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**UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NEW JERSEY**

AQUA PRODUCTS, INC.,

Plaintiff,

-against-

SMARTPOOL, INC. and
RICHARD HOLSTEIN,

Defendants.

Civil Action No. 05-5856(SRG)

**COMPLAINT and
JURY DEMAND**

The plaintiff, Aqua Products, Inc. ("Aqua Products"), alleges as follows:

NATURE OF THE CASE

1. This is an action seeking injunctive relief and damages for patent infringement arising from violations of the Patent Act of the United States, more particularly 35 U.S.C. §§ 271 and 281, for cyber-piracy in violation of the Trademark Act of the United States, more particularly 15 U.S.C. § 1125(d), for trademark infringement in violation of the Trademark Act of the United States, more particularly 15 U.S.C. § 1114(1); for false designation of origin in violation of the Trademark Act of the United States, more particularly 15 U.S.C. § 1125(a), for unfair competition causing injury to plaintiff's business reputation and dilution of the distinctive quality of its unique and distinctive trademarks in violation of the Trademark Act of the United States, more particularly 15 U.S.C. § 1125(c), for the use of false or misleading descriptions or representations of fact in violation of the Trademark Act of the United States, more particularly 15 U.S.C. § 1125(a), and for pending acts of trademark infringement in violation of New Jersey statute, more particularly, N.J. Stat. § 56:3-13.16, unfair competition in violation of New Jersey statute, more particularly, N.J. Stat. § 56:4-1, and unfair competition in violation of the common law.

JURISDICTION AND VENUE

2. This Court has jurisdiction over the subject matter of this action pursuant to 15 U.S.C. § 1121 (Lanham Act), 28 U.S.C. § 1331 (federal question), 28 U.S.C. § 1338 (patent, trademark and copyright), and pursuant to 28 U.S.C. § 1367 (supplemental jurisdiction).

3. Venue is proper in the District of New Jersey pursuant to 28 U.S.C. §§ 1391(b) and (c).

THE PARTIES

4. Aqua Products is and was at all relevant times a corporation organized and existing under the laws of the State of Delaware, with offices at 25 Rutgers Avenue, Cedar Grove, New Jersey.

5. Aqua Products is a manufacturer and distributor of high quality, state-of-the-art robotic pool cleaning devices for residential and commercial markets.

6. Upon information and belief, the defendant Smartpool, Inc. ("Smartpool") is and was at all relevant times a corporation organized under the laws of the State of Delaware, with offices at 575 Prospect Street Lakewood, New Jersey.

7. Upon information and belief, Smartpool manufactures and distributes swimming pool products including robotic pool cleaners, and does business within this judicial district.

8. Upon information and belief, the defendant, Mr. Holstein is an individual doing business in this jurisdiction.

9. Upon information and belief, Mr. Holstein is a principal owner and/or corporate officer of Smartpool and has actively and knowingly aided and abetted in the commission of the infringing acts of the corporate defendant.

10. Upon information and belief, Smartpool is the alter ego of Mr. Holstein and both defendants have cooperated in furtherance of the acts complained of herein.

FACTS COMMON TO ALL CAUSES OF ACTION

11. For over 20 years, Aqua Products has developed and sold the most comprehensive line of high quality, state-of-the art robotic pool cleaners for residential and commercial markets in nearly 40 countries.

12. Aqua Products is a leader in the development of new technology to improve robotic pool cleaners and has patented many of its innovative technologies.

13. Aqua Products is the owner of U.S. Patent N^o. 6,742,613 ("613 Patent"), among others, for water jet reversing propulsion and directional controls for automated swimming pool cleaners, a copy of which is attached as Exhibit 1.

14. Aqua Products is the owner of U.S. Patent N^o. 6,099,658 ("658 Patent"), for an apparatus and method of operation for high-speed swimming pool cleaner, a copy of which is attached as Exhibit 2.

15. Aqua Products is the owner of U.S. Patent N^o. 6,758,226 ("226 Patent"), among others, for an automated pool cleaning apparatus including motion detection and directional control, a copy of which is attached as Exhibit 3.

16. For residential use, Aqua Products manufactures robotic pool cleaners identified by the trademarks Aquabot, Aquabot Pool Rover, Aquabot Pool Rover Plus, Aquabot Turbo, Aquabot Turbo Remote Control, Aquabot Turbo Solo Remote Control, Aquabot Plus Remote Control, Aquabot Ultra, Ultra, Viva, and Bravo.

17. For commercial applications, Aqua Products manufactures robotic pool cleaners identified by the trademarks the AquaMax, AquaMax Junior HT, AquaMax Junior Plus, AquaMax BiTurbo, AquaMax BiTurbo Remote Control, UltraMax, and UltraMax Junior.

18. Aqua Products robotic pool cleaners are unmatched in quality, features, service and benefits. Over the years, many competitors have tried to copy Aqua Products' patented technology. Many of these copy-cat products appear similar but have significant engineering and mechanical differences.

19. Other competitors have tried to appropriate and trade on the goodwill and consumer recognition of Aqua Products' trademarks, or to disseminate false and misleading advertising concerning their or Aqua Products' pool cleaners.

20. The defendants have undertaken a strategy and scheme to unlawfully compete with Aqua Products, and to mislead and cheat the public by, *inter alia*, copying Aqua Product's patented innovations and products, and by misleading the public by suggesting that their products originate and are affiliated with, or are sponsored by Aqua Products, or by distributing advertising and promotional materials that misstate the features and attributes of their and/or Aqua Products' pool cleaners.

21. The defendants' conduct includes their infringement of Aqua Products' '613 Patent, the '658 Patent and the '226 Patent, as well as their systematic registration of numerous Internet uniform resource locators ("URLs") that incorporated and were confusingly similar, if not identical, to Aqua Products's distinctive trademarks, *e.g.*, Smartpool registered "aquabot2.com".

22. The defendants configured these URLs so that visitors were forwarded, immediately and without any notice, to Smartpool's home page.

23. When members of the public accessed a URL that incorporated one of Aqua Products' trademarks, such as the "aquabot2.com" URL, and were immediately forwarded to the Smartpool home page, they were likely to be confused and assume there was a connection, sponsorship or affiliation between Aqua Products and the defendants and their products.

24. The defendants also distributed a Commercial Robotic Cleaners Comparison Chart that misstates the "ETL" approval status of Aqua Products' pool cleaners, as well as the features and attributes for several of Aqua Products' pool cleaners.

25. By this action Aqua Products seeks to enjoin this deliberate scheme to infringe its patents, to deliberately confuse the trade and public concerning the source, origin or sponsorship of the defendants' products and services, to trade upon and destroy Aqua Products's distinctive trademarks, business reputation and good will, and to mislead the public by distributing false advertising, promotional and marketing materials.

26. Aqua Products further seeks monetary damages for the injury incurred as a result of the defendants' activities.

Aqua Products' Patents

27. The '613 patent, relates to water jet reversing propulsion and directional controls for automated swimming pool cleaners, issued on June 1, 2004.

28. The '613 patent was duly and legally assigned to Aqua Products, its current owner.

29. The '613 patent relates to a robotic pool or tank cleaner that is supported by wheels that are mounted on fixed or movable axles that form an acute angle with the longitudinal axis of the pool cleaner's body when the cleaner moves in either or both of two opposing directions to thereby provide a variable path as the device moves back and forth across the bottom surface of the pool or tank that is being cleaned.

30. The '658 patent, relates to an apparatus and method of operation for high-speed swimming pool cleaner, issued on August 8, 2000.

31. The '658 patent was duly and legally assigned to Aqua Products, its current owner.

32. The '658 patent relates to an apparatus and method for cleaning the bottom and vertical side walls of a swimming pool, pond or tank and employs a robotic, self-propelled cleaner having a protective housing of conventional design, the cleaner being operated at a primary cleaning speed as it traverses the surfaces to be cleaned and until the cleaner housing emerges from the water along a sidewall of the pool.

33. As discussed in the '658 Patent, the cleaner is adapted to operate at a secondary drive speed that is relatively slower than the primary speed and the cleaner thereafter reverses direction and descends for a pre-determined period of time at the slower secondary speed in order to permit the air entrained under the housing to escape without destabilizing the cleaner during descent. After the predetermined period of time, the cleaner resumes operation at the more rapid primary speed until the cleaner housing once again emerges from the water's surface, after which the cycle is repeated.

34. The '226 Patent, relates to an automated power-driven pool cleaning apparatus including a programmable control device for directing the movement of the cleaning apparatus, and issued on July 6, 2004.

35. The '226 Patent was duly and legally assigned to Aqua Products, its current owner.

Aqua Products's Trademarks

36. Aqua Products has sold its products in interstate commerce for over 20 years, and has prominently identified the same using the following trademarks:

Aquahot;
Aquahot Pool Rover;
Aquahot Pool Rover Plus;
Aquahot Turbo;
Aquahot Turbo Remote Control;
Aquahot Turbo Solo Remote Control;
Aquahot Plus Remote Control;
Aquahot Ultra;
Ultra;
Viva;
Bravo;
AquaMax;
AquaMax Junior HT;
AquaMax Junior Plus;
AquaMax BiTurbo;
AquaMax BiTurbo Remote Control;
UltraMax;
UltraMax Junior; and
Power Handi Vac (collectively, the "Aqua Products Trademarks").

37. Aqua Products has expended substantial sums on promotion and advertising in order to establish and maintain the trade's and public's awareness and recognition of the Aqua Products Trademarks and to develop an association in the public's and trade's mind between its trademarks and its services and products.

38. Long before the acts of the defendants complained of herein, as the result of the promotion and sale of services and goods identified by the Aqua Products Trademarks, and as a result of the high quality of services and goods offered in connection with the Aqua Products Trademarks, they have acquired a valuable reputation and are now recognized by the trade and consumers as originating from and being associated only with Aqua Products.

39. As a direct result of this usage, the unique and distinctive Aqua Products Trademarks are well-known, famous, are associated by the trade and public with Aqua Products, and represent a business and goodwill of significant and inestimable value to it.

40. Aqua Products is the owner of Federal Trademark Registration No. 2,700,593 for the trademark "AQUABOT TURBO". The registration issued on March 25, 2003, is registered on the principal register maintained by the United States Patent and Trademark Office, and is valid and subsisting.

41. Aqua Product's federal trademark registration puts defendants on constructive notice, pursuant to 15 U.S.C. § 1072, of its trademark rights.

Defendants' Patent Infringement

42. The defendants manufacture, and/or sell, and/or induce others to use and sell pool cleaning products some of which are identified as the "Dolphin" and "Robo-Kleen" and which, upon information and belief, embody the subject matter protected under the '613 Patent, the '658 Patent and the '226 Patent.

43. Aqua Products has advised the defendants that their products infringe the '613 Patent, the '658 Patent and the '226 Patent and have demanded that they cease the manufacture and sale of such products.

44. The defendants have refused to comply with plaintiff's demands.

Defendants' Cyber-Piracy and Trademark Infringement

45. Aqua Products learned that Smartpool systematically and maliciously registered the following Internet URLs:

aquahot-storm.com;
aquabot2.com;
aquabotautomaticpoolcleaner.com;
aquabotbravo.com;
aquabotcleaners.com;
aquabotpoolrover.com;
aquabotpoolroverplus.com;
aquabotpoolvacuum.com;
aquahotpoolvacuums.com;
aquabotroboticpoolcleaner.com;
aquabotrover.com;
aquahotterminator.com;
aquabotturbopoolcleuner.com;
aquabotultra.com; and
aquabotviva.com (collectively the "Infringing URLs").

46. When any of the Infringing URLs were opened, the user was forwarded to Smartpool's home page at "<http://www.smartpool.com/> website/".

47. The defendants used the Infringing URLs in interstate commerce without the permission, authority or consent of Aqua Products.

48. Upon information and belief, defendants recently ceased use and abandoned ownership of the Infringing URLs.

49. Upon information and belief, the defendants used the Infringing URLs with actual knowledge of Aqua Products's use, rights in, and registration of its well-known and famous Aqua Products Trademarks.

50. Upon information and belief, the registration of the Infringing URLs, and the forwarding of visitors to the Smartpool home page appropriated and infringed the Aqua Products Trademarks, and falsely suggested that defendants' services, products and website originated with, or were sponsored by Aqua Products, and that their services, products and website were in some way affiliated with Aqua Products.

51. Upon information and belief, the defendants infringing activities was systematically undertaken with an intent to profit from the reputation and value of the Aqua Products Trademarks.

Defendants' False Advertising

52. Aqua Products learned that the defendants were disseminating to dealers and distributors of robotic swimming pool cleaners a document entitled the "Commercial Robotic Cleaners Comparison Chart" ("Comparison Chart"), which includes false and misleading information.

53. The Comparison Chart misstates the maximum pool lengths, filter surface, number of gallons filtered per hour, bottom inlet size, and cable length for the several of Aqua Products' pool cleaners.

54. The Comparison Chart also misstates the "ETL" approval status of several of Aqua Products' pool cleaners.

55. The aforementioned activities will cause irreparable injury to Aqua Products.

**AS AND FOR A FIRST CLAIM FOR RELIEF FOR PATENT
INFRINGEMENT PURSUANT TO 35 U.S.C. §§ 271 AND 281**

56. Aqua Products rec alleges paragraphs 1 through 55 as if fully set forth herein.

57. The defendants have and are infringing the '613 Patent by manufacturing, importing, offering for sale and by selling pool cleaning products which embody the subject matter of the patented invention of the '613 Patent, in the District of New Jersey and elsewhere in the United States, in violation of the patent laws of the United States.

58. Upon information and belief, the defendants have actual notice of Aqua Products' patent rights.

59. Upon information and belief, the defendants have continued to commit acts of infringement of the '613 Patent, despite notice of Aqua Products's rights under the '613 Patent, within the District of New Jersey and elsewhere in the United States, and will continue to do so unless enjoined by this Court.

60. Upon information and belief, despite knowledge of Aqua Products's rights under the '613 Patent, the defendants have continued to actively induce infringement of the '613 Patent within the District of New Jersey and elsewhere in the United States and will continue to do so unless enjoined by this Court.

61. Aqua Products does not have an adequate remedy at law.

62. Upon information and belief, defendants' infringement and active inducement of infringement is willful, intentional and deliberate, and has deprived Aqua Products of sales and profits which lawfully belong to it and which it otherwise would have made.

63. On account of the defendants activities in this State and District of New Jersey and throughout the United States Aqua Products has been injured in an amount not yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

64. This is an exceptional case within the provisions of 35 U.S.C. § 285 and Aqua Products is therefore, entitled to the recovery of its attorneys' fees upon prevailing in this action.

**AS AND FOR A SECOND CLAIM FOR RELIEF FOR PATENT
INFRINGEMENT PURSUANT TO 35 U.S.C. §§ 271 AND 281**

65. Aqua Products realleges paragraphs 1 through 55 as if fully set forth herein.

66. The defendants have and are infringing the '658 Patent by manufacturing, importing, offering for sale and by selling pool cleaning products which embody the subject matter of the patented invention of the '658 Patent, in the District of New Jersey and elsewhere in the United States, in violation of the patent laws of the United States.

67. Upon information and belief, the defendants have actual notice of Aqua Products' patent rights.

68. Upon information and belief, the defendants have continued to commit acts of infringement of the '658 Patent, despite notice of Aqua Products's rights under the '658 Patent, within the District of New Jersey and elsewhere in the United States, and will continue to do so unless enjoined by this Court.

69. Upon information and belief, despite knowledge of Aqua Products's rights under the '658 Patent, the defendants have continued to actively induce infringement of the '658 Patent within the District of New Jersey and elsewhere in the United States and will continue to do so unless enjoined by this Court.

70. Aqua Products does not have an adequate remedy at law.

71. Upon information and belief, defendants' infringement and active inducement of infringement is willful, intentional and deliberate, and has deprived Aqua Products of sales and profits which lawfully belong to it and which it otherwise would have made.

