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(54) **INFLATABLE AIR MATTRESS SNORING DETECTION AND RESPONSE**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

3,727,606 A 4/1973 Sielaff
3,998,209 A 12/1976 Macvaugh
4,146,885 A 3/1979 Lawson, Jr.
(Continued)

FOREIGN PATENT DOCUMENTS

DE 40 05 822 8/1991
GB 2 471 401 12/2010
(Continued)

OTHER PUBLICATIONS

U.S. Appl. No. 13/933,285, filed Jul. 2, 2013, Palashewski.
(Continued)

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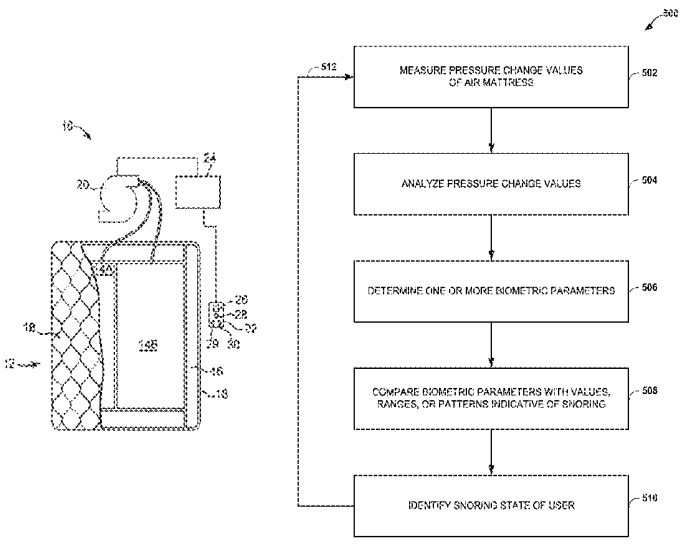
(57) **ABSTRACT**

A method can be provided that includes measuring sound waves using a sound measuring device, determining, at a central controller of an air mattress system, one or more parameter values of the sound waves, comparing the one or more parameter values with values, ranges, or patterns indicative of snoring, identifying a snoring state of a user, and initiating, with the central controller, a change to one or more adjustable features of the air mattress system.

11 Claims, 8 Drawing Sheets



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(56) **References Cited**

U.S. PATENT DOCUMENTS

4,299,233	A	11/1981	Lemelson	
4,657,026	A	4/1987	Tagg	
4,662,012	A	5/1987	Torbet	
4,766,628	A	8/1988	Walker	
4,788,729	A	12/1988	Walker	
4,829,616	A	5/1989	Walker	
4,890,344	A	1/1990	Walker	
4,897,890	A	2/1990	Walker	
4,908,895	A	3/1990	Walker	
4,991,244	A	2/1991	Walker	
5,062,169	A	11/1991	Kennedy et al.	
5,144,706	A	9/1992	Walker	
5,170,522	A	12/1992	Walker	
5,197,490	A	3/1993	Steiner et al.	
5,459,452	A	10/1995	DePonte	
5,509,154	A	4/1996	Shafer et al.	
5,515,865	A	5/1996	Scanlon	
5,564,140	A	10/1996	Shoenhair et al.	
5,642,546	A	7/1997	Shoenhair	
5,652,484	A	7/1997	Shafer et al.	
5,675,855	A	10/1997	Culp	
5,684,460	A	11/1997	Scanlon	
5,699,038	A	12/1997	Ulrich et al.	
5,724,990	A	3/1998	Ogino	
5,765,246	A	6/1998	Shoenhair	
5,771,511	A	6/1998	Kummer et al.	
5,796,340	A	8/1998	Miller	
5,844,488	A	12/1998	Musick	
5,848,450	A	12/1998	Oexman et al.	
5,903,941	A	5/1999	Shafer et al.	
5,904,172	A	5/1999	Gifft et al.	
5,948,303	A	9/1999	Larson	
5,964,720	A	10/1999	Pelz	
5,989,193	A	11/1999	Sullivan	
6,024,699	A	2/2000	Surwit et al.	
6,037,723	A	3/2000	Shafer et al.	
6,058,537	A	5/2000	Larson	
6,062,216	A	5/2000	Corn	
6,079,065	A	6/2000	Luff et al.	
6,108,844	A	8/2000	Kraft et al.	
6,120,441	A	9/2000	Griebel	
6,146,332	A	11/2000	Pinsonneault et al.	
6,147,592	A	11/2000	Ulrich et al.	
6,161,231	A	12/2000	Kraft et al.	
6,202,239	B1	3/2001	Ward et al.	
6,208,250	B1	3/2001	Dixon et al.	
6,234,642	B1	5/2001	Bokamper	
6,272,378	B1	8/2001	Baumgart-Schmitt	
6,386,201	B1 *	5/2002	Fard	128/848
6,396,224	B1	5/2002	Luff et al.	
6,397,419	B1	6/2002	Mechache	
6,438,776	B2	8/2002	Ferrand et al.	
6,450,957	B1	9/2002	Yoshimi et al.	
6,468,234	B1	10/2002	Ford et al.	
6,483,264	B1	11/2002	Shafer et al.	
6,485,441	B2	11/2002	Woodward	
6,546,580	B2	4/2003	Shimada	
6,547,743	B2	4/2003	Brydon	
6,561,047	B1	5/2003	Gladney	
6,566,833	B2	5/2003	Bartlett	
6,643,875	B2	11/2003	Boso et al.	
6,686,711	B2	2/2004	Rose et al.	
6,698,432	B2	3/2004	Ek	
6,708,357	B2	3/2004	Gaboury et al.	
6,719,708	B1	4/2004	Jansen	
6,763,541	B2	7/2004	Mahoney et al.	
6,778,090	B2	8/2004	Newham	
6,804,848	B1	10/2004	Rose	
6,832,397	B2	12/2004	Gaboury et al.	
6,840,117	B2	1/2005	Hubbard, Jr.	
6,840,907	B1	1/2005	Brydon	
6,847,301	B1	1/2005	Olson	
6,878,121	B2	4/2005	Krausman	
6,883,191	B2	4/2005	Gaboury et al.	
6,993,380	B1	1/2006	Modarres	
7,041,049	B1	5/2006	Raniere	
7,077,810	B2	7/2006	Lange et al.	
7,150,718	B2	12/2006	Okada	
7,237,287	B2	7/2007	Weismiller et al.	
7,253,366	B2	8/2007	Bhai	
7,304,580	B2	12/2007	Sullivan et al.	
7,314,451	B2	1/2008	Halperin et al.	
7,321,811	B1	1/2008	Rawls-Meehan et al.	
7,330,127	B2	2/2008	Price et al.	
7,389,554	B1	6/2008	Rose	
7,396,331	B2	7/2008	Mack	
7,429,247	B2	9/2008	Okada et al.	
7,437,787	B2	10/2008	Bhai	
7,465,280	B2	12/2008	Rawls-Meehan	
7,480,951	B2	1/2009	Weismiller	
7,506,390	B2	3/2009	Dixon et al.	
7,520,006	B2	4/2009	Menkedick et al.	
7,524,279	B2	4/2009	Auphan	
7,532,934	B2	5/2009	Lee et al.	
7,538,659	B2	5/2009	Ulrich et al.	
7,568,246	B2	8/2009	Weismiller et al.	
7,631,377	B1	12/2009	Sanford	
7,637,859	B2	12/2009	Lindback et al.	
7,652,581	B2	1/2010	Gentry et al.	
7,666,151	B2	2/2010	Sullivan et al.	
7,669,263	B2	3/2010	Menkedick et al.	
7,676,872	B2	3/2010	Block et al.	
7,685,663	B2	3/2010	Rawls-Meehan	
7,698,761	B2	4/2010	Neuenswander et al.	
7,699,784	B2	4/2010	Wan et al.	
7,717,848	B2	5/2010	Heruth et al.	
7,749,154	B2	7/2010	Cornel	
7,784,128	B2	8/2010	Kramer	
7,785,257	B2	8/2010	Mack et al.	
7,805,785	B2	10/2010	Rawls-Meehan	
7,841,031	B2	11/2010	Rawls-Meehan	
7,849,545	B2	12/2010	Flocard et al.	
7,854,031	B2	12/2010	Rawls-Meehan	
7,860,723	B2	12/2010	Rawls-Meehan	
7,862,523	B2	1/2011	Ruotoistenmaki	
7,865,988	B2	1/2011	Koughan et al.	
7,868,757	B2	1/2011	Radivojevic et al.	
7,869,903	B2	1/2011	Turner et al.	
7,930,783	B2	4/2011	Rawls-Meehan	
7,933,669	B2	4/2011	Rawls-Meehan	
7,953,613	B2	5/2011	Gizewski	
7,954,189	B2	6/2011	Rawls-Meehan	
7,956,755	B2	6/2011	Lee et al.	
7,967,739	B2	6/2011	Auphan	
7,979,169	B2	7/2011	Rawls-Meehan	
8,019,486	B2	9/2011	Rawls-Meehan	
8,020,230	B2	9/2011	Rawls-Meehan	
8,028,363	B2	10/2011	Rawls-Meehan	
8,032,263	B2	10/2011	Rawls-Meehan	
8,032,960	B2	10/2011	Rawls-Meehan	
8,046,114	B2	10/2011	Rawls-Meehan	
8,046,115	B2	10/2011	Rawls-Meehan	
8,046,116	B2	10/2011	Rawls-Meehan	
8,046,117	B2	10/2011	Rawls-Meehan	
8,050,805	B2	11/2011	Rawls-Meehan	
8,052,612	B2	11/2011	Tang	
8,065,764	B2	11/2011	Kramer	
8,069,852	B2	12/2011	Burton	
8,073,535	B2	12/2011	Jung et al.	
8,078,269	B2	12/2011	Suzuki et al.	
8,078,336	B2	12/2011	Rawls-Meehan	
8,078,337	B2	12/2011	Rawls-Meehan	
8,083,682	B2	12/2011	Dalal et al.	
8,090,478	B2	1/2012	Skinner et al.	
8,092,399	B2	1/2012	Sasaki	
8,094,013	B1	1/2012	Lee	
8,096,960	B2	1/2012	Loree, IV et al.	
8,146,191	B2	4/2012	Bobey et al.	
8,150,562	B2	4/2012	Rawls-Meehan	

