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Flow Direction and Magnitude — A Suspension Wire Application

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SUMMARY A modified form of the suspension wire flow measuring device removes an ambiguity of flow direction and allows simultaneous dynamic observation of direction and flow magnitude. Spectral analysis of wave current and corresponding wave amplitude in a laboratory test demonstrates the dynamic capabilities.

1 INTRODUCTION

The measurement of velocity in streams and the ocean is normally performed with a propellor type instrument and there are limitations to the dynamic response. The flow direction is usually found by a vane device which has significantly less accuracy and less dynamic response. The better dynamic devices such as the hot wire or hot film anemometer that are suitable for laboratory work (and mainly air), are not easily used in water in a field environment. The suspension wire device the development of which began 15 years ago (Sharp 1962-1964) has a mechanical electrical principle and has evolved as a potential dynamic technique suitable for field work (Sharp, B.B. and Sharp, D.B., 1975 and A.W.R.C. Report 1977). To achieve the greatest sensitivity and for various desirable laboratory configurations the device has normally consisted of a wire transverse to the flow the drag on which is detected by the deflection of a shielded beam lying in a perpendicular direction.

The beam with strain gauges mounted on it has very small inertia and thus the dynamic response is good. With this arrangement however, the device acts like a full wave rectifier and thus the flow direction is ambiguous. A new configuration with the sensing beam laid in the same longitudinal direction as the wire eliminates the rectification and a single wire has the dynamic capability of flow direction measurement in one plane. A grouping of wires will enable the absolute velocity vector to be determined. The purpose of this presentation is to demonstrate the dynamic response of a single wire with a specific laboratory test.

2 LABORATORY TEST

A small laboratory wave tank provided a fluctuating flow by means of a manual wave generator. The water depth was observed near the suspension wire device with a probe that was of the capacitance type (Moore, 1964) which had a suitable linear dynamic response.

The output of the suspension wire (non linear) and the water depth were recorded simultaneously using a voltage to frequency conversion on to a magnetic tape with a constant interrupt frequency on a third channel.

The data for analysis was processed by a mini computer (Interdata 70) by means of a special frequency modulation to digital conversion interface.

3 EXPERIMENTAL RESULTS

Two wave patterns were observed, one substantially regular and the other with a random mixture of wave effects. In both cases the limitations of the wave tank facility meant that there were also significant wave reflections.

In Figure 1 is shown a sample of the wave height and the wave current for a regular wave pattern. The wave tank was 400 mm. deep with maximum wave height of the order 100 mm. and the suspension wire device was centred at approximately 2/3rd the water depth above the bottom.

In Figure 2 the result for a random wave generation is shown. The results in both cases are very similar with a suggestion that the depth probe also detected some additional surface effects.

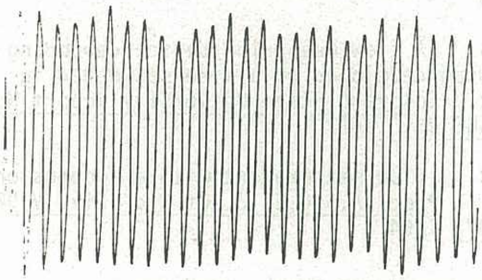
The data was analysed to determine the spectral composition of the two measurements and comparisons should indicate similarities in the dynamic response.

It is sufficient for this purpose to present normalised spectra, that is, $S(f)/\sigma^2$. The log log form of the spectrum is used as this amplifies the lower frequencies where the majority of the energy is concentrated but still demonstrates the higher frequency content adequately. In these tests the Nyquist frequency was 20 Hertz with a frequency increment of 0.04 Hz. The amplitude of the spectral span was more than 5 decades.

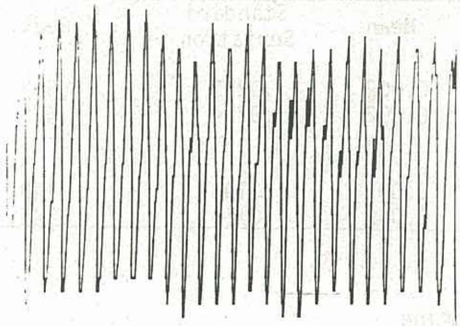
In Figure 3 the spectra for the regular wave are depicted and the result shows the characteristic spikes corresponding to the prominent wave and its harmonics and the traces are substantially identical. In Figure 4 the spectra for the random wave set are displayed. There is a dominant wave but the energy cascades monotonically with increase in frequency.

There is clearly much to be derived from these traces regarding the characteristics of the wave tank but the present concern is the dynamic response of the suspension wire device which clearly matches the wave probe response.

In Table 1, some comparative statistics of the relative spectra are shown.