72. On account of the defendants activities in this State and District of New Jersey, and throughout the United States, Aqua Products has been injured in an amount not yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

73. This is an exceptional case within the provisions of 35 U.S.C. § 285 and Aqua Products is therefore, entitled to the recovery of its attorneys' fees upon prevailing in this action.

**AS AND FOR A THIRD CLAIM FOR RELIEF FOR PATENT
INFRINGEMENT PURSUANT TO 35 U.S.C. §§ 271 AND 281**

74. Aqua Products realleges paragraphs 1 through 55 as if fully set forth herein.

75. The defendants have and are infringing the '226 Patent by manufacturing, importing, offering for sale and by selling pool cleaning products which embody the subject matter of the patented invention of the '226 Patent, in the District of New Jersey and elsewhere in the United States, in violation of the patent laws of the United States.

76. Upon information and belief, the defendants have actual notice of Aqua Products' patent rights.

77. Upon information and belief, the defendants have continued to commit acts of infringement of the '226 Patent, despite notice of Aqua Products's rights under the '226 Patent, within the District of New Jersey and elsewhere in the United States, and will continue to do so unless enjoined by this Court.

78. Upon information and belief, despite knowledge of Aqua Products's rights under the '226 Patent, the defendants have continued to actively induce infringement of the '226 Patent within the District of New Jersey and elsewhere in the United States and will continue to do so unless enjoined by this Court.

79. Aqua Products does not have an adequate remedy at law.

80. Upon information and belief, defendants' infringement and active inducement of infringement is willful, intentional and deliberate, and has deprived Aqua Products of sales and profits which lawfully belong to it and which it otherwise would have made.

81. On account of the defendants activities in this State and District of New Jersey, and throughout the United States, Aqua Products has been injured in an amount not yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

82. This is an exceptional case within the provisions of 35 U.S.C. § 285 and Aqua Products is therefore, entitled to the recovery of its attorneys' fees upon prevailing in this action.

**AS AND FOR A FOURTH CLAIM FOR RELIEF FOR
CYBERPIRACY PURSUANT TO 15 U.S.C §1125(d)**

83. Aqua Products realleges paragraphs 1 through 55 as if fully set forth herein.

84. The registration of URLs confusingly similar to Aqua Products's distinctive Aqua Products Trademarks was undertaken in bad faith and with the intent to profit thereby.

85. Upon information and belief, the registration and use of the Infringing URLs was intended to appropriate and trade upon the goodwill and reputation associated with the Aqua Products Trademarks, and was undertaken in bad faith and in reckless disregard of the potential damage and injury to Aqua Products and the Aqua Products Trademarks.

86. By reason of the foregoing, the defendants have engaged in acts of cyberpiracy which have injured the Aqua Products Trademarks, business and business reputation in violation of 15 U.S.C. § 1125(d).

87. By reason of the foregoing, Aqua Products has suffered and continues to suffer irreparable injury, including injury to its reputation and the distinctive quality of its distinctive Aqua Products Trademarks, for which it has no adequate remedy at law.

88. On account of the defendants' activities in this State and District of New Jersey, Aqua Products has been damaged in an amount not as yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

**AS AND FOR A FIFTH CLAIM FOR RELIEF FOR
TRADEMARK INFRINGEMENT PURSUANT TO 15 U.S.C. § 1114**

89. Plaintiff realleges paragraphs 1 through 55 as if fully set forth herein.

90. The registration and use of the infringing URLs was without the permission, consent or authorization of Aqua Products, gave rise to a likelihood of confusion, deception and mistake among the consuming public and trade as to the source, origin or sponsorship of the defendants' services and products and constitutes infringement of the Aqua Products registered trademark.

91. Upon information and belief, the defendants registered and used the Infringing URLs with the willful purpose and intent of misleading the trade and public, and trading upon Aqua Products's goodwill and reputation.

92. These acts violate the Trademark Act of the United States and constitute infringement of the Aqua Products' registered trademark in violation of 15 U.S.C. § 1114 *et seq.*

93. On account of the defendants' activities, the trade and public were confused, misled or deceived as to the source, origin or sponsorship of their website, services and products, and Aqua Products has suffered damages including injury to its reputation and goodwill.

94. On account of the defendants' activities in this State and District of New Jersey, Aqua Products has been damaged in an amount not as yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

**AS AND FOR A SIXTH CLAIM FOR RELIEF FOR
FALSE DESIGNATION OF ORIGIN PURSUANT TO 15 U.S.C. § 1125(a)**

95. Aqua Products realleges paragraphs 1 through 55 as if fully set forth herein.

96. The use of the Infringing URLs constituted the offering of goods and services bearing, and the use of false and misleading descriptions and representations of fact in interstate commerce, and violates the Trademark Act of the United States.

97. By reason of the foregoing, the trade and public were confused, misled or deceived, and Aqua Products has suffered damages including injury to its goodwill and reputation for which it has no adequate remedy at law.

98. Upon information and belief, the defendants developed and used the Infringing URLs with knowledge that it is false, misleading and deceptive, and with the intent to unfairly compete with Aqua Products.

99. On account of the activities of the defendants in this State and District of New Jersey, Aqua Products has been damaged in an amount not as yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

**AS AND FOR A SEVENTH CLAIM FOR RELIEF FOR
INJURY TO BUSINESS REPUTATION AND
DILUTION PURSUANT TO 15 U.S.C §1125(c)**

100. Aqua Products realleges paragraphs 1 through 55 as if fully set forth herein.

101. The defendants' conduct was without the permission, consent or authorization of Aqua Products and blurred and tarnished the reputation of Aqua Products's unique, widely recognized, distinctive and famous Aqua Products Trademarks, thereby diminishing their value.

102. Upon information and belief, the aforementioned activity is part of a deliberate plan or scheme intended to appropriate and trade upon the goodwill and reputation of Aqua Products and was undertaken in total disregard of the resultant damage and injury to it.

103. By reason of the foregoing, the defendants have engaged in acts which damaged the business reputation and diluted and blurred the distinctive quality of the Aqua Products Trademarks in violation of the Trademark Act of the United States (15 U.S.C. § 1125(c)).

104. By reason of the foregoing, the trade and public were confused, misled or deceived, and Aqua Products sustained damages including injury to its reputation and dilution of the distinctive quality of its Aqua Products Trademarks.

105. On account of the activities of the defendants in this State and District of New Jersey, including their dilution of the Aqua Products Trademarks, Aqua Products has been damaged in an amount not as yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

**AS AND FOR AN EIGHTH CLAIM FOR RELIEF FOR FALSE
OR MISLEADING DESCRIPTIONS OR REPRESENTATIONS
OF FACT PURSUANT TO 15 U.S.C. § 1125(a)**

106. Plaintiff realleges paragraphs 1 through 55 as if fully set forth herein.

107. The misrepresentations and falsehoods published by the defendants in the Comparison Chart constitute the use of false descriptions and representations in interstate commerce.

108. Upon information and belief, the defendants included the misrepresentations in the Comparison Chart with full knowledge that they were false, misleading and deceptive, and with the intent to unfairly compete with plaintiff.

109. Such acts violate the Trademark Act of the United States and constitute the offering of services and sale of goods using false or misleading descriptions or representations of fact.

110. By reason of the foregoing, the public is likely, and will continue to be confused, misled or deceived, and the plaintiff is now and will continue to suffer irreparable injury, including injury to its good will and reputation for which it has no adequate remedy at law.

111. On account of the activities of the defendants in this State and District of New Jersey, and in interstate commerce, plaintiff has been damaged in an amount not as yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

**AS AND FOR AN NINTH CLAIM FOR RELIEF FOR
TRADEMARK INFRINGEMENT PURSUANT
TO NEW JERSEY STATUTE § 56:3-13.16**

112. Aqua Products realleges paragraphs 1 through 55 as if fully set forth herein.

113. This cause of action arises under New Jersey statute § 56:3-13.16.

114. The registration and use of the Infringing URLs was without the permission, consent or authorization of Aqua Products and gave rise to confusion, deception and mistake among the consuming public and trade as to the source, origin or sponsorship of the defendants' services and products and constitutes infringement of the Aqua Products Trademarks.

115. Upon information and belief, the defendants registered and used the Infringing URLs with the willful purpose and intent of misleading the trade and public, and trading upon Aqua Products's goodwill and reputation.

116. These acts violate the Trademark Act of the United States and constitute infringement of the Aqua Products' registered trademark in violation of the New Jersey Trafficking or Attempting to Traffic in Counterfeit Marks Law, N.J. Stat. § 56:3-13.16.

117. On account of the defendants' activities, the trade and public were confused, misled or deceived as to the source, origin or sponsorship of their website, services and products, and Aqua Products sustained damages including injury to its reputation and goodwill, for which Aqua Products has no adequate remedy at law.

118. On account of the defendants' activities in this State and District of New Jersey, Aqua Products has been damaged in an amount not as yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

**AS AND FOR A TENTH CLAIM FOR RELIEF
FOR UNFAIR COMPETITION PURSUANT
TO NEW JERSEY STATUTE § 56:4-1**

119. Aqua Products realleges paragraphs 1 through 55 as if fully set forth herein.

120. This cause of action arises under New Jersey statute § 56:4-1.

121. The defendants' use of the Infringing URLs misled and confused the public and trade, and damaged Aqua Products' public image and reputation.

122. Upon information and belief, the trade and public falsely attributed the attributes and characteristics of Aqua Products' services and products to those sold by the defendants as a result of their use of the Infringing URLs.

123. By reason of the foregoing, the defendants have engaged in acts of unfair competition in violation of New Jersey statute § 56:4-1.

124. Upon information and belief, the registration and use of the Infringing URLs was undertaken by the defendants with knowledge that doing so was misleading, and with the intent to confuse, mislead and deceive the trade and consumers, and to unfairly compete with Aqua Products.

125. By reason of the foregoing, Aqua Products suffered damages including injury to its goodwill and reputation for which it has no adequate remedy at law.

126. On account of the activities of the defendants in this State and District of New Jersey, and throughout the United States, Aqua Products has been damaged in an amount not as yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

**AS AND FOR AN ELEVENTH CLAIM FOR RELIEF FOR
UNFAIR COMPETITION PURSUANT TO THE COMMON LAW**

127. Aqua Products realleges paragraphs 1 through 55 as if fully set forth herein.

128. This cause of action arises under the common law.

129. The use of the Infringing URLs misled and confused the public and trade, and damaged Aqua Products' public image and reputation.

130. Upon information and belief, the trade and public falsely attributed the attributes and characteristics of Aqua Products' services and products to those sold by the defendants as a result of their use of the Infringing URLs.

131. By reason of the foregoing, the defendants have engaged in acts of unfair competition in violation of the common law.

132. Upon information and belief, the registration and use of the Infringing URLs was undertaken by the defendants with knowledge that doing so was misleading, and with the intent to confuse, mislead and deceive the trade and consumers, and to unfairly compete with Aqua Products.

133. By reason of the foregoing, Aqua Products sustained damages including injury to its goodwill and reputation for which it has no adequate remedy at law.

134. On account of the activities of the defendants in this State and District of New Jersey, and throughout the United States, Aqua Products has been damaged in an amount not as yet ascertained, but believed to be in excess of one million dollars (\$1,000,000.00).

WHEREFORE, Aqua Products demands judgment:

- a. finding that the defendants have copied Aqua Product's patented innovations and products, have mislead the public by suggesting that their products originate and are affiliated with, or are sponsored by Aqua Products, and have distributed advertising and promotional materials that misstate the features and attributes of their and/or Aqua Products' pool cleaners;
- b. preliminarily and permanently enjoining and restraining the defendants, their agents, servants, employees, successors and assigns, and all those acting in concert or participation with them, from:
 - (i) manufacturing, producing, distributing, importing, purchasing or selling pool cleaning products embodying the subject matter of the invention of the '613 Patent, the '658 Patent or the '226 Patent;
 - (ii) engaging in any other activity constituting an infringement of the '613 Patent, the '658 Patent or the '226 Patent;
 - (iii) assisting, aiding or abetting any other person or business entity in engaging in or performing any of the activities referred to herein;
 - (iv) applying for, registering, activating, trafficking in, using or displaying any URL, domain name, e-mail address, hyperlink, metatag or web site using any simulation, reproduction, copy or colorable imitation of the Aqua Products Trademarks;
 - (v) manufacturing, having manufactured, producing, having produced, distributing, circulating, selling, offering for sale, advertising, promoting, using or displaying any services or products using any simulation, reproduction, copy or colorable imitation of the Aqua Products Trademarks;

(vi) making any statement or representation whatsoever, or using any false or misleading descriptions or representations of fact in connection with the manufacture, production, distribution, circulation, sale, offering for sale, advertising, promotion, use or display of any products or services using any simulation, reproduction, copy or colorable imitation of the Aqua Products Trademarks;

(vii) distributing, publishing, distributing, selling or shipping any advertising, marketing, promotional or any other materials that misstate the features and attributes of their and/or Aqua Products' pool cleaners; and

(viii) engaging in any other activity constituting unfair competition with Aqua Products, or constituting infringement of the Aqua Products Trademarks, or any of Aqua Products' rights in, or to use or to exploit said trademarks, or constituting any dilution of the goodwill, name or reputation of Aqua Products;

c. directing that the defendants, at their own expense, recall all pool cleaning products that embody the inventions of the claims of the '613 Patent, the '658 Patent or the '226 Patent which were manufactured, distributed, sold or shipped by them and to reimburse their customers from whom said merchandise was recalled;

d. ordering that any URLs, domain names, e-mail addresses, hyperlinks, metatags or web sites, owned, operated or controlled by the defendants, which use or incorporate any simulation, reproduction, copy or colorable imitation of the Aqua Products Trademarks, whether or not previously returned or surrendered, be permanently transferred to the plaintiff and/or forfeited;

e. directing that the defendants, at their own expense, recall all their marketing, promotional and advertising material which bear or incorporate any misstatements concerning the features and attributes of their and/or Aqua Products' pool cleaners which has been published, distributed, sold or shipped by it, and to reimburse all customers from which said materials are recalled;

f. directing that the defendants deliver to Aqua Products' attorneys or representatives for destruction all products, molds, plates, dies and any other materials in their possession or under their control which embody the inventions of the claims of the '613 Patent, the '658 Patent or the '226 Patent;

g. directing that the defendants deliver to Aqua Products' attorneys or representatives for destruction all products, labels, signs, prints, packages, molds, plates, dies; wrappers, receptacles and advertisements in their possession or under their control bearing any simulation, reproduction, copy or colorable imitation of the Aqua Products Trademarks, and all plates, molds, matrices and any other means of making the same;

h. directing that the defendants deliver to Aqua Products' attorneys or representatives for destruction all copies of the Comparison Chart in their possession or under their control;

i. directing that the defendants file with the Court and serve on Aqua Products' counsel a report in writing and under oath setting forth in detail the manner in which they have complied with any temporary restraining order, or preliminary or permanent injunction entered herein within thirty (30) days of receipt of service of any such order or injunction;

j. directing such other relief as the Court may deem appropriate to prevent the trade and public from being misled or deceived;

k. directing the defendants to account to Aqua Products for actual damages suffered by it, including its lost sales, as a result of the infringement and the active inducement of infringement of the '613 Patent, the '658 Patent and the '226 Patent, directing that such damages be trebled because of the willful and deliberate nature and character of the infringement, together with an assessment of interest, and awarding Aqua Products judgment in that amount against the defendants;

l. directing the defendants to account to Aqua Products for the defendants' unjustly received profits resulting from infringement of the '613 Patent, the '658 Patent and the '226 Patent;

m. awarding Aqua Products its damages caused by defendants' registration and use of the Infringing URLs, and any other URLs, domain names, e-mail addresses, hyperlinks, metatags or web sites, owned, operated or controlled by the defendants, which use or incorporates any simulation, reproduction, copy or colorable imitation of the Aqua Products Trademarks, and the defendants' total profit realized thereby, and that such award be trebled pursuant to 15 U.S.C. § 1114 *et seq.*;

n. awarding Aqua Products maximum statutory damages pursuant to 15 U.S.C. § 1117(d);

o. awarding Aqua Products its compensatory, special and consequential damages including treble statutory damages pursuant to N.J. Stat. § 56:4-2 and N.J. Stat. 56:3-13.16;

p. awarding punitive damages to Aqua Products for defendants' willful and malicious conduct;

q. for an assessment of costs, interest and attorneys' fees incurred by Aqua Products; and


r. for such other and further relief as the Court deems just and proper.