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,166,589 B2 5/2012 Hijlkema
8,181,296 B2 5/2012 Rawls-Meehan
8,266,742 B2 9/2012 Andrienko
8,272,892 B2 9/2012 McNeely et al.
8,276,585 B2 10/2012 Buckley
8,279,057 B2 10/2012 Hirose
8,280,748 B2 10/2012 Allen
8,281,433 B2 10/2012 Riley et al.
8,282,452 B2 10/2012 Grigsby et al.
8,284,047 B2 10/2012 Collins, Jr. et al.
8,287,452 B2 10/2012 Young et al.
8,336,369 B2 12/2012 Mahoney
8,341,784 B2 1/2013 Scott et al.
8,341,786 B2 1/2013 Oexman et al.
8,348,840 B2 1/2013 Heit et al.
8,350,709 B2 1/2013 Receveur
8,375,488 B2 2/2013 Rawls-Meehan
8,376,954 B2 2/2013 Lange et al.
8,382,484 B2 2/2013 Wetmore et al.
8,386,008 B2 2/2013 Yuen et al.
8,398,538 B2 3/2013 Dothie
8,403,865 B2 3/2013 Halperin et al.
8,413,274 B2 4/2013 Weismiller et al.
8,421,606 B2 4/2013 Collins, Jr. et al.
8,428,696 B2 4/2013 Foo
8,444,558 B2 5/2013 Young et al.
8,517,953 B2 8/2013 Lange et al.
8,620,615 B2 12/2013 Oexman
8,672,853 B2 3/2014 Young
8,679,034 B2 3/2014 Halperin et al.
8,769,747 B2 7/2014 Mahoney et al.
8,840,564 B2 9/2014 Pinhas et al.
8,909,357 B2 12/2014 Rawls-Meehan
8,931,329 B2 1/2015 Mahoney et al.
8,966,689 B2 3/2015 McGuire et al.
8,973,183 B1 3/2015 Palashewski et al.
8,984,687 B2 3/2015 Stusynski et al.
2002/0124311 A1 9/2002 Peftoulidis
2002/0184711 A1 12/2002 Mahoney et al.
2002/0189621 A1 12/2002 Ek
2003/0045806 A1 3/2003 Brydon
2003/0128125 A1* 7/2003 Burbank et al. 340/605
2003/0163874 A1 9/2003 Boso et al.
2003/0166995 A1 9/2003 Jansen
2003/0182728 A1 10/2003 Chapman et al.
2003/0221261 A1 12/2003 Torbet et al.
2004/0049132 A1 3/2004 Barron et al.
2005/0022606 A1 2/2005 Partin et al.
2005/0038326 A1 2/2005 Mathur
2005/0115561 A1* 6/2005 Stahmann et al. 128/200.24
2005/0190065 A1 9/2005 Ronholm
2005/0190068 A1 9/2005 Gentry et al.
2005/0283039 A1 12/2005 Cornel
2006/0020178 A1 1/2006 Sotos et al.
2006/0031996 A1 2/2006 Rawls-Meehan
2006/0047217 A1 3/2006 Mirtalebi
2006/0152378 A1 7/2006 Lokhorst
2006/0162074 A1 7/2006 Bader
2007/0049842 A1 3/2007 Hill et al.
2007/0118054 A1 5/2007 Pinhas et al.
2007/0149883 A1 6/2007 Yesha
2007/0179334 A1 8/2007 Groves et al.
2007/0180047 A1 8/2007 Dong et al.
2007/0180618 A1 8/2007 Weismiller et al.
2007/0276202 A1 11/2007 Raisanen et al.
2008/0052837 A1 3/2008 Blumberg
2008/0071200 A1 3/2008 Rawls-Meehan
2008/0077020 A1 3/2008 Young et al.
2008/0092291 A1 4/2008 Rawls-Meehan
2008/0092292 A1 4/2008 Rawls-Meehan
2008/0092293 A1 4/2008 Rawls-Meehan
2008/0092294 A1 4/2008 Rawls-Meehan
2008/0093784 A1 4/2008 Rawls-Meehan
2008/0097774 A1 4/2008 Rawls-Meehan
2008/0097778 A1 4/2008 Rawls-Meehan
2008/0097779 A1 4/2008 Rawls-Meehan
2008/0104750 A1 5/2008 Rawls-Meehan
2008/0104754 A1 5/2008 Rawls-Meehan
2008/0104755 A1 5/2008 Rawls-Meehan
2008/0104756 A1 5/2008 Rawls-Meehan
2008/0104757 A1 5/2008 Rawls-Meehan
2008/0104758 A1 5/2008 Rawls-Meehan
2008/0104759 A1 5/2008 Rawls-Meehan
2008/0104760 A1 5/2008 Rawls-Meehan
2008/0104761 A1 5/2008 Rawls-Meehan
2008/0109959 A1 5/2008 Rawls-Meehan
2008/0109964 A1 5/2008 Flocard et al.
2008/0109965 A1 5/2008 Mossbeck
2008/0115272 A1 5/2008 Rawls-Meehan
2008/0115273 A1 5/2008 Rawls-Meehan
2008/0115274 A1 5/2008 Rawls-Meehan
2008/0115275 A1 5/2008 Rawls-Meehan
2008/0115276 A1 5/2008 Rawls-Meehan
2008/0115277 A1 5/2008 Rawls-Meehan
2008/0115278 A1 5/2008 Rawls-Meehan
2008/0115279 A1 5/2008 Rawls-Meehan
2008/0115280 A1 5/2008 Rawls-Meehan
2008/0115281 A1 5/2008 Rawls-Meehan
2008/0115282 A1 5/2008 Rawls-Meehan
2008/0120775 A1 5/2008 Rawls-Meehan
2008/0120776 A1 5/2008 Rawls-Meehan
2008/0120777 A1 5/2008 Rawls-Meehan
2008/0120778 A1 5/2008 Rawls-Meehan
2008/0120779 A1 5/2008 Rawls-Meehan
2008/0120784 A1 5/2008 Warner et al.
2008/0122616 A1 5/2008 Warner
2008/0126122 A1 5/2008 Warner et al.
2008/0126132 A1 5/2008 Warner
2008/0127418 A1 6/2008 Rawls-Meehan
2008/0127424 A1 6/2008 Rawls-Meehan
2008/0147442 A1 6/2008 Warner et al.
2008/0162171 A1 7/2008 Rawls-Meehan
2008/0262657 A1 10/2008 Howell et al.
2008/0275314 A1 11/2008 Mack et al.
2008/0281611 A1 11/2008 Rawls-Meehan
2008/0281612 A1 11/2008 Rawls-Meehan
2008/0281613 A1 11/2008 Rawls-Meehan
2008/0288272 A1 11/2008 Rawls-Meehan
2008/0288273 A1 11/2008 Rawls-Meehan
2008/0306351 A1 12/2008 Izumi
2008/0307582 A1 12/2008 Flocard et al.
2009/0018853 A1 1/2009 Rawls-Meehan
2009/0018854 A1 1/2009 Rawls-Meehan
2009/0018855 A1 1/2009 Rawls-Meehan
2009/0018856 A1 1/2009 Rawls-Meehan
2009/0018857 A1 1/2009 Rawls-Meehan
2009/0018858 A1 1/2009 Rawls-Meehan
2009/0024406 A1 1/2009 Rawls-Meehan
2009/0037205 A1 2/2009 Rawls-Meehan
2009/0043595 A1 2/2009 Rawls-Meehan
2009/0064420 A1 3/2009 Rawls-Meehan
2009/0100599 A1 4/2009 Rawls-Meehan
2009/0121660 A1 5/2009 Rawls-Meehan
2009/0139029 A1 6/2009 Rawls-Meehan
2009/0203972 A1 8/2009 Heneghan et al.
2009/0275808 A1 11/2009 DiMaio et al.
2009/0314354 A1 12/2009 Chaffee
2010/0025900 A1 2/2010 Rawls-Meehan
2010/0090383 A1 4/2010 Rawls-Meehan
2010/0094139 A1 4/2010 Brauers et al.
2010/0099954 A1 4/2010 Dickinson et al.
2010/0152546 A1 6/2010 Behan et al.
2010/0170043 A1 7/2010 Young et al.
2010/0170044 A1 7/2010 Kao et al.
2010/0174198 A1 7/2010 Young et al.
2010/0174199 A1 7/2010 Young et al.
2010/0191136 A1 7/2010 Wolford
2010/0199432 A1 8/2010 Rawls-Meehan
2010/0231421 A1 9/2010 Rawls-Meehan
2010/0302044 A1 12/2010 Chacon et al.
2010/0317930 A1 12/2010 Oexman et al.
2011/0001622 A1 1/2011 Gentry et al.
2011/0010014 A1 1/2011 Oexman et al.
2011/0015495 A1 1/2011 Dothie et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0041592	A1	2/2011	Schmoeller et al.	
2011/0068935	A1	3/2011	Riley et al.	
2011/0087113	A1	4/2011	Mack et al.	
2011/0094041	A1	4/2011	Rawls-Meehan	
2011/0115635	A1	5/2011	Petrovski et al.	
2011/0138539	A1	6/2011	Mahoney et al.	
2011/0144455	A1	6/2011	Young et al.	
2011/0156915	A1	6/2011	Brauers et al.	
2011/0224510	A1	9/2011	Oakhill	
2011/0239374	A1	10/2011	Rawls-Meehan	
2011/0252569	A1	10/2011	Rawls-Meehan	
2011/0258784	A1	10/2011	Rawls-Meehan	
2011/0282216	A1	11/2011	Shinar et al.	
2011/0283462	A1	11/2011	Rawls-Meehan	
2011/0291795	A1	12/2011	Rawls-Meehan	
2011/0291842	A1	12/2011	Oexman	
2011/0295083	A1*	12/2011	Doelling et al.	600/301
2011/0302720	A1	12/2011	Yakam et al.	
2011/0306844	A1	12/2011	Young	
2012/0017371	A1	1/2012	Pollard	
2012/0025992	A1	2/2012	Tallent et al.	
2012/0053423	A1	3/2012	Kenalty et al.	
2012/0053424	A1	3/2012	Kenalty et al.	
2012/0056729	A1	3/2012	Rawls-Meehan	
2012/0057685	A1	3/2012	Rawls-Meehan	
2012/0090698	A1	4/2012	Giori et al.	
2012/0110738	A1	5/2012	Rawls-Meehan	
2012/0110739	A1	5/2012	Rawls-Meehan	
2012/0110740	A1	5/2012	Rawls-Meehan	
2012/0112890	A1	5/2012	Rawls-Meehan	
2012/0112891	A1	5/2012	Rawls-Meehan	
2012/0112892	A1	5/2012	Rawls-Meehan	
2012/0116591	A1	5/2012	Rawls-Meehan	
2012/0119886	A1	5/2012	Rawls-Meehan	
2012/0119887	A1	5/2012	Rawls-Meehan	
2012/0138067	A1*	6/2012	Rawls-Meehan	128/845
2012/0154155	A1	6/2012	Brasch	
2012/0186019	A1	7/2012	Rawls-Meehan	
2012/0198632	A1	8/2012	Rawls-Meehan	
2012/0204887	A1	8/2012	Connor	
2012/0240340	A1	9/2012	Driscoll et al.	
2012/0304391	A1	12/2012	Driscoll et al.	
2012/0311790	A1	12/2012	Nomura et al.	
2013/0160212	A1	6/2013	Oexman et al.	
2013/0174347	A1	7/2013	Oexman et al.	
2013/0227787	A1	9/2013	Herbst et al.	
2014/0007656	A1	1/2014	Mahoney	
2014/0047644	A1	2/2014	Mossbeck	
2014/0137332	A1	5/2014	McGuire et al.	
2014/0182061	A1	7/2014	Zaiss	
2014/0250597	A1	9/2014	Chen et al.	
2014/0257571	A1	9/2014	Chen et al.	
2014/0259418	A1	9/2014	Nunn et al.	
2014/0259419	A1	9/2014	Stusynski	
2014/0259431	A1	9/2014	Fleury	
2014/0259433	A1*	9/2014	Nunn et al.	5/713
2014/0259434	A1*	9/2014	Nunn et al.	5/713
2014/0277611	A1	9/2014	Nunn et al.	
2014/0277778	A1	9/2014	Nunn et al.	
2014/0277822	A1	9/2014	Nunn et al.	
2014/0313700	A1	10/2014	Connell et al.	
2015/0025327	A1	1/2015	Young et al.	
2015/0026896	A1	1/2015	Fleury et al.	
2015/0136146	A1*	5/2015	Hood et al.	128/845
2015/0157137	A1	6/2015	Nunn et al.	
2015/0157519	A1	6/2015	Stusynski et al.	
2015/0182033	A1	7/2015	Brosnan et al.	
2015/0182397	A1	7/2015	Palashewski et al.	
2015/0182399	A1	7/2015	Palashewski et al.	
2015/0182418	A1	7/2015	Zaiss	

FOREIGN PATENT DOCUMENTS

JP	2004-229875	A	8/2004
WO	WO-2004/082549	A1	9/2004
WO	WO 2008/128250		10/2008
WO	WO-2009/108228	A1	9/2009
WO	WO 2009/123641		10/2009
WO	WO 2010/149788		12/2010

OTHER PUBLICATIONS

U.S. Appl. No. 14/146,281, filed Jan. 2, 2014, Palashewski et al.
U.S. Appl. No. 14/146,327, filed Jan. 2, 2014, Palashewski et al.
"International Application Serial No. PCT/US2014/024891, International Search Report mailed May 15, 2014", 4 pgs,
"International Application Serial No. PCT/US2014/024891, Written Opinion mailed May 15, 2014", 4 pgs.
"International Application Serial No. PCT/US2014/026288, International Search Report mailed May 15, 2014", 4 pgs.
"International Application Serial No. PCT/US2014/026288, Written Opinion mailed May 15, 2014", 4 pgs.
"International Application Serial No. PCT/US2014/026526, International Search Report mailed May 15, 2014", 3 pgs.
"International Application Serial No. PCT/US2014/026526, Written Opinion mailed May 15, 2014", 4 pgs.
International Application Serial No. PCT/US2014/027752, International Search Report mailed Jul. 15, 2014, 5 pages.
International Application Serial No. PCT/US2014/026568, International Search Report mailed May 26, 2014, 3 pages.
International Application Serial No. PCT/US2014/026390, International Search Report mailed May 26, 2014, 4 pages.
International Application Serial No. PCT/US2014/026347, International Search Report mailed Jun. 27, 2014, 6 pages.
International Preliminary Report on Patentability and Written Opinion in International Application No. PCT/US2014/024891, dated Sep. 15, 2015, 5 pages.
International Preliminary Report on Patentability and Written Opinion in International Application No. PCT/US2014/026347, dated Sep. 15, 2015, 8 pages.
International Preliminary Report on Patentability and Written Opinion in International Application No. PCT/US2014/026526, dated Sep. 24, 2015, 6 pages.
International Preliminary Report on Patentability and Written Opinion in International Application No. PCT/US2014/026568, dated Sep. 24, 2015, 6 pages.
International Preliminary Report on Patentability and Written Opinion in International Application No. PCT/US2014/027752, dated Sep. 15, 2015, 6 pages.
International Preliminary Report on Patentability and Written Opinion in International Application No. PCT/US2014/028137, dated Sep. 24, 2015, 6 pages.
International Search Report in International Application No. PCT/US2014/028137, dated Jul. 7, 2014, 2 pages.
U.S. Appl. No. 14/687,633, filed Apr. 15, 2015, Brosnan et al.
U.S. Appl. No. 14/675,355, filed Mar. 31, 2015, Palashewski et al.
U.S. Appl. No. 14/283,675, filed May 21, 2014, Mahoney et al.

