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QUARTERLY PROGRESS REPORT NUMBER 1, 28 JANUARY - 28 APRIL 1971.(U)

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11 May 1971

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QUARTERLY PROGRESS REPORT NO. 1
UNDER CONTRACT N00024-71-C-1185, Task 12876
28 January - 28 April 1971

NAVAL SHIP SYSTEMS COMMAND
Contract N00024-71-C-1185
Proj. Ser. No. SF 11552101, Task 12876

[redacted]

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AUSTIN, TEXAS 78712

[redacted]

ABSTRACT

Quarterly Progress Report No. 1 under Task 12876 describes progress made during the period 28 January - 28 April 1971 on the exploratory development program of relating environmental parameters at Lake Travis Test Station (LTTS) to the measured behavior of acoustic energy.

A. Introduction

Task 12876 is a new effort in the ASW Classification Program. The long-term goal of the task is to relate acoustic environmental parameters to the behavior of acoustic energy propagated in the marine medium. The program is divided into two phases. The first phase, which has now begun, is to relate measured environmental parameters to the behavior of propagated acoustic energy.

Applied Research Laboratories, The University of Texas at Austin, has an extensive research facility located on Lake Travis approximately 20 m from the ARL laboratory location. There are several acoustic measurement programs in progress at the Lake Travis Test Station (LTTS) (Refs. 1, 2, 3, 4), including several measurement programs in support of the ARL ASW Classification Program (Refs. 5, 6, 7). There has long been a need at Lake Travis for a better understanding of environmental parameters that affect behavior of acoustic energy. This need is also recognized to exist in the ocean environment where there has been only limited success in closely relating measured environmental parameters to the behavior of acoustic energy. The intent of the program at LTTS is to predict acoustic behavior that is verified by measurements of acoustic behavior. The second phase of the program will then be to extend this measurement program to the ocean environment. At LTTS two environmental parameters will be accented initially as being the major contributors to the behavior of propagated sound. These two parameters are temperature structure and surface profile. The first step in the program is to understand scale and statistics of temperature and surface wave behavior in order to specify a measurement program that will be efficient and meaningful. This first report period describes the initial step in the measurement program to determine what temperature measurements and what surface profile measurements are necessary.

B. Temperature Measurements

Lake Travis (Travis County, Texas; see Fig. 1) is a relatively large body of water that is known to develop pronounced thermal stratification each year, after an isothermal period in winter. There are available more than ten years of historical data on the lake's thermal structure and weather conditions which have been recorded at the ARL LTTS. These data are in the form of periodic bathythermograph (BT) casts and standard weather observations taken at the test station. The intent of the study is to develop an understanding of vertical, horizontal, and temporal variations in water temperature at several levels of detail and to relate this knowledge to the measured acoustic propagation. For convenience, these variations have been divided into the two catagories of macrostructure and microstructure. Macrostructure includes the overall vertical and temporal temperature variations of the water column, horizontal variations over large segments of the lake, and the effect of weather on these variations. The study of macrostructure will be based in part on approximately 650 BT casts, taken at roughly weekly intervals since 1961. The BT station is located in the deepest part of the lake just behind Mansfield Dam (Fig. 1). During this reporting period, the traces of the BT slides have been redrawn onto graph paper. From these graphs data have been transferred to computer cards (a temperature reading, to the nearest 1/4°F, every 5 ft of water depth) so that the computer can be used to plot a near facsimile of the original graphs (Fig. 2).

Similarly, the weather data (which include observations taken every 4 hours of air temperature, water surface temperature, wind speed, wind direction, cloud cover, and precipitation) have been transferred to computer cards. These data will be used to compute more general climatic parameters, such as average temperatures, average wind speed and directions, "norther" strength and duration, and air-water thermal interaction.