JURY DEMAND

Plaintiff Aqua Products, Inc. hereby demands a trial by jury for all issues so triable.

Dated: December __, 2005
New York, New York

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Counsel for Plaintiff
Aqua Products, Inc.



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

(10) **Patent No.:** US 6,742,613 B2
 (45) **Date of Patent:** Jun. 1, 2004

- (54) **WATER JET REVERSING PROPULSION AND DIRECTIONAL CONTROLS FOR AUTOMATED SWIMMING POOL CLEANERS**
- (75) **Inventors:** Giora Erlich, North Caldwell, NJ (US);
 Tibor Horvath, Springfield, NJ (US)
- (73) **Assignee:** Aqua Products Inc., Cedar Grove, NJ (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.

- (21) **Appl. No.:** 10/109,689
- (22) **Filed:** Mar. 29, 2002
- (65) **Prior Publication Data**
 US 2002/0129839 A1 Sep. 19, 2002

- Related U.S. Application Data**
- (62) Division of application No. 09/237,301, filed on Jan. 25, 1999, now Pat. No. 6,412,133.
- (51) **Int. Cl.⁷** B62D 61/00
- (52) **U.S. Cl.** 180/21; 301/127
- (58) **Field of Search** 15/1.7; 180/21, 180/24.01; 280/5.52; 301/127, 131

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6,412,133 B1	*	7/2002	Erlich et al.	15/1.7

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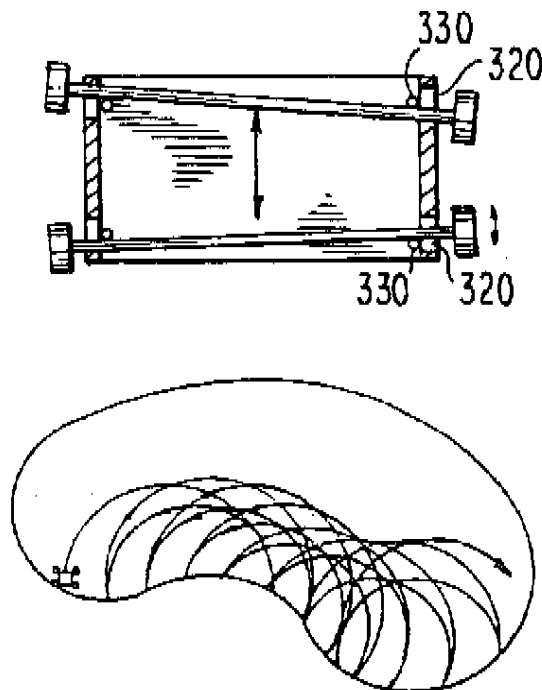
* cited by examiner

Primary Examiner—David Dunn
 (74) *Attorney, Agent, or Firm*—Abelman, Frayne & Schwab

(57) **ABSTRACT**

A robotic pool or tank cleaner is supported by wheels that are mounted on fixed or movable axles that form an acute angle with the longitudinal axis of the pool cleaner's body when the cleaner moves in either or both of two opposing directions to thereby provide a variable path as the device moves back and forth across the bottom surface of the pool or tank that is being cleaned.

21 Claims, 15 Drawing Sheets



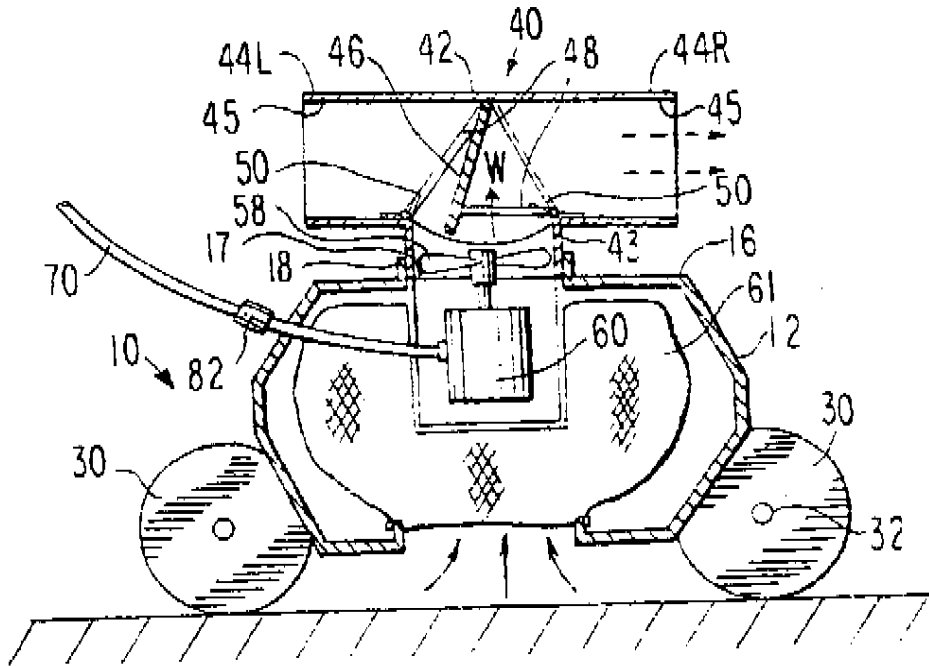


FIG. 1

FIG. 1A

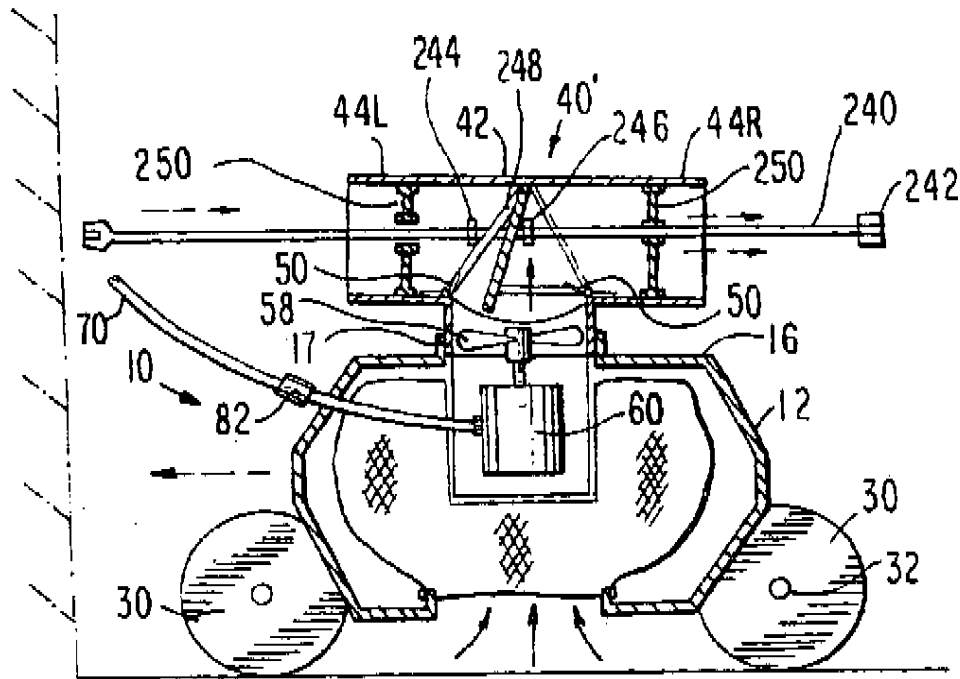


FIG. 1B

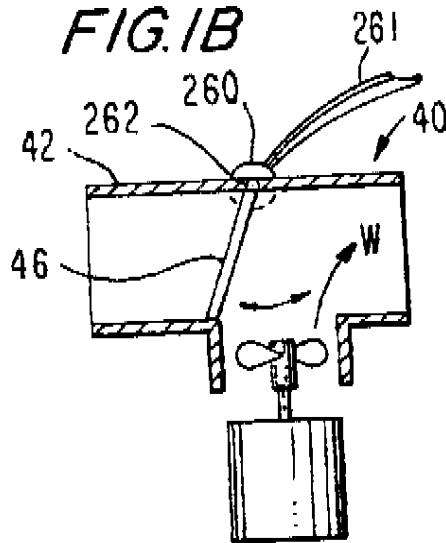


FIG. 2

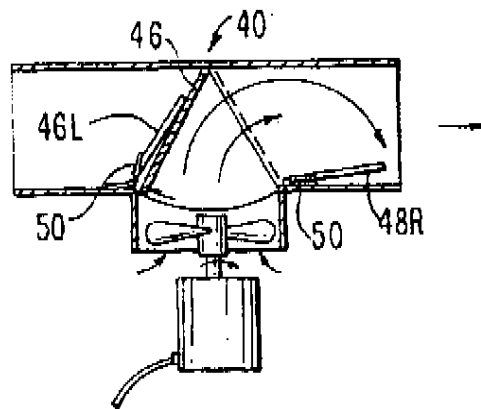


FIG. 3

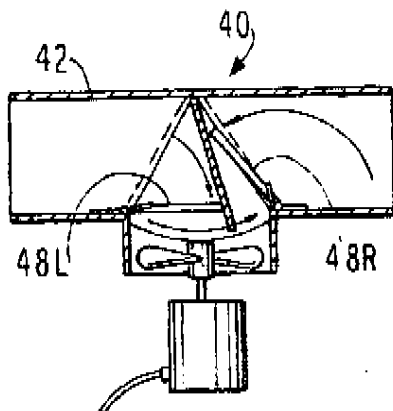


FIG. 4

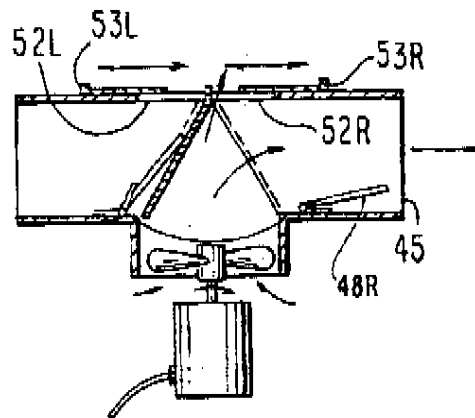


FIG. 5

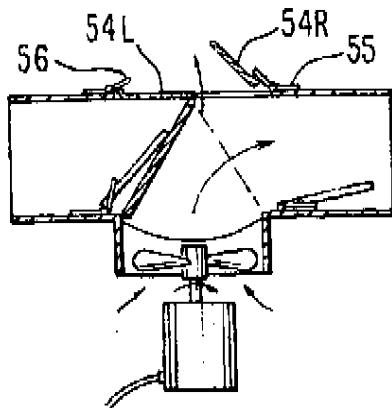


FIG. 6

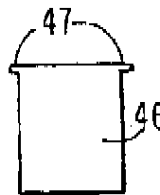
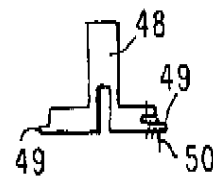
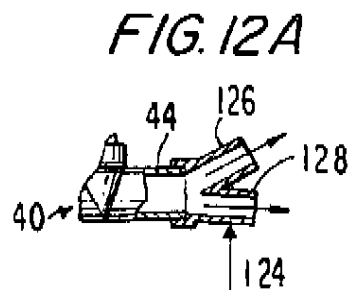
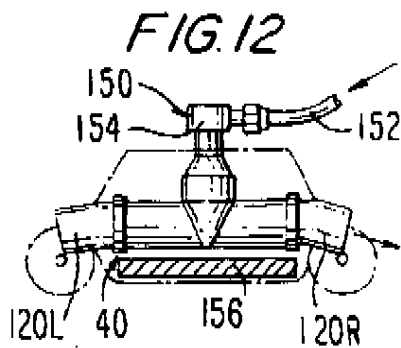
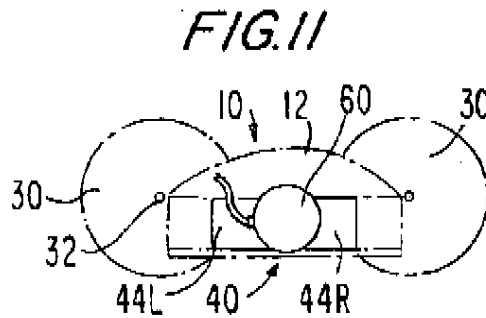
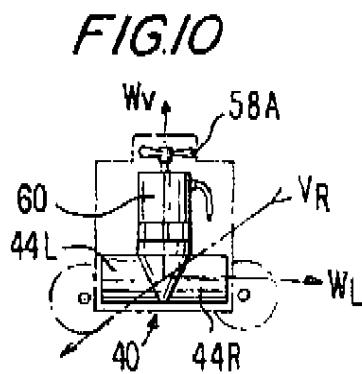
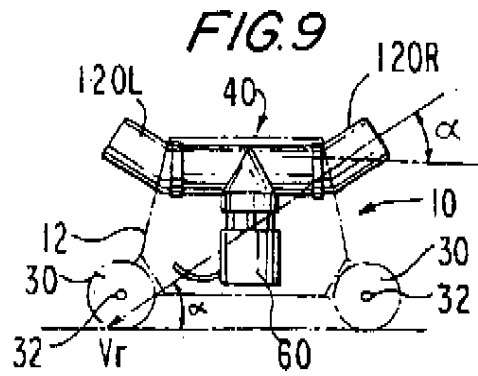
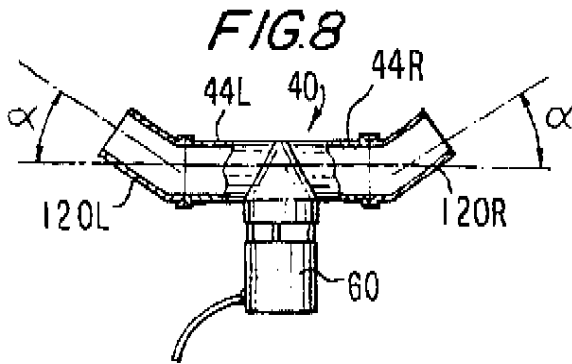


FIG. 7





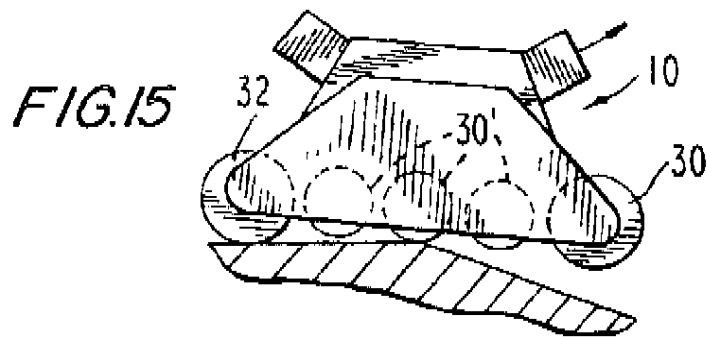
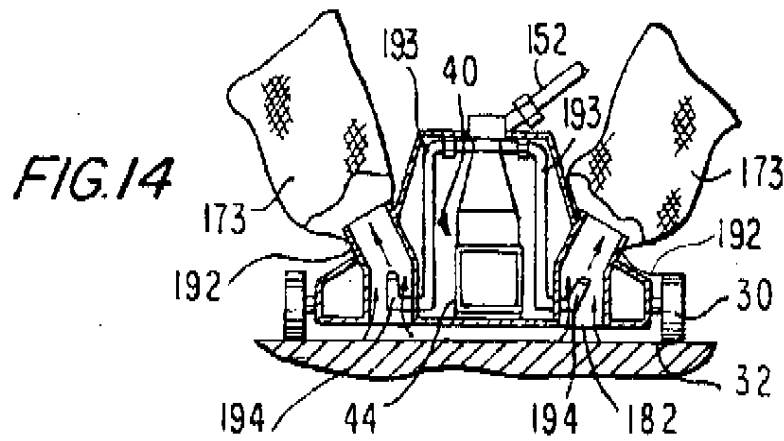
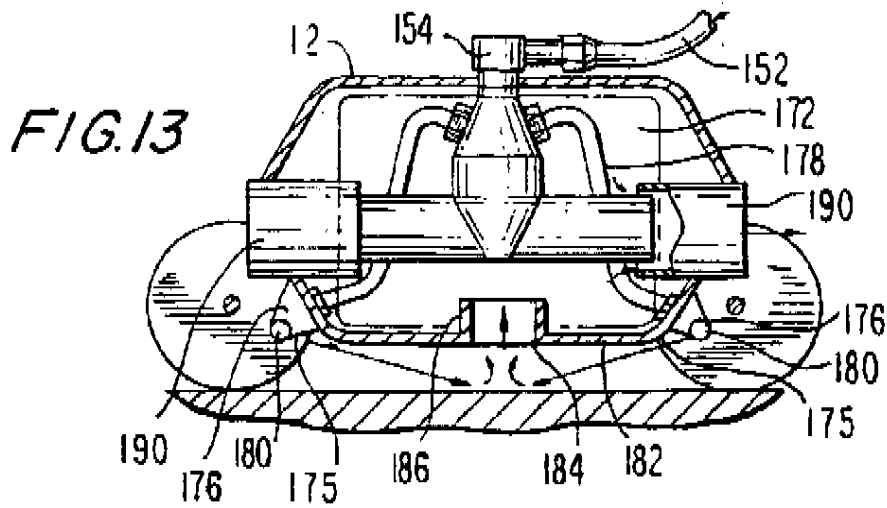


