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Levine

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(54) **ROBUST WATERMARK METHOD AND APPARATUS FOR DIGITAL SIGNALS**

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(51) **Int. Cl.^{7}** **H04K 1/02**; H04L 9/18; G06K 9/64

(52) **U.S. Cl.** **380/205**; 380/38; 380/37; 380/54; 713/176; 713/179; 382/284

(58) **Field of Search** 713/176, 179; 380/37, 38, 51, 54, 55, 59, 205, 210, 212; 341/50, 55; 348/584; 382/284, 305

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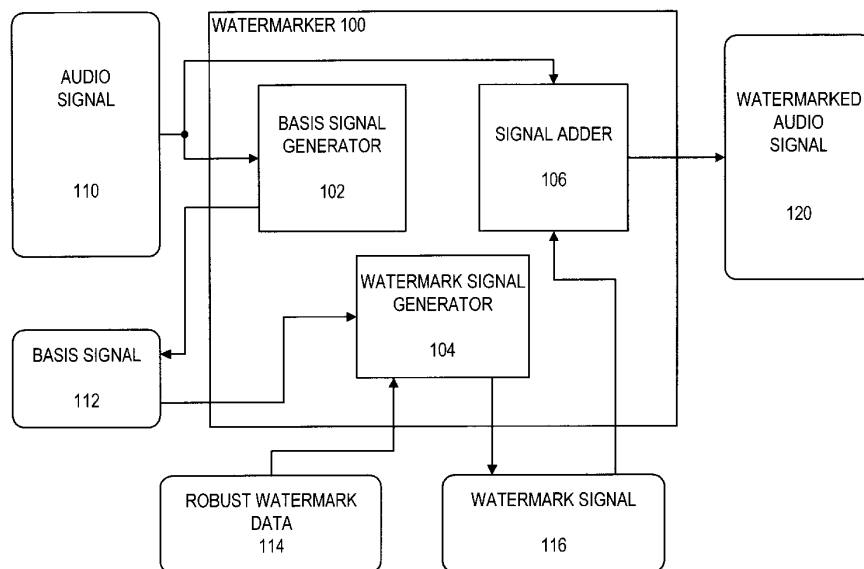*Primary Examiner*—Gail Hayes
Assistant Examiner—Justin T. Darrow
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(57) **ABSTRACT**

