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Baker, Jr. et al.

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(54) **METHOD AND APPARATUS FOR ESTIMATING PHYSIOLOGICAL PARAMETERS USING MODEL-BASED ADAPTIVE FILTERING**

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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 0 days.

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(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 09/435,144, filed on Nov. 5, 1999, now abandoned, which is a continuation of application No. 09/137,479, filed on Aug. 20, 1998, now Pat. No. 6,083,172, which is a continuation of application No. 08/660,510, filed on Jun. 7, 1996, now Pat. No. 5,853,364.
(60) Provisional application No. 60/000,195, filed on Jun. 14, 1995.

(51) **Int. Cl.⁷** **A61B 5/00**

(52) **U.S. Cl.** **600/323**

(58) **Field of Search** **600/310, 322, 600/323, 331, 330, 336**

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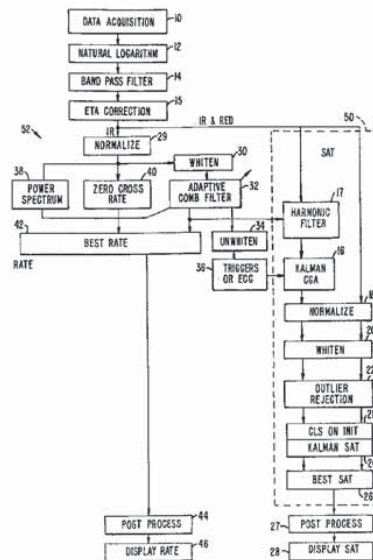
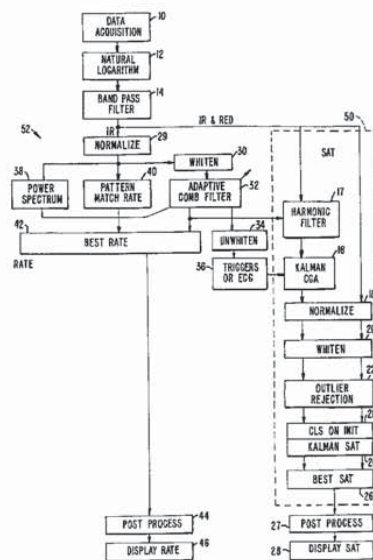
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(57) **ABSTRACT**

A method and apparatus for reducing the effects of noise on a system for measuring physiological parameters, such as, for example, a pulse oximeter. The method and apparatus of the invention take into account the physical limitations on various physiological parameters being monitored when weighting and averaging a series of measurements. Varying weights are assigned different measurements, measurements are rejected, and the averaging period is adjusted according to the reliability of the measurements. Similarly, calculated values derived from analyzing the measurements are also assigned varying weights and averaged over adjustable periods. More specifically, a general class of filters such as, for example, Kalman filters, is employed in processing the measurements and calculated values. The filters use mathematical models which describe how the physiological parameters change in time, and how these parameters relate to measurement in a noisy environment. The filters adaptively modify a set of averaging weights to optimally estimate the physiological parameters.

4 Claims, 12 Drawing Sheets



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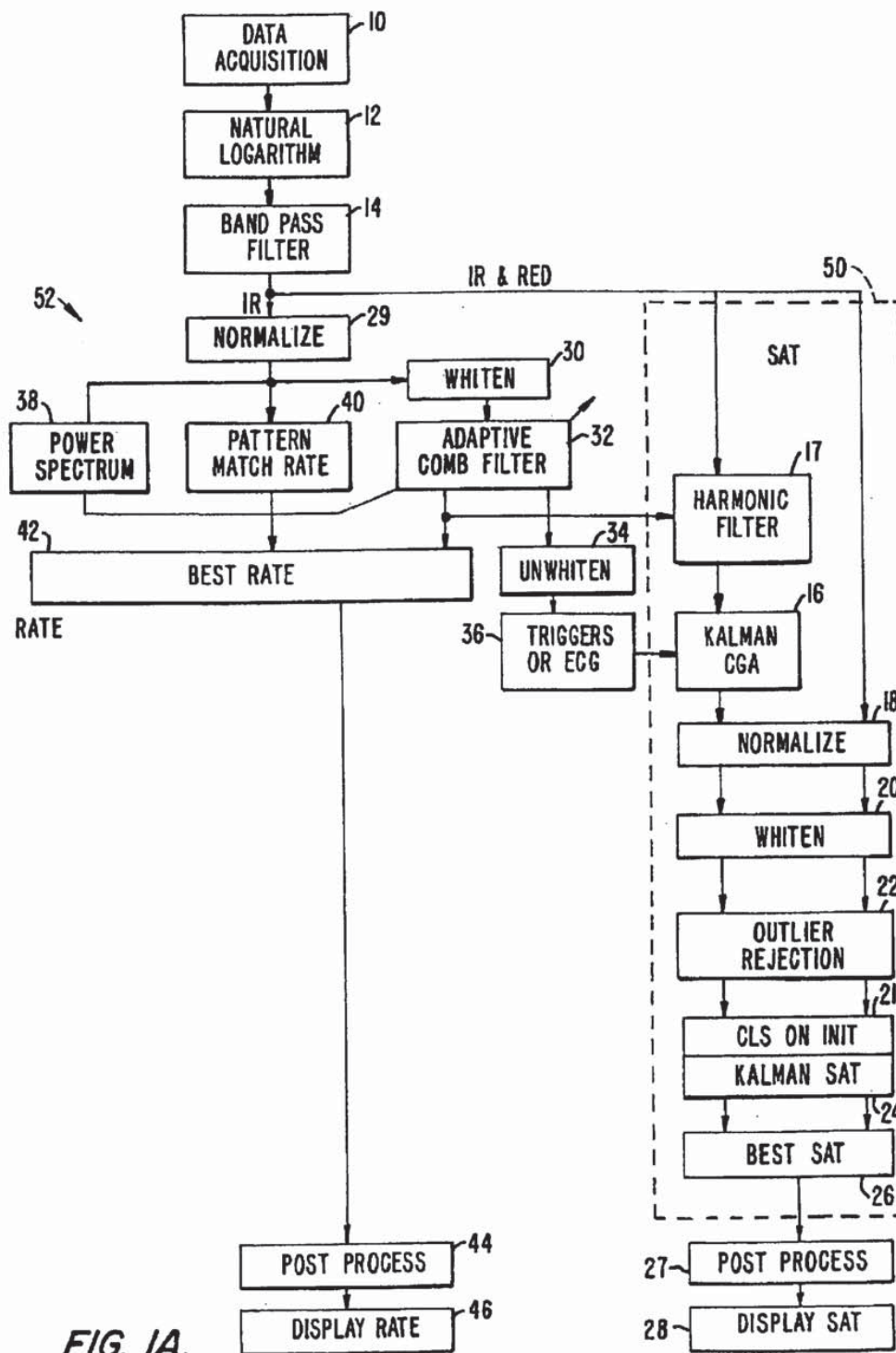


