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FLOW-GENERATED NOISE OF A CYLINDRICAL HYDROPHONE

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A procedure for measuring water-flow-generated noise in the USRD type H62 hydrophone has been developed. The hydrophone was towed through water at a constant speed of 1 knot to simulate deep-ocean currents, and noise spectra were obtained with spectrum analyzer and averager equipment in the frequency range 0 to 1000 Hz. As much as 10 dB increase in noise was induced by the 1-knot water flow.

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Introduction

Flow-generated noise is an important factor in any measurement of low-level acoustic signals in the ocean. The noise produced by a reasonable equivalent of deep ocean currents, which have been reported as generally less than a few tenths of a knot [1], was the primary concern of this investigation. A hydrophone (USRD type H62 [2]) specifically designed for making deep-ocean, low-level acoustic measurements was rigged for towing and used to determine flow-generated noise at a constant speed of approximately 1 knot. The experiment described here provides some indication of the effects of deploying hydrophones in locations where such currents exist.

Measurement Procedure

The basic problem in measuring flow noise is producing a uniform flow of constant velocity about the hydrophone. Because the flow velocity for this measurement is low, it was decided that elaborate facilities such as a water tunnel would not be necessary. Also, it was felt that the boundary conditions associated with a confined flow would add unnecessary difficulty to the analysis.

Initially, it was thought possible to produce a constant flow relative to the hydrophone by lowering it into a deep body of water with a buoy to regulate the rate of descent. Preliminary investigations at the USRD Leesburg, Florida, Facility, where the usable depth is about 45 m, showed that this method was not practical for two reasons: (1) the weight of the hydrophone cable increased the rate of descent as more and more cable was submerged, and (2) as pressure increased with depth, sufficient voltage was generated at the hydrophone preamplifier to mask low-frequency components of any flow-generated noise.

A towing arrangement then was devised to provide the desired water flow relative to the hydrophone at the USRD Lake Facility as shown in Figs. 1 and 2. The hydrophone was towed at the end of a 0.95-cm-diam nylon line fastened to a shallow-draft float that was drawn through the water by a continuous towline between two 20.3-cm-diam pulleys, one of

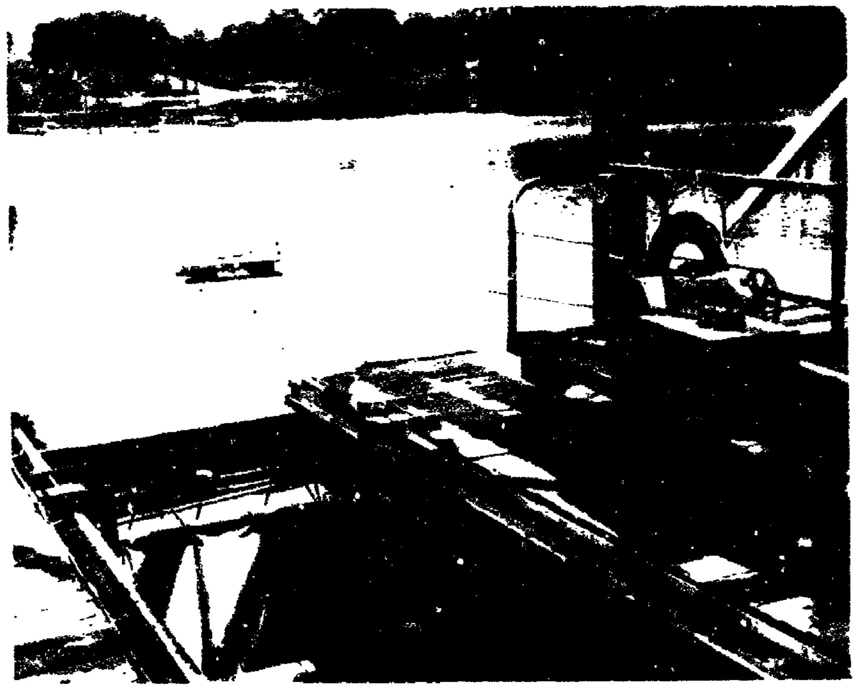

Fig. 1. Towing arrangement for producing constant water flow relative to hydrophone, viewed from North Pier looking across Lake Gem Mary toward East Pier.

whi·h was secured on the East Pier and the other was coupled to a 2-hp d-c electric motor on a flatbed cart on the North Pier. A block and tackle was fastened to the cart to maintain tension on the towline.

To determine the effects of surface-generated noise, some measurements were made while the hydrophone depth was varied from 4 to 8 m (Fig. 3).