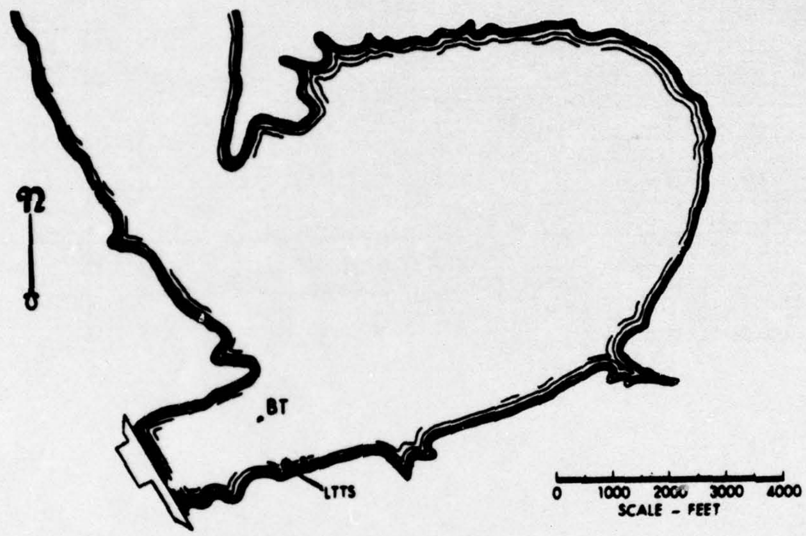

FIGURE 1
LAKE TRAVIS, TEXAS
LTTS: APPLIED RESEARCH LABORATORIES LAKE TRAVIS TEST STATION
BT: BATHYTHERMOGRAPH STATION

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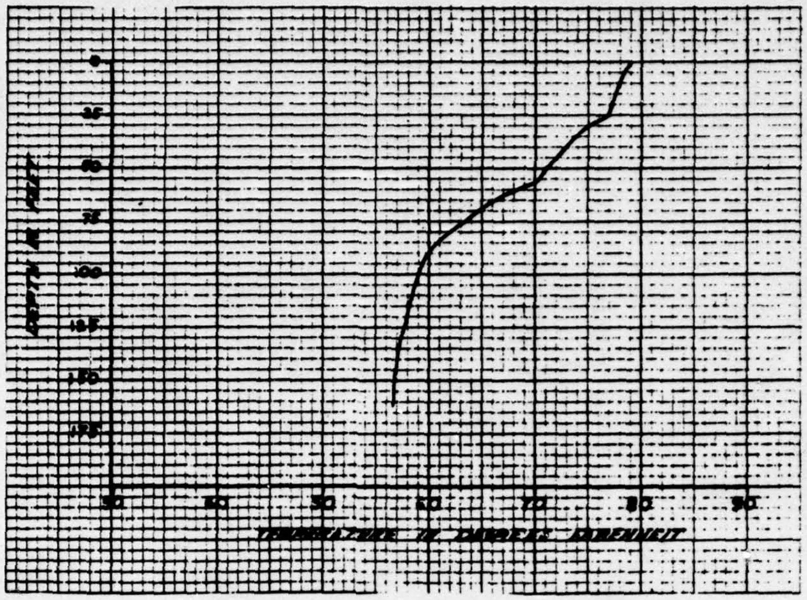
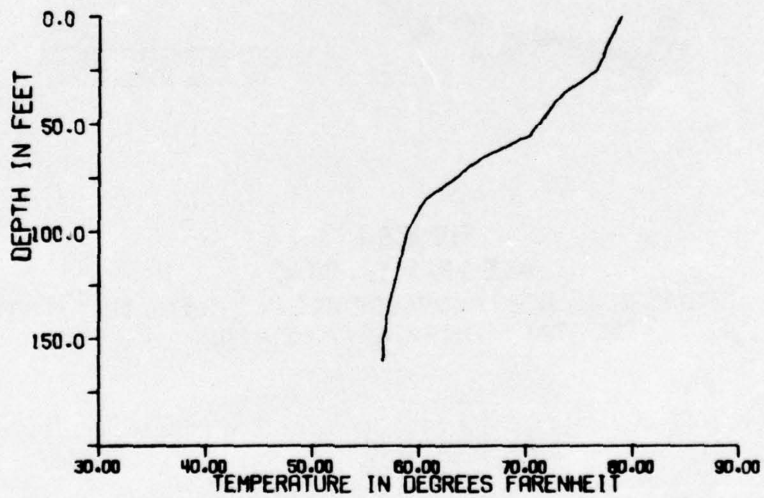


(a)



(b)

FIGURE 2
COMPARISON OF ORIGINAL BT GRAPH (a) WITH COMPUTER REPRODUCTION (b) FOR 12 JUNE 1969. (b) IS BASED ON TEMPERATURE POINTS TAKEN FROM (a) AT 5 ft DEPTH INTERVALS TO NEAREST 1/4° F.

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The ultimate aim of computerizing the data is to use the computer to analyze the BT graphs for such parameters as thermocline development and depth, water mass temperatures and heat content, and rates of temperature change, and, most important, to make correlations between "lake temperature structure" and "weather." These computations should lead to a thorough understanding of the lake's macrostructure and annual heat budget and should form a firm basis for guiding more detailed temperature and other environmental and acoustic measurements.