* cited by examiner

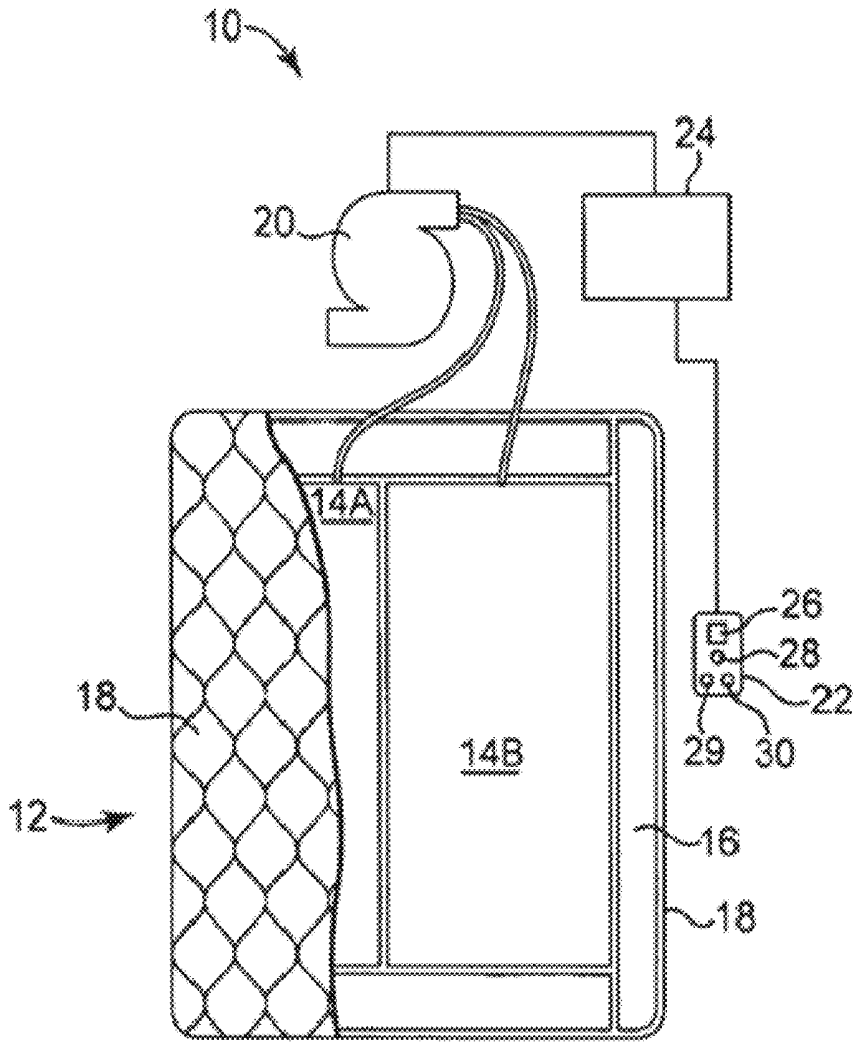


Fig. 1

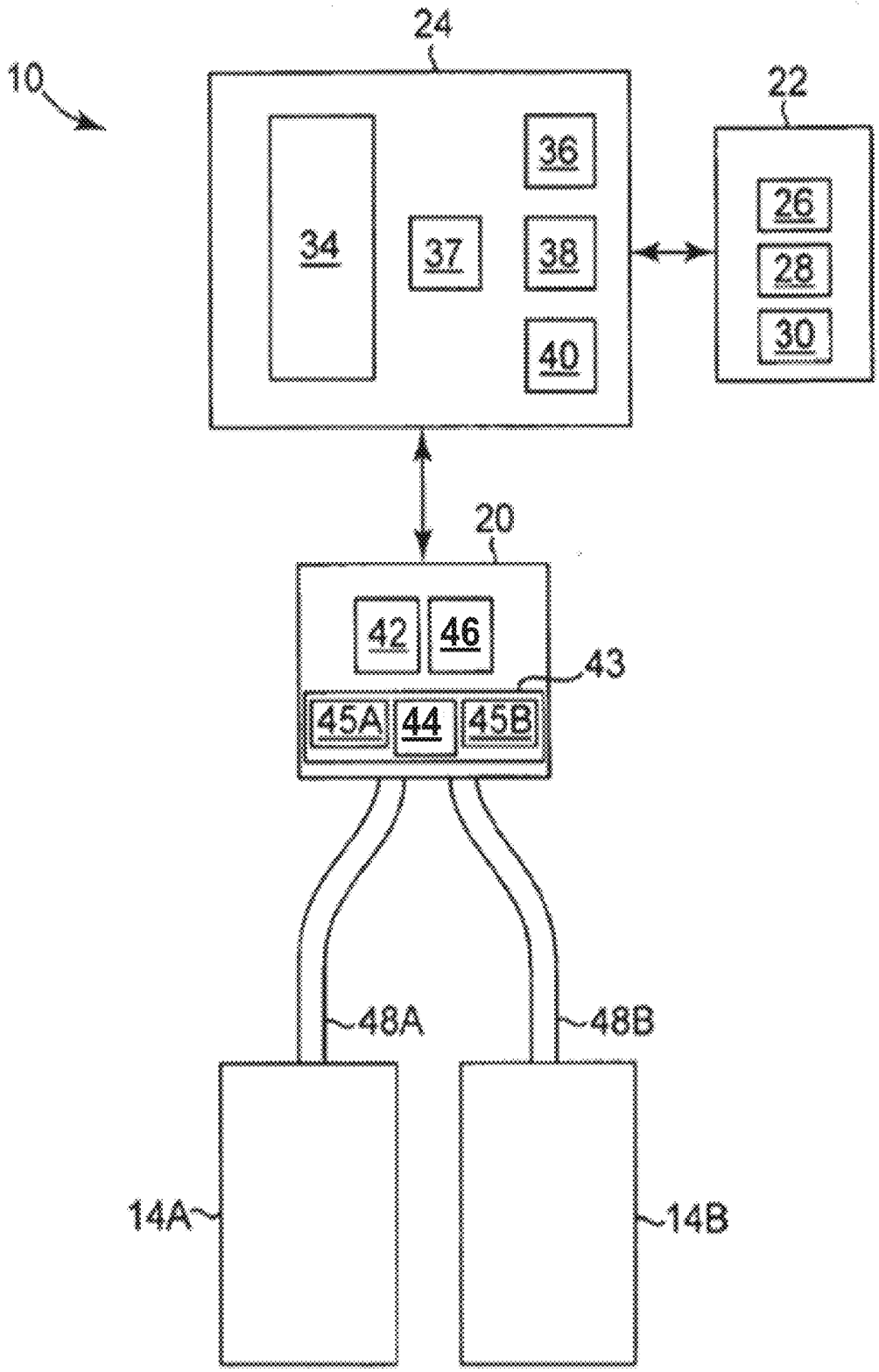
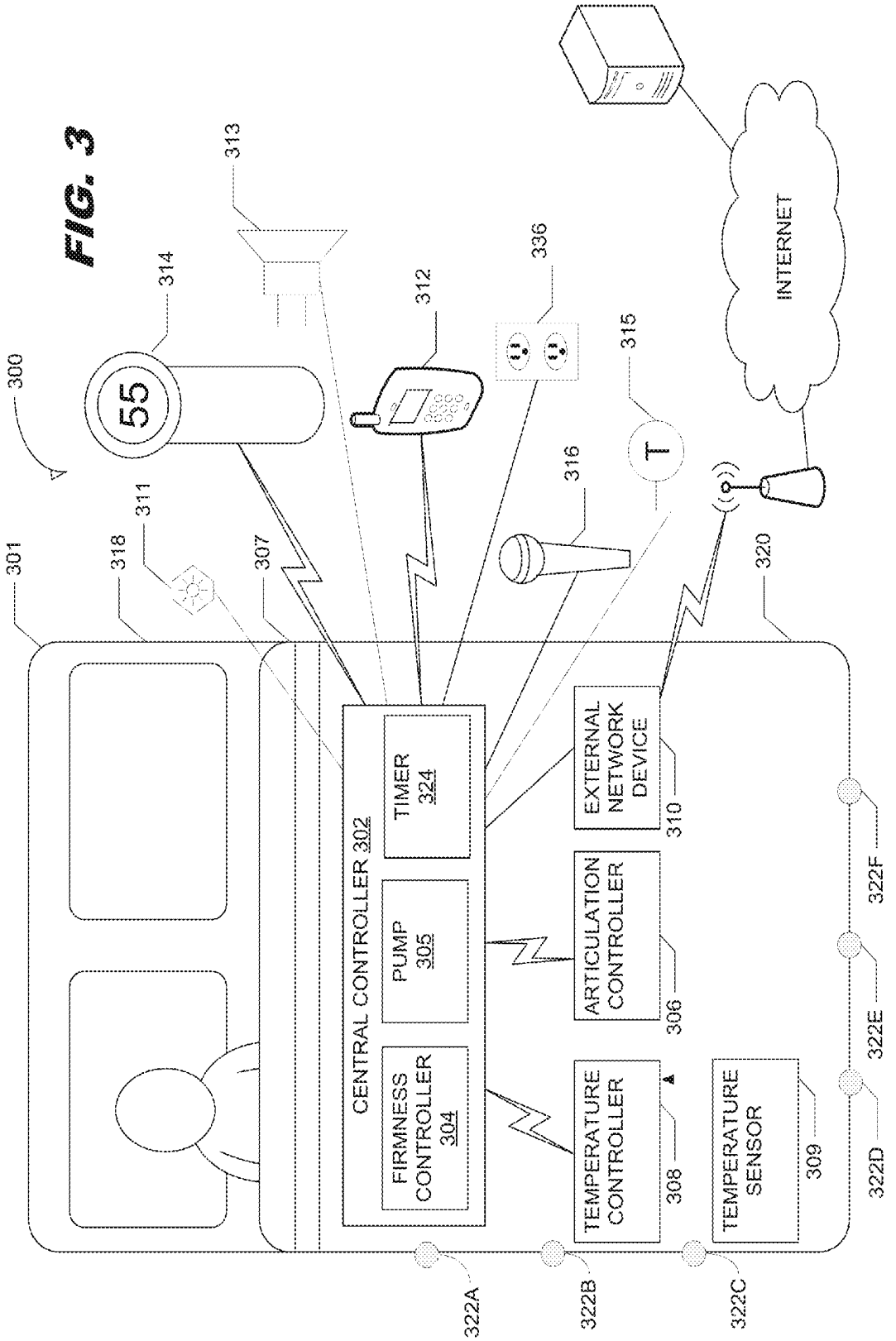

10
24
22
34
36
37
38
40
26
28
30
20
42
46
43
45A
44
45B
48A
48B
14A
14B

Fig. 2

FIG. 3


300
301
311
313
314
55
312
336
315
316
318
307
320
INTERNET
CENTRAL CONTROLLER 302
FIRMNESS CONTROLLER 304
PUMP 305
TIMER 324
EXTERNAL NETWORK DEVICE 310
ARTICULATION CONTROLLER 306
TEMPERATURE CONTROLLER 308
TEMPERATURE SENSOR 309
322A
322B
322C
322D
322E
322F

