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**Walton et al.**

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(54) **METHOD AND APPARATUS FOR PROCESSING DATA IN A MULTIPLE-INPUT MULTIPLE-OUTPUT (MIMO) COMMUNICATION SYSTEM UTILIZING CHANNEL STATE INFORMATION**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 478 days.

This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**[7] ..... **H04B 7/02**
(52) **U.S. Cl.** ..... **375/267**; 375/346
(58) **Field of Search** ..... 375/267, 260, 375/144, 148, 346, 347

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 5,471,647 | A | 11/1995 | Gerlach et al. | |
| 6,131,016 | A | 10/2000 | Greenstein et al. | 455/69 |
| 6,141,567 | A | 10/2000 | Youssefmir et al. | |
| 6,473,467 | B1 * | 10/2002 | Wallace et al. | 375/267 |

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| EP | 0951091 | 10/1999 |
| EP | 0951091 A2 | 10/1999 |
| WO | 96/22662 | 7/1996 |
| WO | 9809381 | 3/1998 |
| WO | 98/30047 | 7/1998 |

OTHER PUBLICATIONS

Jongren, et al. "Utilizing Quantized Feedback Information in Orthogonal Space–Time Block Coding" 2000 IEEE Global Telecommunications Conference 2: 995–999 (Nov. 27, 2000).

John A.C. Bingham, "Multicarrier Modulation for Data Transmission: An Idea Whose Time Has Come," IEEE Communications Magazine, May 1990 (pp. 5–13).

B. Hassibi, et al. "High–Rate Codes that are Linear in Space and Time," LUCENT Technologies, Murray Hill, NY (USA), Aug. 22, 2000, (pp. 1–54).

P.W. Wolniansky, et al. "V–BLAST: An Architecture for Realizing Very High Data Rates Over the Rich–Scattering Wireless Channel," LUCENT Technologies, Holmdel, NJ.

* cited by examiner

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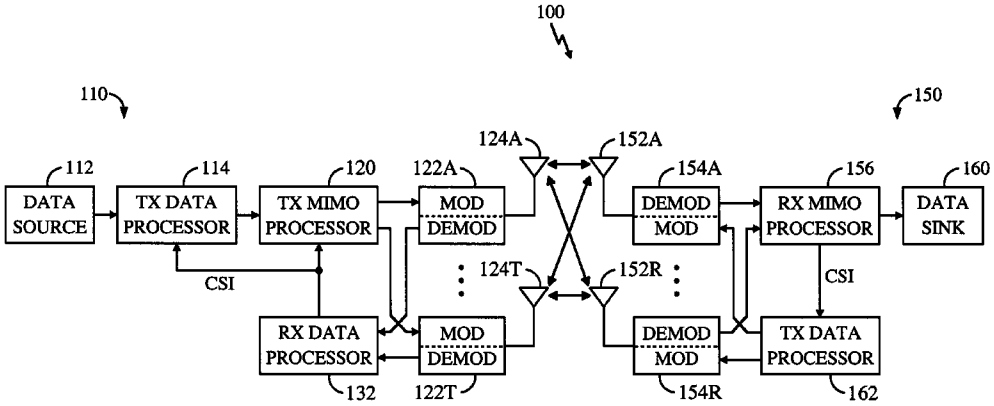
(57) **ABSTRACT**

Techniques to "successively" process received signals at a receiver unit in a MIMO system to recover transmitted data, and to "adaptively" process data at a transmitter unit based on channel state information available for the MIMO channel. A successive cancellation receiver processing technique is used to process the received signals and performs a number of iterations to provide decoded data streams. For each iteration, input (e.g., received) signals for the iteration are processed to provide one or more symbol streams. One of the symbol streams is selected and processed to provide a decoded data stream. The interference due to the decoded data stream is approximately removed (i.e., canceled) from the input signals provided to the next iteration. The channel characteristics are estimated and reported back to the transmitter system and used to adjust (i.e., adapt) the processing (e.g., coding, modulation, and so on) of data prior to transmission.