FIG. 16

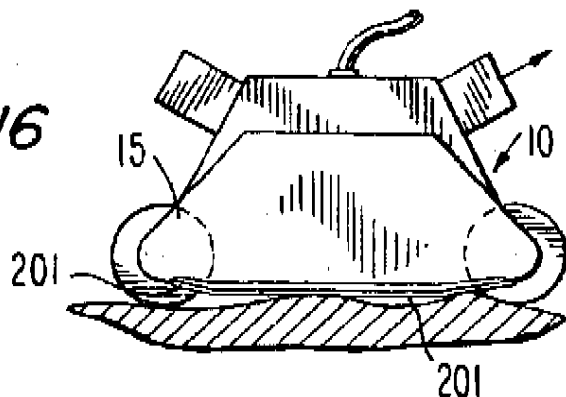


FIG. 17

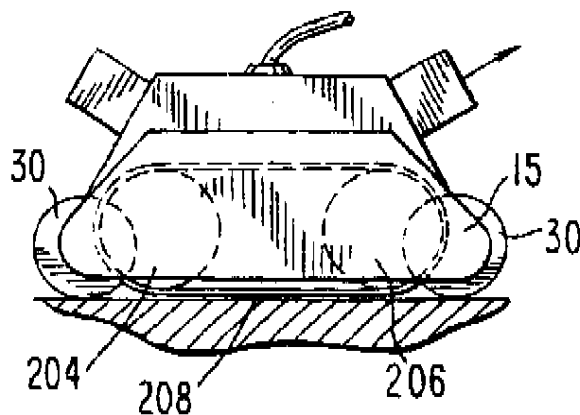


FIG. 18

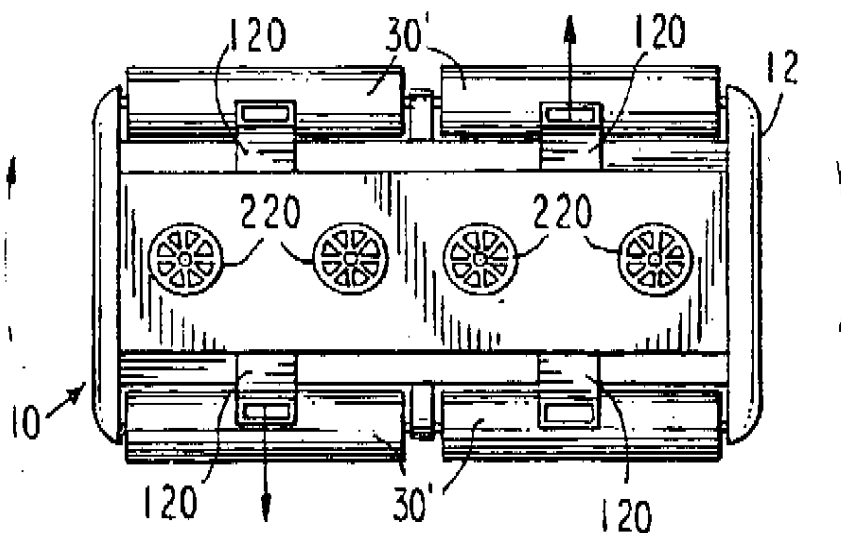


FIG. 21

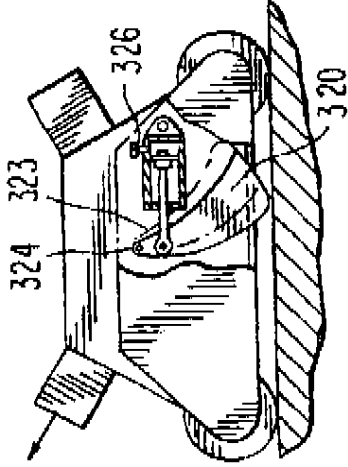


FIG. 19
PRIOR ART

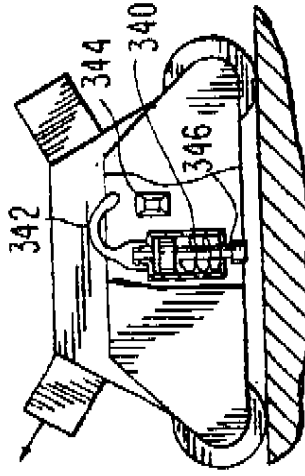


FIG. 20

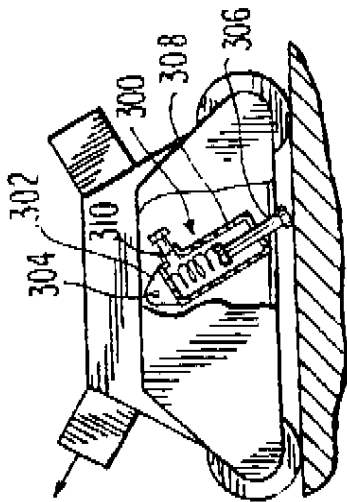


FIG. 22

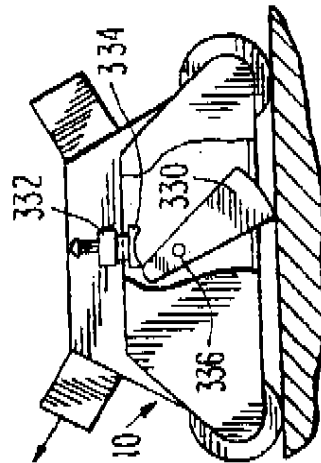


FIG. 24
PRIOR ART

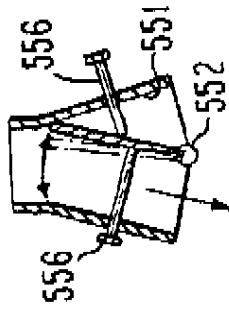


FIG. 26

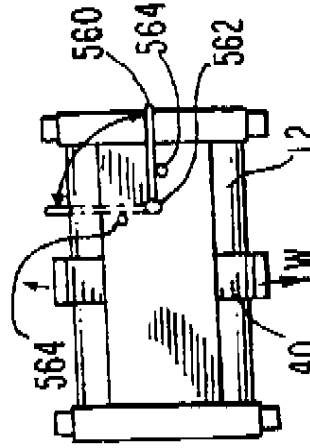


FIG. 23

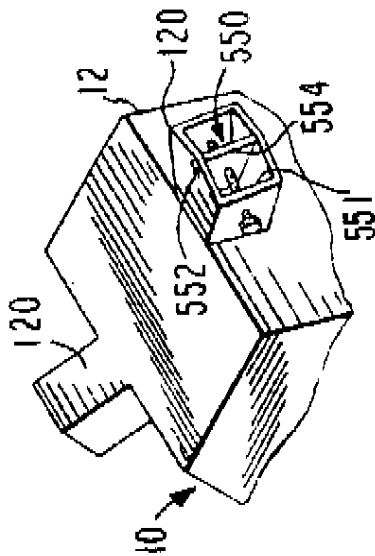
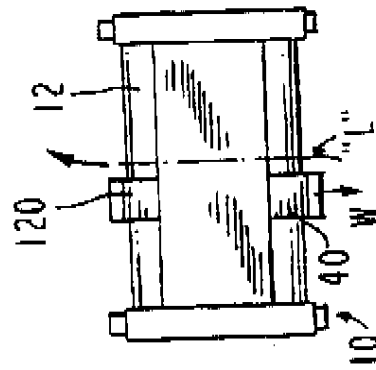
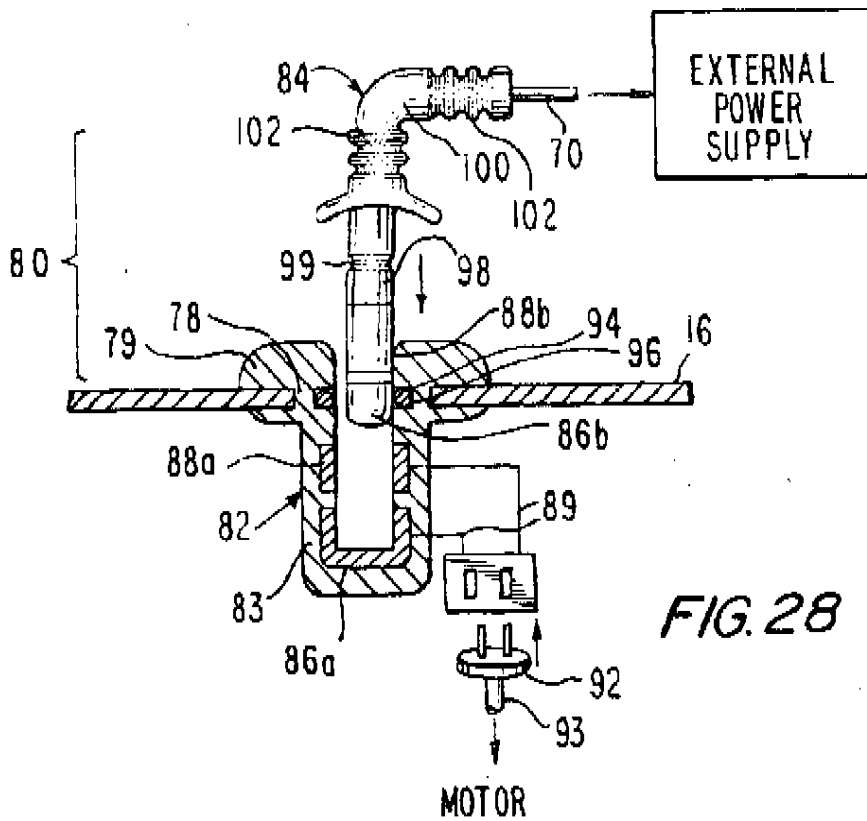
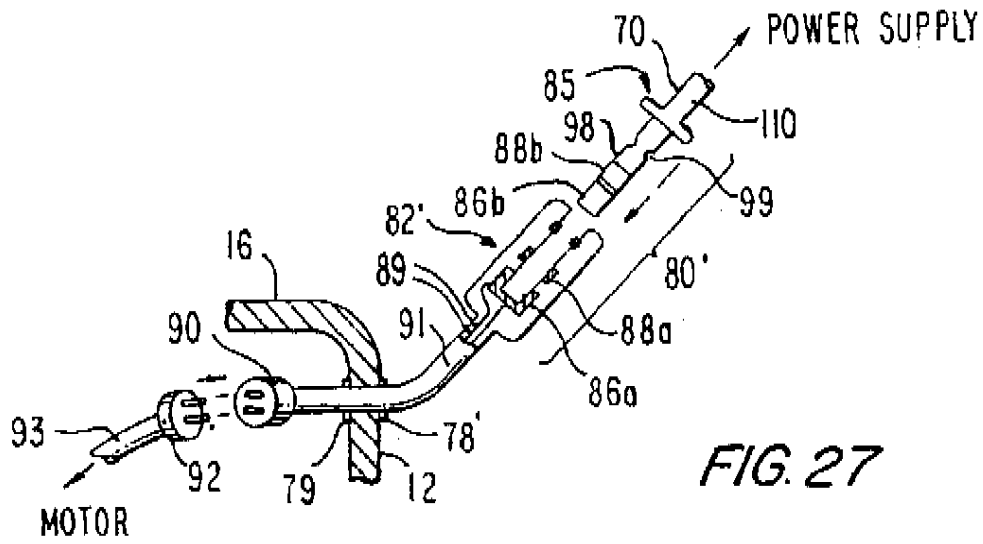