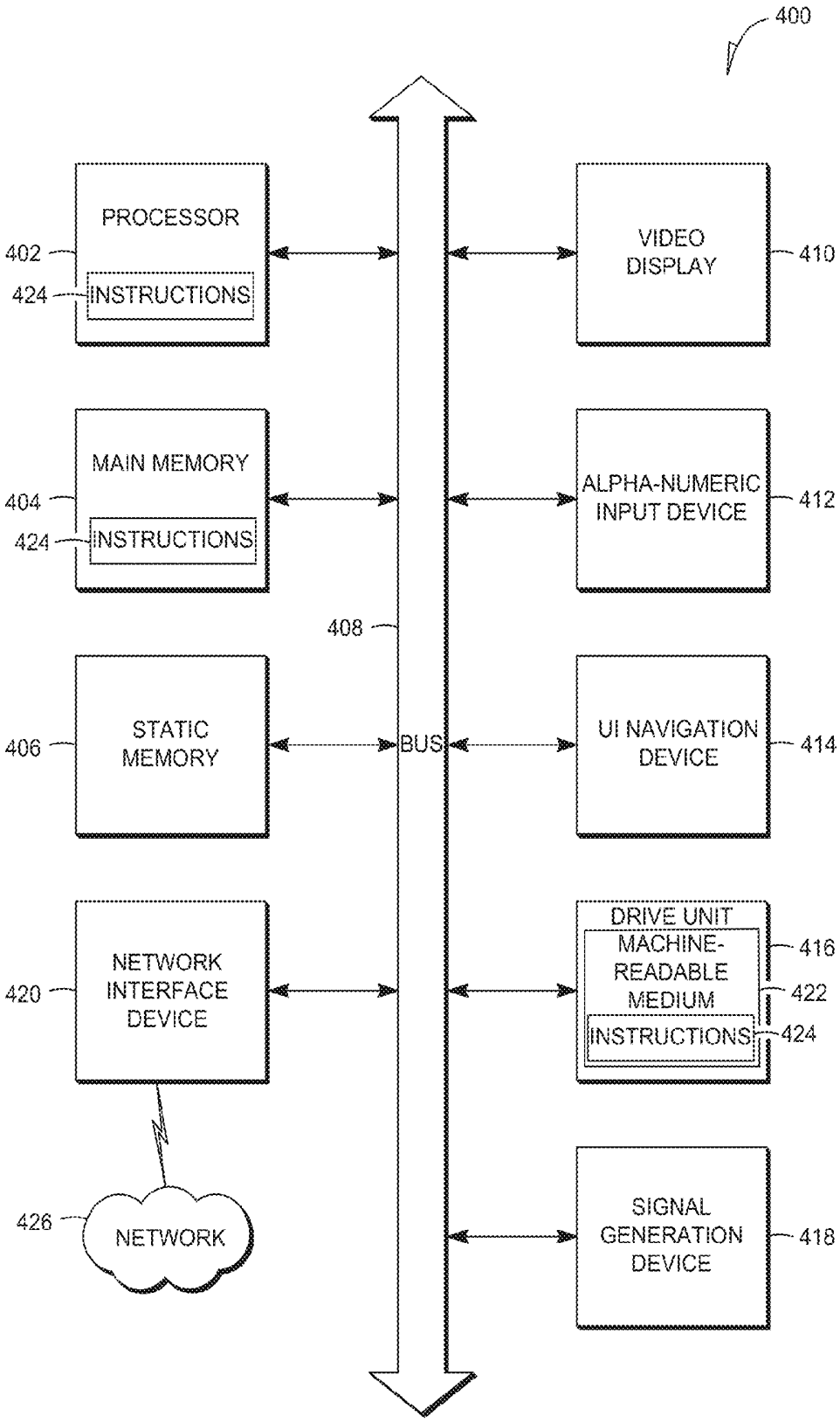

400
PROCESSOR
402
INSTRUCTIONS
424
MAIN MEMORY
404
INSTRUCTIONS
424
STATIC MEMORY
406
NETWORK INTERFACE DEVICE
420
426
NETWORK
408
BUS
VIDEO DISPLAY
410
ALPHA-NUMERIC INPUT DEVICE
412
UI NAVIGATION DEVICE
414
DRIVE UNIT
MACHINE-READABLE MEDIUM
INSTRUCTIONS
416
422
424
SIGNAL GENERATION DEVICE
418

FIG. 4

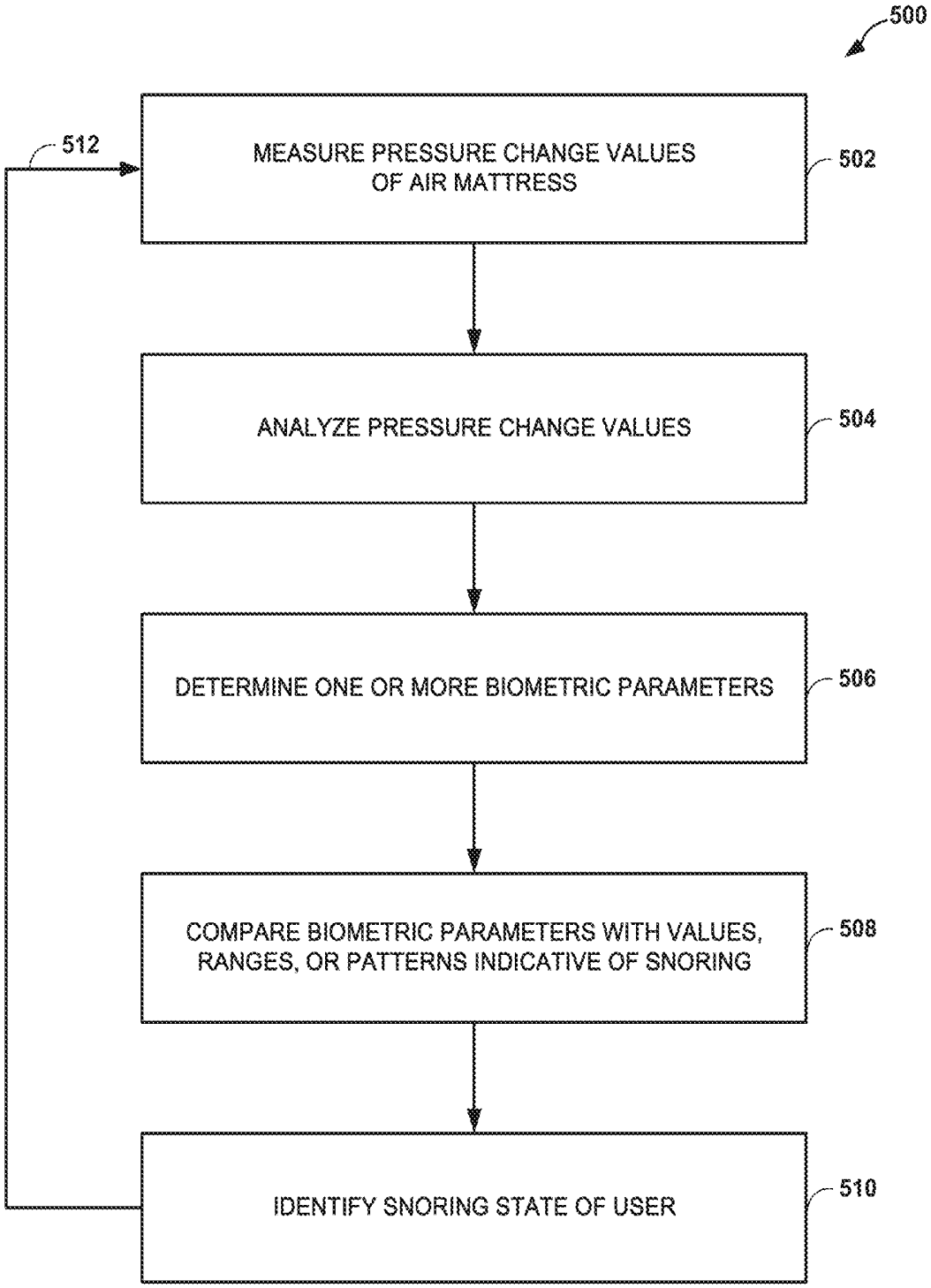

500
512
MEASURE PRESSURE CHANGE VALUES OF AIR MATTRESS
502
ANALYZE PRESSURE CHANGE VALUES
504
DETERMINE ONE OR MORE BIOMETRIC PARAMETERS
506
COMPARE BIOMETRIC PARAMETERS WITH VALUES, RANGES, OR PATTERNS INDICATIVE OF SNORING
508
IDENTIFY SNORING STATE OF USER
510

FIG. 5

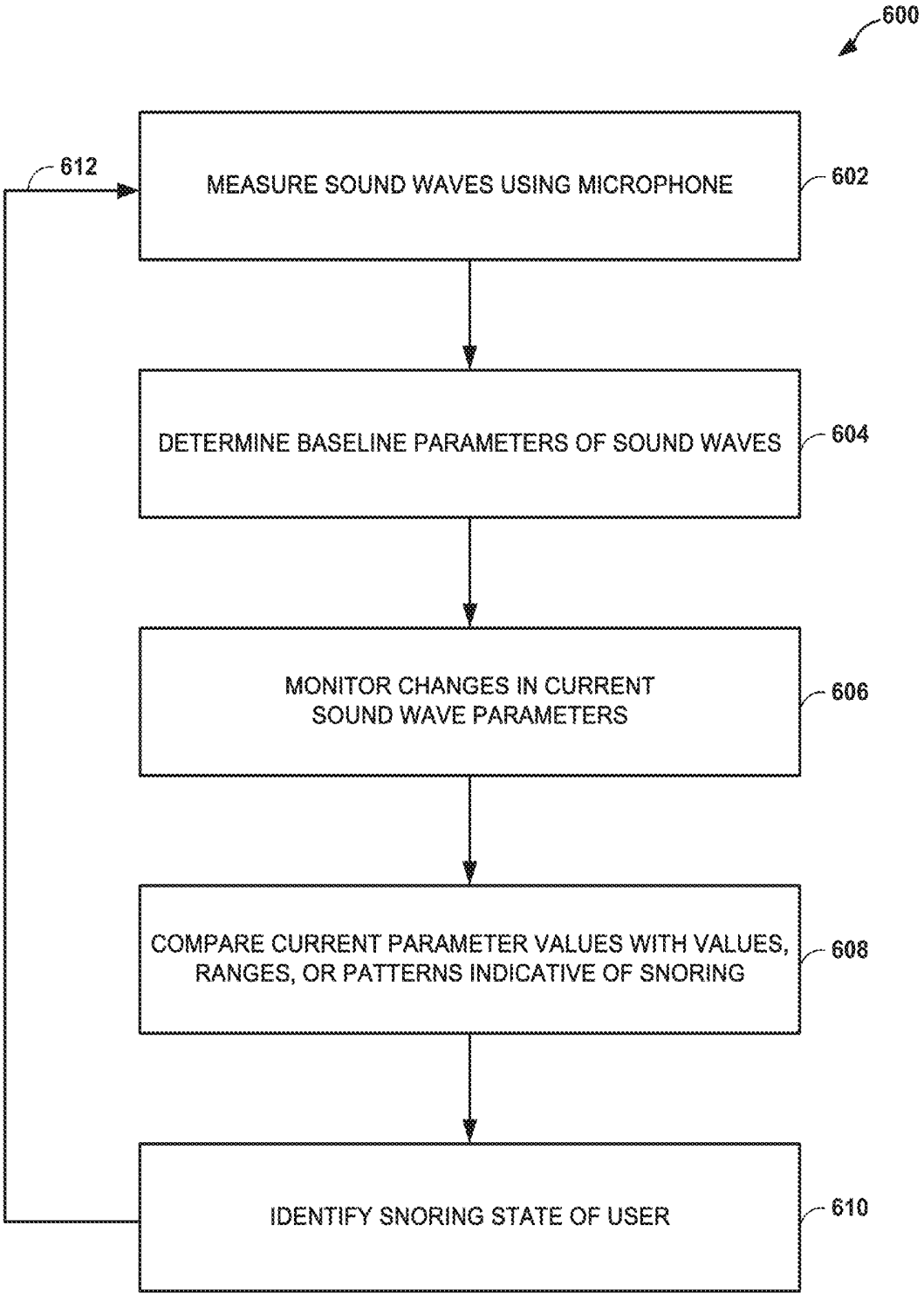

600
612
MEASURE SOUND WAVES USING MICROPHONE
602
DETERMINE BASELINE PARAMETERS OF SOUND WAVES
604
MONITOR CHANGES IN CURRENT SOUND WAVE PARAMETERS
606
COMPARE CURRENT PARAMETER VALUES WITH VALUES, RANGES, OR PATTERNS INDICATIVE OF SNORING
608
IDENTIFY SNORING STATE OF USER
610

