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# United States Patent [19]

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Jeričević et al.

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[54] ENERGY MINIMIZATION IN SURFACE MULTIPLE ATTENUATION

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[22] Filed: **Sep. 4, 1997**

[51] Int. Cl.<sup>6</sup> ..... **G01V 1/38**

[52] U.S. Cl. .... **367/24; 367/45; 367/24; 367/53**

[58] Field of Search ..... **367/21, 24, 38, 367/45, 53**

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Primary Examiner—Christine K. Oda

Assistant Examiner—Anthony Jolly

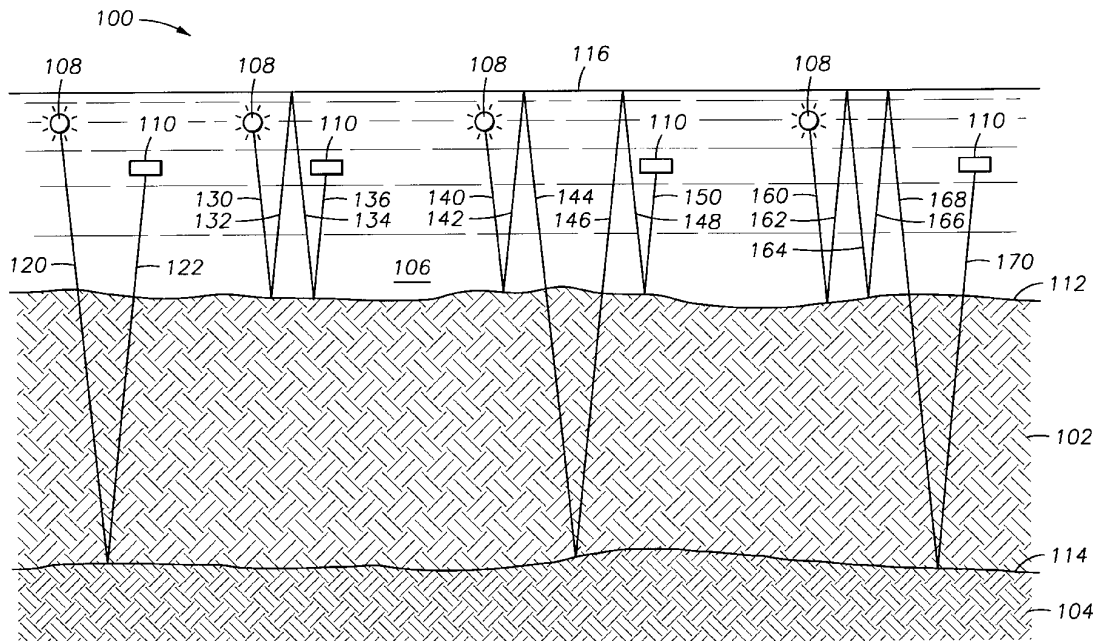
## [57] ABSTRACT

A marine seismic signal is transformed from time domain into frequency domain and represented by matrix D. The marine data signal is truncated in time, transformed into the frequency domain and represented by matrix  $D_T$ . Eigenvalue decomposition  $D_{T=SA}^{-1}$  of matrix  $D_T$  is computed. Matrix product D S is computed and saved in memory. Conjugate transpose  $[D S]^*$  is computed and saved in memory. Matrix product  $[D S]^*[D S]$  is computed and saved in memory. Matrix inverse  $S^{-1}$  is computed and saved in memory. Conjugate transpose  $(S^{-1})^*$  is computed and saved in memory. Matrix product  $S^{-1}(S^{-1})^*$  is computed and saved in memory. An initial estimate of the source wavelet w is made. Source wavelet w is optimized by iterating the steps of computing the diagonal matrix  $[I-w^{-1}\Lambda]$ , computing matrix inverse  $[I-w^{-1}\Lambda]^{-1}$ , computing conjugate transpose  $[(I-w^{-1}\Lambda)^{-1}]^*$ , retrieving matrix products  $[D S]^*[D S]$  and  $S^{-1}(S^{-1})^*$  from memory, and minimizing the total energy in trace of matrix product

$$S^{-1}(S^{-1})^*[(I-w^{-1}\Lambda)^{-1}]^*[D S][D S][I-w^{-1}\Lambda]^{-1}$$

Primary matrix P representing the wavefield free of surface multiples is computed by inserting computed value for w into the expression  $[D S][I-w^{-1}\Lambda]^{-1}S^{-1}$ . Primary matrix P is inverse transformed from frequency domain into time domain.