**57 Claims, 10 Drawing Sheets**



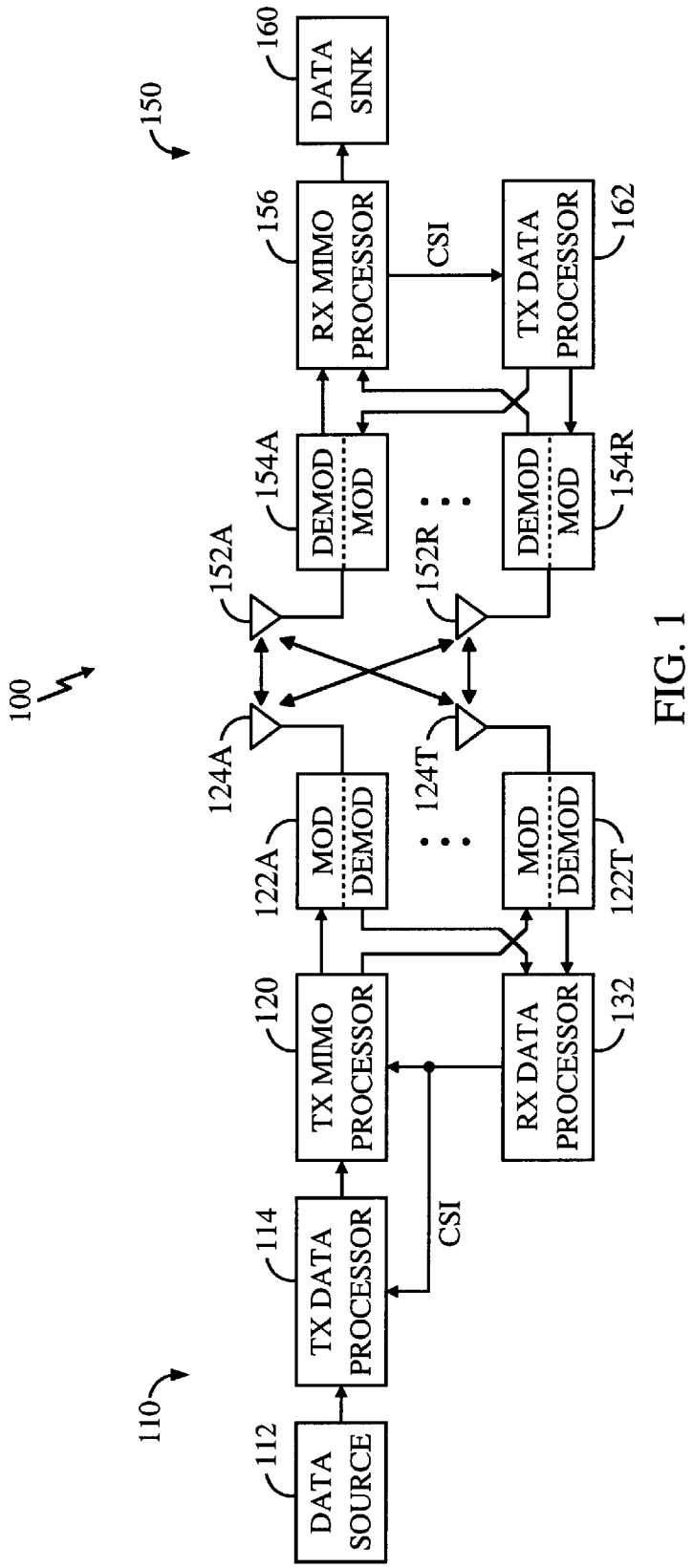