FIG. 25





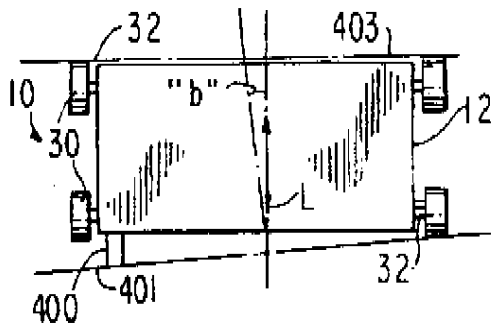


FIG. 31
PRIOR ART

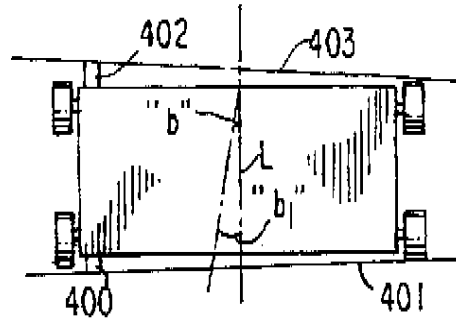


FIG. 32A
PRIOR ART

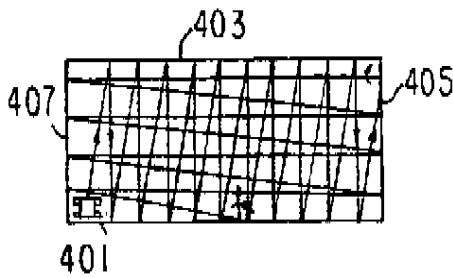


FIG. 31B

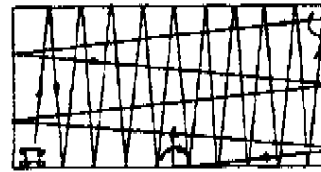


FIG. 32B

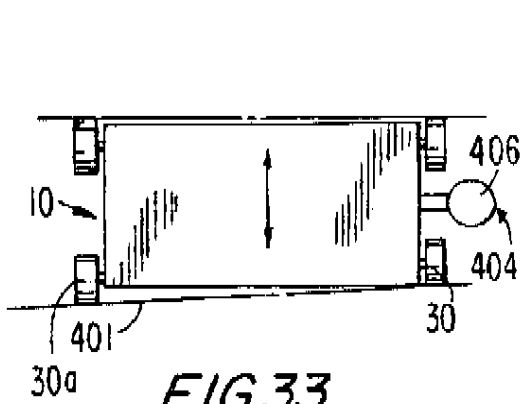


FIG. 33

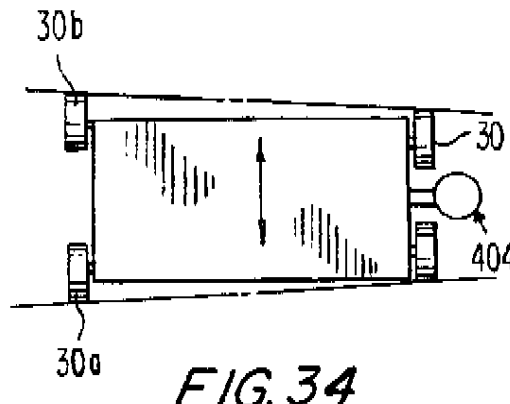


FIG. 34

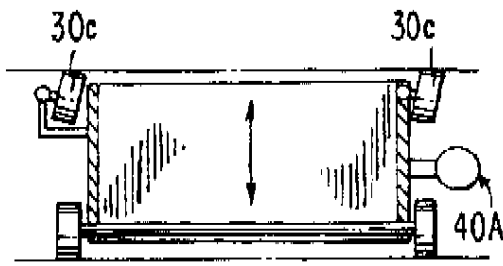


FIG. 35

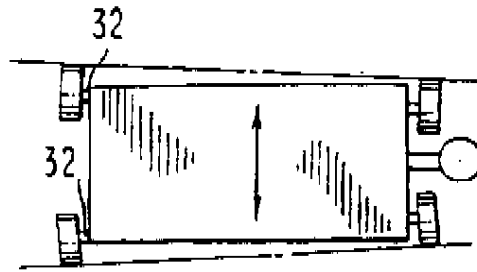


FIG. 36

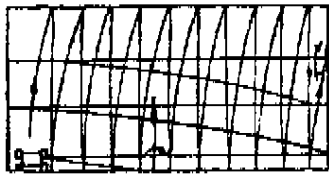


FIG. 35A

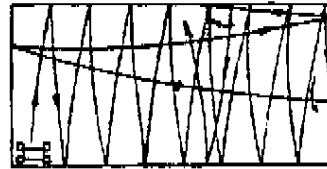


FIG. 35B

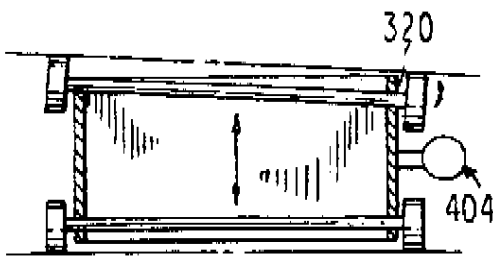


FIG. 37

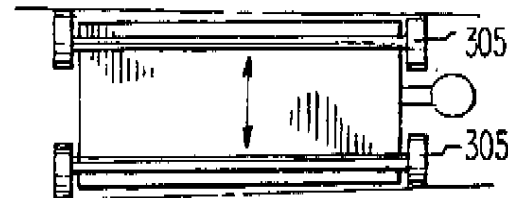


FIG. 38

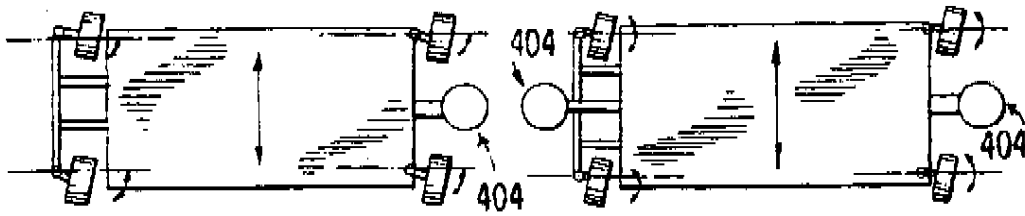


FIG. 39

FIG. 40

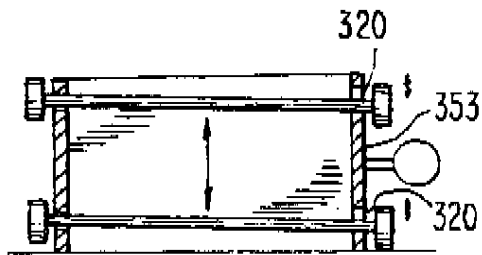


FIG. 41

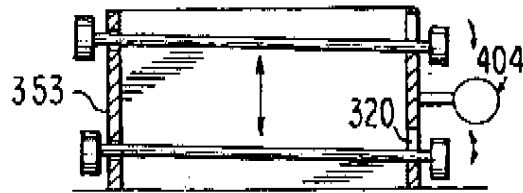


FIG. 42

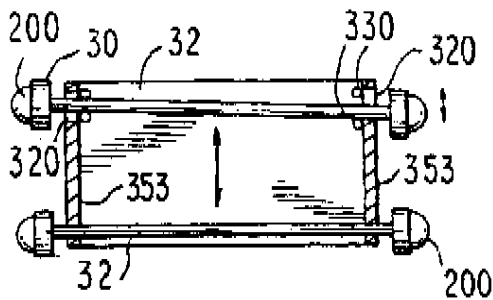


FIG. 43

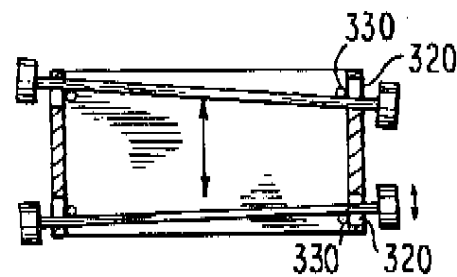


FIG. 44

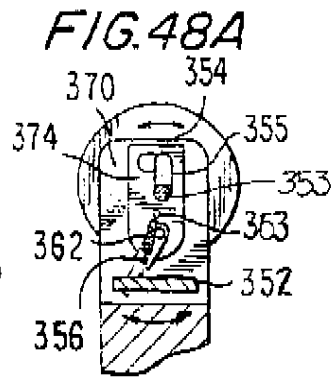
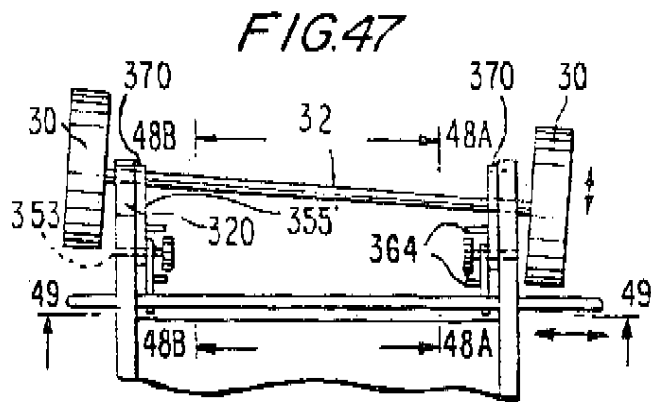
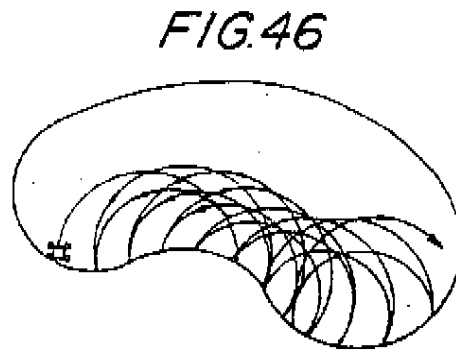
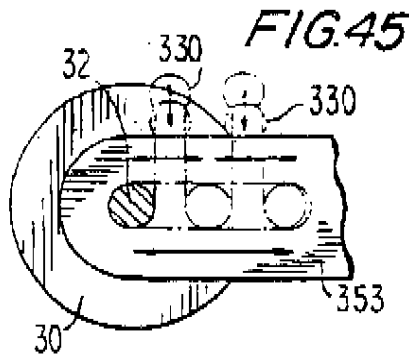


FIG. 48B

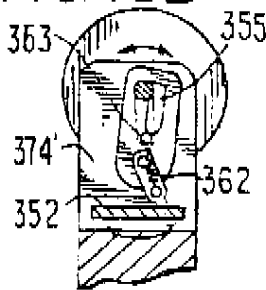


FIG. 49

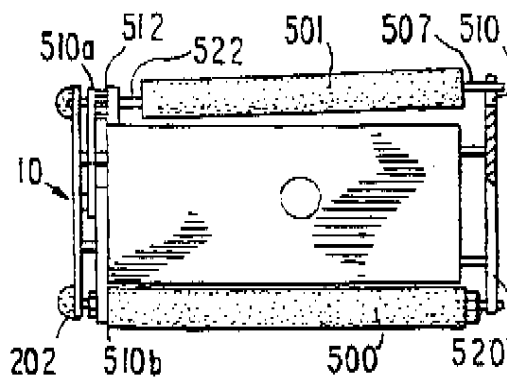
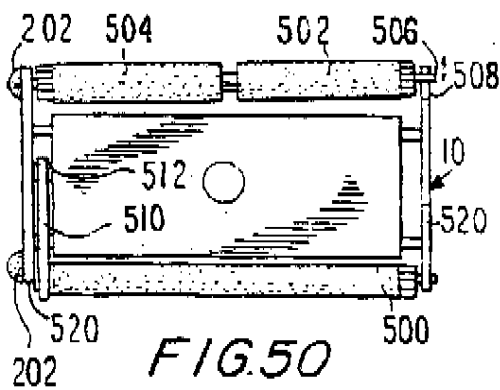
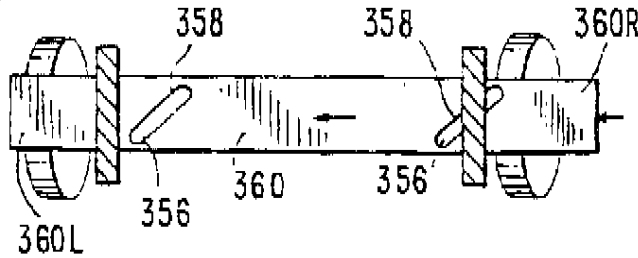


FIG. 50

FIG. 51

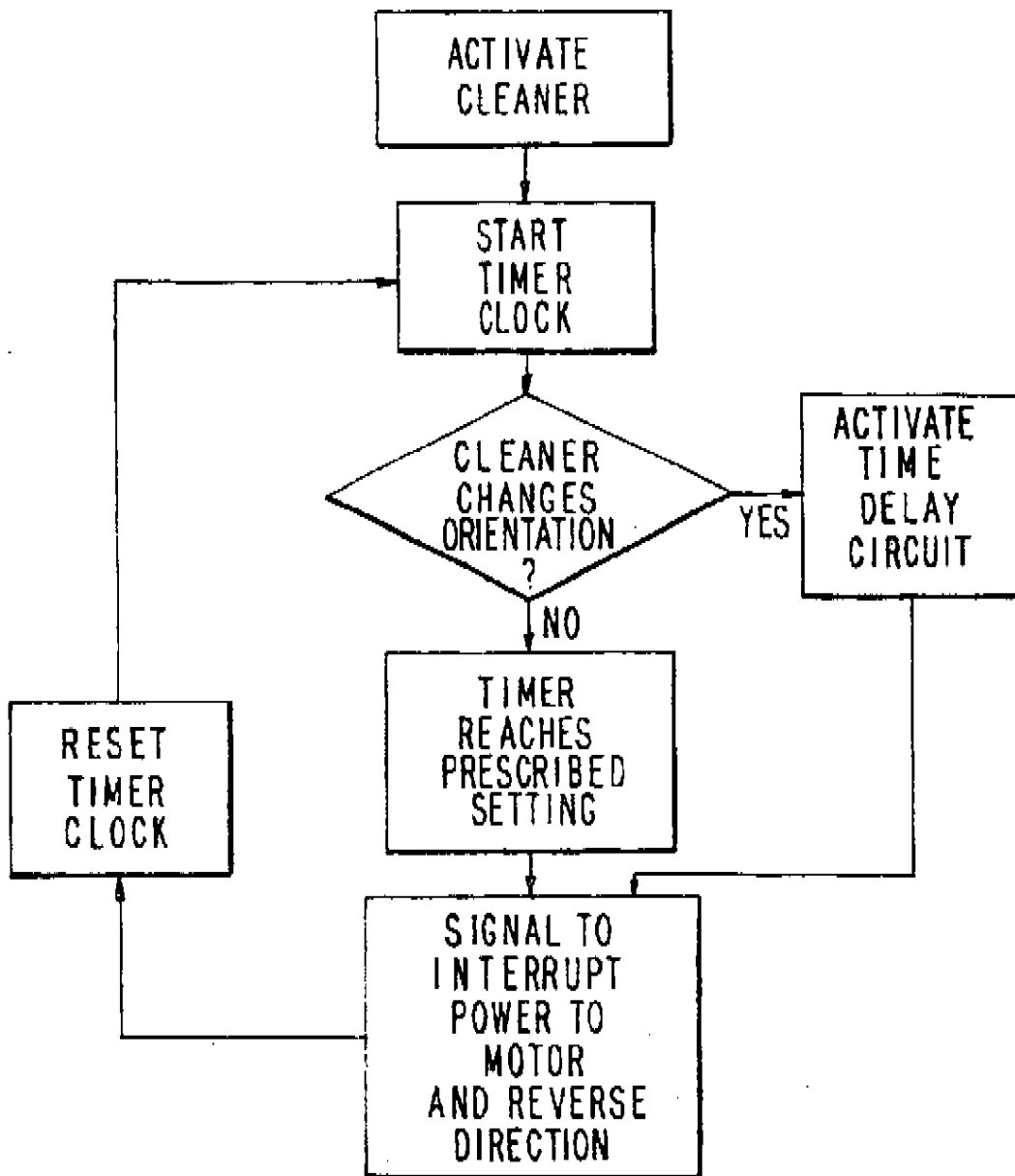


FIG. 52

US 6,742,613 B2

1

**WATER JET REVERSING PROPULSION
AND DIRECTIONAL CONTROLS FOR
AUTOMATED SWIMMING POOL
CLEANERS**

This application is a division of application Ser. No. 09/237,301 filed on Jan. 25, 1999, now U.S. Pat. No. 6,412,133.

FIELD OF THE INVENTION

The invention relates to methods and apparatus for propelling automated or robotic swimming pool and tank cleaners and for controlling the scanning or traversing patterns of the automated cleaners with respect to the bottom and sidewalls of the pool or tank.

BACKGROUND OF THE INVENTION

Automated or robotic swimming pool cleaners traditionally contact and move about on the pool surfaces being cleaned on axle-mounted wheels or on endless tracks that are powered by a separate drive motor through a gear train. The wheels or tracks are aligned with the longitudinal axis of the cleaner. Swimming pool cleaning robots that move on wheels generally have two electric motors—a pump motor powers a water pump that is used to dislodge and/or vacuum debris up into a filter; the drive motor is used to propel the robot over the surfaces of the pool that are to be cleaned. The drive motor can be connected through a gear train directly to one or more wheels or axles, or through a belt and pulleys to propel the cleaner; or to a water pump, which can be external to the robotic cleaner that produces a pressurized stream, or water jet, that moves the cleaning apparatus by reactive force or by driving a water turbine connected via a gear train to the wheels or endless track. The movement of the pool cleaners of the prior art, when powered by either the turbine or the direct or reactive jet is in one direction and the movement is random.

Control of the longitudinal directional movement of the robot can be accomplished by elaborate electronic circuitry, as is the case when stepper and D.C. brushless motors are employed. Other control systems require the cleaner to climb the vertical sidewall of the pool until a portion of the cleaner extends above the waterline and/or the unit has moved laterally along the sidewall, after which the motor drive reverses and the cleaner returns to the bottom surface of the pool along a different path. The water powered cleaners of the prior art also rely on the reorientation of the cleaner while on contact with the wall to effect a random change in direction. However, under certain circumstances; it is a waste of time, energy and produces unnecessary wear and tear to have the robotic cleaner climb the sidewall solely for purpose of changing the pattern of movement of the cleaner.

It is known from U.S. Pat. No. 2,988,762 to provide laterally offset fixed bumper elements at each end of the cleaner to contact the facing sidewall and provide a pivot point as the cleaner approaches the wall. Another transverse slide rod can be provided to contact a side wall and causes the drive motor to reverse. The bumper elements are adjustable to provide variable angles. A third slide rod attached to a shut-off switch extends outboard of side facing the far end of the pool, so that when the cleaner has covered the entire length of the pool and approaches the wall is a generally parallel path, the third slide rod is pushed inboard and shuts off power to the unit.

