resulting uniform array main lobe radiation pattern is the order of 8 - 10 degrees between the 3 db points. The array is suspended from a simple wooden support which has wooden stabilizing fins. It is normally towed astern of the source transducer and it consequently rides at about the same depth, just beneath the wave zone. The array support structure serves as a partial acoustic reflector and reduces the surface induced interference effect.

Standard wide chart scanning recorders, usually employed in profiling, are large, heavy, and consume considerable power. They serve a most useful purpose as indication of overall system performance, but usually provide the final and unchangable form of the profile. In the present system, the data is recorded on a tape recorder in nearly an unmodified form. The performance is continuously monitored by means of a battery operated oscilloscope.

The taped results are returned to the laboratory where they are processed (filtered) and delivered to the photographic recording system. In this process, much time can be gained by playing the magnetic tape back at a higher speed than the original recording was made (time-compression). Additionally, the playback can be repeated under different conditions--changing the signal process, varying the filter settings, time-gating out the water column, changing the scan rate, expanding the depth scale at special points, etc.

3.0 Operations

When the system is further refined, it will be used to do more routine and extensive bay floor surveys for the general BAY WATCH objective. At present the effort is more developmental in nature, and the system performance is being checked under different bay floor conditions. To illustrate the results, several profiles will be shown. Figure 1 shows a sketch of a section of the West Passage between Quonset Point and Prudence Island just east of Hope Island. Two tracks are indicated. The first track corresponds to the profile of Figure 2 and the second track corresponds to the profile shown in Figure 3. The interesting feature of Figure 2 is the clear evidence of the penetrating capability that this system displays. Figure 3 shows how the display indicates a rather small pinnacle.

Figure 4 is another sketch of the West Passage, somewhat lower in the Bay, and indicates the track location of the last sample profile shown in

Figure 5. This profile was selected because of its display of fine vertical resolution. A thin sediment layer is apparent overlying a material of different acoustical properties.

Shallow gravity cores have been taken in the bay to investigate correlation between cores and profiles obtained in the same region. To date these efforts have been somewhat hampered by the inaccuracies of the boat positioning system. Also data discrepancies exist because to obtain a core, the vessel must stop. However, profiles are obtained while the vessel maintains a steady speed of several knots. Interesting sub-bottom features often have small horizontal expressions and the profile is not produced until the day after the cruise. Improved navigation would make it possible to return to a precise spot to obtain a desired core. This vessel capability is receiving considerable attention although commercial solutions that are readily available are quite expensive. Perhaps the most suitable solution, considering the moderate size of the Bay areas of interest, would be bottom-mounted acoustic responding beacons.

4.0 Future Plans

As mentioned earlier, signal processing is a high priority area of future system developments. An example of one useful device that is commercially available, although expensive, is a replica correlator. Operationally, the transmitted waveform is stored in a digital memory, and the echo waveform is correlated with the stored signal. The output of the correlator is introduced to the photographic display system described earlier. The optimum waveform for this type of signal processing is definately not the short CW pulse that we have used to date. Rather, it should be one with a large "time-bandwidth-product". An example of such a suitable pulse is what is known as "an FM slide" or "chirp tone" pulse.

The pulse length can be made to correspond to the round trip travel distance from the source to the bottom in the shallowest water of interest. An appreciable amount of Bay profile data using this "chirp-tone" pulse has been stored on magnetic tape to await the time when a correlator becomes available.

With the cooperation of the Underseas Division of the Westinghouse Electric Corporation (Annapolis, Md.) some very interesting Bay bottom scans have been made. The Westinghouse group brought one of their side-scan-sonar systems up to Narragansett Bay for use on the Islander. The purpose was to produce simultaneous side-scan and sub-bottom profiles. Some of these have been obtained and will be the subject of future reports. One two-day trial operation was completed on the Islander on Narragansett Bay, profiling a variety of bottoms. Another two-day mission was completed on the Chesapeake Bay, which displayed entirely different characteristics. The main interest in Chesapeake Bay is the shell fish areas such as oyster bars and quahog and clam beds. In the latter cruise, the two video signals (side-scan and sub-bottom) were recorded on parallel channels of the same magnetic tape. Both systems worked from the same sychronizing pulse so that the playback can be synchronized between the two systems. These results will also be the subject of future reports.

