



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

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(54) **LINEAR VIBRATION MODULES AND  
LINEAR-RESONANT VIBRATION MODULES**

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- (73) Assignee: **Resonant Systems, Inc.**, Seattle, WA (US)
- (\*) 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. 13/345,607, filed on Jan. 6, 2012, now Pat. No. 8,860,337, which is a continuation-in-part of application No. 12/782,697, filed on May 18, 2010, now Pat. No. 8,093,767.

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(51) **Int. Cl.**  
**H02K 33/00** (2006.01)  
**H02P 25/02** (2016.01)  
**H02K 33/16** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H02P 25/027** (2013.01); **H02K 33/16** (2013.01)

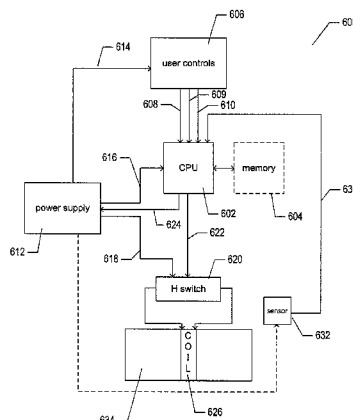
(58) **Field of Classification Search**  
CPC ..... H02P 25/027; F15B 2211/327; F15B 2211/85; F15B 2211/6346

See application file for complete search history.

(57) **ABSTRACT**

The current application is directed to various types of linear vibrational modules, including linear-resonant vibration modules, that can be incorporated in a wide variety of appliances, devices, and systems to provide vibrational forces. The vibrational forces are produced by linear oscillation of a weight or member, in turn produced by rapidly alternating the polarity of one or more driving electromagnets. Feedback control is used to maintain the vibrational frequency of linear-resonant vibration module at or near the resonant frequency for the linear-resonant vibration module. Both linear vibration modules and linear-resonant vibration modules can be designed to produce vibrational amplitude/frequency combinations throughout a large region of amplitude/frequency space.

**18 Claims, 20 Drawing Sheets**



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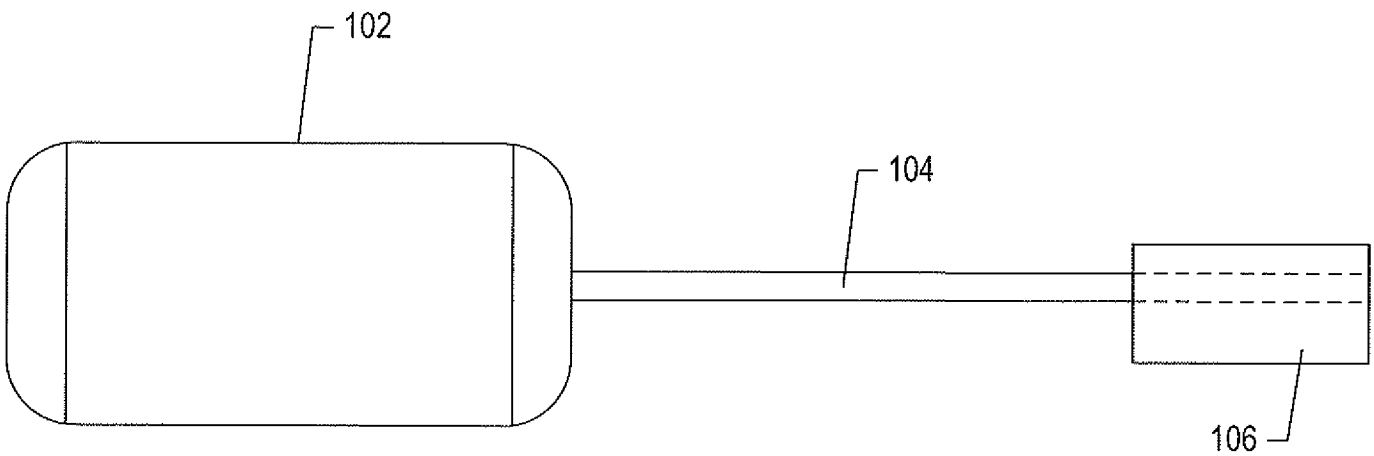


