

[54] METHOD AND APPARATUS FOR ADAPTIVE LINE ENHANCEMENT IN CORIOLIS MASS FLOW METER MEASUREMENT

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[52] U.S. Cl. 364/510; 73/861.356

[58] Field of Search 364/509, 510, 364/572; 73/861.38, 861.37, 861.03, 861; 324/76, 77-85, 601

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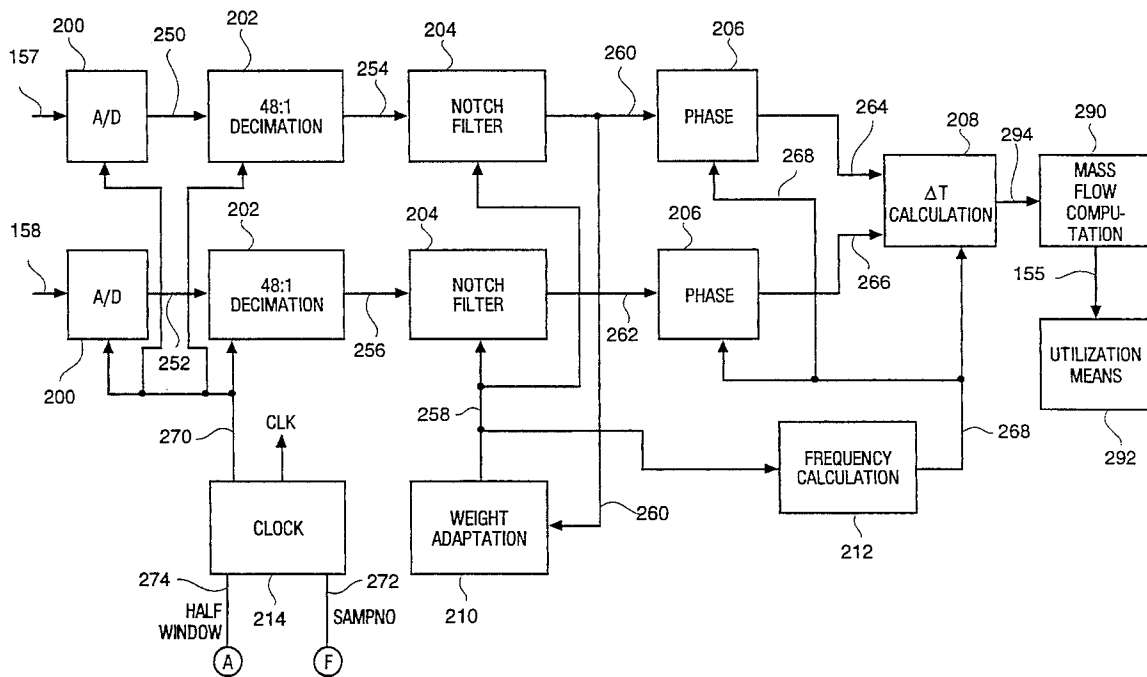
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35 Claims, 20 Drawing Sheets

[57] ABSTRACT

An apparatus and method for determining frequency and phase relationships of vibrating flow tubes in a Coriolis mass flow meter. Adaptive line enhancement (ALE) techniques and apparatus are used in a digital signal processing (DSP) device to accurately determine frequency and phase relationships of the vibrating flow tube and to thereby more accurately determine mass flow rate of a material flowing through the mass flow meter. In a first embodiment, an adaptive notch filter is used to enhance the signal from each corresponding sensor signal on the vibrating flow tubes. In a second embodiment, a plurality of adaptive notch filters are cascaded to enhance the signal from each corresponding sensor signal. In both embodiments an anti-aliasing decimation filter associated with each sensor signal reduces the computational complexity by reducing the number of samples from a fixed frequency A/D sampling device associated with each sensor signal. Computational adjustments are performed to compensate for spectral leakage between the fixed sampling frequency and the variable fundamental frequency of the vibrating flow tubes. Despite this added computational complexity, the present invention is simpler than prior designs and provides better noise immunity due to the adaptive notch filtration. Heuristics are applied to the weight adaptation algorithms of the notch filters to improve convergence of the digital filters and to reduce the possibility of instability of the filters interfering with mass flow measurements.