FIG. 1

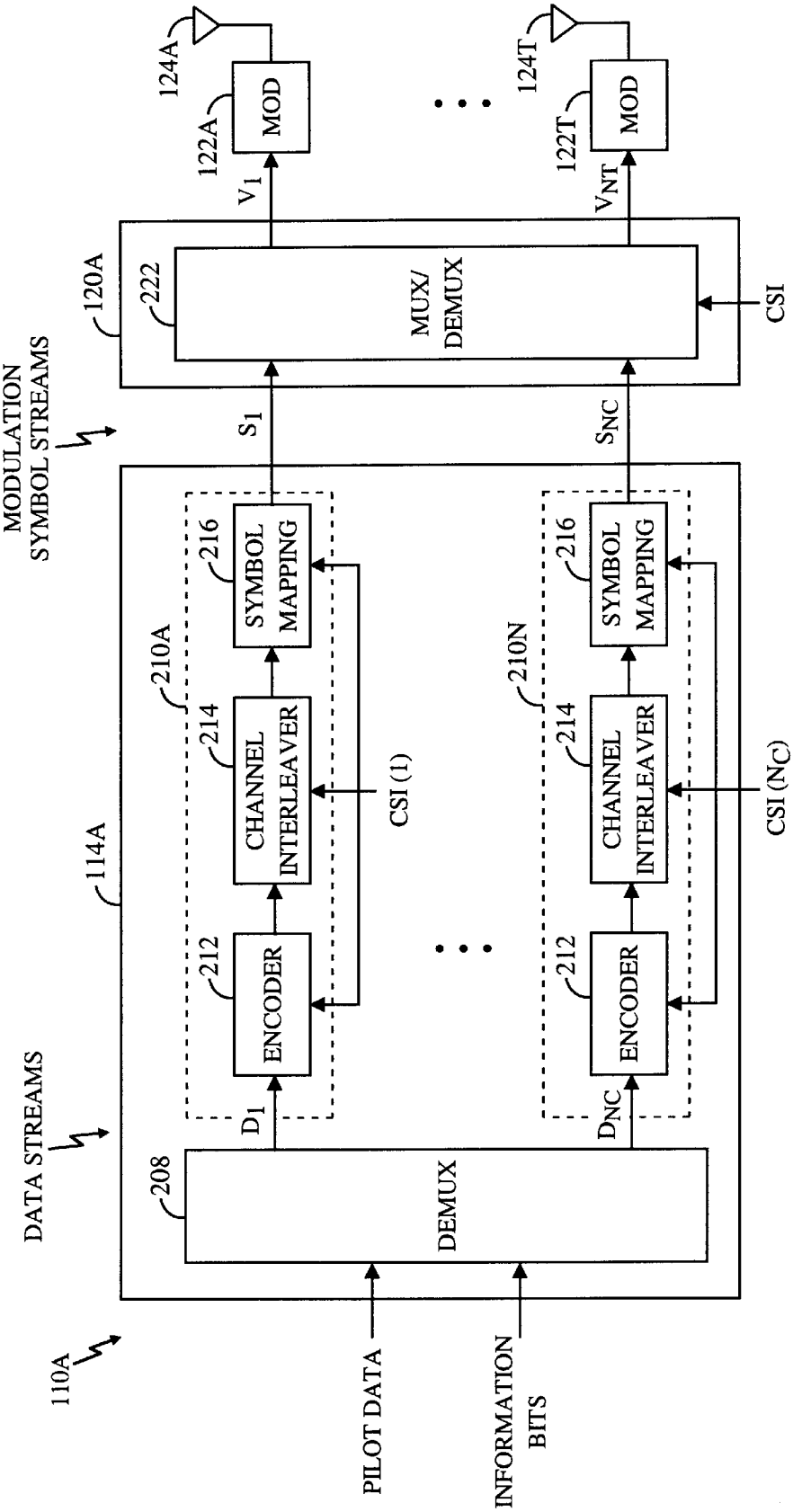



FIG. 2