17 Claims, 4 Drawing Sheets



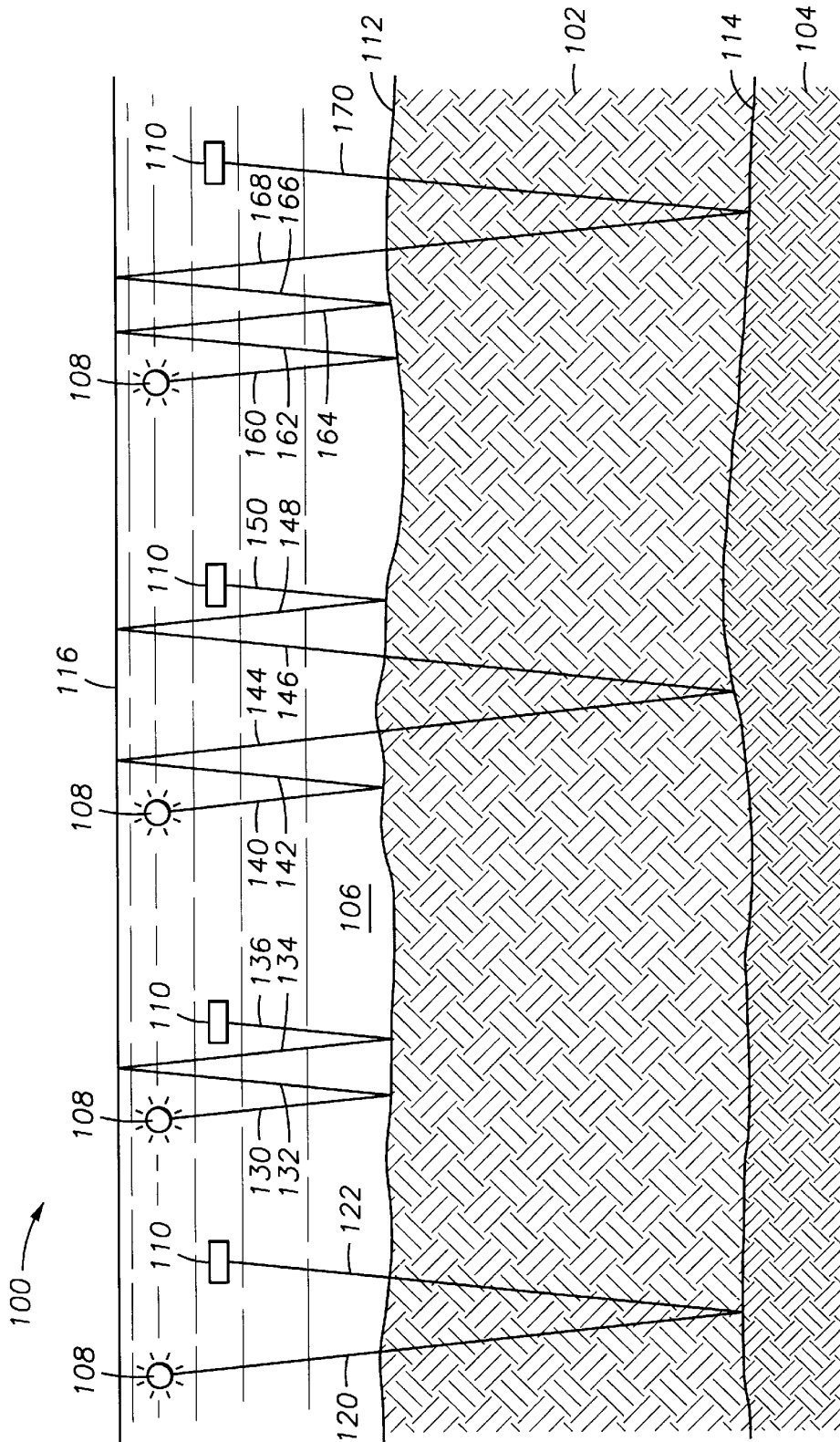


FIG. 1