FIG. 6

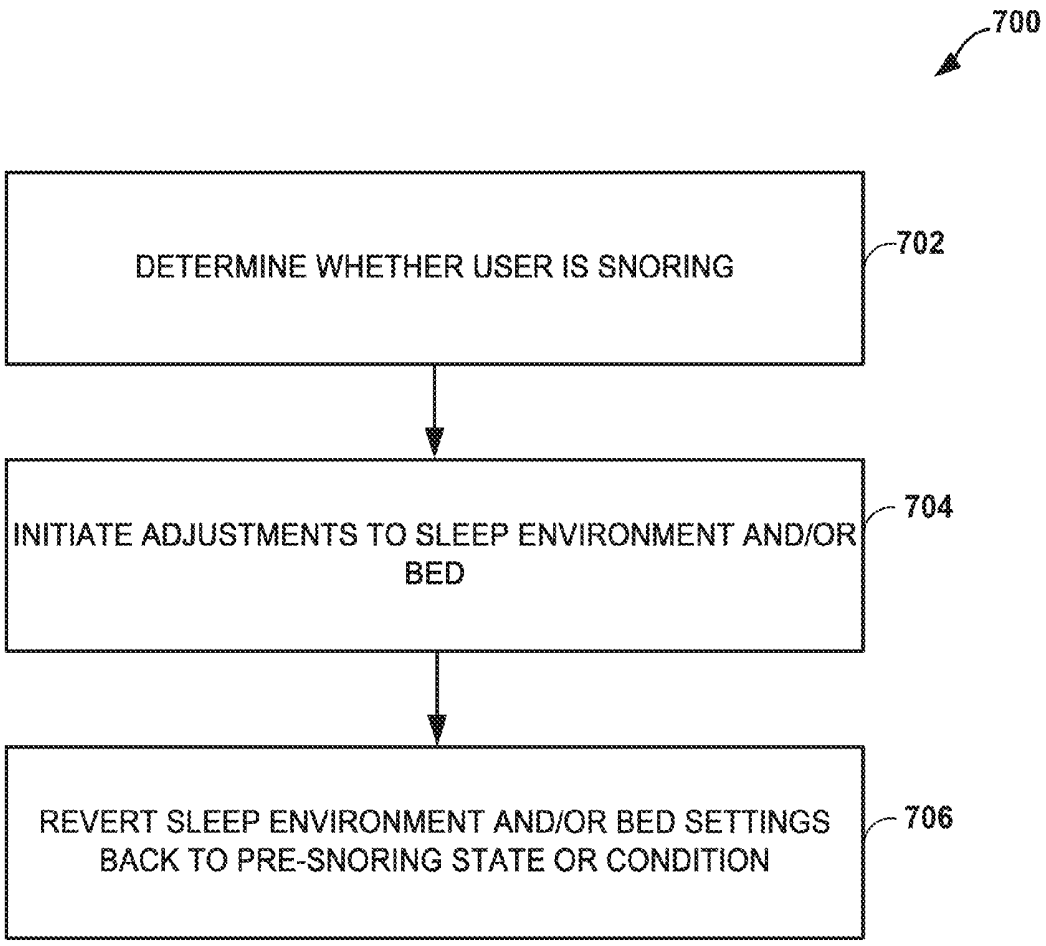

700
DETERMINE WHETHER USER IS SNORING
702
INITIATE ADJUSTMENTS TO SLEEP ENVIRONMENT AND/OR BED
704
REVERT SLEEP ENVIRONMENT AND/OR BED SETTINGS BACK TO PRE-SNORING STATE OR CONDITION
706

FIG. 7

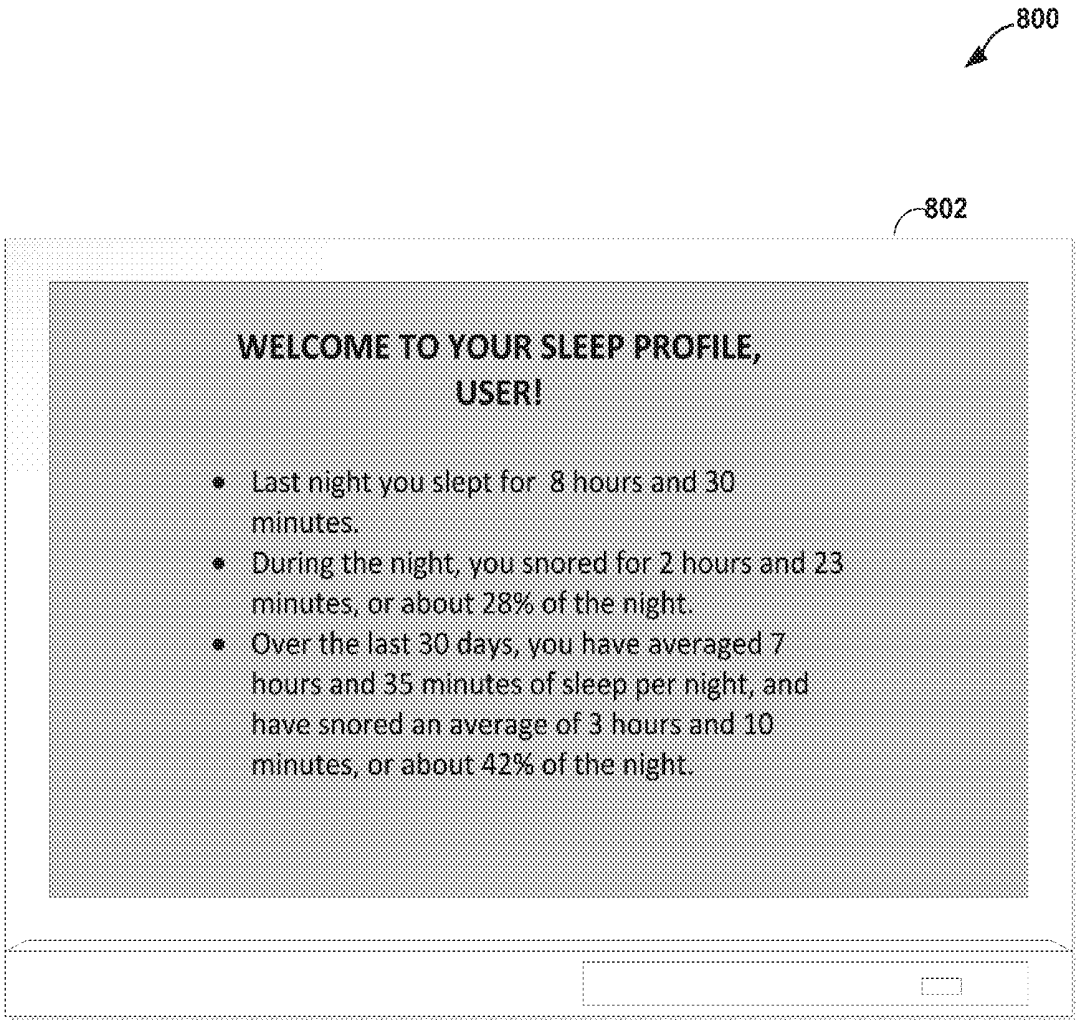

800
802
WELCOME TO YOUR SLEEP PROFILE, USER!
• Last night you slept for 8 hours and 30 minutes.
• During the night, you snored for 2 hours and 23 minutes, or about 28% of the night.
• Over the last 30 days, you have averaged 7 hours and 35 minutes of sleep per night, and have snored an average of 3 hours and 10 minutes, or about 42% of the night.

FIG. 8

INFLATABLE AIR MATTRESS SNORING DETECTION AND RESPONSE

CROSS-REFERENCES

This application claims the benefit of priority to U.S. Provisional Application No. 61/782,394, filed on Mar. 14, 2013, the disclosure of which is incorporated herein in its entirety by reference.

The subject matter described in this application is related to subject matter disclosed in the following applications: U.S. Application Ser. No. 61/781,266, filed on Mar. 14, 2013, entitled "INFLATABLE AIR MATTRESS ALARM AND MONITORING SYSTEM"; U.S. Application Ser. No. 61/781,503, filed on Mar. 14, 2013, entitled "INFLATABLE AIR MATTRESS SYSTEM ARCHITECTURE"; U.S. Application Ser. No. 61/781,541, filed on Mar. 14, 2013, entitled "INFLATABLE AIR MATTRESS AUTOFILL AND OFF BED PRESSURE ADJUSTMENT"; U.S. Application Ser. No. 61/781,571, filed on Mar. 14, 2013, entitled "INFLATABLE AIR MATTRESS SLEEP ENVIRONMENT ADJUSTMENT AND SUGGESTIONS"; U.S. Application Ser. No. 61/781,296, filed on Mar. 14, 2013, entitled "INFLATABLE AIR MATTRESS WITH LIGHT AND VOICE CONTROLS"; U.S. Application Ser. No. 61/781,311, filed on Mar. 14, 2013, entitled "INFLATABLE AIR MATTRESS SYSTEM WITH DETECTION TECHNIQUES." The contents of each of the above-referenced U.S. patent applications are herein incorporated by reference in their entirety.

TECHNICAL FIELD

This patent document pertains generally to mattress systems and more particularly, but not by way of limitation, to an inflatable air mattress system.

BACKGROUND

Air bed systems, such as the one described in U.S. Pat. No. 5,904,172 which is incorporated herein by reference in its entirety, generally allow a user to select a desired pressure for each air chamber within the mattress. Upon selecting the desired pressure, a signal is sent to a pump and valve assembly in order to inflate or deflate the air bladders as necessary in order to achieve approximately the desired pressure within the air bladders.

In various examples, an air mattress control system allows a user to adjust the firmness or position of an air mattress bed. The mattress may have more than one zone thereby allowing a left and right side of the mattress to be adjusted to different firmness levels. Additionally, the bed may be adjustable to different positions. For example, the head section of the bed may be raised up while the foot section of the bed stays in place. In various examples, two separate remote controls are used to adjust the position and firmness, respectively.

A common problem experienced by many people is snoring. Snoring can not only result in poor sleep quality and potential health issues, but it can also disturb another person who is sleeping in the same room, such as a spouse sleeping in the same bed. Some people deal with the problem by waking the snorer up in order to stop the snoring. However, the snorer often begins snoring again after going back to sleep. Moreover, waking the snorer also interrupts the snorer's sleep.

BRIEF DESCRIPTION OF DRAWINGS

Some embodiments are illustrated by way of example and not limitation in the figures of the accompanying drawings in which:

FIG. **1** is a diagrammatic representation of an air bed system, according to an example.

FIG. **2** is a block diagram of various components of the air bed system of FIG. **1**, according to an example.

FIG. **3** is a block diagram of an air bed system architecture, according to an example.

FIG. **4** is a block diagram of a machine in the example form of a computer system within which a set instructions, for causing the machine to perform any one or more of the methodologies discussed herein, may be executed.

FIG. **5** is a flow diagram depicting an example method of detecting snoring of a user using biometric parameters, in accordance with various techniques of this disclosure.

FIG. **6** is a flow diagram depicting an example method of detecting snoring of a user using sound waves, in accordance with various techniques of this disclosure.

FIG. **7** is a flow diagram depicting an example method of making adjustments to a room environment or a bed in response to detecting snoring of a user, in accordance with various techniques of this disclosure.

FIG. **8** is a diagrammatic representation of a sleep profile report generated on a laptop computer, in accordance with various techniques of this disclosure.

DETAILED DESCRIPTION

FIG. **1** is a diagrammatic representation of an air bed system **10** in an example embodiment. The system **10** can include a bed **12**, which can comprise at least one air chamber **14** surrounded by a resilient border **16** and encapsulated by bed ticking **18**. The resilient border **16** can comprise any suitable material, such as foam.

As illustrated in FIG. **1**, the bed **12** can be a two chamber design having a first air chamber **14**A and a second air chamber **14**B. The first and second air chambers **14**A and **14**B can be in fluid communication with a pump **20**. The pump **20** can be in electrical communication with a remote control **22** via a control box **24**. The remote control **22** can communicate via wired or wireless means with the control box **24**. The control box **24** can be configured to operate the pump **20** to cause increases and decreases in the fluid pressure of the first and second air chambers **14**A and **14**B based upon commands input by a user through the remote control **22**. The remote control **22** can include a display **26**, output selecting means **28**, a pressure increase button **29**, and a pressure decrease button **30**. The output selecting means **28** can allow the user to switch the pump output between the first and second air chambers **14**A and **14**B, thus enabling control of multiple air chambers with a single remote control **22**. For example, output selecting means may by a physical control (e.g., switch or button) or an input control displayed on the display **26**. Alternatively, separate remote control units can be provided for each air chamber and may each include the ability to control multiple air chambers. The pressure increase and decrease buttons **29** and **30** can allow a user to increase or decrease the pressure, respectively, in the air chamber selected with the output selecting means **28**. Adjusting the pressure within the selected air chamber can cause a corresponding adjustment to the firmness of the air chamber.

FIG. **2** is a block diagram detailing data communication between certain components of the air bed system **10** according to various examples. As shown in FIG. **2**, the control box

24 can include a power supply 34, a processor 36, memory 37, a switching means 38, and an analog to digital (A/D) converter 40. The switching means 38 can be, for example, a relay or a solid state switch. The switching means 38 can be located in the pump 20 rather than the control box 24.

The pump 20 and the remote control 22 can be in two-way communication with the control box 24. The pump 20 can include a motor 42, a pump manifold 43, a relief valve 44, a first control valve 45A, a second control valve 45B, and a pressure transducer 46, and can be fluidly connected with the first air chamber 14A and the second air chamber 14B via a first tube 48A and a second tube 48B, respectively. The first and second control valves 45A and 45B can be controlled by the switching means 38, and can be operable to regulate the flow of fluid between the pump 20 and the first and second air chambers 14A and 14B, respectively.

