



[54] DIGITAL PHASE LOCKED LOOP SIGNAL PROCESSING FOR CORIOLIS MASS FLOW METER

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[56] References Cited

U.S. PATENT DOCUMENTS

Re. 31,450	11/1983	Smith .	
4,422,338	12/1983	Smith .	
4,491,025	1/1985	Smith et al. .	
4,757,390	7/1988	Mehrgardt et al. ....	358/310
4,852,410	8/1989	Corwon et al. .	
4,934,196	6/1990	Romano .	
5,218,869	6/1993	Pummer .....	83/629
5,429,002	7/1995	Colman .	
5,469,748	11/1995	Kalotay .....	73/861.356
5,555,190	9/1996	Derby et al. ....	73/861.356
5,578,764	11/1996	Yokoi et al. ....	73/861.356

OTHER PUBLICATIONS

Spitzer, Davd A.; "Industries Flow Measurement"; pp. 197-210; 1990 U.S.A.

DeCarlo, Joseph P.; Fundamentals of Flow Mesurement; pp. 208-220; 1984 U.S.A.

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[57] ABSTRACT

A Coriolis-type fluid flow rate measuring system uses phase locked loop-based signal processing to estimate a tube vibration signal and maintain optimum tube vibrations. Analog sinusoidal sensor signals from the flow meter are digitized and processed through heterodyne mixing as part of phase locked loop tracking of the fundamental vibration or oscillation frequency. Digital signal processing is used to implement filtering and signal manipulation so as to respectively determine phase and frequency estimates for both of the two digitized signals. Frequency estimate data is used to adjust the tracker frequency mixed with the respective sensor signals. Digitally obtained phase and frequency estimate data are used to determine an optimized drive signal for continuing tube vibration. Phase estimate information for the two respective sensor signals is used to determine phase shift data, used in turn to determine a fluid flow rate through the flow meter.

29 Claims, 6 Drawing Sheets