FIG. 1A

--Prior Art--

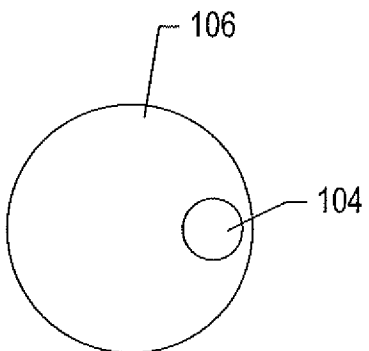


FIG. 1B

--Prior Art--

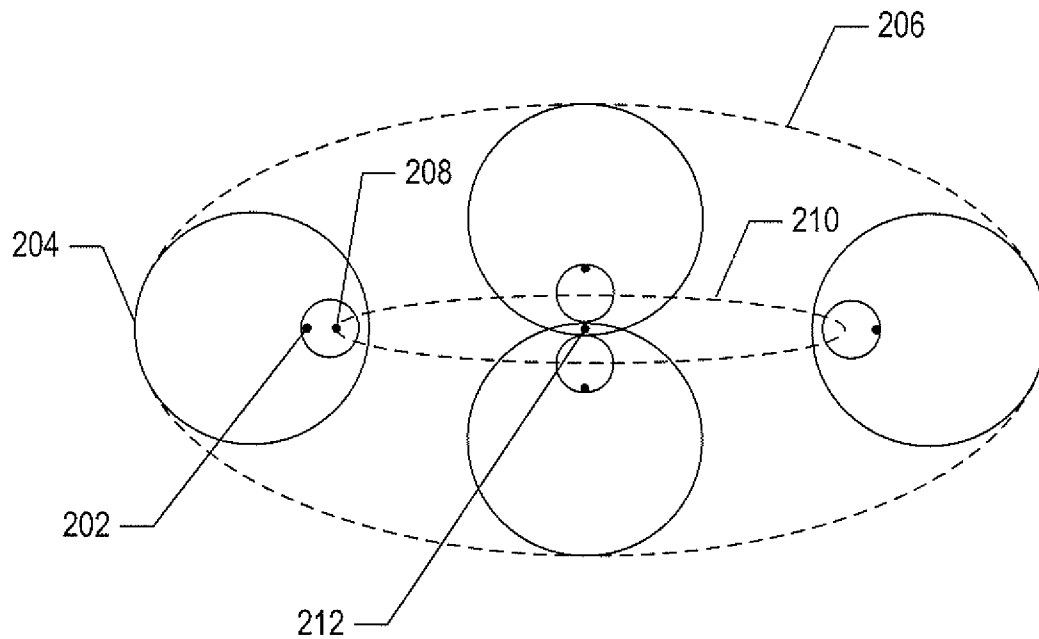


FIG. 2A

--Prior Art--

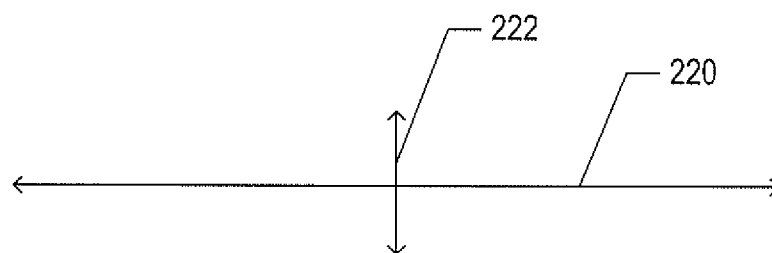


FIG. 2B

--Prior Art--

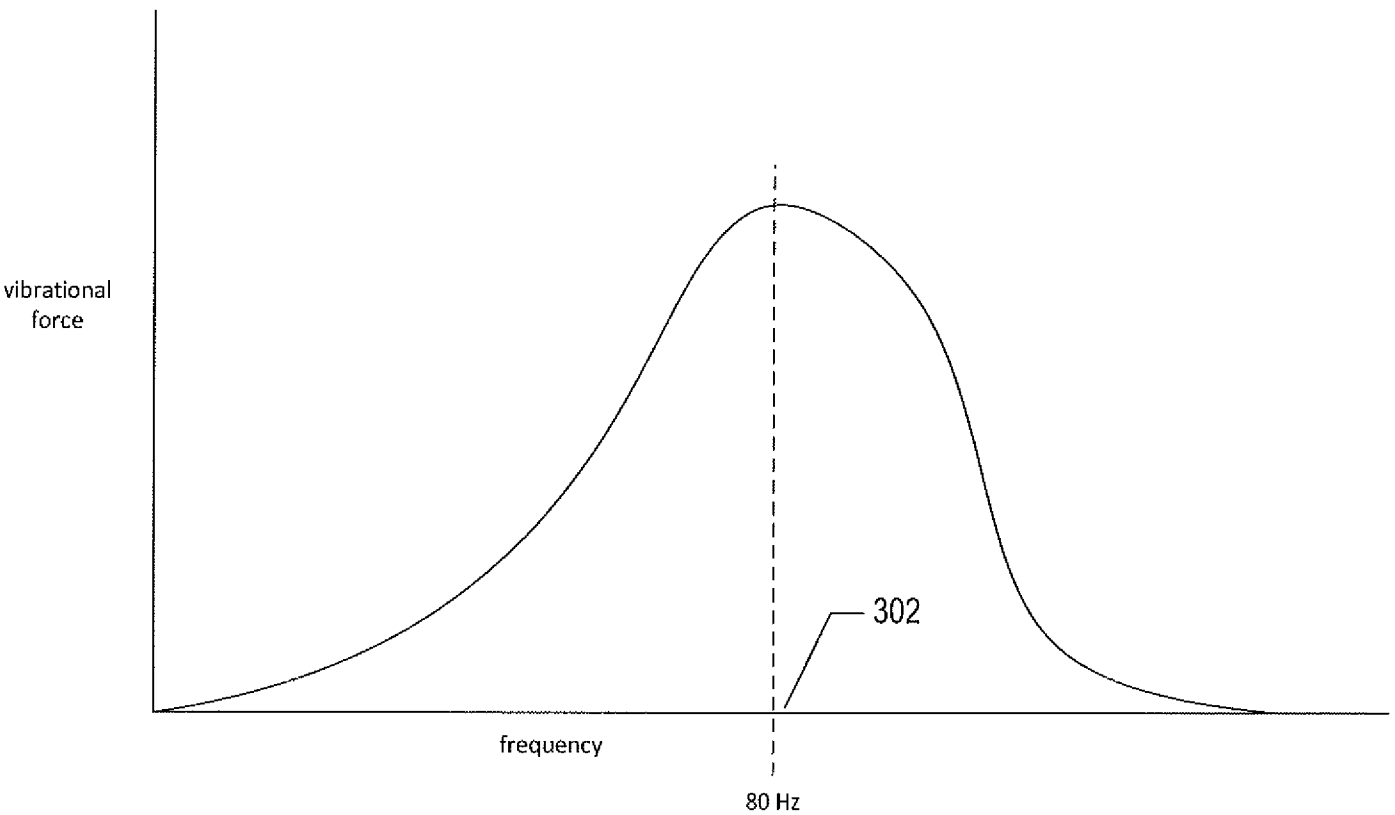


FIG. 3  
--Prior Art--

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