



[54] ELASTIC WAVE SENSING SYSTEM

[75] Inventors: Yi Liu, Acton; Lawrence C. Lynnworth, Waltham, both of Mass.

[73] Assignee: Panametrics, Inc., Waltham, Mass.

[21] Appl. No.: 52,159

[22] Filed: Apr. 23, 1993

[51] Int. Cl.<sup>6</sup> ..... G08B 17/12

[52] U.S. Cl. .... 73/597; 73/290 V; 73/61.79; 73/64.53; 73/861.18

[58] Field of Search ..... 340/621; 73/290 V, 73/597, 599, 61.79, 64.53, 82 A, 861.18

[56] References Cited

U.S. PATENT DOCUMENTS

4,118,983	10/1978	Braznikov .....	73/290 V
4,248,087	2/1981	Dennis .....	340/621
4,320,659	3/1982	Lynnworth et al. ....	73/589
4,461,178	7/1984	Chamuel .....	73/599
4,838,127	6/1989	Herremans .....	73/642
5,159,838	11/1992	Lynnworth .....	73/644

OTHER PUBLICATIONS

Ageeva, N. S., Ultrasonic Method for Measuring the Height of the Fluid Level in a Vessel by Means of Flexural Oscillations of a Thin Elastic Strip, Acoustics Institute, Academy of the Sciences of the USSR, Moscow, Jan.-Mar., 1960, vol. 6, No. 1 pp. 120-121.

Dieulesaint et al., A Guided Acoustic Wave Liquid Level Sensor, 1987 IEEE Ultrasonics Symposium, pp. 569-572.

Royer et al., Remote Sensing of the Thickness of Hollow Cylinder From Optical Excitation and Detection of Lamb Waves, 1989 IEEE Ultrasonics Symposium (first page).

Lynnworth, L., Flexural Wave Externally-Attached Mass Flowmeter for Two-Phase Fluids in Small-Diameter Tubing, 1-MM ID to 16-MM ID, 1990 IEEE Ultrasonics Symposium.

Royer, D., et al., Capteurs `a ondes élastiques guidées, *J. Phys. III France* 2 Jan., 1992, 145-168.

Primary Examiner—Hezron E. Williams

Assistant Examiner—Christine Oda

[57] ABSTRACT

A sensing system detects elastic waves propagated along a sensing path in a sheet to detect a characteristic of material contacting the other side of the sheet. An acoustic load applied between transducers discriminates characteristics in diverse environments. Different systems detect density, stiffness, presence, degree of coupling, thickness, or fill height of the material, with applications to areas as diverse as aircraft wing ice measurement, storage tank fill height detection, and mass flow detection. In one preferred embodiment a protective housing covers and protects the first side of the sheet over a region of the sheet encompassing the sensing path, and may secure transducers in defined positions. The housing preferably defines a closed reservoir that is temporarily filled to determine a normative measurement such as transit time or change in phase velocity. The normative measurement provides an empirical calibration that, in turn, allows a final parameter or a detection threshold to be precisely determined.

21 Claims, 12 Drawing Sheets