To help visualize the dynamics of the macrostructure, the BT traces have been animated into a motion picture by photographing successive graphs with a movie camera. As a preliminary trial, a movie for the years 1966 and 1967 has been made. It has proved helpful in visualizing changes in the lake's thermal structure and justifies continuing this effort. We are now in the process of making technical improvements in photography and preparing the entire set of BT's to be photographed.

Those aspects of the macrostructure concerned with temperature differences with depth and time are two-dimensional. The third dimension of horizontal temperature variations is to be studied on the macrostructure scale by simultaneously obtaining multiple BT casts with two bathythermographs operated from boats separated by distances of a few hundred yards.

Consideration of microstructure adds considerable detail to the time dimension, as well as to the vertical and horizontal space dimensions. These additions will aid in describing surface insolation, wind surface currents and mixing, thermal patch development, internal waves, upwelling, fall overturn and diurnal heat exchange between water and atmosphere and the relation of all of these to acoustic behavior. Several approaches to studying the microstructure in this context are being pursued. A thermistor thermometer and recorder have been used for several years to obtain temperature versus depth profiles once per hour at the ARL Test Station. These profiles are obtained beneath the calibration barge to assist acoustic calibration measurements and extend over the depth interval from 3 to 60 ft. They are recorded on rolls of strip chart recorder paper and have been preserved since 1962. Coverage is, however, not complete over this time span (gaps occur at times when the instrument was down for repair and for other reasons). The available records should provide data regarding upwelling, internal seiche, and general temperature trends of the upper 60 ft of the water column.

The near surface portion of these profiles is subject to modification by the overlying barges. In order to obtain a surface water temperature measurement at a point not under the barges, the temperature recorder shown in Fig. 3 has been installed on the northeastern corner of the barges. The instrument is a surplus hygrothermograph which is designed to measure wet and dry bulb air temperature and soil temperature. The three temperature measurements are obtained with mercury filled pressure thermometers. In this study the soil temperature probe is placed at a 1 ft depth in the water beneath a white shade, thus giving a continuous recording of near surface water temperature. The two air temperature probes are shown in Fig. 4 installed inside a white box and suspended approximately 5 ft above the water. The box is louvered for air circulation. Only dry bulb air temperature is presently being recorded.

A 10 ft by 10 ft array of thermistors has been prepared for measurements of near surface temperature structure, thermal patches, and internal waves. The array is shown floating on the water surface in Fig. 5. The 1-1/2 ft long dowel rods which extend vertically in the picture are the thermistor holders. In actual use, the portion of the array in the lower left hand portion of Fig. 5 is weighted so that the array floats with one axis vertical and the other horizontal. This is illustrated in Fig. 6. The horizontal axis of the array is at the