In an example, the pump 20 and the control box 24 can be provided and packaged as a single unit. Alternatively, the pump 20 and the control box 24 can be provided as physically separate units.

In operation, the power supply 34 can receive power, such as 110 VAC power, from an external source and can convert the power to various forms required by certain components of the air bed system 10. The processor 36 can be used to control various logic sequences associated with operation of the air bed system 10, as will be discussed in further detail below.

The example of the air bed system 10 shown in FIG. 2 contemplates two air chambers 14A and 14B and a single pump 20. However, other examples may include an air bed system having two or more air chambers and one or more pumps incorporated into the air bed system to control the air chambers. In an example, a separate pump can be associated with each air chamber of the air bed system or a pump may be associated with multiple chambers of the air bed system. Separate pumps can allow each air chamber to be inflated or deflated independently and simultaneously. Furthermore, additional pressure transducers can also be incorporated into the air bed system such that, for example, a separate pressure transducer can be associated with each air chamber. Additionally, one or both of the chambers 14A and 14B can include multiple separate bladders or "zones" within the chamber, such as one bladder for the head and one bladder for the body.

In the event that the processor 36 sends a decrease pressure command to one of the air chambers 14A or 14B, the switching means 38 can be used to convert the low voltage command signals sent by the processor 36 to higher operating voltages sufficient to operate the relief valve 44 of the pump 20 and open the control valves 45A or 45B. Opening the relief valve 44 can allow air to escape from the air chamber 14A or 14B through the respective air tube 48A or 48B. During deflation, the pressure transducer 46 can send pressure readings to the processor 36 via the A/D converter 40. The A/D converter 40 can receive analog information from the pressure transducer 46 and can convert the analog information to digital information useable by the processor 36. The processor 36 may send the digital signal to the remote control 22 to update the display 26 on the remote control in order to convey the pressure information to the user.

In the event that the processor 36 sends an increase pressure command, the pump motor 42 can be energized, sending air to the designated air chamber through the air tube 48A or 48B via electronically operating the corresponding valve 45A or 45B. While air is being delivered to the designated air chamber in order to increase the firmness of the chamber, the pressure transducer 46 can sense pressure within the pump manifold 43. Again, the pressure transducer 46 can send pressure readings to the processor 36 via the A/D converter 40. The processor 36 can use the information received from the A/D converter 40 to determine the difference between the actual pressure in the air chamber 14A or 14B and the desired pressure. The processor 36 can send the digital signal to the remote control 22 to update the display 26 on the remote control in order to convey the pressure information to the user.

Generally speaking, during an inflation or deflation process, the pressure sensed within the pump manifold 43 provides an approximation of the pressure within the air chamber. An example method of obtaining a pump manifold pressure reading that is substantially equivalent to the actual pressure within an air chamber is to turn off the pump 20, allow the pressure within the air chamber 14A or 14B and the pump manifold 43 to equalize, and then sense the pressure within the pump manifold 43 with the pressure transducer 46. Thus, providing a sufficient amount of time to allow the pressures within the pump manifold 43 and the chamber 14A or 14B to equalize may result in pressure readings that are accurate approximations of the actual pressure within the air chamber 14A or 14B. In various examples, the pressure of 48A/B is continuously monitored using multiple pressure sensors.

In an example, another method of obtaining a pump manifold pressure reading that is substantially equivalent to the actual pressure within an air chamber is through the use of a pressure adjustment algorithm. In general, the method can function by approximating the air chamber pressure based upon a mathematical relationship between the air chamber pressure and the pressure measured within the pump manifold 43 (during both an inflation cycle and a deflation cycle), thereby eliminating the need to turn off the pump 20 in order to obtain a substantially accurate approximation of the air chamber pressure. As a result, a desired pressure setpoint within the air chamber 14A or 14B can be achieved without the need for turning the pump 20 off to allow the pressures to equalize. The latter method of approximating an air chamber pressure using mathematical relationships between the air chamber pressure and the pump manifold pressure is described in detail in U.S. application Ser. No. 12/936,084, the entirety of which is incorporated herein by reference.

FIG. 3 illustrates an example air bed system architecture 300. The architecture 300 includes a bed 301, e.g., an inflatable air mattress, a central controller 302, a firmness controller 304, an articulation controller 306, a temperature controller 308 in communication with one or more temperature sensors 309, an external network device 310, remote controllers 312, 314, and a voice controller 316. In addition to providing for the input of vocal commands, the voice controller 316 can also be used for detecting snoring of a sleeper as described in further detail below. Thus, the voice controller 316 can include any detection means capable of detecting sound waves, such as a microphone. While described as using an air bed, the system architecture may also be used with other types of beds.

As illustrated in FIG. 3, the central controller 302 includes the firmness controller 304 and a pump 305. The system architecture 300 is configured as a star topology with the central controller 302 and the firmness controller 304 functioning as the hub and the articulation controller 306, the temperature controller 308, the external network device 310, the remote controllers 312, 314, and the voice controller 316 functioning as possible spokes, also referred to herein as components. Thus, in various examples, the central controller 302 acts a relay between the various components.

In yet another example, central controller 302 listens to communications (e.g., control signals) between components even if the communication is not being relayed through cen-

tral controller **302**. For example, consider a user sending a command using remote **312** to temperature controller **308**. Central controller **302** may listen for the command and check to determine if instructions are stored at central controller **302** to override the command (e.g., it conflicts with a previous setting). Central controller **302** may also log the command for future use (e.g., determining a pattern of user preferences for the components).

In other examples, different topologies may be used. For example, the components and the central controller **302** may be configured as a mesh network in which each component may communicate with one or all of the other components directly, bypassing the central controller **302**. In various examples, a combination of topologies may be used. For example, the remote controller **312** may communicate directly to the temperature controller **308** but also relay the communication to the central controller **302**.

In various examples, the controllers and devices illustrated in FIG. **3** may each include a processor, a storage device, and a network interface. The processor may be a general purpose central processing unit (CPU) or application-specific integrated circuit (ASIC). The storage device may include volatile or non-volatile static storage (e.g., Flash memory, RAM, EPROM, etc.). The storage device may store instructions which, when executed by the processor, configure the processor to perform the functionality described herein. For example, a processor of the firmness controller **304** may be configured to send a command to a relief valve to decrease the pressure in a bed.

In various examples, the network interface of the components may be configured to transmit and receive communications in a variety of wired and wireless protocols. For example, the network interface may be configured to use the 802.11 standards (e.g., 802.11a/b/c/g/n/ac), PAN network standards such as 802.15.4 or Bluetooth, infrared, cellular standards (e.g., 3G/4G etc.), Ethernet, and USB for receiving and transmitting data. The previous list is not intended to be exhaustive and other protocols may be used. Not all components of FIG. **3** need to be configured to use the same protocols. For example, the remote controller **312** may communicate with the central controller **302** via Bluetooth while the temperature controller **308** and the articulation controller **306** are connected to the central controller using 802.15.4. Within FIG. **3**, the lightning connectors represent wireless connections and the solid lines represent wired connections, however, the connections between the components is not limited to such connections and each connection may be wired or wireless. For example, the voice controller **316** can be connected wirelessly to the central controller **302**.

Moreover, in various examples, the processor, storage device, and network interface of a component may be located in different locations than various elements used to effect a command. For example, as in FIG. **1**, the firmness controller **302** may have a pump that is housed in a separate enclosure than the processor used to control the pump. Similar separation of elements may be employed for the other controllers and devices in FIG. **3**.

In various examples, the firmness controller **304** is configured to regulate pressure in an air mattress. For example, the firmness controller **304** may include a pump such as described with reference to FIG. **2** (see e.g., pump **20**). Thus, in an example, the firmness controller **304** may respond to commands to increase or decrease pressure in the air mattress. The commands may be received from another component or based on stored application instructions that are part of the firmness controller **304**.

As illustrated in FIG. **3**, the central controller **302** includes the firmness controller **304**. Thus, in an example, the processor of the central controller **302** and the firmness controller **304** may be the same processor. Furthermore, the pump may also be part of the central controller **302**. Accordingly, the central controller **302** may be responsible for pressure regulation as well as other functionality as described in further portions of this disclosure.

In various examples, the articulation controller **306** is configured to adjust the position of a bed mattress (e.g., bed **301**) by adjusting a foundation **307** that supports the bed mattress. In an example, the bed **301** can include a single foundation **307** configured to adjust the position of a bed having a single mattress. In another example, the bed **301** can include two side-by-side foundations **307** configured to operate in tandem to adjust the position of a bed having a single mattress. In yet another example, the bed **301** can include two side-by-side mattresses supported by two side-by-side foundations **307**, wherein the foundations **307** are operable independently such that separate positions may be set for the two different mattresses of the bed **301**. The foundation **307** may include more than one zone, e.g., a head portion **318** and a foot portion **320**, which may be independently adjusted. The articulation controller **306** may also be configured to provide different levels of massage to a person on the bed.

In various examples, the temperature controller **308** is configured to increase, decrease, or maintain the temperature of a user. For example, a pad may be placed on top of or be part of the air mattress. Air may be pushed through the pad and vented to cool off a user of the bed. Conversely, the pad may include a heating element that may be used to keep the user warm. In various examples, the pad includes the temperature sensor **309** and the temperature controller **308** receives temperature readings from the temperature sensor **309**. In other examples, the temperature sensor **309** can be separate from the pad, e.g., part of the air mattress or foundation. Alternatively or in addition, a blanket can be provided having similar functionality to the pad.

In various examples, additional controllers may communicate with the central controller **302**. These controllers may include, but are not limited to, illumination controllers for controlling the power status (e.g., on or off) or intensity of light elements **311** and **322**A-F placed on and around the bed, audio/visual controllers for controlling the power status or volume of one or more audio/visual components **313** located near the bed, thermostat controllers for controlling a temperature setting of a thermostat device **315**, and outlet controllers for controlling power to one or more power outlets **336**. In an example, the light elements **311** and **322**A-F can be network controlled lights.

In various examples, the external network device **310**, the remote controllers **312**, **314** and the voice controller **316** may be used to input commands (e.g., from a user or remote system) to control one or more components of the system architecture **300**. The commands may be transmitted from one of the controllers **312**, **314**, or **316** and received in the central controller **302**. The central controller **302** may process the command to determine the appropriate component to route the received command. For example, each command sent via one of controllers **312**, **314**, or **316** may include a header or other metadata that indicates which component the command is for. The central controller **302** may then transmit the command via the central controller **302**'s network interface to the appropriate component.

For example, a user may input a desired temperature for the user's bed into the remote controller **312**. The desired temperature may be encapsulated in a command data structure

that includes the temperature as well as identifies the temperature controller **308** as the desired component to be controlled. The command data structure may then be transmitted via Bluetooth to the central controller **302**. In various examples, the command data structure is encrypted before being transmitted. The central controller **302** may parse the command data structure and relay the command to the temperature controller **308** using a PAN. The temperature controller **308** may then configure its elements to increase or decrease the temperature of the pad depending on the temperature originally input into the remote controller **312**.

In one example implementation, the central controller **302** can detect user presence using temperature changes detected in the mattress, e.g., using one or more temperature sensors positioned in or on the mattress. The temperature sensors and the central controller **302** can detect a rise in temperature, e.g., over a specified period of time, and determine that a user is present in the bed. For example, if the central controller **302** detects a rise in temperature and then determines that the detected rise in temperature was not caused by the system's temperature controller **308**, the central controller **302** can determine that the user is present.

In various examples, data may be transmitted from a component back to one or more of the remote controllers. For example, the current temperature as determined by a sensor element of the temperature controller **308**, e.g., the temperature sensor **309**, the pressure of the bed, the current position of the foundation or other information may be transmitted to the central controller **302**. The central controller **302** may then transmit the received information and transmit it to the remote controller **312** where it may be displayed to the user.

In various examples, multiple types of devices may be used to input commands to control the components of the architecture **300**. For example, the remote controller **312** may be a mobile device such as a smart phone or tablet computer running an application. Other examples of the remote controller **312** may include a dedicated device for interacting with the components described herein. In various examples, the remote controllers **312/314** include a display device for displaying an interface to a user. The remote controller **312/314** may also include one or more input devices. Input devices may include, but are not limited to, keypads, touchscreen, gesture, motion and voice controls.

The remote controller **314** may be a single component remote configured to interact with one component of the mattress architecture. For example, the remote controller **314** may be configured to accept inputs to increase or decrease the air mattress pressure. The voice controller **316** may be configured to accept voice commands to control one or more components. In various examples, more than one of the remote controllers **312/314** and the voice controller **316** may be used.