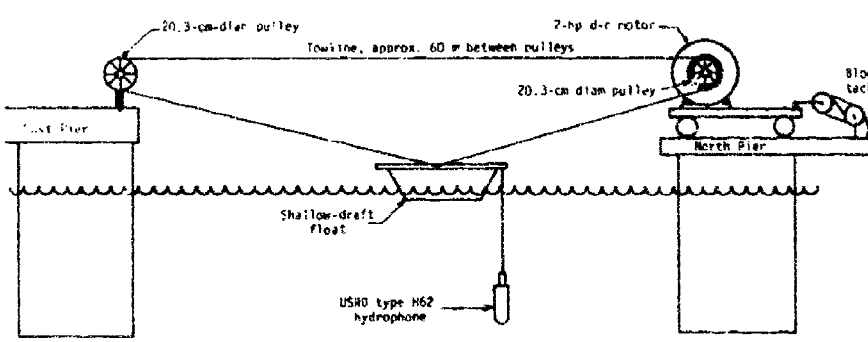

Fig. 2. Towline rigging for producing constant water flow relative to hydrophone.

Fig. 3. USRD type H62 hydrophone suspended from 8-m cable attached to shallow-draft float prior to towing run.

Results of measurements at depths of 6 and 8 m were essentially the same, which indicated that surface noise was not significant at these depths. All flow noise measurements were made on calm days during periods when no other measurements were being made in the lake. Before each run, an ambient noise measurement of the lake was made with the hydrophone stationary in the water.

Flow-noise measurements were made only when the ambient noise was at the minimum level. Mechanical vibrations from shore-based machinery increased ambient noise considerably. Biological noise prevalent in the lake consists of sharp snaps of acoustic energy above 1000 Hz; a low-pass filter was used to eliminate this problem. Two sources of mechanical noise were identified as a large air compressor located in the main laboratory building and an air-conditioning cooling tower located near one of the outlying buildings. The compressor produces strong spectral lines at 5 Hz and higher harmonics, and the air-conditioning unit introduces relatively broad-band noise that increases the ambient noise by 2 to 6 dB. Measurements of flow noise were made only when the air conditioning was not operating.

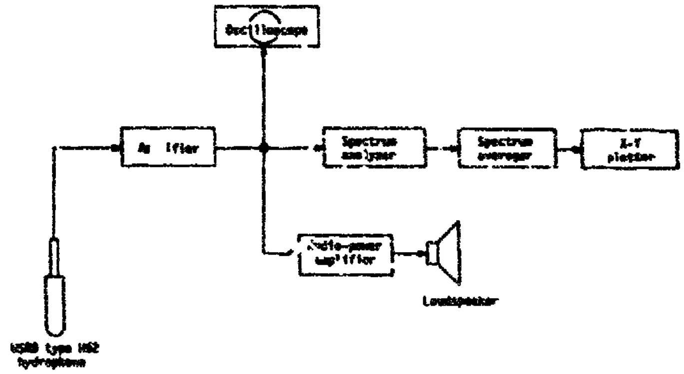

Fig. 4. Simplified block diagram of flow noise measurement system.

Measurement Technique

The measuring system used to determine noise spectra is shown schematically in Fig. 4. Three successive towing runs were made for each of the frequency ranges investigated: 0 to 20 Hz, 0 to 100 Hz, and 0 to 1000 Hz. The sensitivity of the H62 hydrophone is shown in Fig. 5. The signal from the hydrophone was amplified by a Princeton Applied Research Model 113 low-noise preamplifier, which has a built-in passband filter with adjustable low-pass and high-pass settings. This differential feature was used to reduce the 60-Hz pickup from the long hydrophone cable. Measurement results are limited by the equivalent noise pressure of the hydrophone (self noise of its element and preamplifier), which is equivalent to the acoustic pressure that would create a voltage at the input to its preamplifier equal to the noise voltage in a 1-Hz band.

The amplified hydrophone output was analyzed in the desired frequency band with the Federal Scientific Model UA-14 Spectrum Analyzer and the Model 1014 Spectrum Averager. The results of the analysis then were displayed by the X-Y plotter.

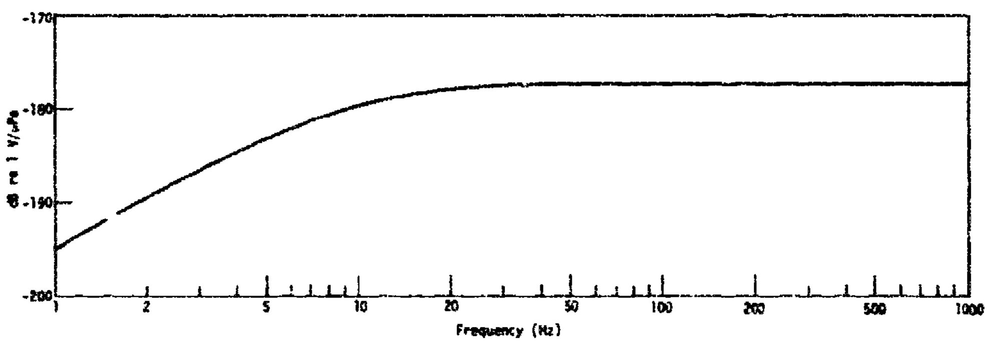

Fig. 5. Typical free-field sensitivity of USRD type H62 hydrophone.

