

(12) **United States Patent**  
**Ozaki et al.**

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(54) **CENTRIFUGAL PUMP APPARATUS**

F04D 29/041; F04D 29/048; F16C 32/044;  
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See application file for complete search history.

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(56) **References Cited**

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(65) **Prior Publication Data**

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Asama, et al., "Suspension Performance of a Two-Axis Actively Regulated Consequent-Pole Bearingless Motor," IEEE Transactions On Energy Conversion, vol. 28, No. 4, Dec. 2013, 8 pages.  
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**Related U.S. Application Data**

(63) Continuation of application No. 13/254,979, filed as application No. PCT/JP2010/053221 on Mar. 1, 2010, now Pat. No. 8,770,945.

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(57) **ABSTRACT**

In this centrifugal blood pump apparatus, one permanent magnet is provided in one surface of an impeller, a second permanent magnet is provided in an inner wall of a blood chamber, a third permanent magnet is provided in the other surface of the impeller, and a fourth permanent magnet and a rotor for driving the impeller to rotate are provided, with an diaphragm being interposed. An amount of change in attractive force between the first permanent magnet and the second permanent magnet and an amount of change in attractive force between the third and fourth permanent magnets when the impeller is eccentric are made substantially equal to each other. Therefore, a levitation position of the impeller can always be maintained at a substantially central position in a housing.

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CPC ..... **F04D 25/026** (2013.01); **A61M 1/101** (2013.01); **A61M 1/1015** (2014.02);  
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(58) **Field of Classification Search**

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**20 Claims, 25 Drawing Sheets**