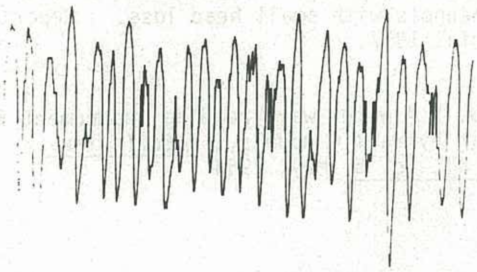


Left: Suspension Wire

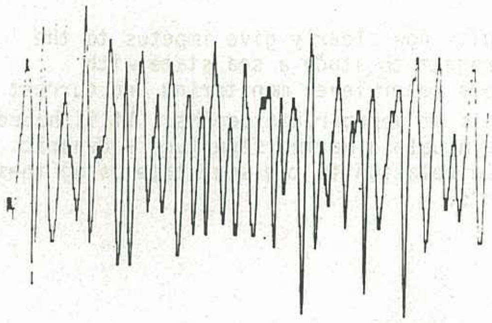


Right: Depth Probe

Figure 1 Regular Wave

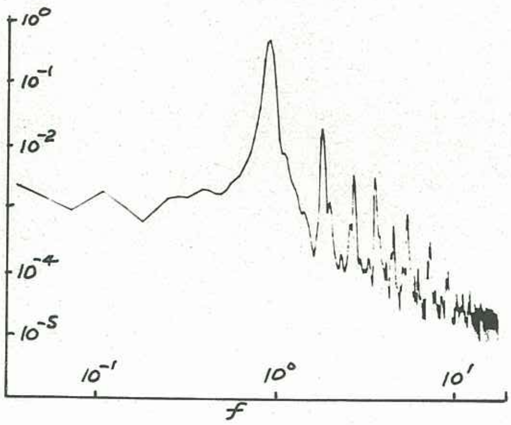


Left: Suspension Wire

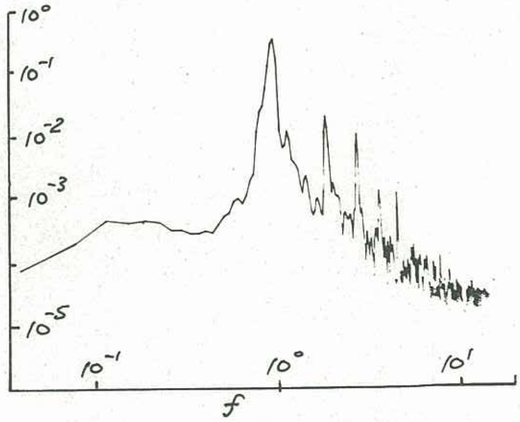


Right: Depth Probe

Figure 2 Random Wave

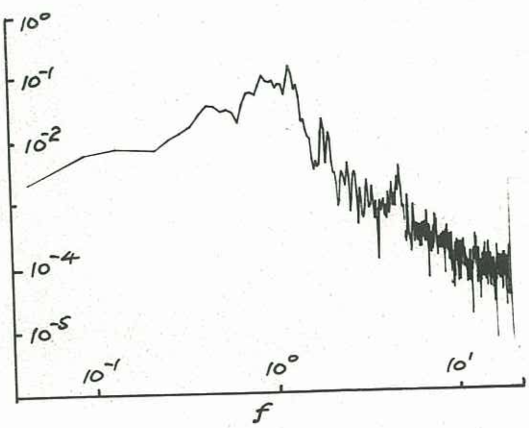


Left: Suspension Wire

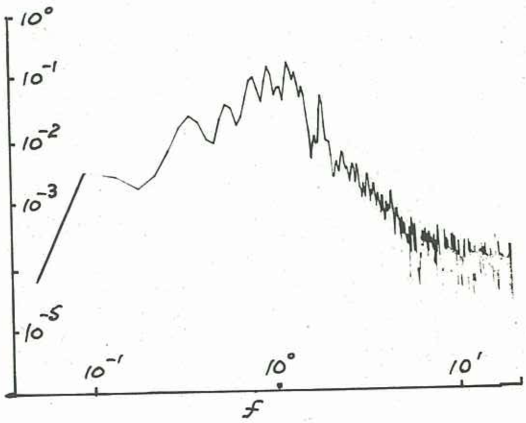


Right: Depth Probe

Figure 3 Spectra for regular wave



Left: Suspension Wire



Right: Depth Probe

Figure 4 Spectra for random wave

TABLE I

	Mean	Standard Seviation	Peak
Regular			
Depth	0.002	.0253	.507
Current	0.002	.0234	.475
Random			
Depth	0.002	.0108	.149
Current	0.002	.0113	.144

4 CONCLUSION

The specific laboratory test of one set of records shows the dynamic response capabilities of the suspension wire are equal to the depth measuring capability of the capacitance type depth probe.

These results now clearly give impetus to the planned program to study a sea state with simultaneous water level monitoring and current measurements at appropriate depths. It is hoped to fully evaluate a marine structure's dynamic response in relation to the sea state using these measurements.

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