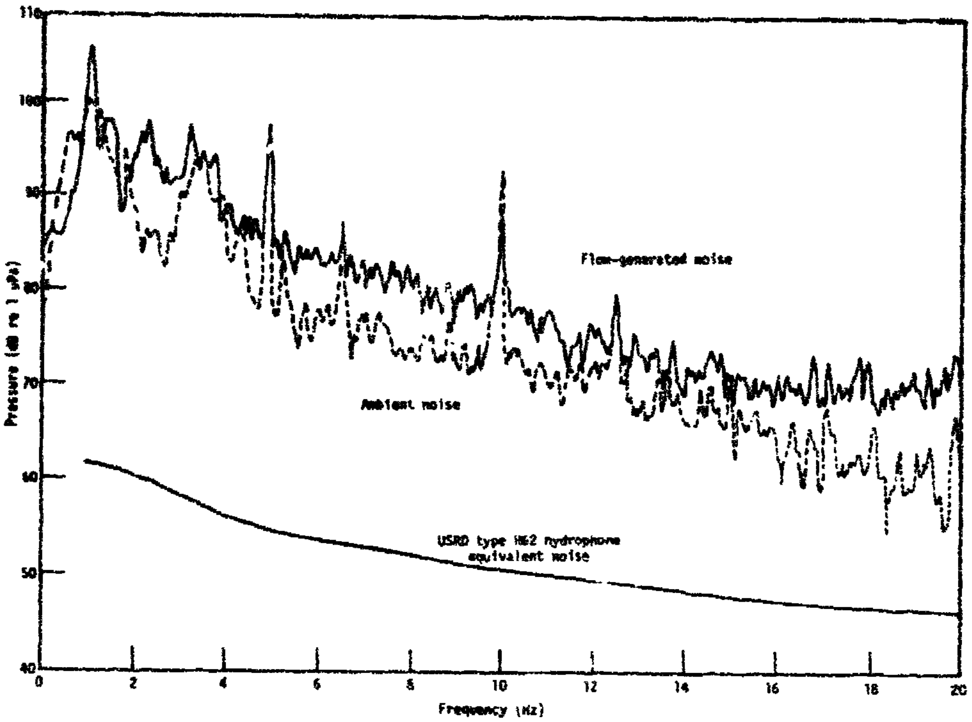

Fig. 6. Water-flow-generated noise at 1 knot, 0 to 20 Hz.

Results

Figures 6, 7, and 8 present the averaged results of at least eight measurements for each of the frequency ranges analyzed, together with the equivalent noise pressure of the hydrophone and the ambient noise spectrum taken before each towing run. For the 0-to-20-Hz range, the analysis bandwidth of the Analyzer and Averager is 0.05 Hz, and the time required to analyze one spectrum is 10 s. Figure 6 shows that a water flow of about 1 knot increased the noise level by as much as 10 dB at some frequencies. Some of the spectral peaks can be identified with the shore-based air compressor, but peaks at 1, 6.6, and 12.5 Hz that coincide with peaks in the ambient noise line spectrum could not be related to either the compressor or the towing process and are thought to be caused by some other machinery that remains to be identified. The most pronounced evidence of towing noise can be seen in Fig. 7 (analysis bandwidth = 0.25 Hz), where the flow noise is as much as 30 dB above the ambient noise in a relatively broad band from 30 to 100 Hz, while Fig. 8 (analysis bandwidth = 2.5 Hz) shows more sharply defined peaks in the frequency range 100 to 1000 Hz. Because the electric motor limited the lowest towing speed to 0.5 m/s, the results reported for a flow of 1 knot probably are somewhat high in comparison with the noise levels produced by actual deep-ocean currents.