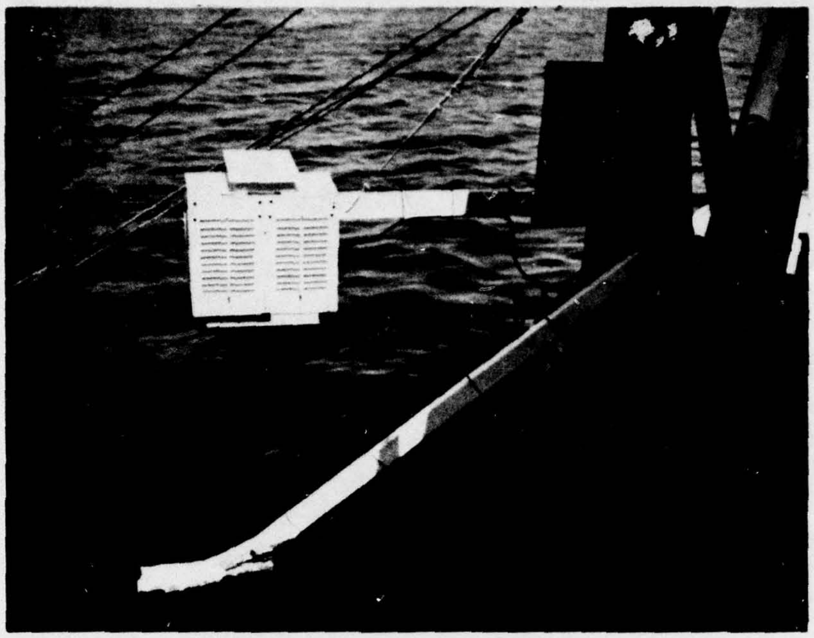

FIGURE 3
AIR AND SURFACE WATER TEMPERATURE MONITOR

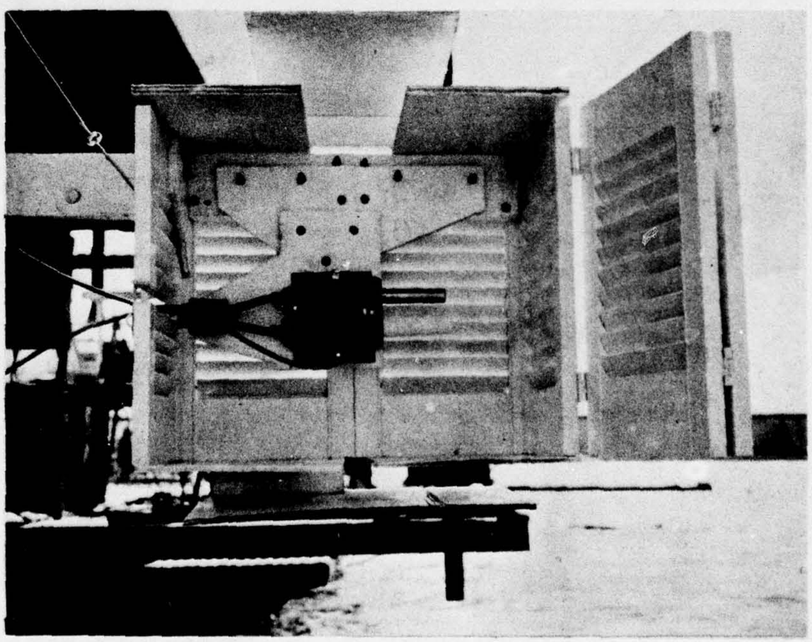

FIGURE 4
AIR TEMPERATURE PROBE

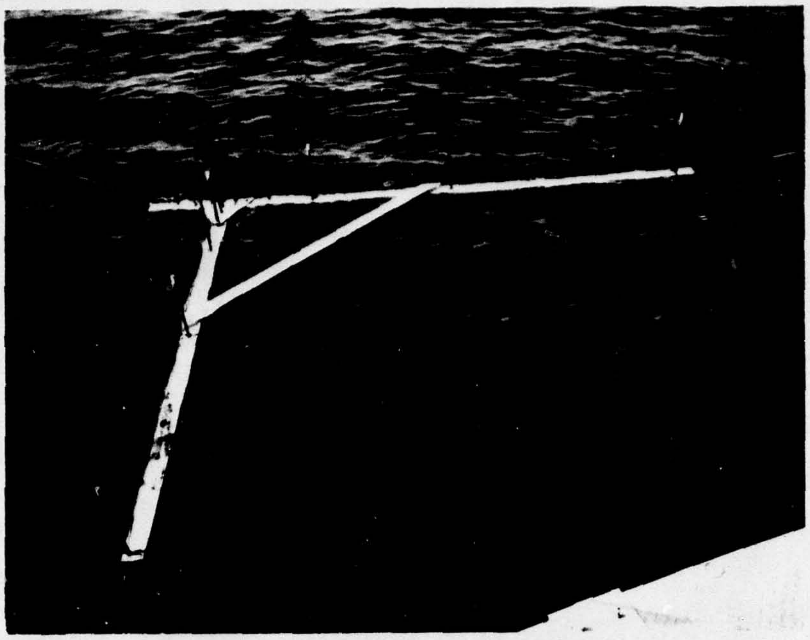

FIGURE 5
THERMISTOR ARRAY FLOATING ON SURFACE

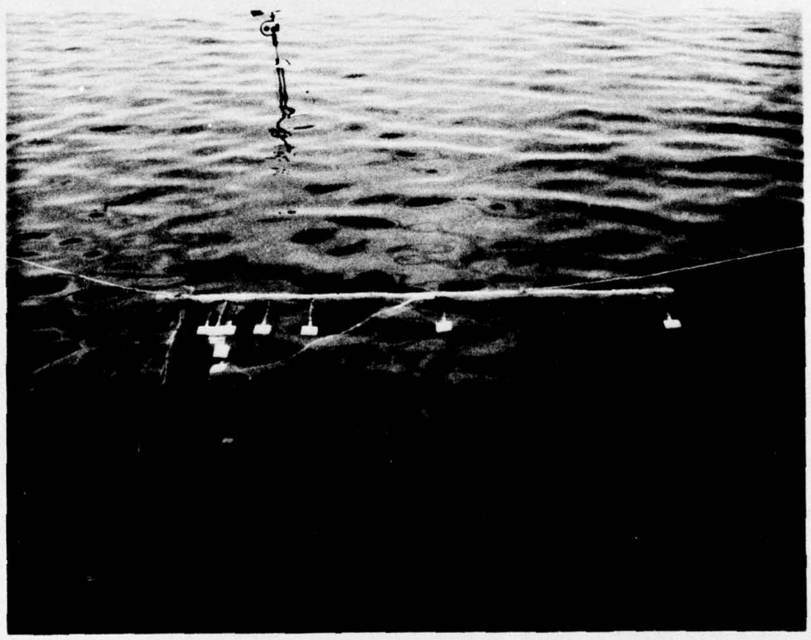

FIGURE 6
THERMISTOR ARRAY AS USED

water surface while the thermistor stations of the upper portion of the vertical axis are visible below the water. The small white squares are shades to prevent radiant heating of the thermistors when making near surface measurements. Possible thermistor separations on each axis range from 3 in. to 10 ft.

The thermistor bridge readout is shown just below the strip chart recorder in Fig. 7 and the ten point thermistor scanner is beside the bridge readout. The thermistors on the array are sequentially scanned as inputs to the bridge readout. The linearized bridge unbalance is available for external recording and is also indicated on a meter with a temperature scale. The bridge output is presently preserved on a strip chart recorder. Also shown beside the recorder is a counter; the readout for a sing-around sound speed probe is to be used in conjunction with the thermistor array. Below the bridge readout and scanner is the readout unit for a Dymec quartz probe thermometer used for calibration and studies of thermal patches.

Six thermistors have been calibrated and used on the array to test its usefulness in the present form. Several recordings of data for spans from an hour to a week have been obtained with the array at the water surface and adjacent to the test station barges. These data are being used in conjunction with the hourly profiler to determine the local thermal influence of the barges and to observe some of the features of thermal stratification development. Though not yet quantified, these data have shown evidence of upwelling and downwelling in response to wind conditions (internal seiche?), as well as details of the near surface stratification and thermal waves (internal waves). Additional probes with longer cables have been ordered. These will be calibrated and placed on the array, allowing the study of details of the thermal conditions at depths up to 140 ft.