It has also been proposed to direct the scanning movement of a pool cleaner mechanically by use of a three-wheeled

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array in which the third wheel is mounted centrally and opposite the other pair of wheels, and the axle upon which the third wheel is mounted is able to rotate in a horizontal plane around a vertical axis. A so-called free-wheeling version of this apparatus is shown on U.S. Pat. No. 3,979,788.

In U.S. Pat. No. 3,229,315, the third wheel is mounted in a plate and the plate is engaged by a gear mechanism that positively rotates the horizontal axle and determines the directional changes in the orientation of the third wheel.

It is also known in the prior art to provide a pool cleaner with a vertical plunger or piston that can be moved by a hydraulic force into contact with the bottom of the pool to cause the cleaner to pivot and change direction. The timing must be controlled by a preprogrammed integrated circuit ("IC") device.

It is also known from U.S. Pat. No. 4,348,192 to equip the feed water hose of a circular floating pool cleaning device with a continuous discharge water jet nozzle that randomly reorients itself to a reversing direction when the forward movement of the floating cleaner is impeded. In addition to the movable water jet discharge nozzle attached to the underside of the floating cleaner, the hose is equipped with a plurality of rearwardly-facing jet nozzles that move the water those in a random pattern and facilitate movement of the cleaner.

Commercial pool cleaners of the prior art that employ pressurized water to effect random movement have also been equipped with so-called "back-up" valves that periodically interrupt and divert the flow of water to the cleaner and discharge it through a valve that has jets facing upstream, thereby creating a reactive force to move the hose and, perhaps, the attached cleaner in a generally backward direction. The back-up valve can be actuated by the flow of water through a fitting attached to the hose. The movement resulting from the activation of the back-up valve jets is also random and may have no effect on reorienting a cleaner that has become immobilized.

The apparatus of the prior art for use in propelling and directing the scanning movement of automated robotic pool cleaners is lacking in several important aspects. For example, the present state-of-the-art machines employ pre-programmed integrated circuit ("IC") devices that provide a specific predetermined scanning pattern. The design and production of these IC devices is relatively expensive and the scanning patterns produced have been found to be ineffective in pools having irregular configurations and/or obstructions built into their bottoms or sidewalls.

Cleaners propelled by a water jet discharge move only in a generally forward direction and their movement is random, such randomness being accentuated by equipping the unit with a flexible hose or tail that whips about erratically to alter the direction of the cleaner.

Cleaners equipped with gear trains for driving wheels or endless tracks represent an additional expense in the design, manufacture and assembly of numerous small, precision-fit parts; the owner or operator of the apparatus will also incur the time and expense of maintaining and securing replacement parts due to wear and tear during the life of the machine. A cleaning apparatus constructed with a pivotable third wheel that operates in a random fashion or in accordance with a program has the same drawbacks associated with the production, assembly and maintenance of numerous small moving parts.

The robotic pool cleaners of the prior art are also lacking in mechanical control means for the on-site adjustment of

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the scanning patterns of the apparatus with respect to the specific configuration of the pool being cleaned.

Another significant deficiency in the design and operation of the pool cleaners of the prior art is their tendency to become immobilized, e.g., in sharp corners, on steps, or even in the skimmer intake openings at the surface of the pool.

It is therefore a principal object of this invention to provide an improved automated or robotic pool and tank cleaning apparatus that incorporates a reliable mechanism and method of providing propulsion using a directional water jet for moving the cleaner in opposite directions along, or with respect to, the longitudinal axis of the apparatus.

It is another object of this invention to provide a method and apparatus for adjustably varying the direction of, and the amount of thrust or force produced by a water jet employed to propel a pool or tank cleaning apparatus, and to effect change in direction by interrupting the flow of water.

It is another important object of the invention to provide a simple and reliable apparatus and method for adjustably controlling the direction of discharge of a propelling water jet that can be utilized by home owners and pool maintenance personnel at the pool site to attain proper scanning patterns in order to clean the entire submerged bottom and side wall surfaces of the pool, regardless of the configuration of the pool and the presence of apparent obstacles.

A further object of the invention is to provide an improved apparatus and method for varying the position of one or more of the wheels or other support means of the cleaner in order to vary the directional movement and scanning patterns of the apparatus with respect to the bottom surface of the pool or tank being cleaned.

It is another object of the invention to provide a novel method and apparatus for periodically changing the direction of movement of a pool cleaner by intermittently establishing at least one fixed pivot point and axis of rotation with respect to the longitudinal axis of the cleaner for at least one pair of supporting wheels

Another object of the present invention is to provide a method and apparatus for assuring the free and unimpaired movement of the pool cleaner in its prescribed or random scanning of the surfaces to be cleaned without interference from the electrical power cord that is attached to the cleaner housing and floats on the surface of the pool.

Yet another object of the invention is to free a pool cleaner that has been immobilized by an obstacle so that it can resume its predetermined scanning pattern.

It is also an object to provide magnetic and infrared ("IR") sensing means for controlling the power circuits for the propulsion means of the cleaner.

Another important object of the invention is to provide an economical and reliable pool cleaner with a minimum number of moving parts and no internal pump and electric motor that can be powered by the discharge stream from the pool filter system or an external booster pump and which can reverse its direction.

Another important object of this invention is to provide an apparatus and method that meets the above objectives in a more cost-effective, reliable and simplified manner than is available through the practices and teachings of the prior art.

SUMMARY OF THE INVENTION

The above objects are met by the embodiments of the apparatus and methods described below. In the description that follows, it will be understood that cleaner moves on

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supporting wheels, rollers or tracks that are aligned with the longitudinal axis of the cleaner body when it moves in a straight line. References to the front or forward end of the cleaner will be relative to its then-direction of movement.

In a first preferred embodiment, a directionally controlled water jet is the means that causes the translational movement of the robotic cleaner across the surface to be cleaned. In a preferred embodiment, the water is drawn from beneath the apparatus and passed through at least one filter medium to remove debris and is forced by a pump through a directional discharge conduit whose axis is aligned with the longitudinal axis of the pool cleaner. The resulting or reactive force of the discharged water jet propels the cleaner in the opposite direction. The water jet can be diverted by various means and/or divided into two or more streams that produce resultant force vectors that also affect the position and direction of movement of the cleaner.

In one preferred embodiment, a diverter or deflector means, such as a flap valve assembly, is interposed between the pump outlet and the discharge conduit, which diverter means controls the direction of movement of the water through one or the other of the opposing ends of the discharge conduit. The positioning of the diverter means, and therefore the direction of travel of the cleaner, can be changed when the unit reaches a sidewall of the pool or after the cleaner has ascended a vertical sidewall. The movement of the diverter means can be in response to application of a mechanical force, such as a lever or slide bar that is caused to move when it contacts a vertical wall, and through a directly applied force or by way of a linkage repositions the diverter means and changes the direction of the discharged water jet to propel the cleaner away from the wall. In one preferred embodiment, power to the pump motor is interrupted and the position of the diverter means is changed in response to the change in hydrodynamic forces acting on the flap valve assembly. Mechanical biasing and locking means are also provided to assure the proper repositioning and seating of the flap valve.

The orientation of the discharged water jet can be varied to provide a downward component or force vector, lateral components, or a combination of such components or force vectors to complement the translational force.

In its broadest construction, the invention comprehends a method of propelling a pool or tank cleaner by means of a water jet that is discharged in at least a first and second direction that result in movement in opposite translational directions. The direction of the water jet is controlled by the predetermined orientation of a discharge conduit that is either stationary or movable with respect to the body of the cleaner. The discharge conduit can be fixed and the pressurized water controlled by one or more valves that operate in one or more conduits to pass the water for discharge in alternating directions. The discharge conduit can also comprise an element of a rotating turret that is preferably mounted on the top wall of the cleaner housing and is caused to rotate between at least two alternating opposed positions in order to propel the cleaner in a first and then a second generally opposite direction. The means for rotating the turret and discharge conduit can include spring biasing means, a motor or water turbine driven gear train, etc. During the change from one position to the alternate opposing position, the cleaner is stabilized by interrupting the flow of water from the discharge conduit, as by interrupting the power to the pump motor or discharging water from one or more other orifices

The invention comprehends methods and apparatus for controlling the movement of robotic tank and swimming

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pool cleaners that can be characterized as systematic scanning patterns, scalloped or curvilinear patterns and controlled random motions with respect to the bottom surface of the pool or tank. For the purposes of this description, references to the front and rear of the cleaning apparatus or its housing will be with respect to the direction of its movement. A conventional pool cleaner comprises a base plate on which are mounted a pump, at least one motor for driving the pump and optionally a second motor for propelling the apparatus via wheels or endless track belts; a housing having a top and depending sidewalls that encloses the pump and motor(s) is secured to the base plate; one or more types of filter media are positioned internally and/or externally with respect to the housing; and a separate external handle is optionally secured to the housing. Power is supplied by floating electrical cables attached to an external source, such as a transformer or a battery contained in a floating housing at the surface of the pool; pressurized water can also be provided via a hose for water turbine-powered cleaners. The invention also has application to tank and pool cleaners which operate in conjunction with a remote pump and/or filter system which is located outside of the pool and in fluid communication with the cleaner via a hose.

While the illustrative figures which accompany this application, and to which reference is made herein, schematically illustrate various embodiments of the invention on robotic cleaners equipped with wheels, it will be understood by one of ordinary skill in the art that the invention is equally applicable to cleaners which move on endless tracks or belts. Specific examples are also provided where the cleaner is equipped with power-driven transverse cylindrical rollers that extend across the width of the cleaner body.

In one embodiment of this aspect of the invention, an otherwise conventional cleaner is provided with at least one wheel or track that projects beyond the periphery of the apparatus in a direction of movement of the apparatus. In operation, this offset projecting wheel will contact the wall to stop the forward movement of the apparatus on one side thereby causing the cleaner to pivot until the opposite side makes contact with the wall so that the longitudinal axis of the cleaner forms an angle "b" with the sidewall of the pool. When the cleaner moves in the reverse direction away from the wall, it will be traversing the bottom of the pool at an angle "b". An apparatus equipped with only one projecting wheel or supporting member at one corner location of the housing will assume a generally normal position to an opposite parallel sidewall.

In a further preferred embodiment, a cleaner provided with a second projecting wheel or supporting member at the opposite end will undergo a pivoting motion as the cleaner approaches a wall in either direction of movement. The angle "b" can be varied or adjusted by changing the distance the wheel projects beyond the periphery of the cleaner. As will be appreciated by one of ordinary skill in the art, the angle "b" will determine the cleaning pattern, which pattern in turn will relate to the size and shape of the pool, the degree of overlap on consecutive passes along the surface to be cleaned, and other customary parameters.

In order to change the direction of movement when the cleaner assumes a path that is generally parallel to an end wall of the pool, the cleaner is provided with at least one side projecting member that extends outwardly from the cleaner housing from a position that can range from at or adjacent the forward end to midway between the drive wheels or ends of the cleaner. The side projecting member acts as a pivot point when contacting a sidewall of the pool so that the

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cleaner assumes an arcuate path until it engages the contact wall. When the unit reverses, the new cleaning pattern is initially at approximately a right angle to the former scanning pattern.

In another embodiment of the invention, a pair of the wheels located at one or both ends of the cleaner are mounted for rotation at an angle that is not at 90° or normal to the longitudinal axis of the cleaner. Where the pairs of front and rear wheels are each mounted on a single transverse axle, one or both of the axles is mounted at an angle that is offset from the longitudinal normal by an angle "b". In another preferred embodiment, one side of the axle is mounted in a slot that permits movement to either the front or rear, or to both front and rear, in response to movement of the apparatus in the opposite direction.

In yet another embodiment, at least one wheel of a diameter smaller than the other wheels is mounted on an axle to induce the apparatus to follow a curved path. In another embodiment, the apparatus is provided with at least one pair of caster or swivel-mounted wheels, the axles of which independently pivot in response to changes in direction so that the apparatus follows a curved path in one or both directions. In this embodiment, providing the apparatus with two pairs of caster-mounted wheels will produce a scalloped or accentuated curvilinear motion as the unit moves from one point of engagement with the vertical sidewalls to another.

In a further preferred embodiment of the slot-mounted axle, one or more position pins are provided to fix and/or change the range of movement of the axle in the slot. These adjustments allow the operator to customize the pattern based upon the size and/or configuration of the specific pool being cleaned.

Another embodiment of the invention improves the ability of the cleaner to follow a particular pattern of scanning without interference or immobilization by providing an improved connector for the power cable. A swivel or rotating electrical connector is provided between the cleaner and the external power cord in order to reduce or eliminate interference with the scanning pattern caused by twisting and coiling of the power cord as the cleaner changes direction. The swivel connector can have two or more conductors and be formed in a right-angle or straight configuration, and is provided with a water-tight seal and releasable locking means to retain the two ends rotatably joined against the forces applied during operation of the cleaner.

In another embodiment of the invention, control means are provided to periodically reverse the propelling means to assure that the cleaner does not become immobilized, e.g., by an obstacle in the pool. If the pool cleaner does not change its orientation with respect to the bottom or sidewall as indicated by a signal from the mercury switch indicating that such transition has occurred during the prescribed period, e.g., three minutes, the control circuit will automatically change the direction of the drive means in order to permit the cleaner to move away from the obstacle and resume its scanning pattern. In a preferred embodiment of the invention, the predetermined delay period between auto-reversal sequences is adjustable by the user in the event that a greater or lesser delay cycle time is desired. Sensors, such as magnetic and infrared responsive devices are provided to change the direction of movement in response to prescribed conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and other advantages and benefits of the invention will be apparent from the following description in which:

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FIG. 1 is a side elevation, partly in cross-section, of a pool cleaner illustrating one embodiment of the directional water jet of the invention;

FIG. 1A is a side elevation, partly in cross-section, of another embodiment of the invention of FIG. 1;

FIG. 1B is a side elevation, partly in cross-section, of a water jet valve assembly schematically illustrating another embodiment of the invention of FIG. 1;

FIGS. 2 and 3 are side elevation views, partly in cross-section, schematically illustrating the operation of the water jet valve assembly shown in FIG. 1;

FIGS. 4 and 5 are side elevation views of the embodiments of the valve assembly of FIGS. 2 and 3 provided with additional vertical discharge valves of the invention;

FIG. 6 is a top plan view of a flap valve member suitable for use with the embodiment of FIG. 1;

FIG. 7 is a top plan view of a flap valve assembly locking bar;

FIG. 8 is a side elevation, partly in cross-section, of the valve assembly of the invention installed on a pump;

FIG. 9 is a side elevation of the embodiment of FIG. 8, schematically illustrated in relation to a pool cleaner, shown in phantom;

FIG. 10 is a side elevation of another embodiment of the water jet valve assembly of the invention schematically illustrated in relation to a cleaner, shown in phantom;

FIG. 11 is a side elevation of another embodiment of the water jet valve assembly of the invention schematically illustrated in relation to a cleaner, shown in phantom;

FIG. 12 is a side elevation of another embodiment of the water jet valve assembly of the invention with pressurized water supplied by an external source, schematically illustrated in relation to a cleaner, shown in phantom;

FIG. 12A is a side elevation view, partly in cross-section, of a modified discharge conduit attachment in accordance with the invention;

FIG. 13 is a side elevation, partly in cross-section, of a pool cleaner equipped with the water jet valve assembly of the invention and external pressurized water source with venturi discharge outlets;

FIG. 14 schematically illustrated an embodiment similar to that of FIG. 13 in which the filter system is externally mounted;

FIGS. 15-17 are side elevation views of a cleaner provided with auxiliary support means in accordance with the invention to improve the movement over obstacles and irregular surfaces;

FIG. 18 is a top plan view of a tandem cleaner provided with two water jet valve assemblies of the invention;

FIG. 19 is a side elevation of a prior art pool cleaner, partly cut away to show a fluid activated plunger assembly;

FIGS. 20-22 are side elevation views of pool cleaners, partly cut away, to show laterally mounted directional pivot assemblies of the invention;

FIG. 23 is a top and side perspective view of a portion of a pool cleaner to show a discharge conduit provided with an adjustable diverter for varying the directional discharge of the water jet from the valve assembly;

FIG. 24 is a top cross-sectional plan view of the diverter mechanism of FIG. 23;

FIG. 25 is a top plan view of a cleaner illustrating one embodiment of offsetting the discharge conduits to produce a non-linear movement of the cleaner in both directions;

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FIG. 26 is a top plan view of a cleaner provided with means to create an uneven hydrodynamic drag force on side of the cleaner to produce a non-linear movement of the cleaner in one direction.