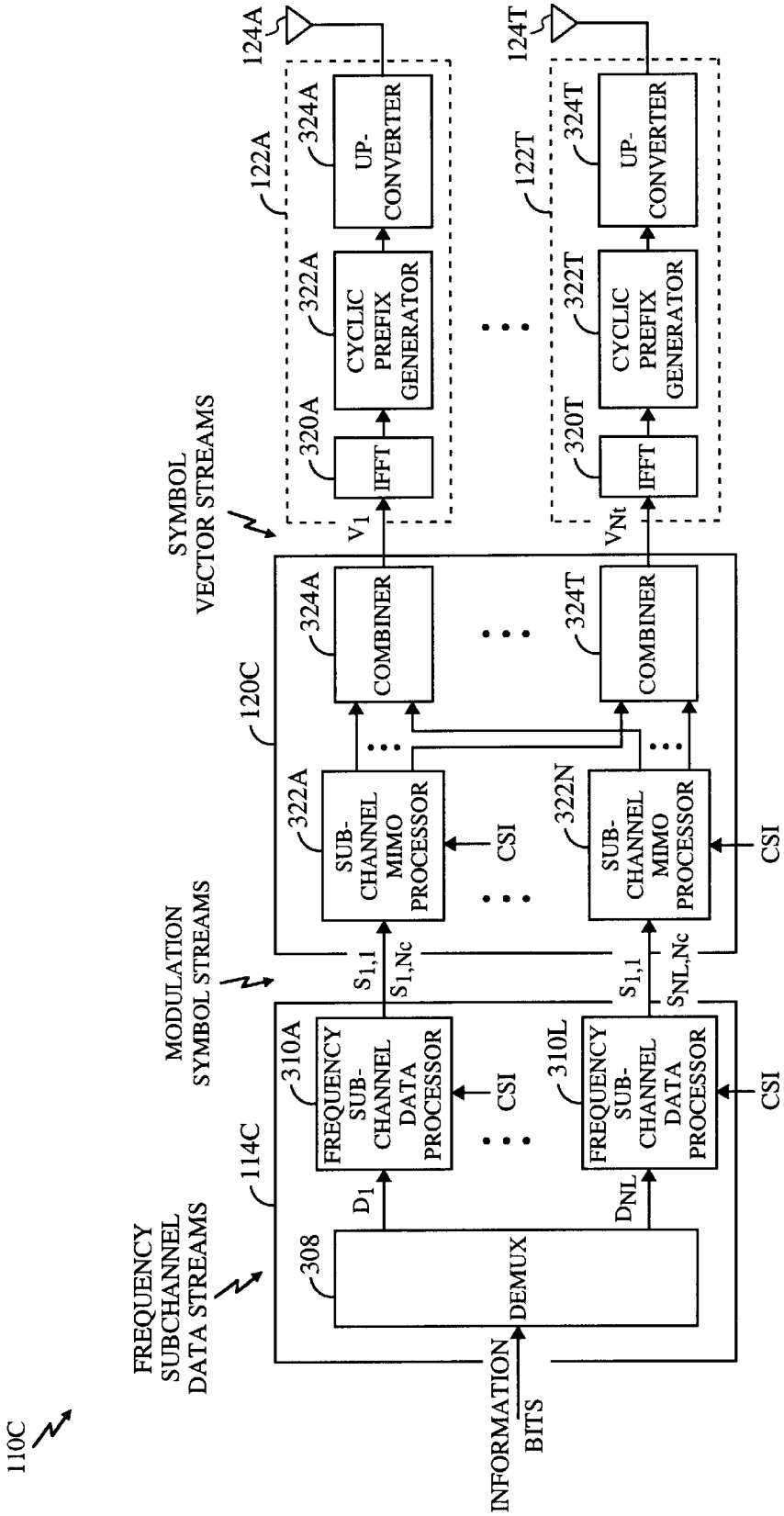



FIG. 3

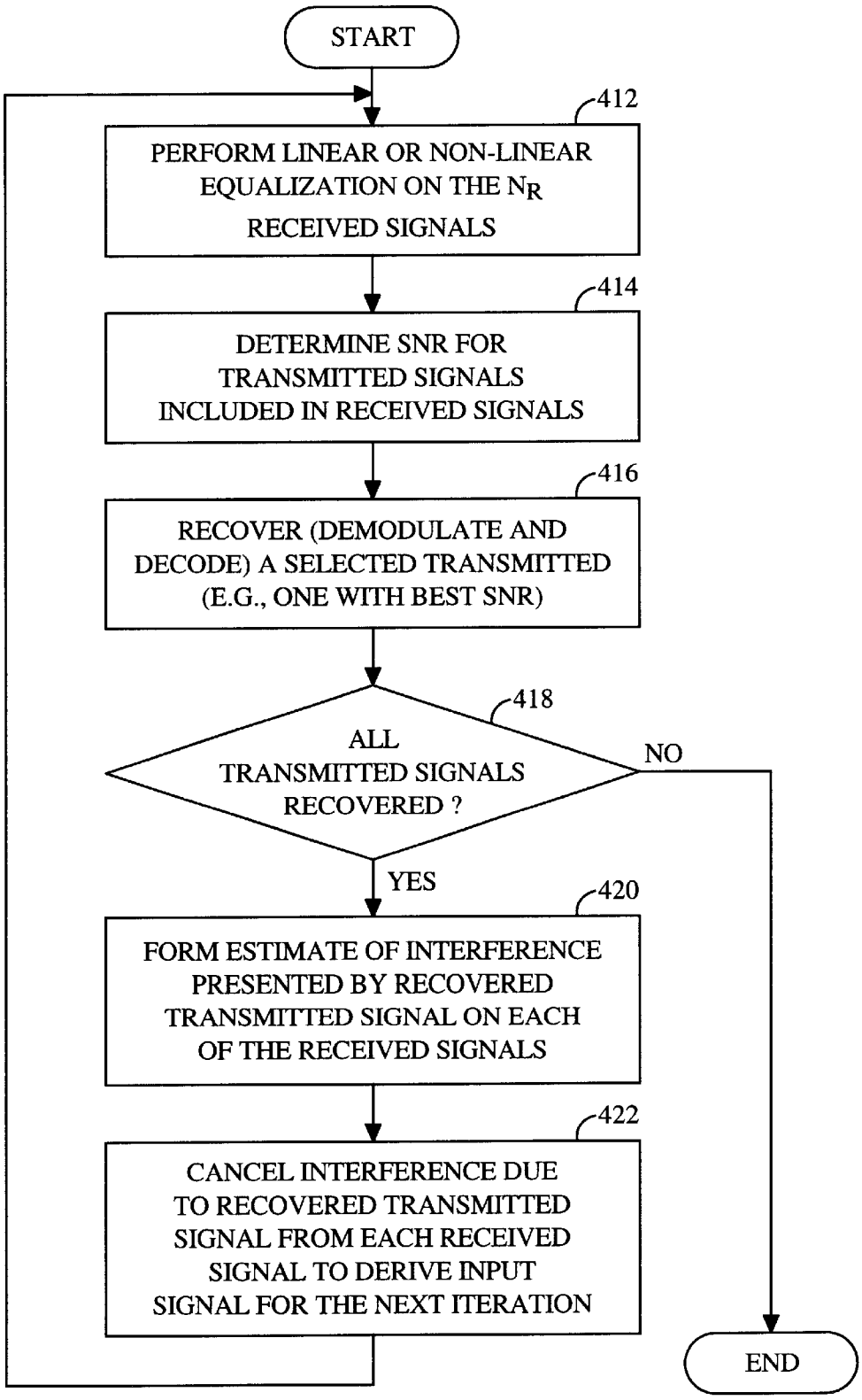



FIG. 4

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