Finally, it is clear that the BAY WATCH Project has now the advantage of a low-powered, high-resolution, shallow-penetration sub-bottom profiling system. As time and weather permit, more of the survey work described above will be done. The system will be improved as time and funds permit, and an extensive program of bottom survey will be carried out.

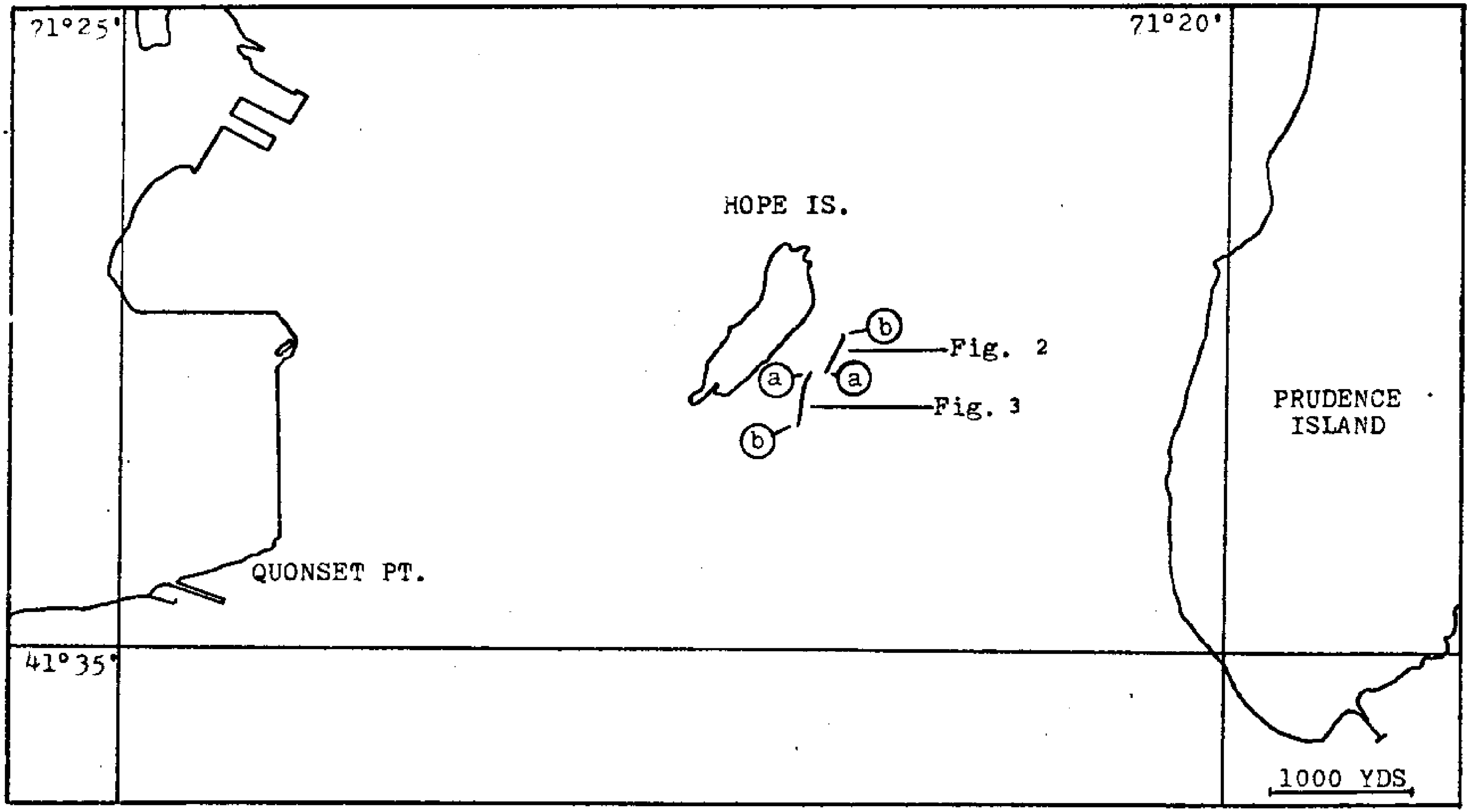


FIGURE 1 -- Profile Tracks of Figure 2 Figure 3

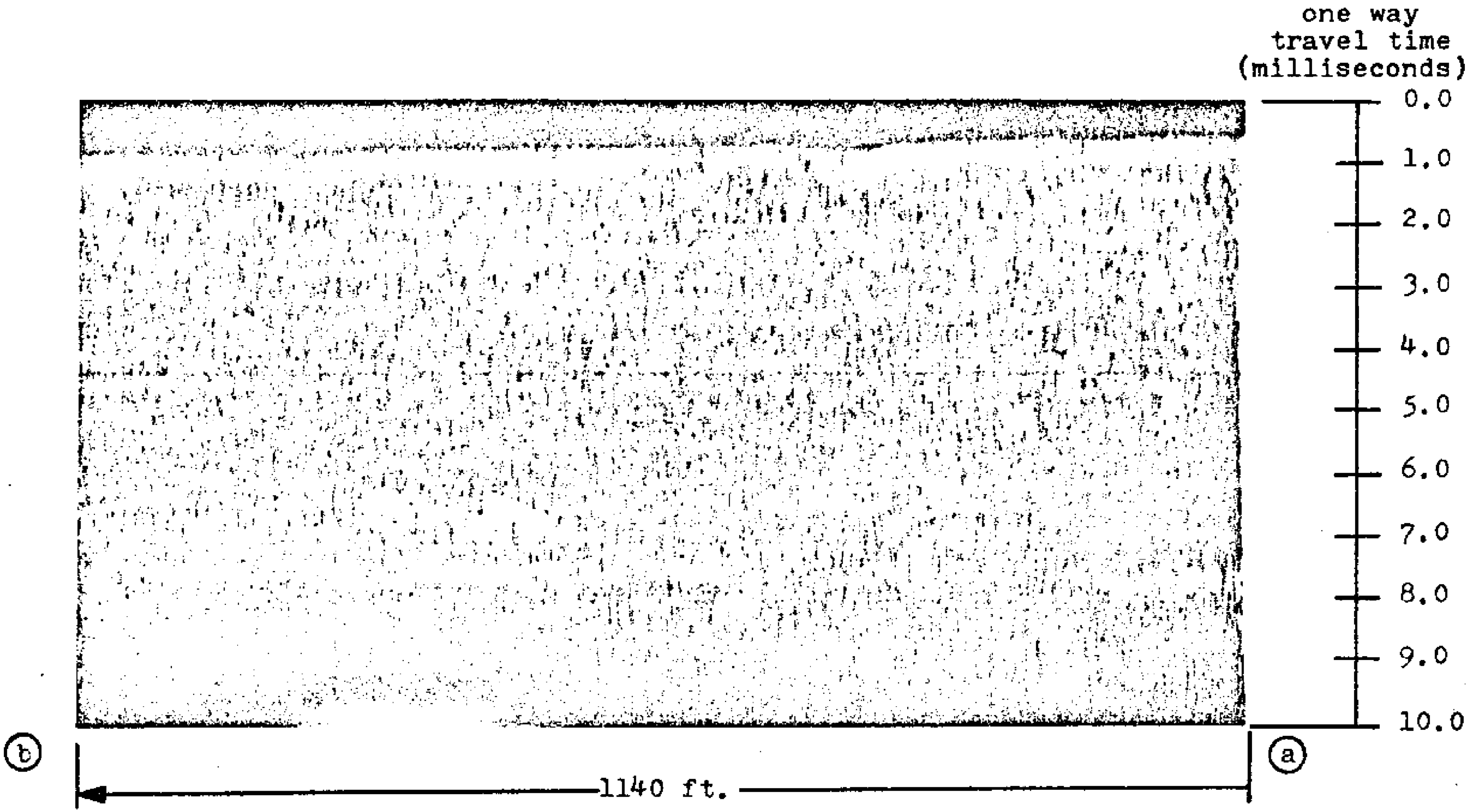


FIGURE 2 — Profile Showing Penetrating Ability.