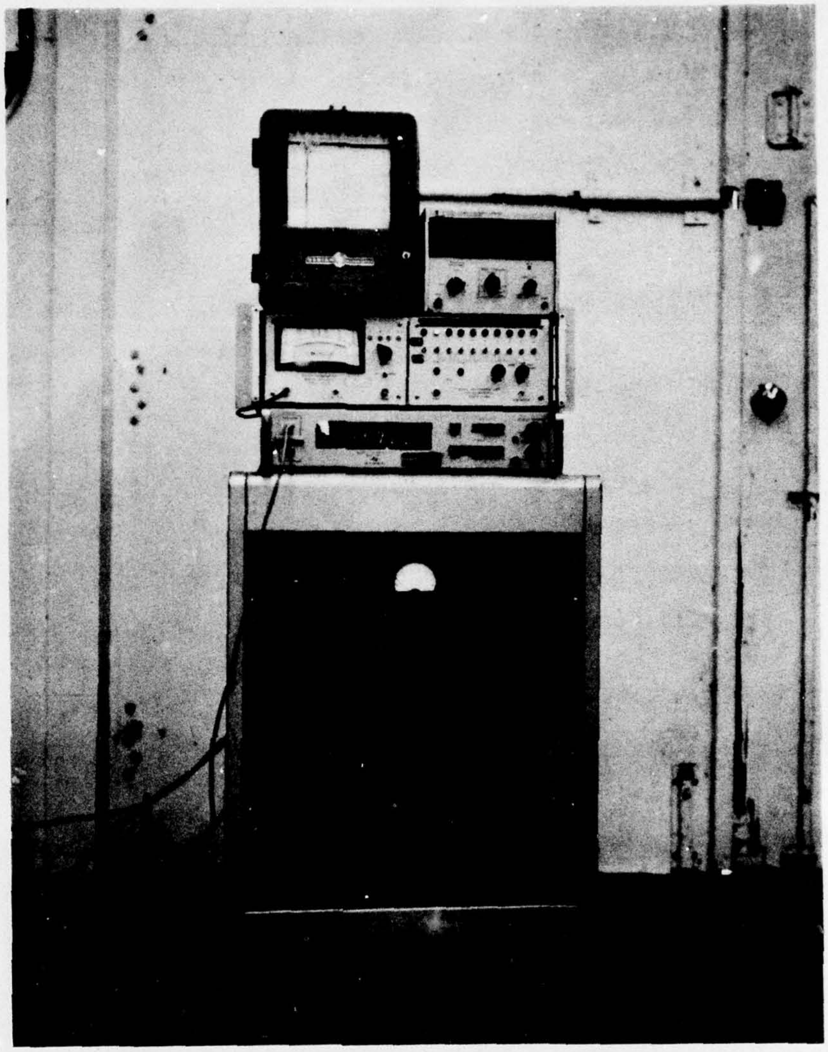

FIGURE 7
PROBE READOUTS

C. Surface Profile Measurements

In conjunction with the temperature measurements described in the preceding section, steps were taken to make measurements of the lake surface profile. Three surface profile measurement techniques have now been implemented and placed in operation on an instrumentation buoy, the one using a capacitive wave staff, the second using a low mass buoyant surface profiler or "bobber," and the third using an acoustic system. The decision was made to implement the measurement program using laboratory-built equipment, and as described in the following sections, the emphasis was placed on a new technique that would have additional meaning to acoustic measurements. The instrumentation buoy shown in Fig. 8 is anchored off the LTTS barges. Water depth is nominally 100 ft, and the buoy is located approximately 50 ft away from the barges. Later it is intended to relocate the buoy approximately 300 ft away from the barges. Also located on the buoy is an annomometer and wind vane approximately 40 in. above mean surface level to sense the wind as near to the point of surface measurement as practical.

The laboratory-built wave staff is approximately linear over a nominal range of 24 in. The output is a dc voltage which varies as the surface is displaced. The sensing element consists of a high grade coaxial cable readily available from laboratory supply. Operated in conjunction with the wave staff is the buoyant surface follower, which consists of a small polystyrene float which contains a 1 MHz acoustic projector. The receiver for this projector is positioned on the acoustic axis. The distance from the bobber to the acoustic receiver is obtained by measuring the time lapse for an acoustic projection. Figure 9 is an oscilloscope photograph of surface displacement profiles measured simultaneously by the wave staff and the bobber. The uppermost

