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(54) **METHOD AND SYSTEM FOR MULTI-MODE COVERAGE FOR AN AUTONOMOUS ROBOT**

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(52) **U.S. Cl.** **318/568.12**; 318/568.16; 318/568.17; 700/245

(58) **Field of Search** 318/568.12, 568.16, 318/568.17; 700/245

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,674,048	A		6/1987	Okumura	364/424
4,962,453	A	*	10/1990	Pong et al.	701/23
5,086,535	A	*	2/1992	Grossmeyer et al.	15/319
5,109,566	A		5/1992	Kobayashi et al.	15/319
5,204,814	A	*	4/1993	Noonan et al.	701/25
5,284,522	A		2/1994	Kobayashi et al.	134/18
5,321,614	A	*	6/1994	Ashworth	701/26
5,341,540	A	*	8/1994	Soupert et al.	15/319
5,548,511	A	*	8/1996	Bancroft	701/23
5,682,313	A	*	10/1997	Edlund et al.	342/127
5,867,800	A	*	2/1999	Leif	701/23
5,935,179	A		8/1999	Kleiner et al.	701/23
5,940,927	A		8/1999	Haegermarck et al.	15/319
5,942,869	A	*	8/1999	Katou et al.	318/568.12
6,076,025	A	*	6/2000	Ueno et al.	701/23
6,076,226	A		6/2000	Reed	15/319
6,240,342	B1		5/2001	Fiegert et al.	701/25
6,327,741	B1		12/2001	Reed	15/319
6,370,453	B2	*	4/2002	Sommer	701/23
6,389,329	B1		5/2002	Colens	700/262
6,459,955	B1		10/2002	Bartsch et al.	700/245
6,463,368	B1	*	10/2002	Feiten et al.	701/23
6,481,515	B1		11/2002	Kirkpatrick et al.	180/25.1
6,493,612	B1		12/2002	Bisset et al.	701/23

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

JP	60259895	6/1987
JP	60293095	7/1987
JP	63-183032	7/1988
JP	62074018	10/1988
JP	2-6312	1/1990

(List continued on next page.)

OTHER PUBLICATIONS

Doty, Keith L. et al., "Sweep Strategies for a Sensory–Driven, Behavior–Based Vacuum Cleaning Agent," AAAI 1993 Fall Symposium Series, US.

Karcher RC 3000 Cleaning Robot—user Manual. Manufacturer: Alfred Karcher GmbH & Co., Cleaning Systems, Alfred–Karcher–Str. 28–40, P.O. Box 160, D–71349 Winnenden, Germany, Dec. 2002.

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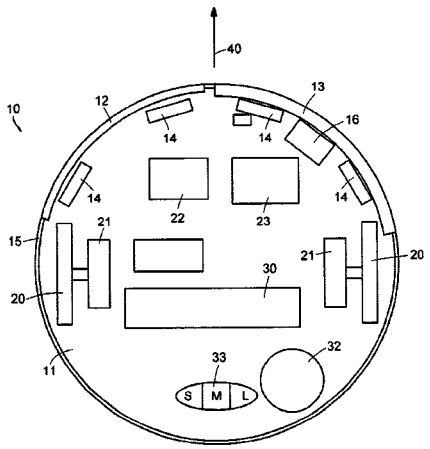
(57) **ABSTRACT**

A control system for a mobile robot (**10**) is provided to effectively cover a given area by operating in a plurality of modes, including an obstacle following mode (**51**) and a random bounce mode (**49**). In other embodiments, spot coverage, such as spiraling (**45**), or other modes are also used to increase effectiveness. In addition, a behavior based architecture is used to implement the control system, and various escape behaviors are used to ensure full coverage.

42 Claims, 16 Drawing Sheets