With respect to the remote controller **312**, the application may be configured to pair with one or more central controllers. For each central controller, data may be transmitted to the mobile device that includes a list of components linked with the central controller. For example, consider that the remote controller **312** is a mobile phone and that the application has been authenticated and paired with the central controller **302**. The remote controller **312** may transmit a discovery request to the central controller **302** to inquire about other components and available services. In response, the central controller **302** may transmit a list of services that includes available functions for adjusting the firmness of the bed, position of the bed, and temperature of the bed. In various embodiments, the application may then display functions for increasing/decreasing pressure of the air mattress, adjusting positions of the bed, and adjusting temperature. If components are added/removed to the architecture under control of the central controller **302**, an updated list may be transmitted to the remote controller **312** and the interface of the application may be adjusted accordingly.

In various examples, the central controller **302** is configured as a distributor of software updates to components in the architecture **300**. For example, a firmware update for the temperature controller **308** may become available. The update may be loaded into a storage device of the central controller **302** (e.g., via a USB interface or using wireless techniques). In wireless applications, the central controller **302** may, for example, receive updates from the cloud either from wifi or from a mobile connection over Bluetooth. The central controller **302** may then transmit the update to the temperature controller **308** with instructions to update. The temperature controller **308** may attempt to install the update. A status message may be transmitted from the temperature controller **308** to the central controller **302** indicating the success or failure of the update.

In various examples, the central controller **302** is configured to analyze data collected by a pressure transducer (e.g., the transducer **46** with respect to FIG. **2**) to determine various states of a person lying on the bed **301**. For example, the central controller **302** may determine the heart rate, respiration rate, or movement of a person lying in the bed **301**. Additional processing may be done using the collected data to determine a possible sleep state of the person. For example, the central controller **302** may determine when a person falls asleep and, while asleep, the various sleep states of the person. The collected data may also be used to determine when a person is snoring. In another example, rather than performing the data analysis in the central controller **302**, a digital signal processor (DSP) can be provided to analyze the data collected by the pressure transducer. Alternatively, the data collected by the pressure transducer could be sent to a cloud-based computing system for remote analysis.

In various examples, the external network device **310** includes a network interface to interact with an external server for processing and storage of data related to components in the architecture **300**. For example, the determined sleep data as described above may be transmitted via a network (e.g., the Internet) from the central controller **302** to the external network device **310** for storage. In an example, the pressure transducer data may be transmitted to the external server for additional analysis. The external network device **310** may also analyze and filter the data before transmitting it to the external server.

In an example, diagnostic data of the components may also be routed to the external network device **310** for storage and diagnosis on the external server. For example, if the temperature controller **308** detects an abnormal temperature reading (e.g., a drop in temperature over one minute that exceeds a set threshold) diagnostic data (sensor readings, current settings, etc.) may be wireless transmitted from the temperature controller **308** to the central controller **302**. The central controller **302** may then transmit this data via USB to the external network device **310**. The external network device **310** may wirelessly transmit the information to an WLAN access point where it is routed to the external server for analysis.

In one example, the bed system architecture **300** can include one or more bed lights **322**A-**322**F (referred to collectively in this disclosure as "bed lights **322**") to illuminate a portion of a room, e.g., when a user gets out of the bed **301**. The lights **322** can be attached around the foundation **307**, e.g., affixed to the foundation around its perimeter. In FIG. **3**, the lights **322** are depicted as extending around two sides of

the foundation **307**. In other configurations, the lights **322** can extend around more than two sides of the foundation **307**, or only a single side. In one example implementation, the lights **322** can be positioned underneath the foundation **307** to project light outwardly from the foundation **307**. The bed system architecture **300** can also include one or more lights **311** that are not positioned on the bed, such as overhead lights or bedside lamps. The bed system architecture **300** can provide for the control of both the bed lights **322** and the surrounding room lights **311**.

Example Machine Architecture and Machine-Readable Medium

FIG. **4** is a block diagram of a machine in the example form of a computer system **400** within which instructions, for causing the machine to perform any one or more of the methodologies discussed herein, may be executed. In alternative embodiments, the machine operates as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine may operate in the capacity of a server or a client machine in a server-client network environment, or as a peer machine in a peer-to-peer (or distributed) network environment. The machine may be a personal computer (PC), a tablet PC, a set-top box (STB), a Personal Digital Assistant (PDA), a cellular telephone, a web appliance, a network router, switch or bridge, or any machine capable of executing instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while only a single machine is illustrated, the term "machine" shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein.

The example computer system **400** includes a processor **402** (e.g., a central processing unit (CPU), a graphics processing unit (GPU), ASIC or a combination), a main memory **404** and a static memory **406**, which communicate with each other via a bus **408**. The computer system **400** may further include a video display unit **410** (e.g., a liquid crystal display (LCD) or a cathode ray tube (CRT)). The computer system **400** also includes an alphanumeric input device **412** (e.g., a keyboard and/or touchscreen), a user interface (UI) navigation device **414** (e.g., a mouse), a disk drive unit **416**, a signal generation device **418** (e.g., a speaker) and a network interface device **420**.

Machine-Readable Medium

The disk drive unit **416** includes a machine-readable medium **422** on which is stored one or more sets of instructions and data structures (e.g., software) **424** embodying or utilized by any one or more of the methodologies or functions described herein. The instructions **424** may also reside, completely or at least partially, within the main memory **404** and/or within the processor **402** during execution thereof by the computer system **400**, the main memory **404** and the processor **402** also constituting machine-readable media.

While the machine-readable medium **422** is shown in an example embodiment to be a single medium, the term "machine-readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more instructions or data structures. The term "machine-readable medium" shall also be taken to include any tangible medium that is capable of storing, encoding or carrying instructions for execution by the machine and that cause the machine to perform any one or more of the methodologies of the present invention, or that is capable of storing, encoding or carrying data structures utilized by or associated with such instructions. The term "machine-readable medium" shall accordingly be taken to include, but not be limited to, solid-state memories, and optical and magnetic media. Specific examples of machine-readable media include non-volatile memory, including by way of example semiconductor memory devices, e.g., Erasable Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM), and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks.

Transmission Medium

The instructions **424** may further be transmitted or received over a communications network **426** using a transmission medium. The instructions **424** may be transmitted using the network interface device **420** and any one of a number of well-known transfer protocols (e.g., HTTP). Examples of communication networks include a local area network ("LAN"), a wide area network ("WAN"), the Internet, mobile telephone networks, Plain Old Telephone (POTS) networks, and wireless data networks (e.g., WiFi and WiMax networks). The term "transmission medium" shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine, and includes digital or analog communications signals or other intangible media to facilitate communication of such software.

Snoring Detection Techniques

In addition to the techniques described above, this disclosure is directed to techniques for detection of various aspects of a user of the system architecture **300**. For example, and as described in further detail below, user snoring can be detected using various techniques described in this disclosure

In a first technique for snoring detection, the system architecture **300** can detect biometric parameters of a user such as motion, respiration, and heartbeat. These biometric parameters can be detected both while the user is awake and while the user is sleeping. In various examples, the biometric parameters can be used to determine a sleep state of the user and whether the user is snoring. Techniques for monitoring a user's sleep using heart rate information, respiration rate information, and other user information are disclosed in U.S. Patent Application Publication No. 20100170043 to Steven J. Young et al., titled "APPARATUS FOR MONITORING VITAL SIGNS," the entire content of which is incorporated herein by reference. After snoring is detected, the system architecture **300** and, in particular, the central controller **302**, can make one or more adjustments to the sleep environment or the bed **301** as will be discussed in further detail below. In an example, the user can instruct the system architecture **300** to monitor for snoring after the user falls asleep and to initiate specific changes to the sleep environment or the bed **301** upon detection of snoring. In another example, the system architecture **300** can automatically, e.g., without user instruction, monitor for snoring and determine what changes should be made, if any, to the sleep environment or the bed **301**. In yet another example, when two users are lying on the bed **301** side-by-side, the system architecture **300** can determine which of the users is snoring and initiate the changes to that user's side of the bed.

In accordance with this disclosure, the central controller **302**, or another processing means associated with the bed **301**, can detect user sleeping motion, respiration, and heartbeat via pressure changes. For example, the pressure transducer **46** (of FIG. **2**) can be used to monitor the air pressure in the air mattress of the bed **301**. If the user on the air mattress is not moving, the air pressure changes in the mattress can be relatively minimal, and can be attributable to respiration and

heartbeat. When the user on the air mattress is moving, however, the air pressure in the mattress can fluctuate by a much larger amount. Thus, the pressure signals generated by the pressure transducer **46** and received by the central controller **302** can be filtered and indicated as corresponding to motion, heartbeat, or respiration.

In one example implementation, the central controller **302** can execute instructions that cause the pressure transducer **46** to measure air pressure values at a predefined sample rate. The central controller **302** can store the pressure signals in a memory device. Processing of the pressure signals can be performed by the central controller **302**, or at a location remote from the bed **301**, such as on a processor of a smartphone, a mobile device, or a cloud-based computing system.

As indicated above, the central controller **302** can determine a user's sleep state, e.g., rapid eye movement ("REM") or non-rapid eye movement ("NREM"), by using one or more of the biometric parameters. In an example, the central controller **302** can execute instructions to monitor the snoring state of the user only after the user has reached a particular sleep state.

FIG. **5** is a flow diagram depicting an example method (**500**) of detecting snoring using biometric parameters. In FIG. **5**, the central controller **302** executes instructions that cause a pressure sensing means, such as the pressure transducer **46** of FIG. **2**, to measure pressure variations (**502**). In an example, the pressure can be measured continuously or at a predetermined sample rate. The central controller **302** can analyze the pressure changes detected by the pressure sensing means (**504**). Using information derived from these analyzed pressure changes, one or more biometric parameters can be determined (**506**). After determining the one or more biometric parameters of the user, the central controller **302** can compare the biometric parameters with predetermined values, ranges, or patterns which are indicative of snoring (**508**). In this manner, the central controller **302** can identify snoring by the user (**510**). After user snoring has been identified, the central controller **302** can continue to monitor the user (**512**) to determine if the snoring ceases, becomes more severe, becomes less severe, or remains at a substantially constant level.

As previously mentioned, in some example implementations, the techniques for detecting the user's sleep state can be combined with the techniques for detecting snoring using biometric parameters. For example, prior to monitoring pressure changes using the pressure sensing means to determine whether the user is snoring, the central controller **302** can determine whether the user has reached a predetermined sleep state. Thus, determining that the user has reached the predetermined state of sleep can be a prerequisite to instructing the central controller **302** to perform the method **500** described above. Alternatively, the central controller **302** can execute instructions to monitor sleep state and pressure changes simultaneously or substantially simultaneously, and the combined results can be used to determine whether the user is snoring.

In another technique for snoring detection, the system architecture **300** can be configured to detect snoring by monitoring sound waves through a microphone, which can be included in the voice controller **316** as discussed above. In various examples, the system architecture **300** can also be configured to detect snoring by monitoring a combination of both sound waves and biometric parameters. In general, snoring sounds are formed when tissues in the user's throat vibrate as air if flowing through the throat during sleep. In one example implementation, the central controller **302** can execute instructions that cause the voice controller **316** to monitor sound waves generated by the user, and to store the corresponding sound wave signals in a memory device. Processing of the sound wave signals can be performed by the central controller **302**, or at a location remote from the bed **301**. A snoring state can be determined by monitoring parameters such as the audible level of the sound waves, the frequency of the sound waves, sound wave patterns, and the like. For example, sound waves generated during normal conversation levels of a user may be 40 decibels or less, while sound waves generated by the user's snoring may be in the range of 60-90 decibels or more. By analyzing the sound waves generated by the user, the presence, intensity, duration, and patterns of snoring can be determined.

FIG. **6** is a flow diagram depicting an example method (**600**) of detecting snoring using sound waves. In FIG. **6**, the central controller **302** executes instructions that cause the voice controller **316** to measure sound waves (**602**). In an example, the sound waves can be measured continuously or at a predetermined sample rate. The central controller **302** can determine baseline parameters of the sound waves (**604**) when the user is falling asleep. Then, the central controller **302** can monitor for changes in the current audible level, frequency, and wave patterns (**606**). If the central controller **302** detects one or more changes with respect to the baseline parameters, the central controller **302** can compare the current parameters with predetermined values or ranges of audible levels and frequencies, as well wave patterns, which are indicative of snoring (**608**). In this manner, the central controller **302** can identify snoring by the user (**610**). After user snoring has been identified, the central controller **302** can continue to monitor the user (**612**) to determine if the snoring ceases, becomes more severe, becomes less severe, or remains at a substantially constant level.

Once again, in some example implementations, the techniques for detecting the user's sleep state can be combined with the techniques for detecting snoring using sound waves. For example, prior to monitoring sound waves using the voice controller **316** to determine whether the user is snoring, the central controller **302** can determine whether the user has reached a predetermined sleep state. Thus, determining that the user has reached the predetermined state of sleep can be a prerequisite to instructing the central controller **302** to perform the method **600** described above. Alternatively, the central controller **302** can execute instructions to monitor sleep state and sound waves simultaneously or substantially simultaneously, and the combined results can be used to determine whether the user is snoring.