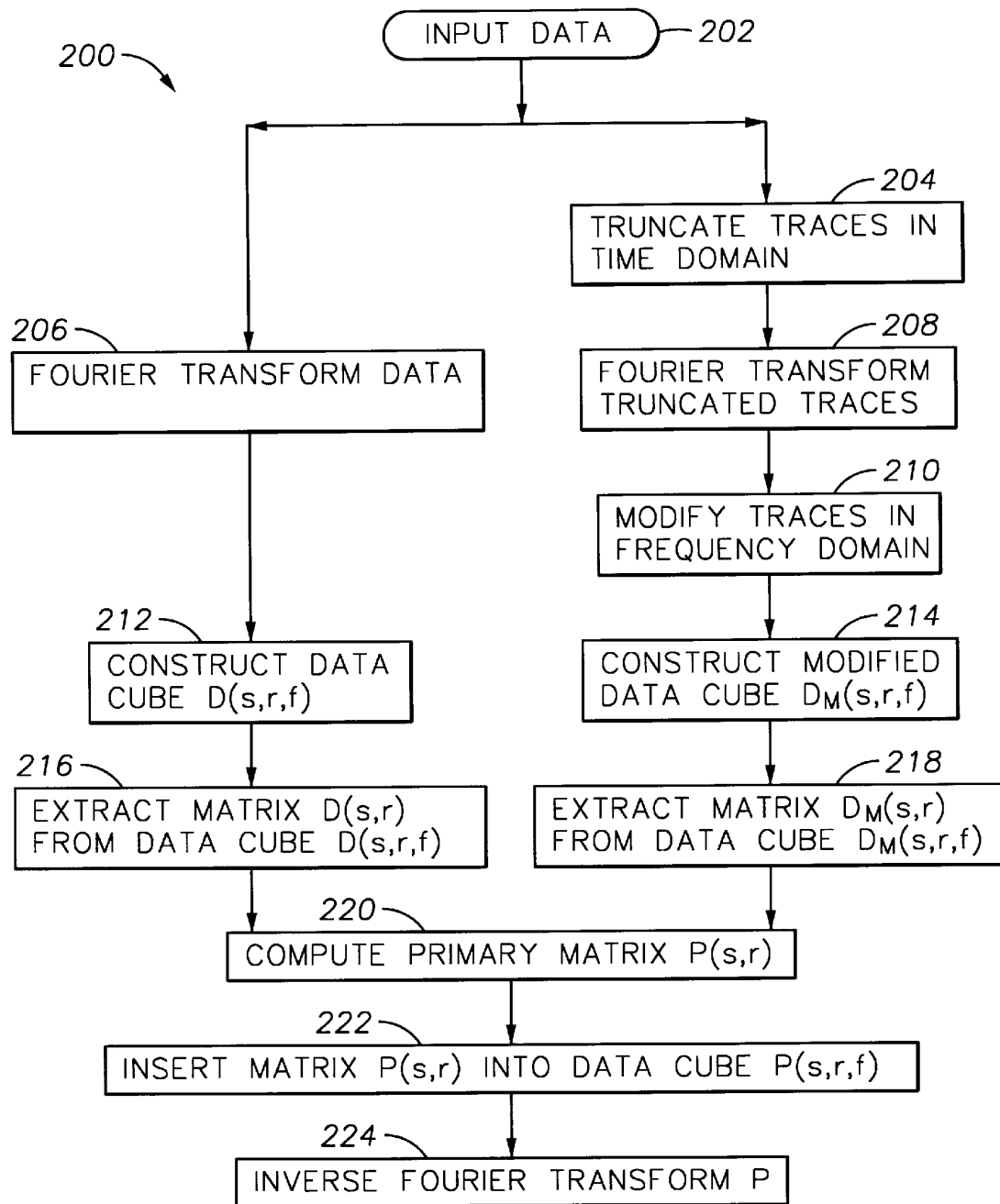


FIG. 2

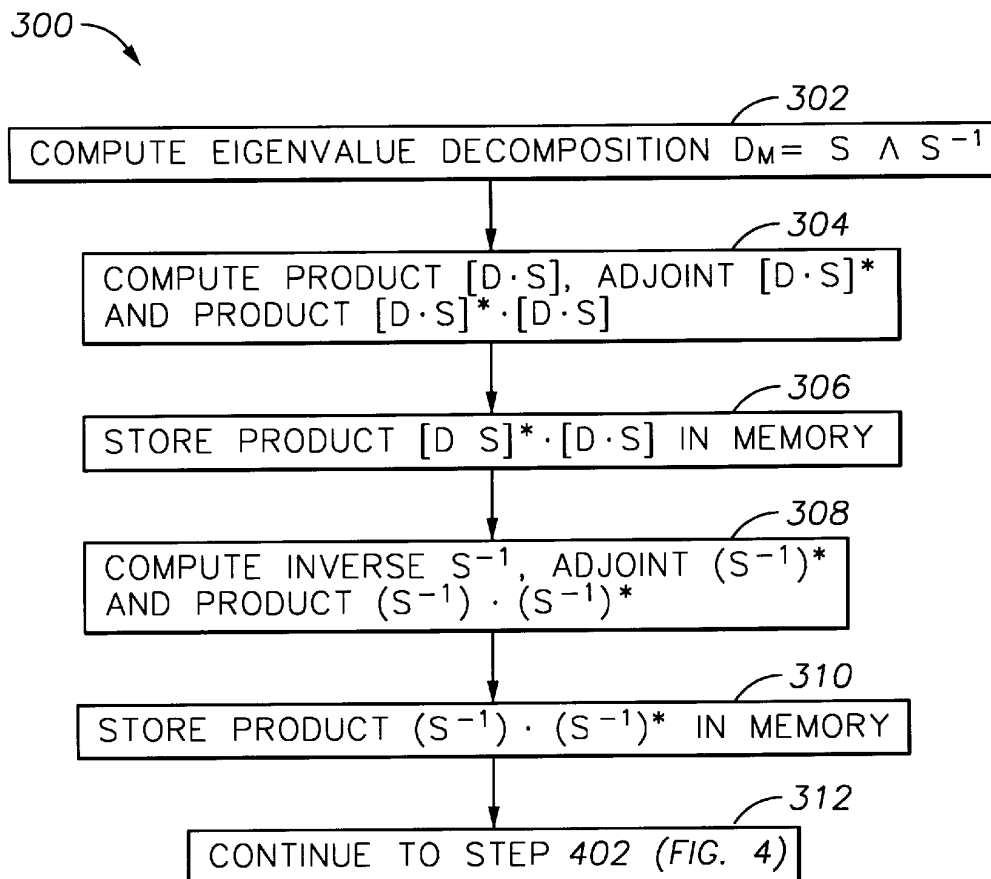


FIG. 3