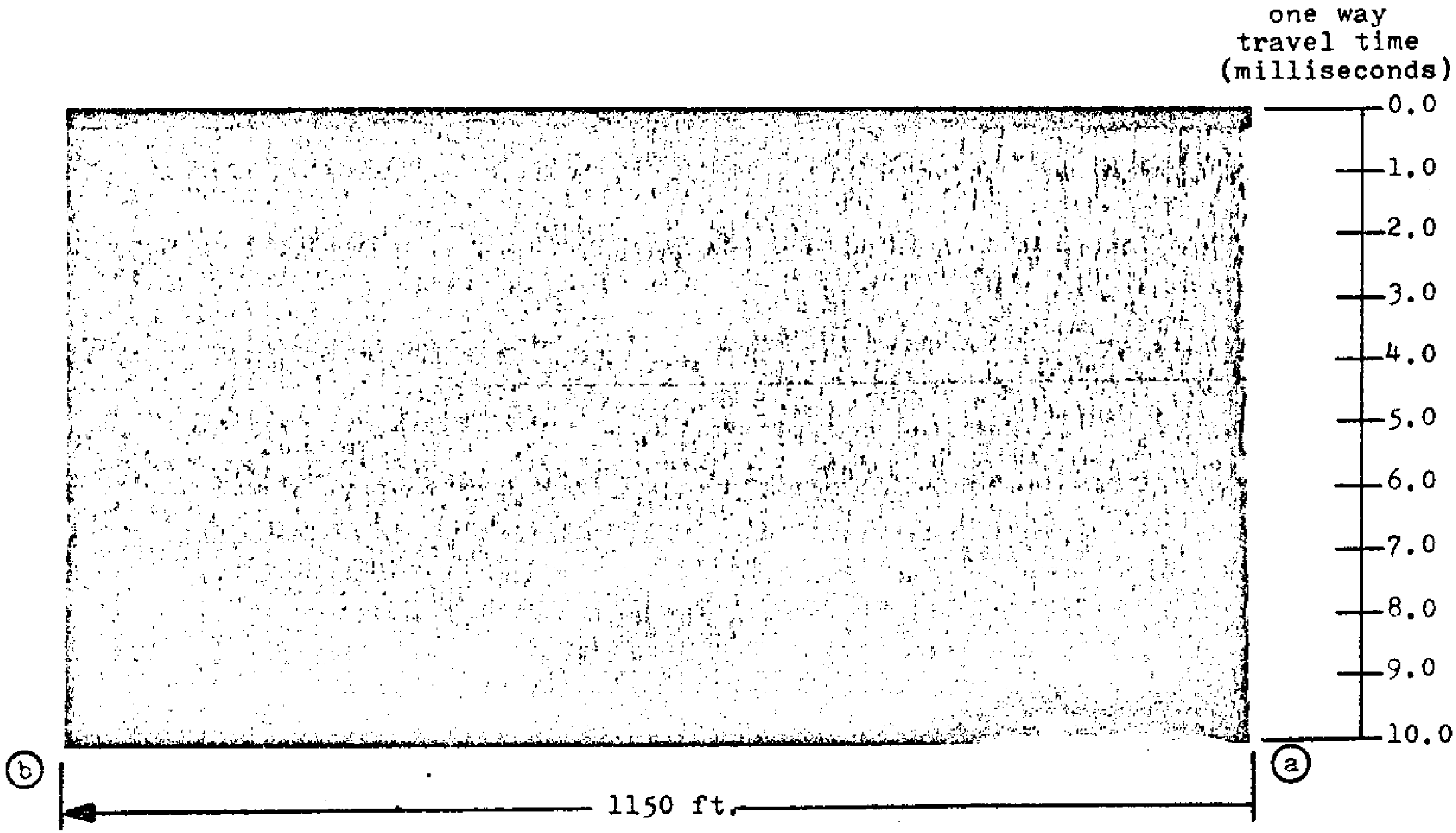


FIGURE 3 -- Profile Showing Pinnacle.