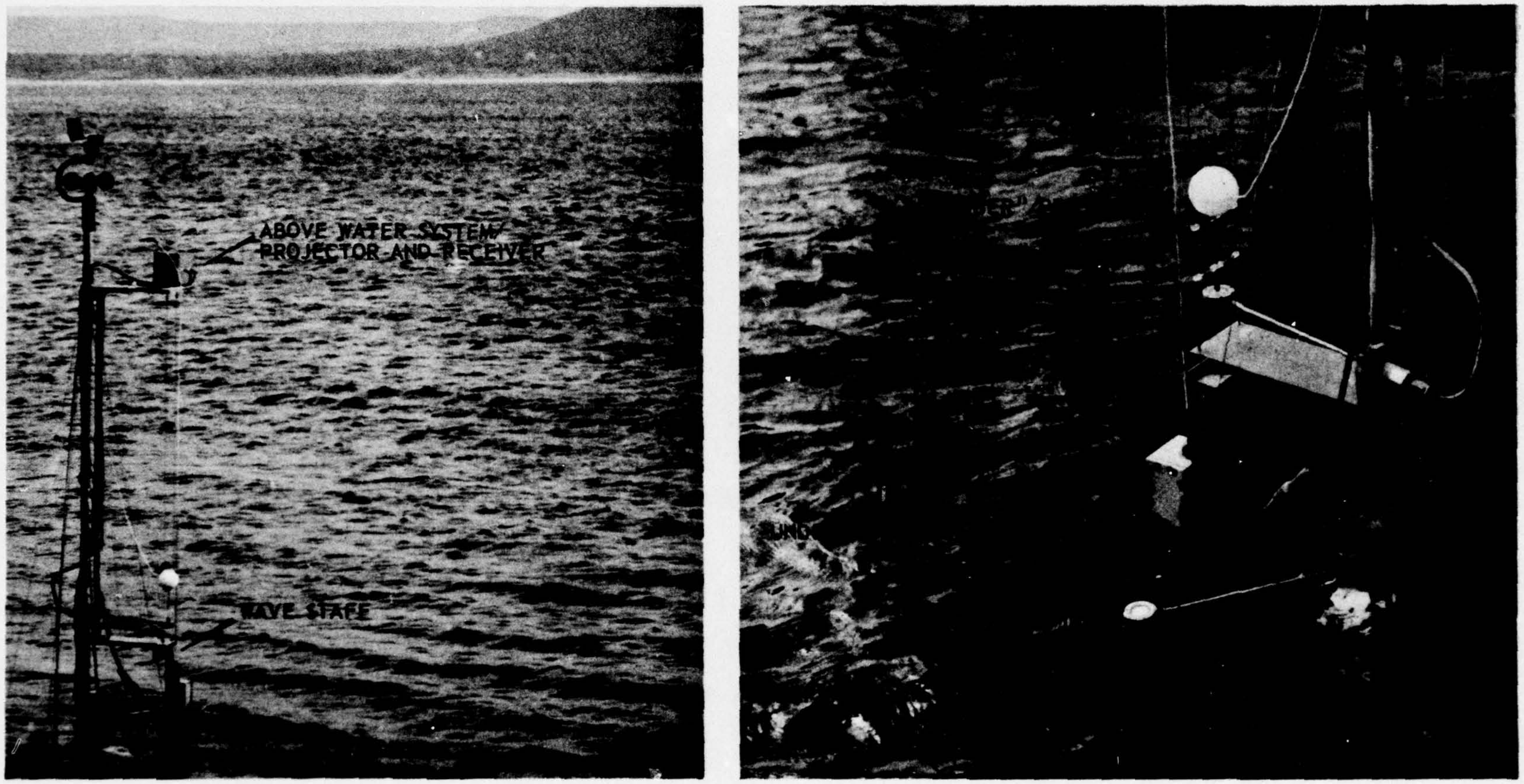

FIGURE 8
SPAR BUOY WITH WAVE SENSORS

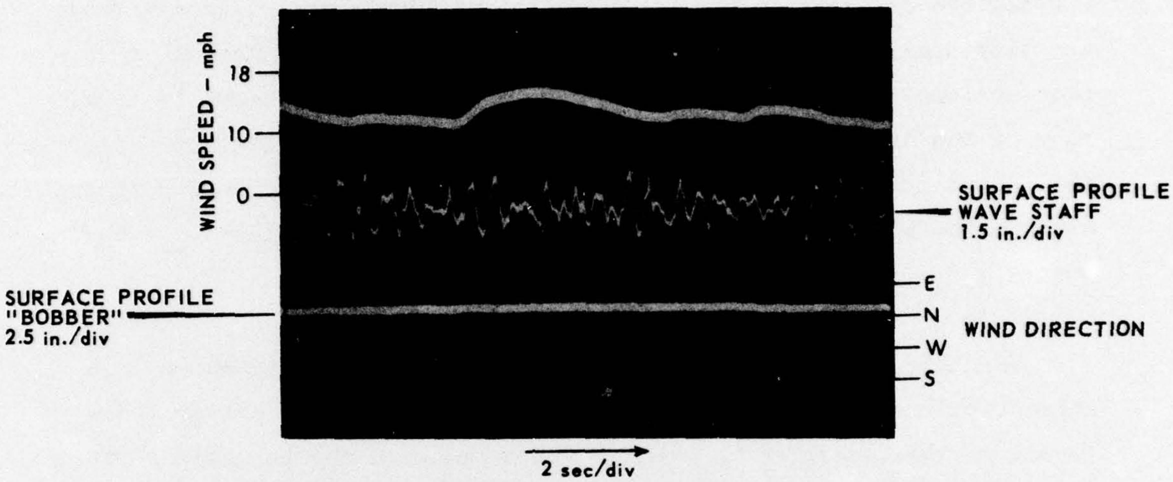

FIGURE 9

LAKE TRAVIS WATER SURFACE PROFILES

trace is wind speed with a range of values of 10 to 15 mph. The second trace is a profile measured by means of the wave staff with a vertical scale of 1.5 in./div. Below the wave staff profile is the time amplitude profile measured by the bobber with a vertical scale of 2.5 in./div. The lower line on the display indicates wind direction. The time base for all the displays is 2 sec per horizontal division. Although there are many similarities between the two simultaneous profiles, there are some obvious differences. The profile from the bobber seems to lack many of the high frequency components observed in the wave staff profile. The intent during the next quarter will be to take additional data and examine the significance of some of the differences indicated in these traces.

