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United States Patent [19]

Diethorn

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[45] Date of Patent: Mar. 7, 2000

[54] **METHOD AND APPARATUS FOR REDUCING NOISE IN SPEECH AND AUDIO SIGNALS**

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[73] Assignee: **Lucent Technologies Inc.**, Murray Hill, N.J.

[21] Appl. No.: **08/877,909**

[22] Filed: **Jun. 18, 1997**

[51] **Int. Cl.**[7] **H04B 15/00**

[52] **U.S. Cl.** **381/94.3**; 704/226

[58] **Field of Search** 381/94.1, 94.2, 381/94.3, 72, 94.5, 94.7, 98, 73.1, 71.1; 704/225, 226

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Primary Examiner—Vivian Chang

Attorney, Agent, or Firm—Martin I. Finston; Ozer M.N. Teitelbaum

[57] **ABSTRACT**

A method and apparatus are disclosed for enhancing, within a signal bandwidth, a corrupted audio-frequency signal. The signal which is to be enhanced is analyzed into plural sub-band signals, each occupying a frequency sub-band smaller than the signal bandwidth. A respective signal gain function is applied to each sub-band signal, and the respective sub-band signals are then synthesized into an enhanced signal of the signal bandwidth. The signal gain function is derived, in part, by measuring speech energy and noise energy, and from these determining a relative amount of speech energy, within the corresponding sub-band. In certain embodiments of the invention, the signal gain function is also derived, in part, by determining a relative amount of speech energy within a frequency range greater than, but centered on, the corresponding sub-band. In other embodiments of the invention, the sub-band noise energy is determined from a noise estimate that is updated at periodic intervals, but is not updated if the newest sample of the signal to be enhanced exceeds the current noise estimate by a multiplicative threshold (i.e., a threshold expressible in decibels). In still other embodiments of the invention, the value of the noise estimate is limited by an upper bound that is matched to the dynamic range of the signal to be enhanced.

12 Claims, 4 Drawing Sheets

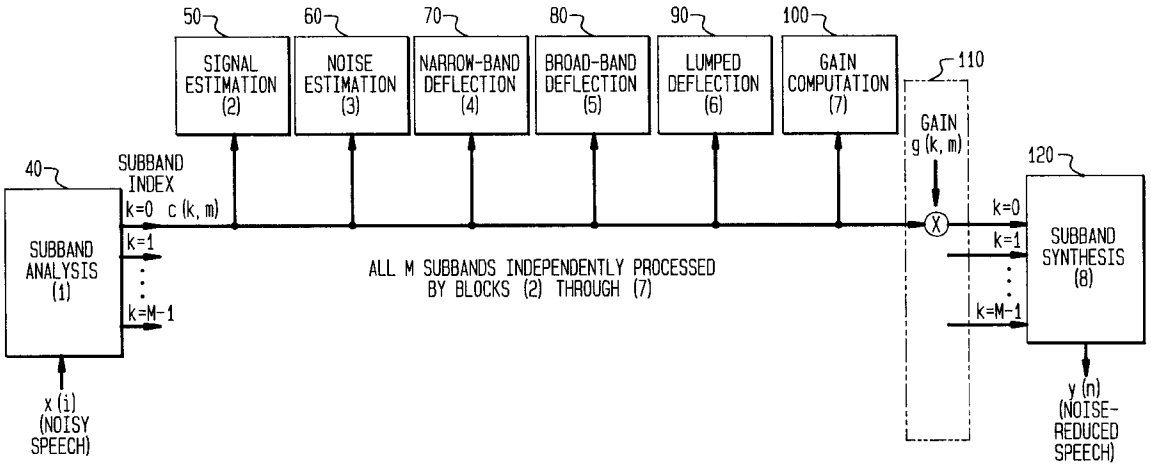

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FIG. 1
(PRIOR ART)