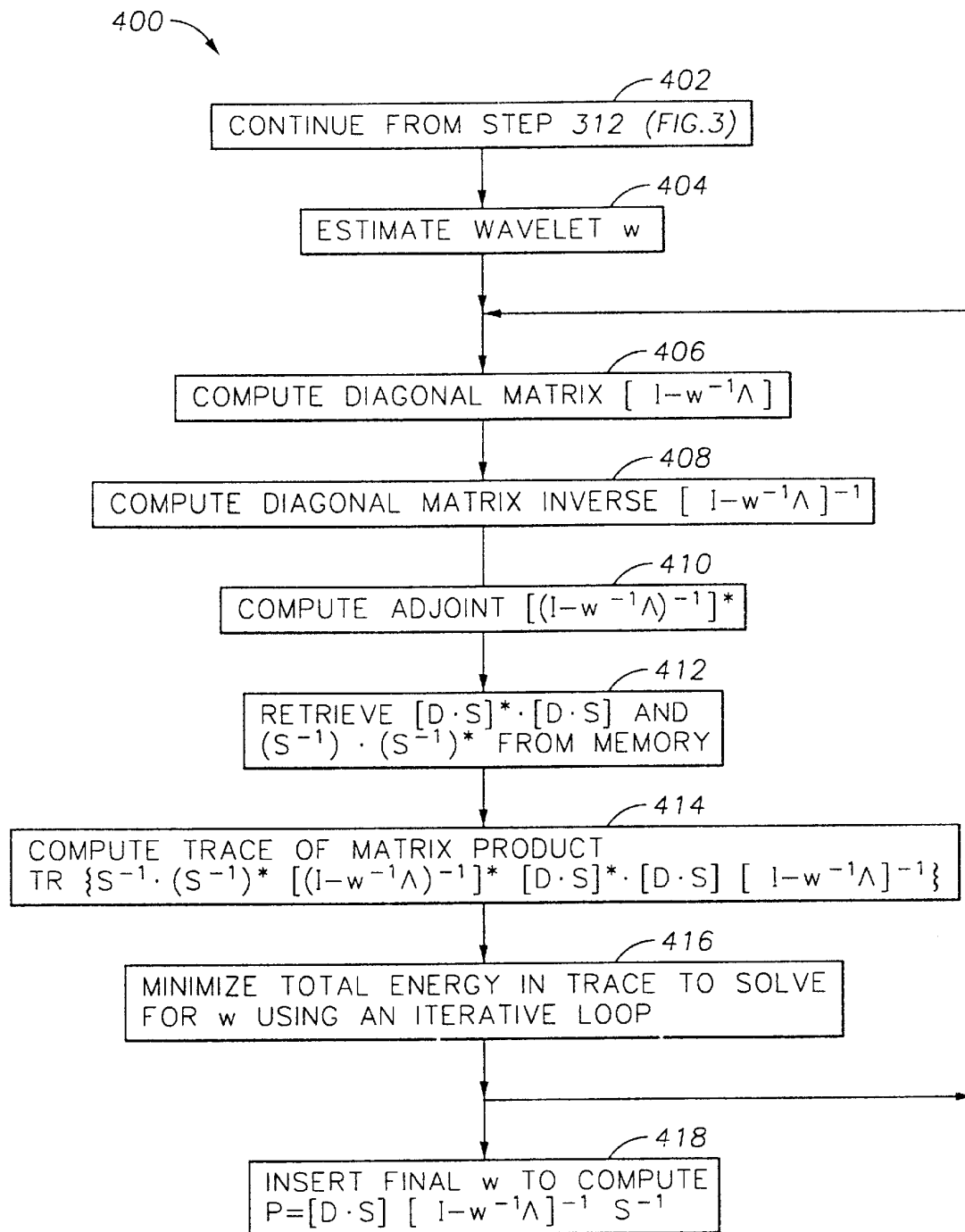


FIG. 4

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