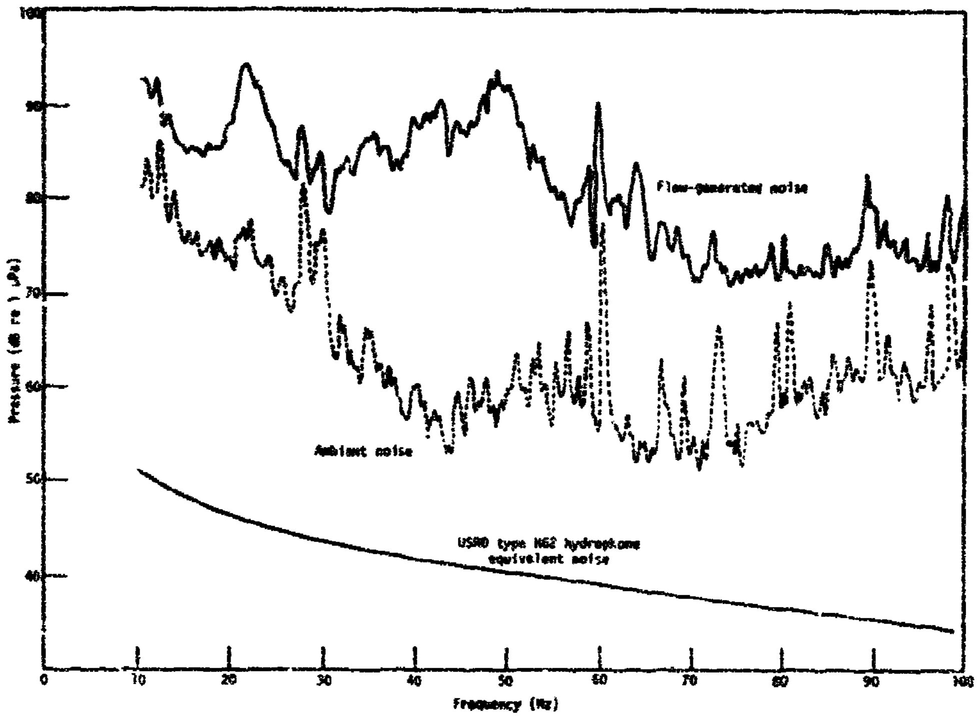

Fig. 7. Water-flow-generated noise at 1 knot, 0 to 100 Hz.

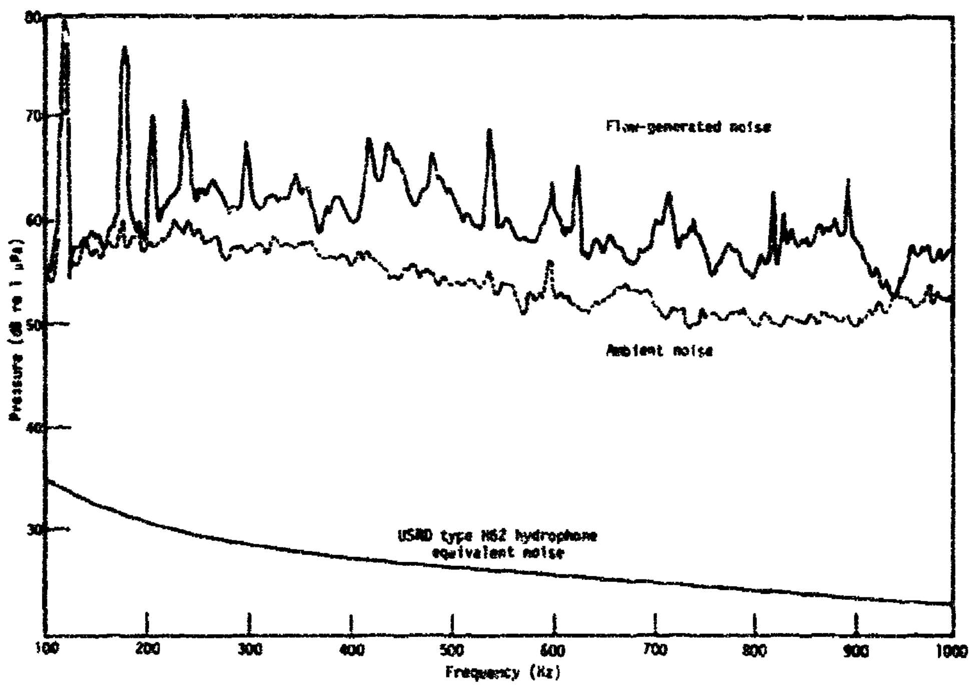

Fig. 8. Water-flow-generated noise at 1 knot, 100 to 1000 Hz.

Conclusions

The relatively simple procedure described here is adaptable to many hydrophone configurations. The mechanical towing arrangement could be modified to provide lower towing speeds to correspond to slower currents. The electronic measuring system is straightforward and reliable. The data are immediately available so that any unusual events can be identified and checked without delay.

Although the ambient noise level in Lake Gem Mary was low enough for the measurements that were made, investigation of slower towing speeds may require a location with a much lower ambient noise level such as the NRL-USRD facility at Leesburg, Florida.

Acknowledgements

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