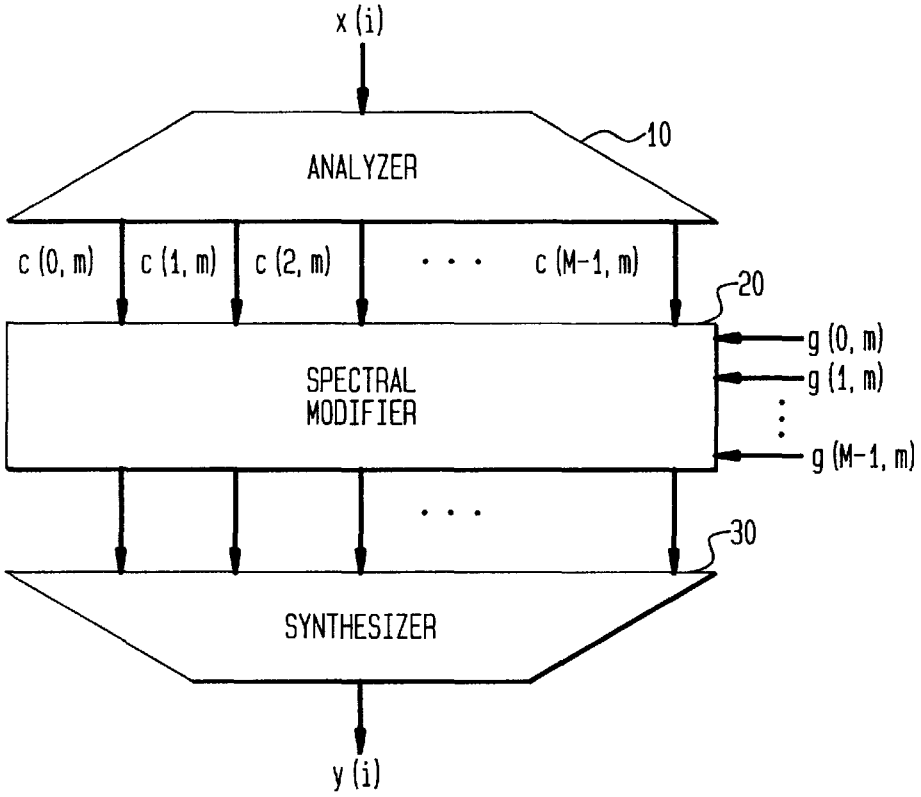
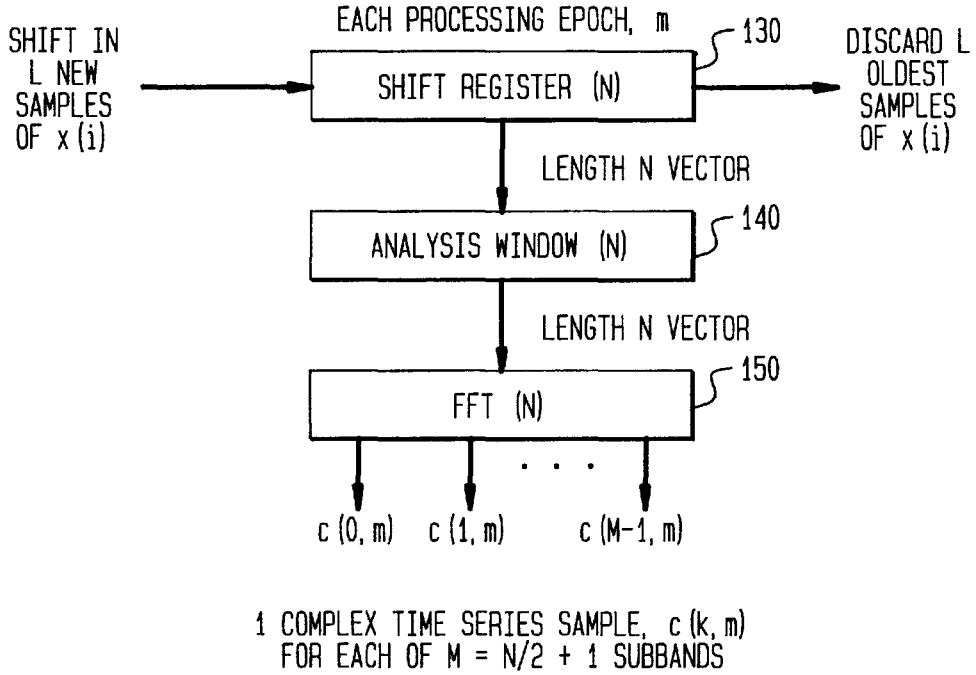