Watermark data is encoded in a digitized signal by forming a noise threshold spectrum which represents a maximum amount of imperceptible noise, spread-spectrum chipping the noise threshold spectrum with a relatively endless stream of pseudo-random bits to form a basis signal, dividing the basis signal into segments, and filtering the segments to smooth segment boundaries. The data encoded in the watermark signal is precoded to make the watermark data inversion robust and is convolutional encoded to further increase the likelihood that the watermark data will subsequently be retrievable notwithstanding lossy processing of the watermarked signal.
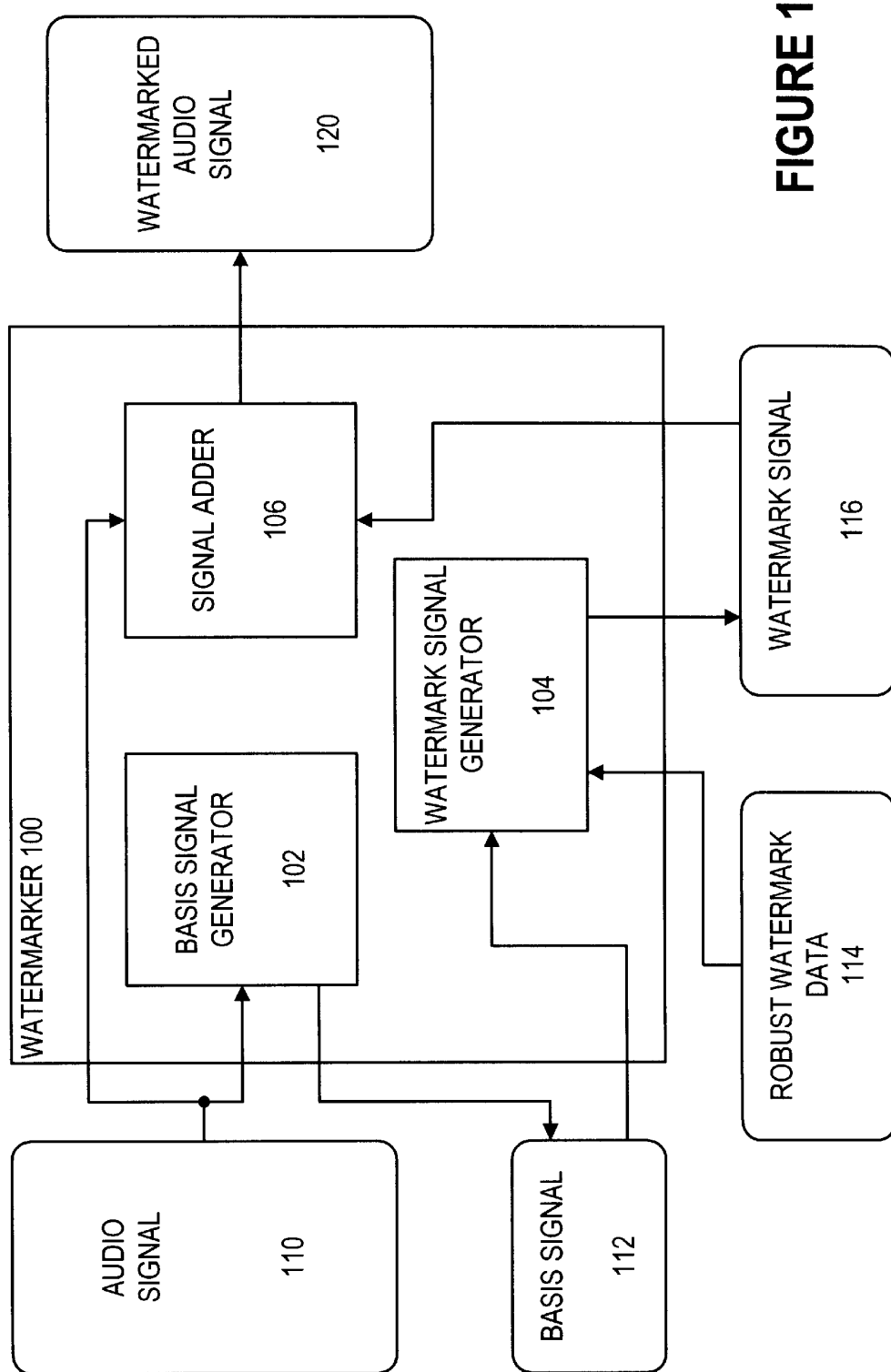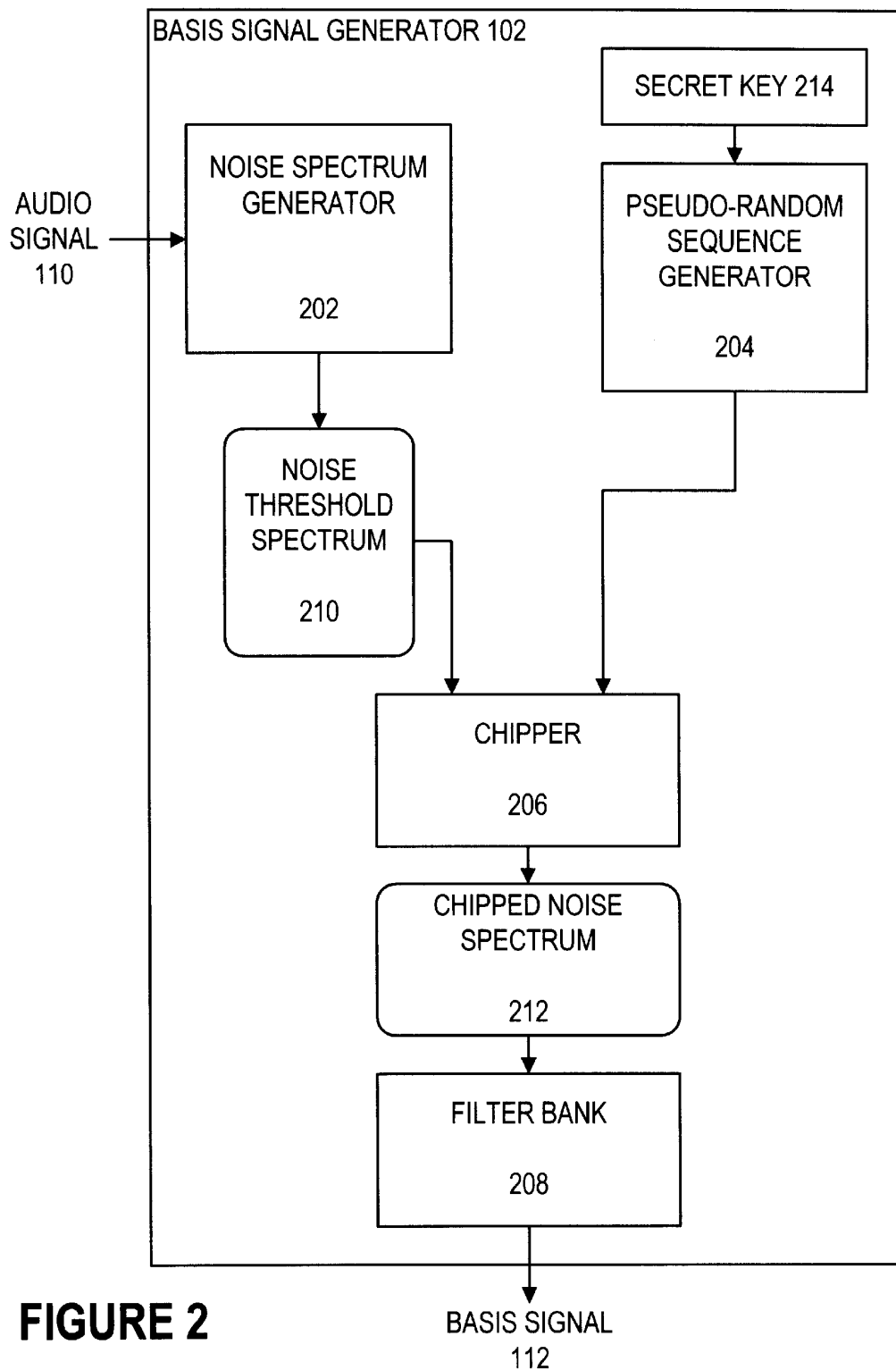
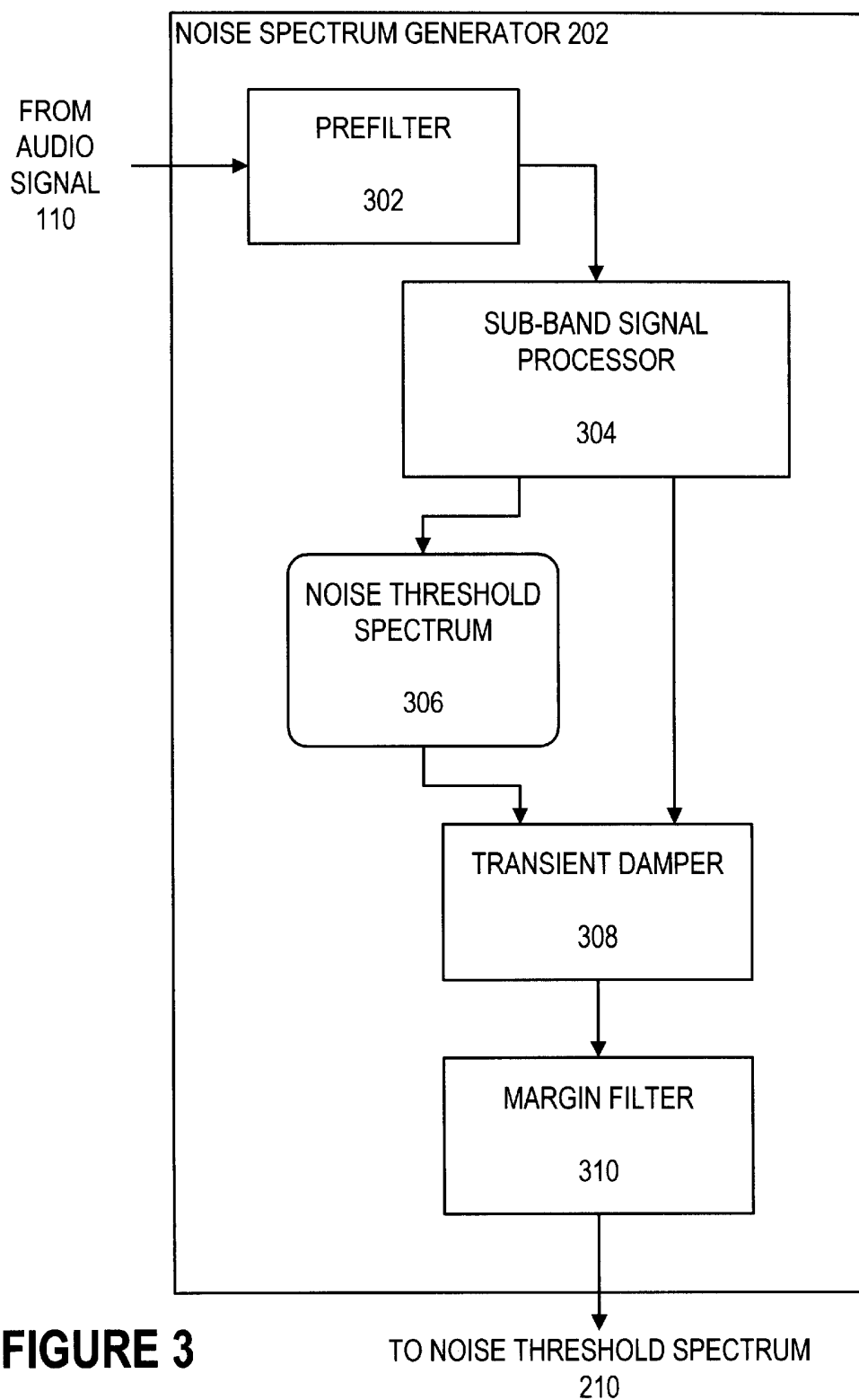**57 Claims, 24 Drawing Sheets**