FIG. 1A.

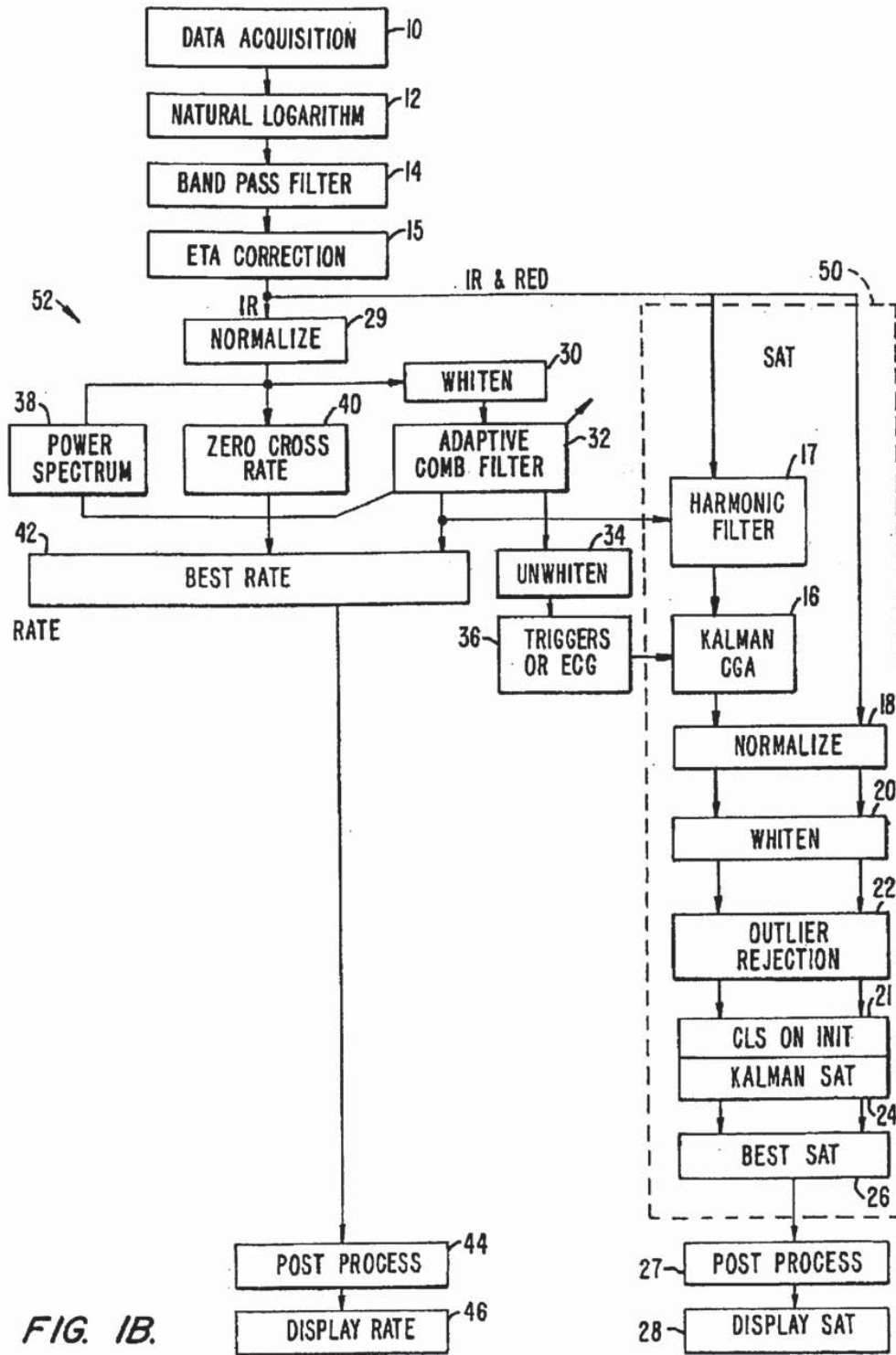


FIG. 1B.