FIG. 3



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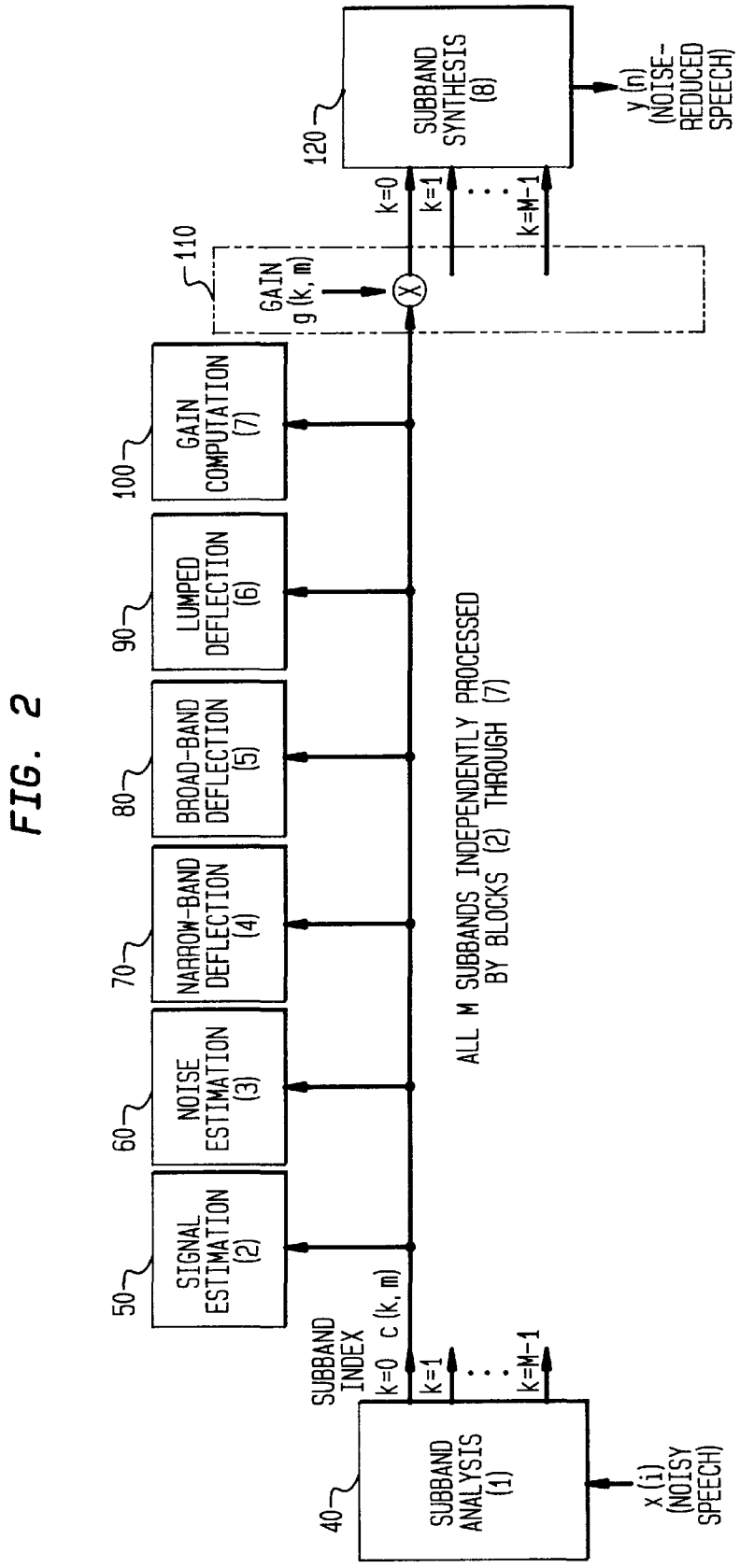