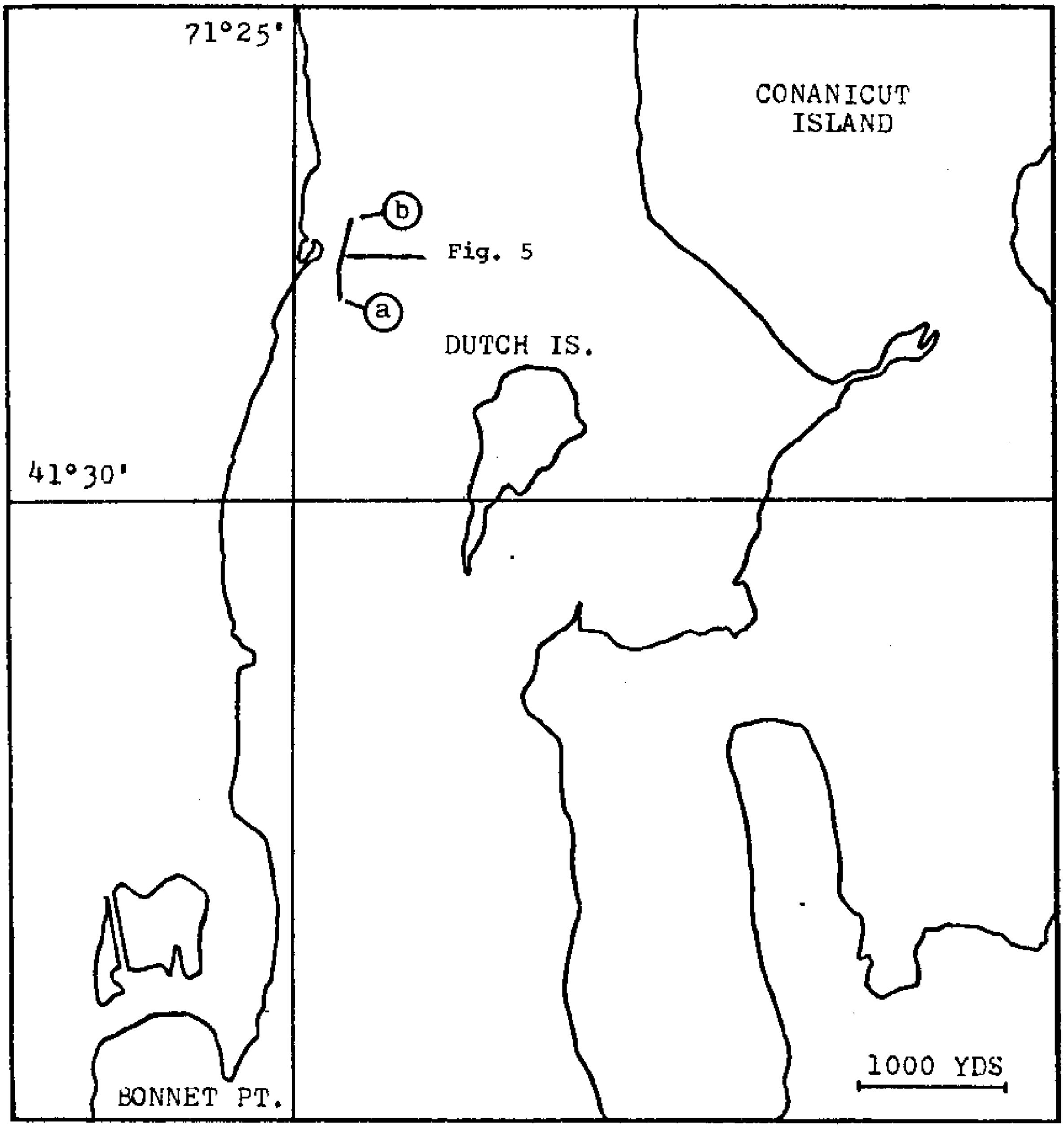


FIGURE 4 -- Profile Track of Figure 5