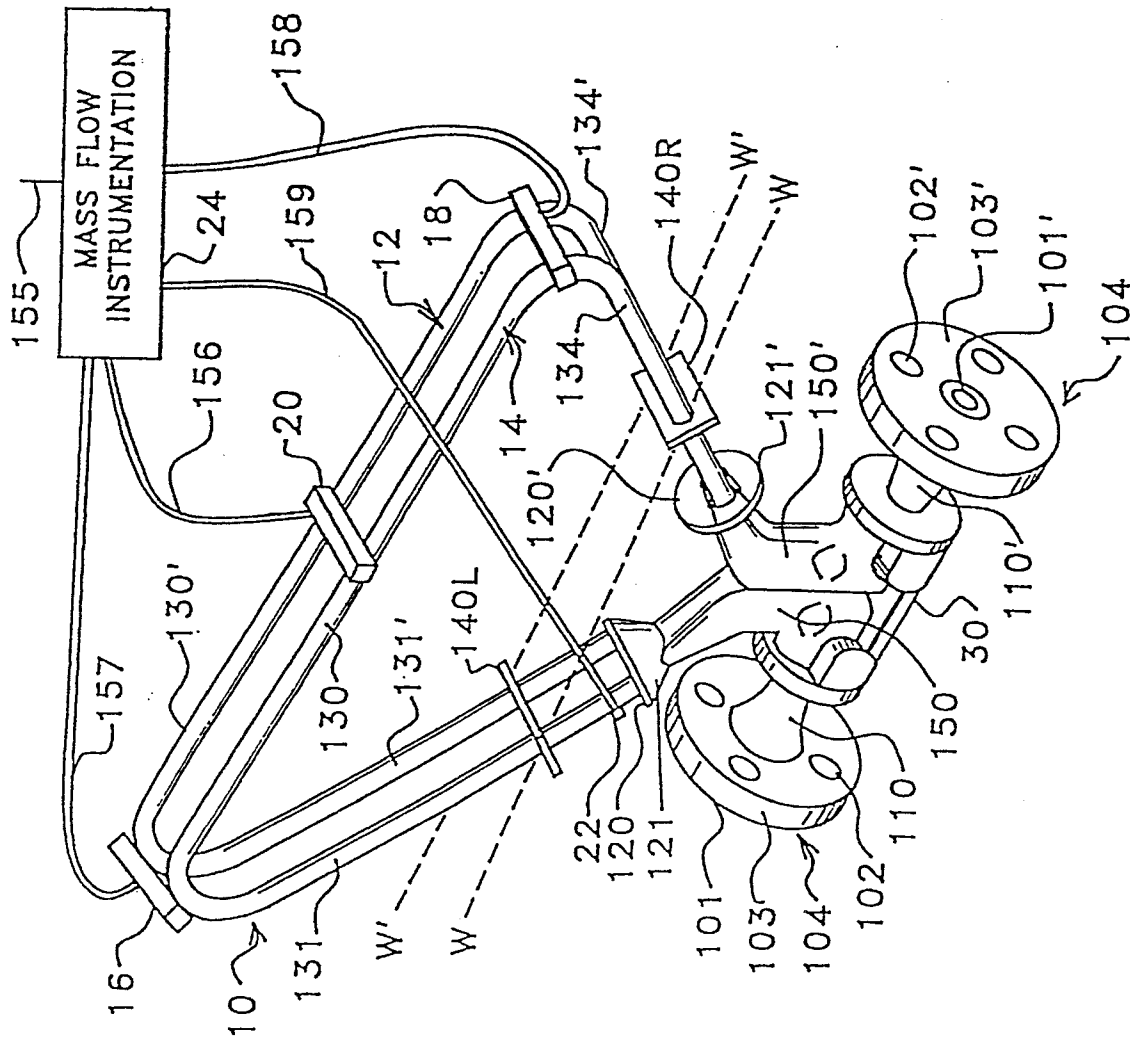


FIG. 1

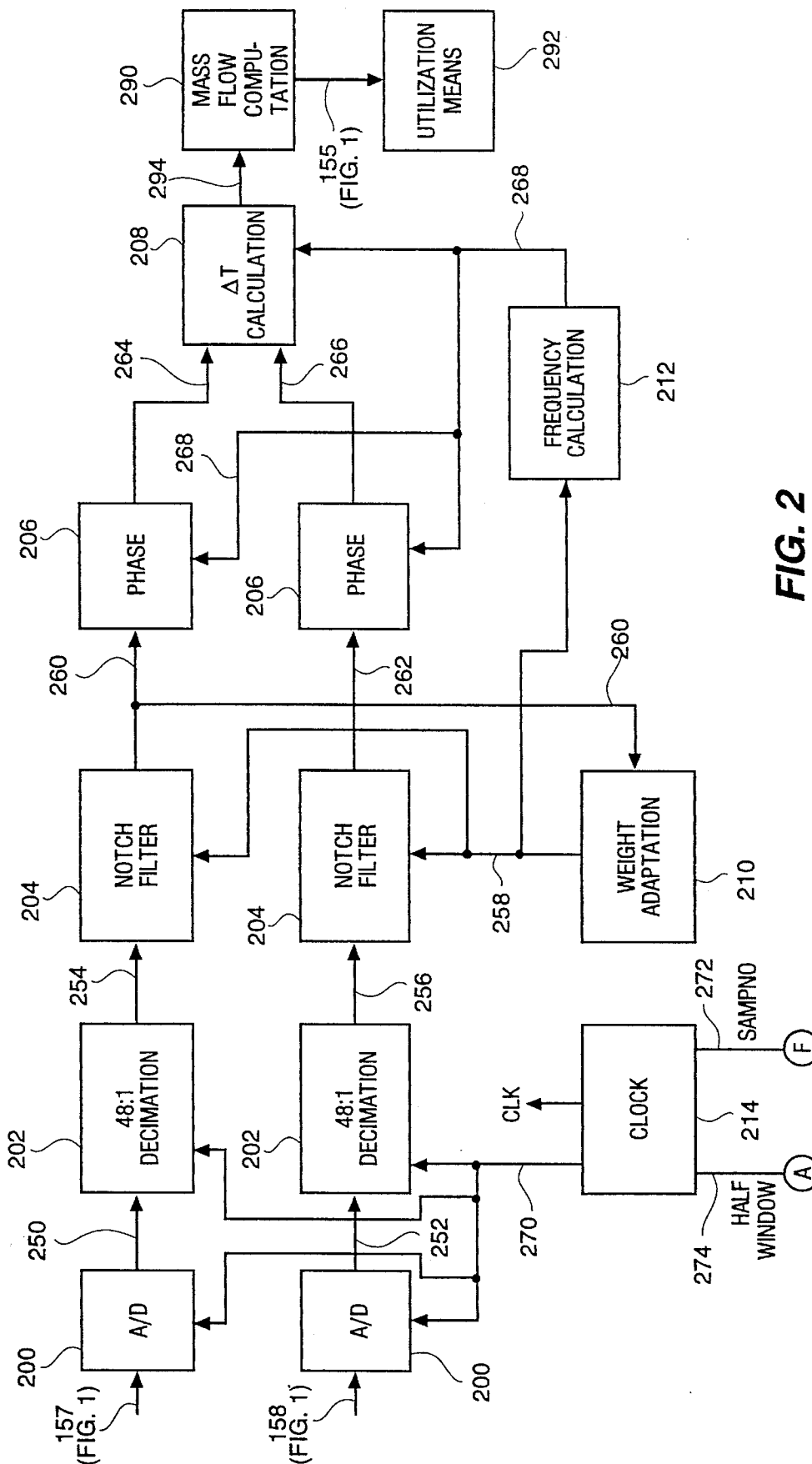