The third measurement technique that has been instrumented is an attempt to measure surface profile by means of acoustic energy. The intent of this measurement program was to measure the acoustic surface of the lake, i.e., the boundary of the lake which yielded the surface acoustic reverberation, and to examine the possibility that this defined surface might differ from the air-water interface due to entrapped air near the surface. To make this measurement, two acoustic systems have been implemented, one operating in the water and directed toward the air-water interface, and the second system operating in air and directed towards the same point on the air-water interface. It was desired that both systems insonify the smallest surface area practical within sensor size limitation and signal-to-noise limitations. To achieve this, an underwater system operating near 1 MHz was constructed. A nominal 1 in. diameter circular area of insonification at the half-power points of the acoustic beam was specified. The unit ultimately constructed insonified a nominal 2 1/2 in. diameter surface area at the half-power points. An initial attempt to use a single unit as both acoustic source and receiver with a T-R switch generated undesirable transients

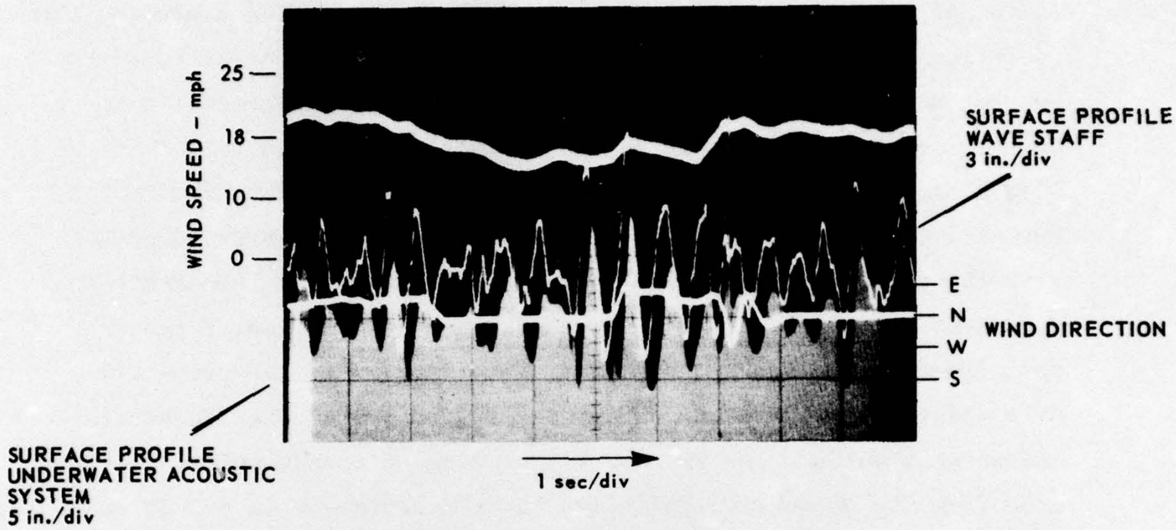

FIGURE 10
LAKE TRAVIS WATER SURFACE PROFILES

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and a small receiving hydrophone positioned along the acoustic axis near the projector has been added, which is also shown in Fig. 8. The above water acoustic system was made by assembling electrostatic transducers designed to operate near 200 kHz. However, the constructed units had a maximum sensitivity near 100 kHz and during operation the operating frequency of these units has dropped two octaves to 25 kHz. The cause of this shift in operating point is at the present time not known. As with the underwater system the "in air" approach initially used a single transducer as source receiver in conjunction with the transmit receive switch. A receiving transducer has been added as with the underwater system to overcome limitations of transients and signal-to-noise ratio. This system is indicated on Fig. 8 and is positioned 30 in. above the mean surface level with the projector axis coincidental with the underwater system axis. The fundamental measurement using these systems is the time of transmission of the echo from the boundary. This time lapse measurement is converted to an amplitude of displacement measurement by generating a linear voltage ramp which starts at transmission and ends upon receipt of the echo. Both the underwater and above water systems operate at a transmission rate of 100 per second. A typical surface profile obtained with the underwater system is illustrated in Fig. 10. The format is the same as Fig. 9 except that the time scale is 1 sec per division.

The spikes along the underwater acoustic profile are caused by the echo signal amplitude falling below the cutoff threshold of the ramp ($S/N \leq 3$ dB). When this occurs, the ramp then continues for a preset duration and automatically resets. If these spikes are ignored, the profile appears smooth and, as with the bobber system, the high frequency components appear to be missing. During the next quarter additional data will be taken and the relation of the three surface measuring systems will be examined. Also, steps will be taken to reduce the dropouts which are apparent in Fig. 10. At present two alternatives are being pursued. One method is by constructing a receiving array which has been configured to detect all but the most severely scattered signals reflected by the surface boundary. This receiving array will be implemented on the underwater system during the next quarter. Another approach is modifying the time amplitude conversion circuitry to provide for sample and hold capability. For this modification the voltage of the ramp at its termination due to echo reception will be held until the next echo is received, at which time the new ramp voltage will be sampled and held. Thus, signal dropouts will be bypassed by holding the level at the last received echo. Low pass filtering and dc amplification of the held signal will be included. These modifications will be completed during the next quarters.

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13. ABSTRACT

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