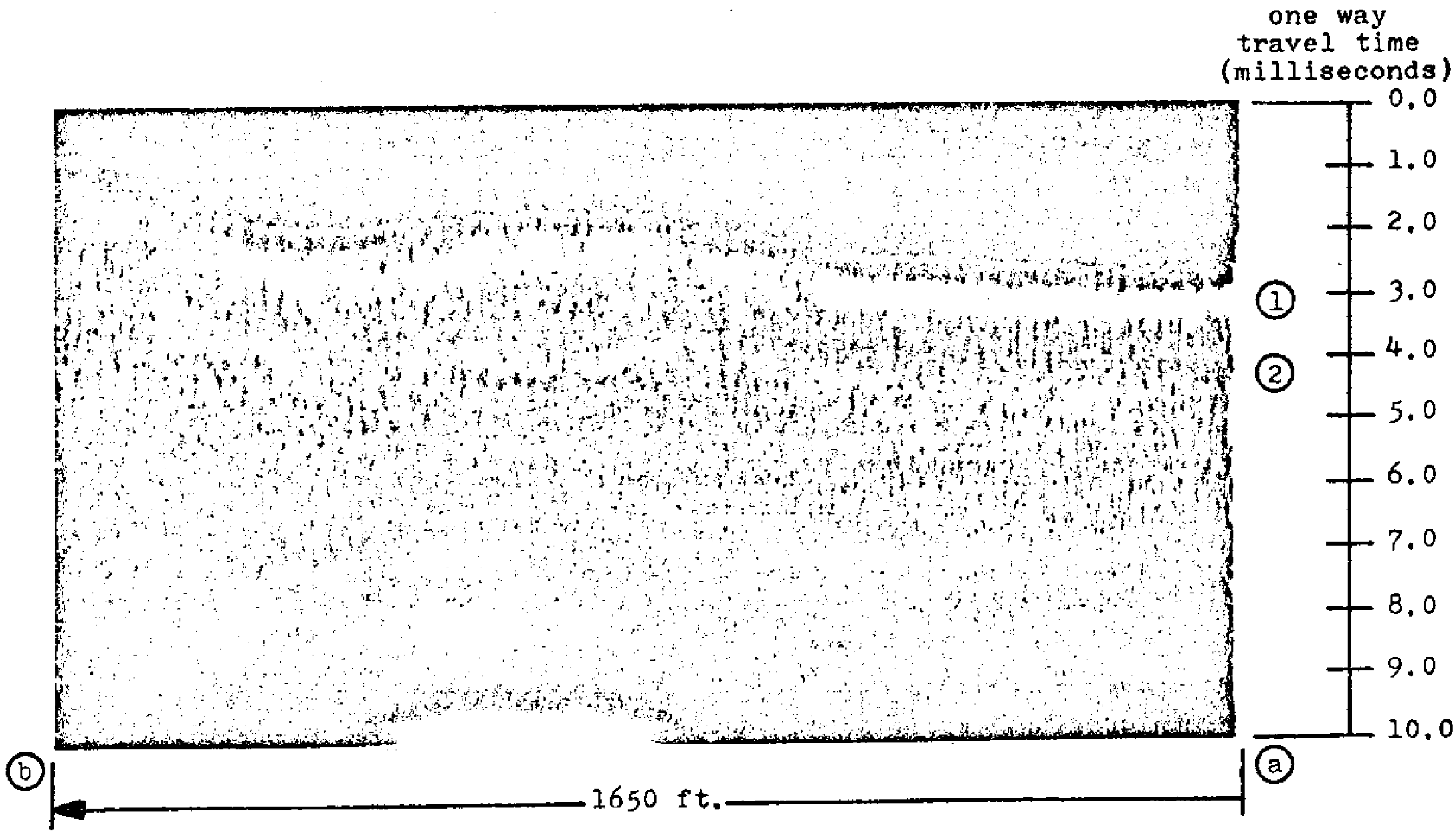


FIGURE 5 -- Profile Showing High Vertical Resolution.