FIG. 2

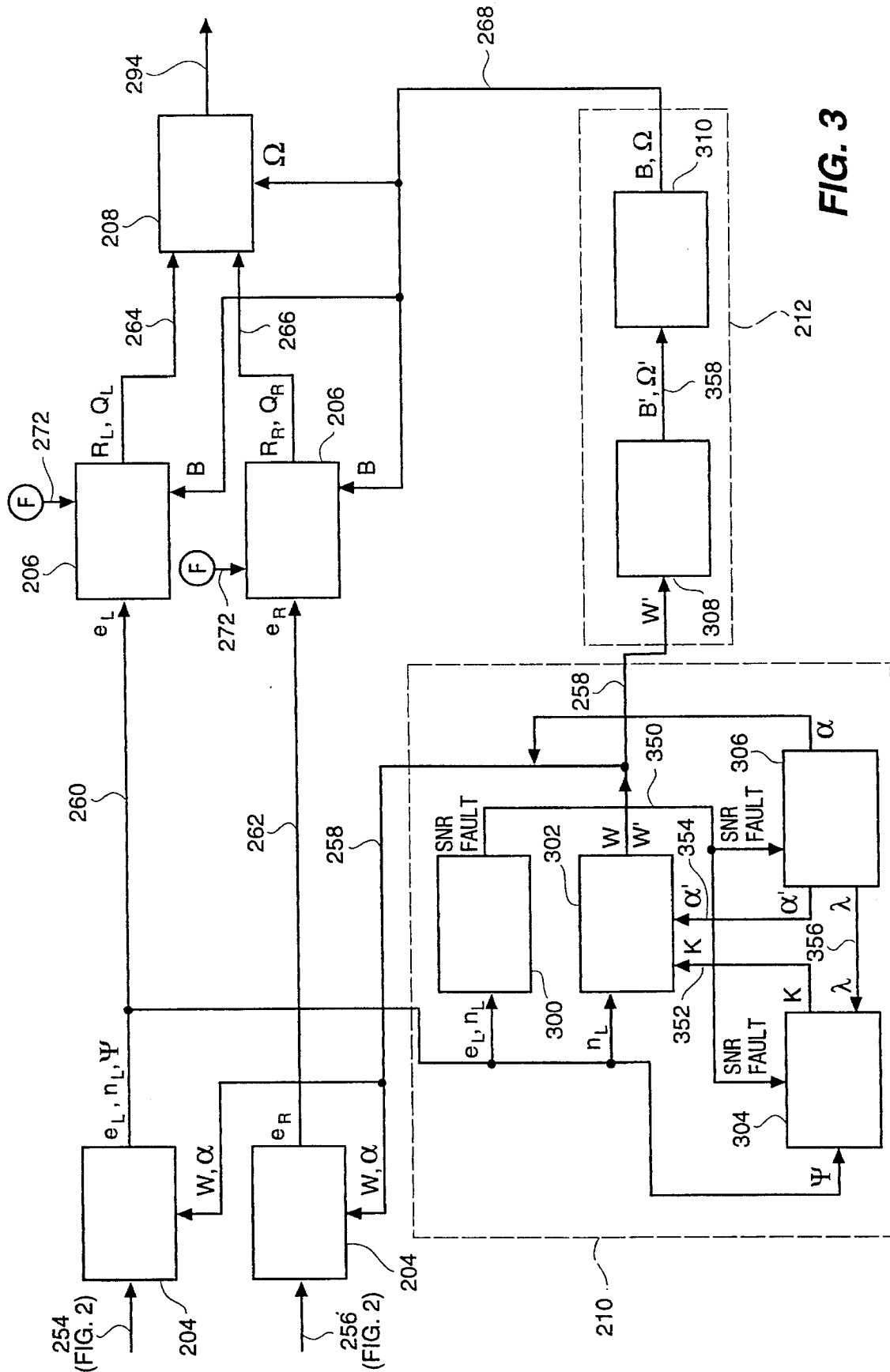


