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Lynnworth et al.

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(54) **STREAM-CLEANED DIFFERENTIAL REFLECTION COEFFICIENT SENSOR**

FOREIGN PATENT DOCUMENTS

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(57) **ABSTRACT**

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(51) **Int. Cl.**⁷ **G01F 1/66**

(52) **U.S. Cl.** **73/861.28**

(58) **Field of Search** 73/290 V, 589, 73/592, 597, 599, 629, 644, 602, 54.41, 64.53, 861.28, 861.27, 861.31

An ultrasonic system employs a path through a fluid to determine fluid density by a differential reflection coefficient measurement of fluid impedance Z and a fluid sound speed c . Preferred configurations use clamp-on (external) transducers and combine ultrasonic measurements of flow velocity V over one or more paths, to obtain the mass flow rate. Z is determined by comparing reflections from a reference target, which may be totally reflective, with reflections from a sensor target having an effectively lower Z , which may be close to that of the fluid. Both targets are preferably located to be cleaned by the natural flow of the fluid. The low- Z target is interrogated at least once. Vee blocks provide a compact combination of reference and sensor targets that can be integrated with a velocity-sensing flowcell. Folded-path flow cells compactly measure V alone or in combination with density. The principal surface may be aligned parallel to the free stream direction and located to yield a flow value substantially equal to the area averaged flow, and the system may further correct for variations in the vicinity of the reflector.

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16 Claims, 47 Drawing Sheets