Snoring Detection Response Techniques

FIG. **7** is a flow diagram depicting an example method (**700**) of initiating one or more adjustments upon detecting that a user is snoring. In FIG. **7**, the central controller **302** executes instructions to determine whether the user is snoring (**702**). Various examples include, but are not limited to, detecting snoring based on analysis of biometric parameters or based on sound waves. When user snoring has been detected, the system architecture **300** and, in particular, the central controller **302**, can execute instructions that cause one or more adjustments to the sleep environment and/or the bed **301** to be implemented (**704**). A non-exhaustive listing and discussion of these various changes is provided below. When the snoring ceases, the central controller **302** can optionally execute instructions that cause one or more of the previous adjustments made to the sleep environment and/or the bed **301** to revert back to the pre-snoring state or condition (**706**). These optional "re-adjustments" can occur immediately upon

detecting that the snoring has ceased, or after a predetermined amount of time has passed since the last snore has been detected.

In an example, the central controller **302** can execute instructions that cause the firmness controller **304** to adjust pressure in the air mattress of the bed **301** when snoring is detected (**704**). For example, the central controller **302** can provide commands to the firmness controller **304** to increase or decrease pressure in the air mattress, via the pump **305**, to a level that can help relieve the snoring. If the system architecture **300** detects that snoring continues even after the pressure in the air mattress has been modified, the central controller **302** can provide additional commands to the firmness controller **304** to further adjust the pressure in the air mattress. Thus, the process of adjusting pressure in the air mattress of the bed **301** to relieve snoring can be iterative. Additionally, if the air mattress includes multiple bladders corresponding to separate zones as discussed above, the central controller **302** can execute instructions that cause the firmness controller **304** to adjust pressure in one or more selected zones, such as the zone corresponding to the head of the user.

In another example, the central controller **302** can execute instructions that cause an adjustment to be made to the foundation **307** when snoring is detected (**704**). As discussed above, the foundation **307** may include more than one zone, such as a head portion **318** and a foot portion **320**, which may be independently adjusted. The user may fall asleep with the foundation **307** in a "flat" position, or with the head portion **318** and/or the foot portion **320** in a raised, articulated position. In various examples, the bed **301** can include a "snore" position defined by a predetermined articulation of the foundation **307**. It has been found that, in some cases, snoring can be reduced or prevented by elevating the head of the snoring user by a small amount, which can reduce vibration of the soft tissue in the user's throat. The slight elevation of the snoring user's head can also induce the snorer to change his or her sleeping position, which can cause the snoring to stop. In an example, the snore position can include the head portion **318** being raised at a preset angle θ relative to horizontal. In an example, the angle θ can be from about 5° to about 15° from horizontal, such as about 7°. However, any angle θ that can help reduce or eliminate vibration of soft tissue within the throat of the user can be used. In various examples, the snore position can be customizable to a particular user based on the amount of articulation that is found to help relieve snoring in that user. For example, a large, heavy-set user may require a larger inclination angle than a thin, petite user. Thus, preprogrammed snore positions can be updated in accordance with user preferences and body types.

In another example, the central controller **302** can execute instructions that cause the temperature controller **308** to adjust a temperature of the bed **301** when snoring is detected (**704**). As discussed above, in various examples, the temperature of the bed **301** (and thus, the user) can be regulated using a pad placed on top of the mattress, a blanket placed on top of the user, or heating/cooling elements incorporated into the mattress, such as a heating/cooling pad integrated into the mattress. Certain users may tend to snore more or less depending on their body temperature and the temperature of the surroundings, such as the bed **301**. Thus, heating up or cooling down the bed **301** can help some users find relief from snoring. For example, the temperature of the sleeping surface of the bed **301** could be lowered from 20° Celsius to 18° Celsius when snoring is detected. However, any temperature change, whether positive or negative, can be utilized. Similarly, the central controller **302** can execute instructions that cause the thermostat device **315** to adjust the temperature of the surrounding environment, such as the bedroom where the bed **301** is located, when snoring is detected (**704**). In view of the foregoing, user temperature can be regulated through use of the temperature controller **308**, the thermostat device **315**, or both.

The level of light and sound in a bedroom environment can affect the depth and quality of sleep for a user. Thus, when the goal is to alleviate snoring and provide a more restful night of sleep, light and sound can also be controlled to provide an ideal set of sleep conditions. In another example, the central controller **302** can execute instructions for controlling the power status (e.g., on or off) or intensity of light elements **311** or **322**A-F placed on and around the bed, and/or for controlling the power status or volume of one or more audio/visual components **313** located near the bed, when snoring is detected (**704**).

Sleep Profile Reporting

In accordance with the present disclosure, the system architecture **300** can also enable feedback related to snoring to be provided to the user. In various examples, the snoring information processed and analyzed by the central controller **302** can be provided to the user in various formats and to various devices.

In an example, the central controller **302** can execute instructions that cause a sleep profile report to be generated and transmitted to one or more of the remote controller **312**, the remote controller **314**, or an external computing device such as, for example, a personal computer (PC), a tablet PC, a Personal Digital Assistant (PDA), or the like. The external computing device can be operably coupled to the bed **301** via any suitable network connection, including those previously described.

FIG. **8** is a diagram illustrating a sleep profile report **800** generated on a laptop computer **802**. In an example, the sleep profile report **800** can indicate the total amount of time that the user was asleep during the night (or day). The sleep profile report **800** can also indicate the times at which the user fell asleep and woke up. The total amount of time that the user was asleep can be determined using any suitable technique, including monitoring pressure changes in an air mattress as discussed above and deriving the sleep time from information related to the user's state of sleep throughout the night. As further shown in FIG. **8**, the sleep profile report **800** can quantify the amount of time that the user was found to be snoring while asleep during the night. In various examples, the snoring duration can be presented as a total number of hours and minutes, as a percentage, or both.

Sleep profile reports **800** can be stored in memory associated with the system architecture **300** for recall at a later time. In an example, the central controller **302** can execute instructions that cause the sleep profile report **800** to display the amount of sleep that a user has averaged over a specified number of days, and the amount of snoring that the user has averaged during that time. For example, the sleep profile report **800** shows average sleep and snoring over the previous 30 days. However, a number of days greater than or less than 30 can also be used.

Although various embodiments have been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof, show by way of illustration, and not of limitation, specific embodiments in which the subject matter may be practiced. The embodiments illustrated are described in suf-

ficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various embodiments is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled. As is common, the terms "a" and "an" may refer to one or more unless otherwise indicated.

The invention claimed is:

1. A bed system comprising:
an inflatable air mattress;
an adjustable foundation;
a pressure sensor for sensing pressure of the air mattress;
a pump; and
a central controller comprising:
a processor configured to:
analyze pressure signals obtained from the pressure sensor to determine one or more biometric parameters for a user on the air mattress;
compare the one or more biometric parameters with predetermined values, the predetermined values being indicative of snoring;
determine whether the user on the air mattress is snoring based on comparing the one or more biometric parameters with the predetermined values; and
transmit, in response to determining that the user is snoring, at least one instruction to adjust a head position of the adjustable foundation.

2. A method comprising:
determining, at the central controller of the bed system of claim **1**, whether the user is snoring; and
in response to determining that the user is snoring, adjusting a head position of the adjustable foundation of the bed system.

3. The method of claim **2**, wherein the bed system includes the inflatable air mattress supported by the adjustable foundation.

4. The method of claim **3**, further comprising adjusting a pressure of the inflatable air mattress, in response to determining that the user is snoring.

5. The method of claim **2**, wherein determining whether a user is snoring comprises measuring sound waves using a sound measuring device.

6. The bed system of claim **1**, wherein the processor is configured to adjust a pressure of the air mattress, in response to determining that the user is snoring.

7. The bed system of claim **1**, wherein the processor is configured to determine whether a user on the air mattress is snoring based on sound waves generated by the user.

8. The bed system of claim **1**, wherein the pump is operably connected to the inflatable air mattress and the pressure sensor comprises a pressure transducer positioned in the pump and fluidically connected to both a manifold of the pump and to the inflatable air mattress.

9. The bed system of claim **1**, further comprising:
a first air chamber; a first pressure sensor for sensing air pressure of the first air chamber a second air chamber; and a second pressure sensor for sensing air pressure of the second air chamber
wherein the processor is further configured to:
detect biometric parameters for a first user supported by the first air chamber;
detect biometric parameters for a second user supported by the second air chamber;
determine, based on the biometric parameters detected for the first and second users, that one of the first and second users is snoring;
transmit, in response to determining that one of the first and second users is snoring, at least one instruction to adjust a head position of a portion of the adjustable foundation supporting one of the first or second air chambers based on determining which of the first and second users is snoring.

10. The bed system of claim **1**, wherein comparing the one or more biometric parameters with the predetermined values indicative of snoring is performed in response to determining that the user has reached a predetermined sleep state.

11. A bed system comprising:
an inflatable air mattress;
an adjustable foundation;
a pressure sensor for sensing pressure of the air mattress; and
a central controller comprising:
a pump; and
a processor configured to:
determine whether a user on the air mattress is snoring based on pressure signals obtained from the pressure sensor;
transmit, in response to determining that the user is snoring, at least one instruction to adjust a head position of the adjustable foundation;
transmit, in response to determining that the user is snoring, at least one instruction to adjust a pressure in the inflatable air mattress;
transmit, in response to determining that the user is snoring, at least one instruction to adjust a temperature;
transmit, in response to determining that the user is snoring, at least one instruction to adjust a light;
transmit, in response to determining that the user is snoring, at least one instruction to adjust a sound volume; and
transmit, in response to determining that the user is snoring, at least one instruction to adjust a vibration.

* * * * *

专利名称(译)	充气气垫打鼾检测和响应		
公开(公告)号	US9370457	公开(公告)日	2016-06-21
申请号	US14/206841	申请日	2014-03-12
[标]申请(专利权)人(译)	ROB NUNN PALASHEWSKI WADE DANIEL TILSTRA MATTHEW WAYNE STUSYNSKI STACY YOUNG史蒂芬 HEWITT CARL		
申请(专利权)人(译)	NUNN，ROB PALASHEWSKI，WADE DANIEL TILSTRA，MATTHEW WAYNE STUSYNSKI，STACY YOUNG，史蒂芬 HEWITT，CARL		
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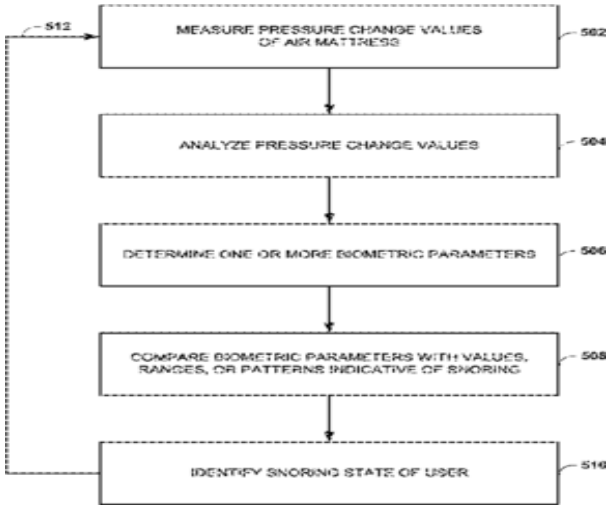
IPC分类号	A47C31/00 A61G7/015 A47C27/08 A61B5/00		
CPC分类号	A61G7/015 A47C27/083 A47C31/00 A61B5/4818 A61B5/6892 A61F5/56 A47C19/025 A47C20/04 A47C21/003 A47C21/006 A47C21/04 A47C27/082 A61B5/4836		
代理机构(译)	FISH & RICHARDSON P.C.		
优先权	61/782394 2013-03-14 US		
其他公开文献	US20140259417A1		
外部链接	Espacenet USPTO		

摘要(译)

可以提供一种方法，包括使用声音测量装置测量声波，在气垫系统的中央控制器处确定声波的一个或多个参数值，将一个或多个参数值与值，范围进行比较，或者指示打鼾的模式，识别用户的打鼾状态，以及利用中央控制器启动对气垫系统的一个或多个可调节特征的改变。


512
MEASURE PRESSURE CHANGE VALUES OF AIR MATTRESS
502
ANALYZE PRESSURE CHANGE VALUES
504
DETERMINE ONE OR MORE BIOMETRIC PARAMETERS
506
COMPARE BIOMETRIC PARAMETERS WITH VALUES, RANGES, OR PATTERNS INDICATIVE OF SNORING
508
IDENTIFY SNORING STATE OF USER
510