FIG. 27 is a side perspective view, partly in cross-section of an in-line electrical connector of the invention shown in relation to a segment of the cleaner housing;

FIG. 28 is a side elevation view, partly in cross-section, of an angular electrical swivel connector of the invention;

FIG. 29 is a plan view, partly in cross-section, of another embodiment of an in-line swivel electrical connector;

FIG. 30 is a prospective view of the assembled in-line swivel connector of FIG. 29 schematically illustrating its relation to the cleaner;

FIGS. 31A and 32A are top plan views schematically illustrating the prior art construction of a pool cleaner with pivot members extending from the front, and from the front and rear, respectively, in the direction of movement of the cleaner;

FIGS. 31B and 32B are schematic representations of the pattern of movement of the prior art pool cleaners of FIGS. 31A and 32A, respectively;

FIGS. 33 and 34 are top plan views schematically illustrating embodiments of the invention in which the cleaner's supporting wheels extend beyond the periphery to the front and to the front and rear, respectively to provide a pivot point;

FIGS. 35A and 35B are schematic illustrations of the patterns created by the embodiments of FIGS. 35 and 36;

FIGS. 35-44 are top plan views schematically illustrating embodiments of the invention in which the cleaner's supporting wheels are mounted on one or more axles that are offset at an angle to line that is normal to the longitudinal axis of the cleaner;

FIG. 45 is a side elevation view of an adjustable axle and wheel assembly similar to the embodiments illustrated in FIGS. 43 and 44;

FIG. 46 is a plan view of a curvilinear or free-form pool or tank schematically illustrating the predetermined scanning pattern in accordance with one embodiment of the invention;

FIG. 47 is a bottom plan view of one end of a pool cleaner wheel and axle assembly illustrating a mechanism for automatically changing the orientation of the wheels in response to a lateral contact with the side wall of a pool;

FIG. 48A is a sectional view of the wheel and mechanism taken along line AA of FIG. 47;

FIG. 48B is a sectional view of the opposite wheel and mechanism taken along line B-B of FIG. 47;

FIG. 49 is a sectional view taken along a line 49-49 of FIG. 47;

FIG. 50 is a top plan view of a cleaner equipped with motor-driven supporting rollers on a moving axle in accordance with the invention;

FIG. 51 is a top plan view having supporting rollers and a sliding axle in accordance with the invention that includes a universal joint; and

FIG. 52 is a flow chart illustrating a method of the invention for reversing the direction of movement of a cleaner in accordance with a prescribed program.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the description that follows, a pool cleaner 10 has an exterior cover or housing 12 with a top wall 16, an internal

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pump and drive motor 60 that draws water and debris through openings in a base plate that are entrained by a filter 61.

The series of FIGS. 1-14 illustrate embodiments in which a single motor is used to vacuum debris and propel a swimming pool cleaning robot in combination with mechanically simple directional control means. In this embodiment, a temporary interruption of power to the motor will result in the reversal of the robot's movement. The interruption of power to the motor can result from a programmable power control circuit or be initiated by physical conditions affecting the cleaner.

FIG. 1 schematically illustrates, in partial cross-section, a pool cleaner 10 having a water jet valve assembly 40 mounted on top of a motor-driven water pump 60 using impeller 58 to drive water "W" up through housing aperture 17 and into the valve assembly. The valve assembly 40 comprises a generally T-shaped valve housing 42 with depending leg 43 secured to cleaner housing flange 18 and in fluid communication with discharge conduits 44R and 44L. Positioned in the interior of valve housing 42 is flap valve member 46 (shown in a transitory position). As best shown in FIGS. 6 and 7, flap 46 is provided with mounting posts 47, and two "I"-shaped spring-loaded lock bars 48R and 48L pivotally mounted on pivot posts 49 on either side of the flap 46. Lock springs 50 urge bars 48 into contact with flap member 46. The cross-section of conduits 44 can be round, rectilinear, or of any other convenient shape, the rectangular configuration illustrated being preferred.

FIG. 2 illustrates the sequence of movements inside valve housing 42. When power to the pump motor 60 is turned on and water is being pumped through jet valve housing 42, the pressurized water stream W entering the housing acts on the flap member 46 to urge it into position to close discharge conduit 44L at the left side of the valve and applies a force that urges the lock bar 48R to fold away from the valve member 46 in the right discharge conduit 44R, resulting in a water jet propulsion force that is emitted from the right end of discharge conduit 44R.

FIG. 3 illustrates the next sequence of steps or movements that result when power to the motor 60 is shut off and/or the flow of water W is interrupted. The sudden interruption of the water W flowing into the valve housing 42 causes the exiting water stream to create a low pressure or partial vacuum, thereby causing flap member 46 to swing towards the right discharge conduit. This movement of the flap member is followed by the movement of left lock bar 46L to lock the valve member 46 into position to the right of center. When power to the motor is turned back on, the water flow will be directed into left discharge conduit 44L. It is possible to operate jet valve assembly 40 without lock bars; however, precise timing is required to turn the power on and to reactivate the pump 60 before valve member 46 swings back to its previous position prior to the interruption of the water flow.

FIG. 4 illustrates a further preferred embodiment in which provision is made for a reduction of excessive water jet pressure through the open end 45 of conduits 44R and 44L. To control and adjust the water pressure, openings are provided at both sides of flap valve 46, and adjustable closures, which can be e.g., sliding 53R, 53L doors proximate the openings provide for the desired amount of by-pass water, the force of which, when directed upward, urges the robot 10 against the surface of the pool.

FIG. 5 illustrates an automatic mechanism to accomplish the above in which spring-loaded doors 54R, 54L open when

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the initial operating pressure is too high to maintain proper speed of robot, e.g., when the filter bag is clean. Doors 54 are mounted by hinged members 55 and biased into a closed position by springs 56. As filter 61 accumulates debris and dirt, the bag clogs up, pressure drops and the spring-loaded doors close partially or completely.

FIG. 6 illustrates the configuration of a preferred embodiment of the flap valve member 46 and FIG. 7 shows one embodiment of the lock bar 48 and the relation of associated lockspring 50. Other forms of biased mechanisms, including electronic and electro-mechanical means can be employed.

In another preferred embodiment of the invention, the flap 46 is moved by positive mechanical means in response to a contact with a side wall or other structure in the pool. For example, FIG. 1A illustrate a cleaner 10, similar in construction to that of FIG. 1, on which is mounted valved assembly 40'. Valve actuating member 240, is slidably mounted internally and parallel to the axis of the discharge conduits 44 in spiders 250 and passes through a slotted opening 248 in flap member 46'. Contact members 244 and 246 are mounted on rod member 240 on either side of flap member 46' and positioned to urge the valve into one or the other of its sealing positions to divert the water flow W. In operation, as the cleaner 10 approaches the sidewall, resilient tip member 242 contacts the wall and rod 240 is moved to the left in FIG. 1A until contact member 244 reaches flap 46' and moves it to the right. When left-hand wheel 30 reaches the wall, the movement of rod 240 ceases and flap 46' is seated. With water W exiting discharge conduit 44L, the cleaner moves away from the wall with actuating rod 240 extending beyond the periphery of the cleaner and positioned to contact the opposite wall. Where the process is repeated.

In another preferred embodiment, the flap 46 is moved by electromechanical means, e.g., a linear or circular solenoid. As schematically illustrated in FIG. 1B, a circular solenoid 260 having power cord 261 is mounted on the exterior of valve housing 42. The axially rotating element 262 of solenoid 260 engages flap 46. In one preferred embodiment, the IC controller for the cleaner sends a signal to activate the solenoid moving the flap 46 to its opposing position. It will be understood that the force of water stream W will seat flap 46 in the reversing position.

FIG. 8 illustrates the jet valve assembly as described in FIGS. 1-3 on which additional directional flow elbows 120R, 120L are secured to the terminal ends of the discharge conduits 44R, 44L. The assembly 40 can be produced with elbows 120 as an integral unit from molded plastic, cast aluminum or other appropriate materials.

The water jet discharged from the elbow 120 at an angle "a" to the translational plane of movement of the cleaner 10 produces a force vector component in a downward direction towards the wheels 30 as well as a translational force vector tending to move the cleaner across the surface being cleaned.

FIG. 9 illustrates the especially preferred location and orientation of the jet valve assembly 40 of FIG. 8 in relation to robotic cleaner 10 (shown in phantom.) In this embodiment, the discharge conduits 44, through their associated elbows 120, project through the sidewalls of housing 12. In a further preferred embodiment, the elbows and valve housing 42 are integrated into the molded housing 12 which is produced from an impact resistant polymer. With further reference to the arrow "VR" indicates the resultant vector force produced by the expelled jet stream, the angle "a" of which is critical to the proper movement of robot 10 while

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on or off the vertical or angled side wall of a pool. As shown in FIG. 9, the projected resultant vector A_r crosses the horizontal or translational plane between the axles 32, and preferably in closer proximity to the front axle, where the front axle is defined by the direction of robot's movement as the leading axle. Providing an angle that places the line of resultant vector " A_r " between the axles assures the stable operation of the cleaner.

In addition to providing a more compact and damage resistant construction, incorporation of discharge valve 40 into housing 12 reduces the number of separate parts required for the practice of the invention, thereby reducing costs. In this regard, use of a source of pressurized water from external source as specifically illustrated in FIGS. 12-14 (and which can be applied to all of the other embodiments described) eliminates the pump and motor assembly 60 resulting in further cost and material savings, as well as a reduction in operating and maintenance expenses. Moreover, by incorporating the valve assembly 40 in the interior of housing 12, other elements conventionally attached to the exterior of cleaners of the prior art can continue to be used, e.g., floating handles that control the alignment of the unit on the sidewall at the water line of the pool.

FIG. 10 illustrates a jet valve assembly similar to that of FIGS. 1-3 that is mounted upside down in a robotic cleaner (shown in phantom). In this embodiment the motor operates two propellers, one located at either end of the drive shaft. The upper propeller 58A creates a downward force, which when coupled with the horizontal or translational jet force emitted from discharge conduit 44R or 44L, produces a resultant vector R that can be set in the proper angle by selecting the appropriate size for the upper propeller. In this embodiment, directional elbows are not required to provide a downward hydrodynamic force vector to urge the apparatus into contact with the surface to be cleaned.

FIG. 11 illustrates a jet valve assembly 40 that is mounted in cleaner 10 in a horizontal position, permitting a low profile for the cleaner housing 12. In the embodiment shown, the housing 12 is supported by large diameter wheels 30 and the axles 32 are positioned above valve assembly 40. As a result of the low center of gravity of the unit the discharge of the propelling force of the water jet can be limited to the horizontal or translational direction. The large wheel diameter allows the unit to traverse uneven surfaces.

FIG. 12 illustrates a jet valve assembly which is connected to an external pump (not shown) by a flexible hose 152 attached to housing adapter 150 and therefore requires no internal pump motor. The hose 152 is secured to the robotic cleaning apparatus by means of swivelling elbow joint 154 to allow unimpeded movement of the robotic cleaner and to prevent twisting of the hose 152. The switching of jet valve is accomplished by a solenoid valve (not shown) installed in-line near the outside pump. Cleaners using this external pump system do not have filter bags to collect debris. Rather, the jet outlet is deflected slightly downward toward the surface being cleaned by directional flow elbows 120R, 120L so that the water jet turbulence stirs up the debris from the bottom of pool; once buoyant, the debris is filtered by the pool's permanent internal filter system. Generally, outside filtering systems have multiple inlets to the pool, one of them usually is equipped with a fitting so that flexible hose 152 can be connected to it. Utilizing this embodiment of the invention, an outside filter system becomes much more efficient since it is able to filter not only floating debris from the water's surface, but also debris dislodged from the bottom of the pool. To assure the

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downward directed jet streams do not flip the cleaner, supplemental weight member 1-56 is added to the bottom of the apparatus to maintain an overall negative buoyancy. The weight member can be one or more batteries for providing power to cleaner 10 where the pump is powered by an internal motor, as in FIGS. 1-11.

FIG. 12A illustrates a bi-axial flow diverter 124 attached to discharge conduit 44 for use with the robot of FIG. 12. It is desirable for ease of handling not to add additional weight to the cleaner. Instead of adding weight 156, the discharge conduit in this embodiment is provided with flow diverted with at least two channels shaped so that part of the emitted water is directed downward at a relatively shallow angle, while the other portion of the stream is directed upwardly at greater angle to the translational plane. The combined force of the two streams results in a vector R that urges the robot against the surface on which it is moving. FIG. 13 illustrates a robot of construction similar to that of the cleaner of FIG. 12.

This embodiment is equipped with a coarse filter medium 172 (shown in phantom) and means 176 to dislodge debris from the pool surface so that it can be drawn into the filter 172. The open ends discharge conduits 44 are each fitted with an expansion sleeve 190 that is larger in its inside dimension(s) than the outside dimension(s) of the discharge conduit. The gap between the conduit 44 and sleeve 190 creates a path through which water drawn by the venturi effect created as a result of the sudden increase in volume of the flow path and corresponding pressure drop. This pressure drop creates a negative pressure inside the robot housing 12 so that the jet streams that converge under the cleaner are able to lift debris and carry it into contact with the robot's filter medium 172. The jet streams are tapped off the inlet side of valve assembly 40 by hoses 178 connected to a transverse manifold 180 at the front and back of the robot. The manifold 180 has multiple openings 175 that extend across the full width of the robot's housing so that the jet cleaning streams impinge on the entire surface to be cleaned.

FIG. 14 illustrates another embodiment of the invention in which the cleaning robot is operated by an external pump (not shown). As shown in the cross-sectional view, the cleaner is provided with two external coarse filter or collector bags 173 that are secured to the outlets of the venturi chambers 192. Outlet jets 194, fed by hoses 193, are positioned in the chambers 192. Water issuing from jets 194 creates a low pressure zone drawing up water and loose debris from beneath cleaner 10, the debris being retained by filter bag 173. The chambers are connected to the intake side of the jet valve housing 44.

FIG. 15 illustrates a robot that is equipped with a plurality of auxiliary wheel or rollers 30' along the bottom or side-walls between the supporting wheels 30 at either end of the cleaner 10. The auxiliary wheels can be mounted for free rotation on the housing 12 or external side plate. This configuration prevents the robot from being immobilized on a hump or other vertical discontinuity in the bottom surface of the swimming pool or tank being cleaned.

FIG. 16 illustrates a robot similar to that of FIG. 15, but instead of wheels or rollers, the bottom edges of the robot's side walls 12 or side plates 15 facing the pool surface are provided with Teflon[®] or other low-friction engineering plastic strips 201 so that the apparatus slides along on the bottom edges.

FIG. 17 illustrates another embodiment of the robot that is equipped with "immobilization" means. These means comprise two idling wheels 204, 206 connected to each

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other by a belt 208. It should be noted that although the so-called "immobilization" devices generally are installed on opposing sidewalls of the robot, there are instances in which it is desirable to equip the robot only on one side. This will result in random turning of the robot in one direction or the other whenever it goes over a hump as shown in FIG. 15.

FIG. 18 illustrates a cleaning robot with two water jet valve assemblies to which are attached directional flow elbows 120. In addition, there are a plurality of pumps having outlets 220 to increase the vacuum effect and cleaning ability of the robot. The multiple jet valve system is especially suited for remote control operation, since each jet valve can be controlled independently. As illustrated, the robot is equipped with rollers 30; however, wheels can also be used with this embodiment.