FIG. 2

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FIG. 4

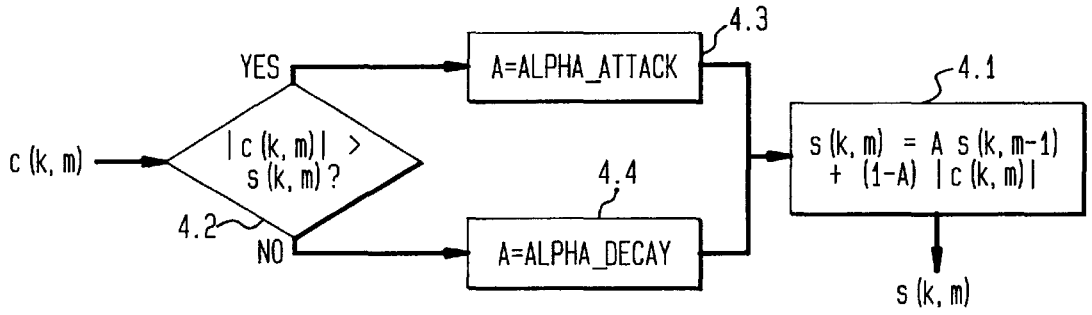

FIG. 5

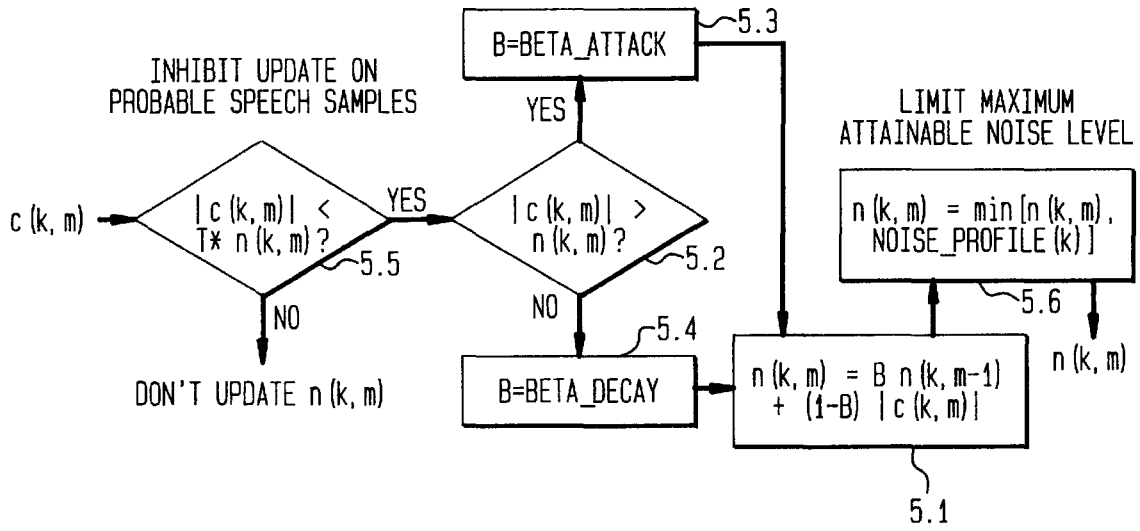

FIG. 6

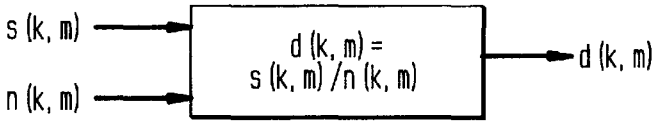

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FIG. 7