FIG. 3

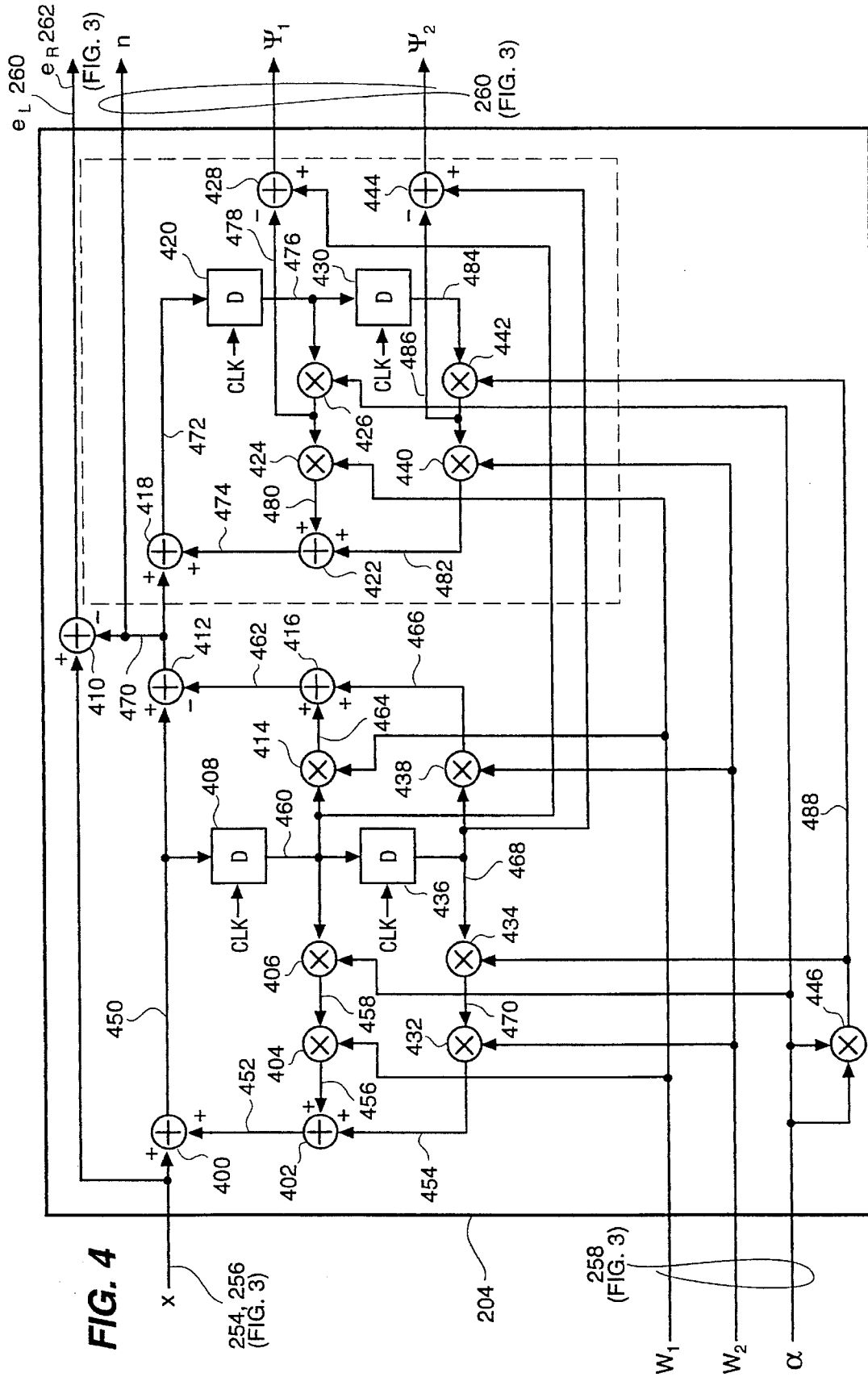


FIG. 4

254, 256 (FIG. 3)

258 (FIG. 3)

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