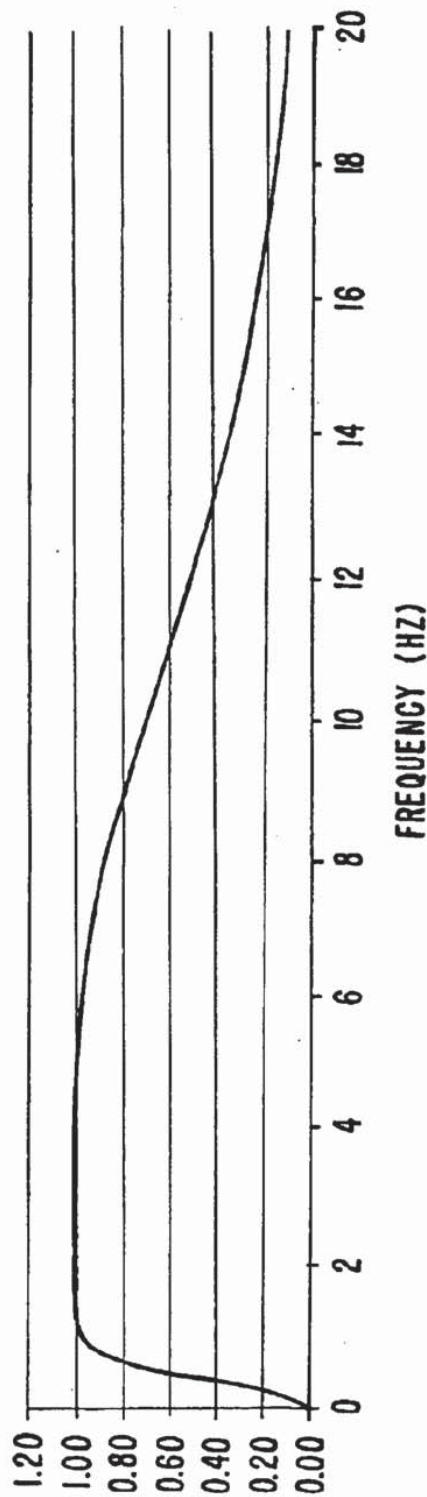


FIG. 2.

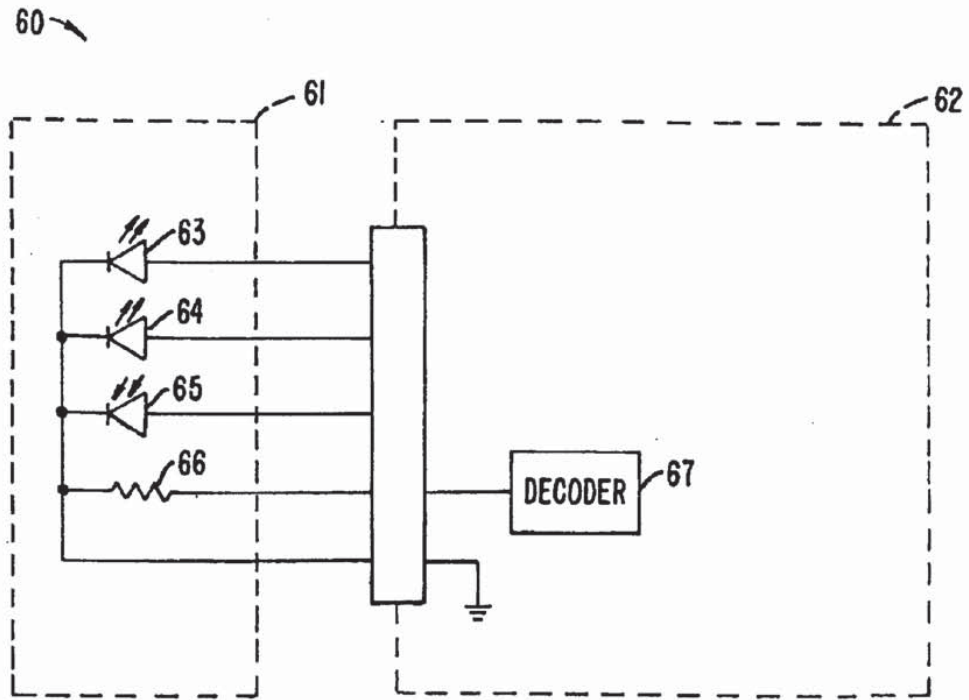


FIG. 3.

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