FIGURE 1

WATERMARKED AUDIO SIGNAL 120

WATERMARKER 100

SIGNAL ADDER 106

BASIS SIGNAL GENERATOR 102

WATERMARK SIGNAL GENERATOR 104

WATERMARK SIGNAL 116

ROBUST WATERMARK DATA 114

AUDIO SIGNAL 110

BASIS SIGNAL 112

BASIS SIGNAL GENERATOR 102

SECRET KEY 214

NOISE SPECTRUM GENERATOR

202

AUDIO SIGNAL 110

PSEUDO-RANDOM SEQUENCE GENERATOR

204

NOISE THRESHOLD SPECTRUM

210

CHIPPER

206

CHIPPED NOISE SPECTRUM

212

FILTER BANK

208

BASIS SIGNAL 112

FIGURE 2

NOISE SPECTRUM GENERATOR 202

FROM
AUDIO
SIGNAL
110

PREFILTER

302

SUB-BAND SIGNAL
PROCESSOR

304

NOISE THRESHOLD
SPECTRUM

306

TRANSIENT DAMPER

308

MARGIN FILTER

310

FIGURE 3
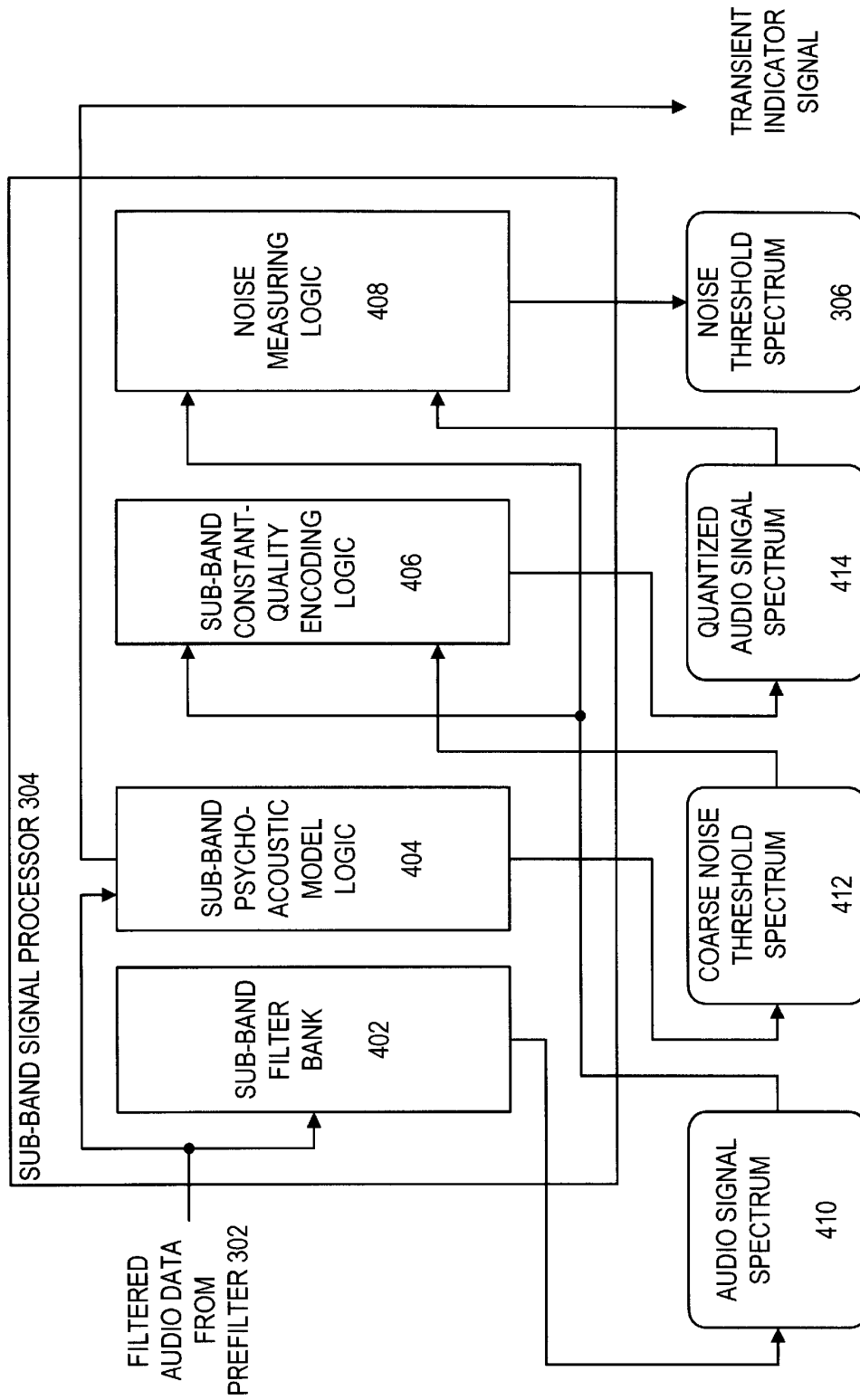
TO NOISE THRESHOLD SPECTRUM
210

FIGURE 4

DOCKET ALARM

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