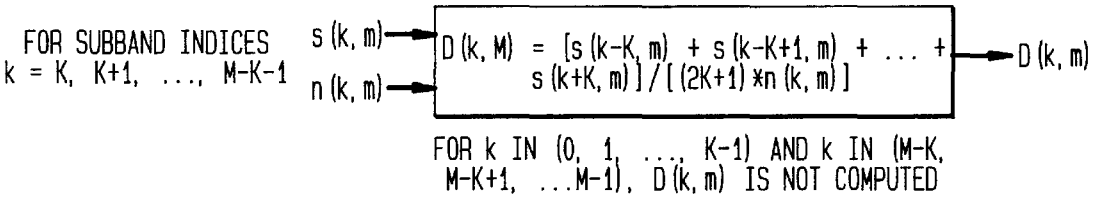


FIG. 8A

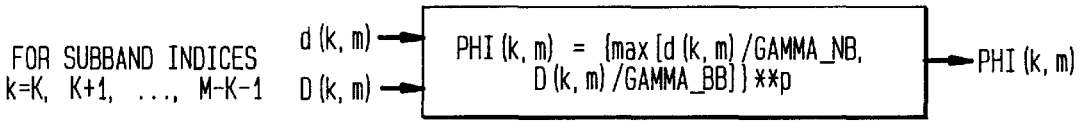


FIG. 8B

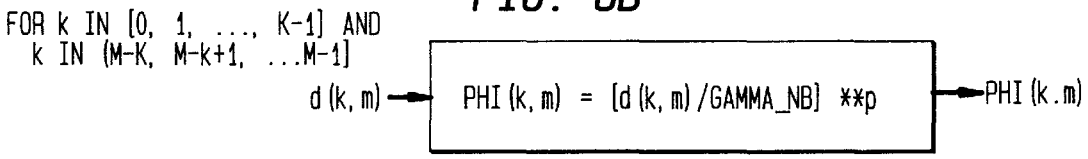


FIG. 9

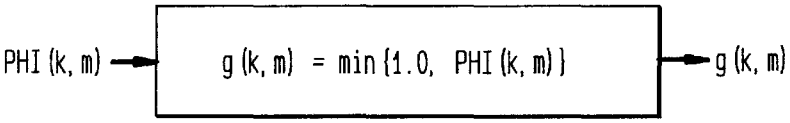
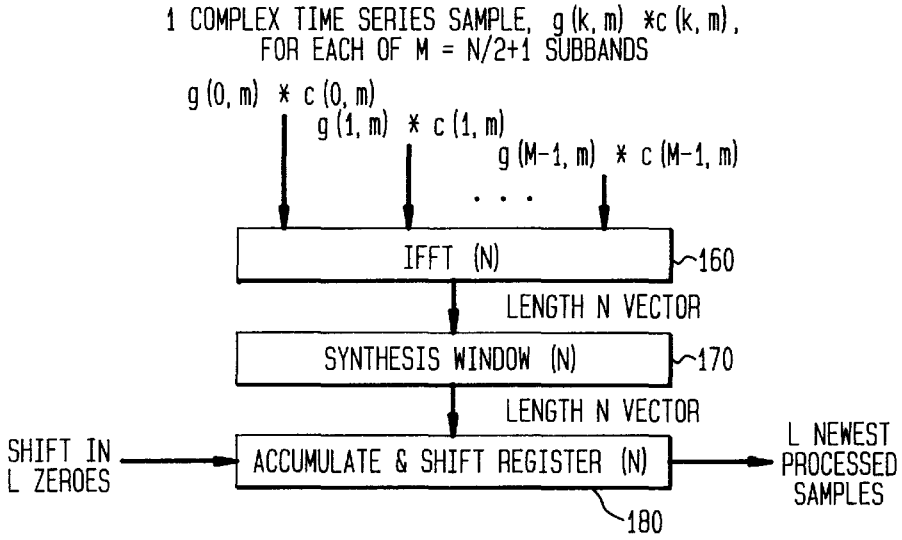


FIG. 10



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