Vertical Pivot Axis

FIG. 19 illustrates a conventional fixed spring-loaded cylinder assembly 330 of the prior art which is activated by hydraulic force supplied by a pump motor (not shown) via hose 342, the timing of which is controlled electronically, e.g., by a pre-programmed integrated circuit device 344. When the hydraulic force is applied, the piston 346 moves to engage the surface causing the cleaner to pivot about the axis of piston 346. Use of this device produces random motion by the cleaner.

FIG. 20 illustrates a robot that is equipped on one side only with a cylinder assembly 300 that is free to rotate longitudinally towards both ends of the cleaner. The assembly's upper end 302 is pivotally mounted at 304 on the side of the robot at a position that is transversely displaced from the central longitudinal axis of the apparatus. At the lower end of the cylinder 300, a spring-loaded piston 306 extends downwardly toward the bottom of the pool. Each time the robot reverses its direction, the cylinder assembly 300 applies a transitory frictional braking force to the motion of the robot on one side which results in a pivoting action about the vertical axis of the piston and the repositioning, of the longitudinal axis of the apparatus. This braking action lasts until the piston 306 is pushed into the surrounding cylinder 308 far enough to allow the cylinder assembly to pivot past its vertical position. The rate at which the piston moves can be controlled, e.g., by an adjustable valve 310 at tie top of the cylinder. In the practice of this embodiment of the invention, the robot can have wheels mounted on fixed axles in parallel relation and still be able to scan the bottom surface of a rectangular pool.

FIG. 21 illustrates a robot that is equipped with an arm 320 pivotally mounted on one side of the cleaner housing at a position similar to that of FIG. 20, but which engages the pool bottom when the cleaner moves in only one direction. The lower end of arm 320 is arcuate, e.g., shaped as a segment of a circle, the center of which coincides with the pivot point 324 of the arm. A cylinder assembly 322 similar to the one described in FIG. 20, but without the spring, is pivotally linked to the arm at 323. However, the piston 326 is free to move in one direction only; movement in the other direction is controlled by an adjustable valve 310. When the robot changes direction, only every second time does the cylinder assembly apply a frictional braking force to halt the forward motion of the robot. Use of this apparatus and method of operation produces a scanning pattern for the cleaner that which consists of alternating perpendicular and angular paths with respect to the sides of a rectangular pool. In pools where the robot climbs the vertical side walls, the braking or pivot arm will continue to pivot while on the wall (due to gravity) as shown in phantom, so that when the robot comes off the wall, the arm will not immediately touch the

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bottom of the pool. In this mode of operation, a few seconds will pass before gravity pulls the arm 320 down to make contact with the bottom surface of the pool. The robot will move horizontally for a short distance before it changes direction by pivoting around the pivot arm.

FIG. 22 illustrates yet another embodiment in which pivot arm 330 extends in a downward direction to make contact with the bottom floor of the pool to provide a frictional braking force in both directions of movement and a pivot axis on one side of the robot 10. This mechanism works similarly to that of FIG. 20, and is relatively simpler and less expensive. A friction pad 334 is attached to adjustment means 332 which permits the frictional contact between the pad 334 and end of pivot arm 330 to be varied to thereby control the pivoting time that the opposite end of said arm is in contact with the pool surface and before disengagement of the pad and pivot arm. The friction pad can be a directional resistance material that is, greater resistance is provided in one direction than in the other.

As shown in FIG. 23, the open end of one or both of the outlets of the discharge conduit or directional flow elbow is provided with internal flow diverter means 550. Internal dove tail configuration 35 has an outwardly tapered throat and is provided with adjustable diverter flap 554 in the discharge flow path that directs the flow of water to one side or the other of the outlet 120. As more clearly shown in the cross-section view of FIG. 24, the dove tail outlet is provided with diverter flap positioning means 556, e.g., two set screws to adjust the position of the diverter flap 554. The cross-sectional area of the elbow when the diverter means is positioned at one side or the other is about the same as the area of the discharge conduit 120, i.e., there is no restriction of the flow, or increased back pressure. By having the water jet exit angularly to the left or to the right of the longitudinal centerline, the robot will follow an arcuate path in one direction or the other. The radius of the arc can be controlled by the adjustable positioning of the diverter flap 554. The cleaning apparatus of this embodiment can also be set to operate in a more random manner by retracting the adjusting screws 556 to allow the diverter flap to pivot freely from left or right each time the water jet impacts it. A manually adjustable flap 554 enables the user to change its position from time to time in order to unwind a twisted power cord, should that occur.

FIG. 25 illustrates another method by which a scanning pattern is achieved without changing the position of the wheels or the axles. The jet valve assembly 40 is positioned off-center of the central longitudinal axis "L" of the cleaner 10 to thereby produce movement in a semi-circular or other curvilinear pattern.

FIG. 26 illustrates another embodiment in which a scanning movement is achieved by providing the exterior of the housing 12 with a configuration that presents an asymmetrical hydrodynamic resistance to movement through the water. In the specific embodiment illustrated, the unequal hydrodynamic resistance is effected by adding a resistance flap 560 to one side of an otherwise symmetrically designed robot housing 12. The water resistance causes the robot to curve to the left or right. If the resistance means is pivotally mounted at 562 as shown, the robot moves straight in one direction and assumes a curved path in the other. A plurality of flap position members 564 are provided for adjusting the stop position of pivoting flap 560 to thereby vary the resistance. The asymmetrical hydrodynamic resistance can also be achieved by integrally molding the housing on one or both ends so that it presents unequal hydrodynamic resistance during movement.

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Power Cord Swivel Connector

In order to reduce or eliminate interference with the scanning pattern of the cleaner associated with twisting and coiling of the floating power cord 70 as the cleaner repeatedly changes direction which results in the tethering of the cleaner, another embodiment of the invention comprehends a swivel or rotatable connection at a position along the power cord, or between the power cord and the moving cleaner.

With reference to FIG. 27, there is schematically illustrated a cross-sectional view of the upper surface 16 of housing 12 provided with an aperture 78 adapted to accommodate socket portion 82 of electrical swivel connector socket 80. Socket 82 is fabricated from dielectric material 83 and is provided with electrical contacts 86a and 88a which in turn are joined to female plug 90 by conductive wires 89. Plug 90 is adapted to mate with male plug 92 which terminates electrical wire 93 from the motor (not shown.)

With further reference to socket 82, a groove 94 is provided proximate the open end to receive an O-ring 96 or other means for sealing the socket and locking the plug or jack portion 84 into secure mating relation. Jack 84 is comprised of insert member 98 fabricated from dielectric material, and electrical contacts 86b and 88b that are adapted to be received in sliding contact with corresponding elements 86a and 88a in socket 82. Insert member 98 is also provided with a groove or annular recess 99 that is adapted to engage ring 96 in fluid-tight sealing and locking relationship when jack 84 engages socket 82. It will also be understood that different or additional means can be provided to secure the mating sections 82 and 84 together, that will also permit them to rotate when mated. Insert member 98 is secured in water-tight relation to right angle member 100, preferably fabricated from a resilient dielectric material, through which are passed a pair of electrically conductive wires (not shown) from power cord 70 that terminate, respectively, at conductors 86b and 88b. Right-angle jack member 100 is also constructed with a plurality of flexure members 102 about its periphery in order to provide additional flexibility between the housing connection and the power cord 70 during operation of the cleaner. It will be understood that the right-angle jack member 100 will freely swivel in the opening of socket member 82 in response to a force applied by power cord 70. Thus, the power cord 70 remains free of coils, does not suffer any effective shortening in its length and therefore does not exert any tethering restraining forces on the cleaner that would adversely effect the ability of the cleaning apparatus to freely traverse its path.

With reference to FIG. 28 there is shown a second embodiment of an electrical swivel connector for joining the power cord 70 to the motor electrical wire 93 via elements as described above in connection with FIG. 27. In the embodiment illustrated, a straight-line swivel is comprised of socket member 82' and plug member 85, the former being joined by a short length of power cord 91 extending through restraining gasket 79 secured in opening 78' in a sidewall of cleaner housing 12. The two sections of the swivel connector are securely joined together in rotating relationship as described above with reference to FIG. 27. As the cleaning apparatus moves about the pool surfaces, the socket 80 moves in response to the tension transmitted through power cord 70 and any twisting or torsional forces are dissipated by the rotation of plug 85 in socket member 82. The power cord therefore does not form coils, or otherwise have its effective length reduced, and does not stop adversely effect the movement of the cleaner.

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In another preferred embodiment of the swivel connector, a permanent in line or straight connection between two sections of power cable 70 is provided by a connector permitting angular displacement between its elements. As illustrated in FIG. 29, connector 104 comprises a rigid non-corroding ferrule 105, which can be in the form of a length of polymeric or stainless steel tubing, that extends between waterproof tubular junction members 106, 106' that also receive opposing cable ends 70. One of the junction members 106 contains electrical connector jack 107 and plug 108 which are axially rotatable with respect to each other. A conductor pair 109 of cable 70 are permanently joined to the adjacent terminals of jack 107 and secured in place within junction member 106, e.g., by a plug of flowable epoxy resin 110 or other potting material that hardens after the elements have been assembled.

With further reference to FIG. 29, a pair of conductors 111 extending from the rear of plug 108 extend axially through ferrule 105 and a bushing 112 is placed on ferrule 105 to engage the rear shoulder of jack 108. In a preferred embodiment, the ferrule end is flared and the adjacent surface of annular bushing 112 is shaped to receive the ferrule. The junction member containing the connector jack and plug is completed by securing on tubular member 106, cap 113 having a central orifice into which is secured axial seal 114 which passes over ferrule 105 and permits rotation of the ferrule in water-tight relation. The assembly of the adjoining junction member 106' is completed by joining conductor pair 111 to the conductor pair 109 of cable 70 and filling the end with flowable epoxy resin 110 and installing cap 113'. When the epoxy or other potting compound has set, it will be understood that the two ends of cable 70 are permanently joined and that ferrule 105 has been secured to junction member 106' in water-tight relation and that plug 108 is free to rotate with respect to jack 107 and the assembly of junction member 106. In this embodiment, the swiveling or rotatable connector assembly 104 is positioned approximately three meters from the cleaner to reduce the likelihood that the user will lift the cleaner from the pool using a section of the power cable that includes the connector.

As schematically illustrated in FIG. 30, any twisting or torsional forces transmitted by the movement of the cleaner 10 through the attached length of power cord 70 will be dissipated by the rotation of member 106.

It will also be understood by one of ordinary skill in the art that various other mechanical constructions can be provided that will permit relative rotation between adjacent sections of the power cable, one end of which is attached to the cleaner and the other to the external fixed power supply to thereby eliminate the known problems of cable twisting, coiling and tethering that adversely effect the desired scanning patterns or random motion of the pool cleaner.

Axle Orientation

By Way of background, the series of FIGS. 31A and 32A are representative of the prior art. FIGS. 33-44 schematically illustrate in plan view the apparatus and methods embodying the invention to control the movement of a swimming pool cleaning robots 10 to produce systematic scanning patterns and scalloped or curvilinear patterns, and to provide controlled random movement on the bottom surface of pool. The configurations will provide one or more of the above three mentioned movements. The cleaner can be propelled either mechanically or by a discharged jet or stream of water.

In the prior art arrangement shown in FIG. 31A, an offset extension member 400 is secured to one end of housing 12

at a position that is displaced laterally from the longitudinal axis "L" of the cleaner and which causes the robot to position itself angularly in relation to vertical swimming pool wall 401 (shown in phantom.) When the robot 10 reverses its direction, it travels at an angle "b" away from the side wall 401. When cleaner 10 contacts the opposite side wall 403, the robot's body again pivots and comes to rest in a position where its longitudinal axis "L" is at a 90° angle to side wall 403. The resulting scanning pattern is illustrated in FIG. 31B.

In the prior art configuration of FIG. 32A, a second offset extension member 402 is added to the housing opposite extension member 400. The scanning pattern provided by two opposing extension members is generally shown in FIG. 32B. The 90° pivoting turns occur in both a clockwise and counter-clockwise direction.

In accordance with the improved method and apparatus of the invention, separate members projecting from the front and rear housing surfaces are eliminated, and in one preferred embodiment, at least one supporting wheel, or track, or roller end, projects beyond the periphery of the cleaner in the direction of movement to contact a vertical side wall or other pool surface.

In the preferred embodiment of FIG. 33 one of the wheels 30a is mounted so that it projects forward of the housing 12 as a pivot point and thereby causes the same angular alignment between the robot 10 and swimming pool wall 401, as the apparatus of FIG. 31 and produces a scanning similar to that of FIG. 3A. With further reference to FIG. 33 is a ball-shaped side extension 404 terminating in tip 406 formed of resilient, soft rubbery material which, when it comes in contact with the end of pool 405,407, causes the robot to make a 90° pivoting, indicated turn by arrow in FIG. 31B. As the pattern shows, every time this 90° turn occurs the cleaner turns in a clockwise direction. It will be understood that if the side projection member 406 been placed at the upper left side of the housing 12, the 90° turns would have been counter-clockwise.

In the embodiment of FIG. 34 two opposing wheels 30a, 30b at the left side of robot 10 are mounted forward of the periphery at their respective ends of the cleaner to provide a transnational pivot axis. This configuration creates a scanning pattern similar to that shown in FIG. 32B. In this embodiment of FIGS. 31A to 34, the wheels are individually rotatable and their axles are stationary. With this embodiment, power cable twisting is not a problem.

With reference to the embodiment of FIG. 35, a pair of wheels 30c are mounted on caster axles pivoted for limited pivoting movement defining an arc in translational plan passing through the center of the wheels. The axles and wheels 30c swivel so that when the robot moves in the direction opposite the caster mounts, all four wheels are parallel with each other along the longitudinal axis of the robot. When the robot moves in the opposite direction, i.e., the caster wheels are leading, the caster wheel axles swivel or pivot to a predetermined angle, which angle can be adjustable. The robot scans a rectangular pool in a manner shown in FIG. 35A, where the path is curvilinear in one direction and straight in the other. The angular arc can be up to about 15° from the normal and is preferably adjustable to account for the pool dimensions.

In an embodiment related to that of FIG. 35 (but not shown), all four wheels are caster mounted, the opposing pairs being set for angular displacement when the cleaner moves in opposite directions. That is, depending on the direction of the robot's movement, when one pair of wheels are at an angle to the robot's longitudinal axis, the opposite

set of wheels are parallel in the axis "L", and vice versa. The scanning pattern would be as illustrated in FIG. 35B.

In the embodiment of FIG. 36, the transverse axes 32 are mounted in an angular relation to each other so that the wheels on one side of the cleaner are closer together than those on the opposite side. The scanning pattern is as illustrated in FIG. 35B.

As shown in FIG. 37, one end of one of the axles is mounted in a slot so when the robot moves one direction it follows a curved path, and when it moves in the opposite direction (i.e.; where the slot is in the rear of the cleaner) the robot follows a straight line. (The pattern is shown in FIG. 35A).

In the embodiment of FIG. 38, the wheel axles are parallel to each other and normal to the longitudinal axis "L" of the robot, and the wheels 305 on one side of the cleaner are smaller in diameter than the wheels on the opposite side. The scanning pattern is as illustrated by FIG. 35B.

As shown in FIG. 39, all four wheels of the robot 10 are caster mounted, and all four wheels move together to be either parallel to the robot's axis, or at an angle to the axis "L", depending on the direction in which the robot moves. The scanning pattern is as shown in FIG. 31B. The angular displacement can be up to 45°, since all four wheels are moving in parallel alignment.

In FIG. 40, the four wheels are mounted to swivel in unison, and move as in FIG. 39. Both of their extreme positions are angular to the robot's body, but symmetrical to each other. This arrangement provides a scanning pattern as shown in FIG. 32B. Again, the angular displacement of the caster wheels can be up to 45° in both directions from the normal. It will be understood that the longitudinal axis of cleaner 10 will be perpendicular to the wall it contacts.

As also illustrated in FIG. 40, both longitudinal side of the cleaner 10 are provided with at least one projecting member 404. As will be described in more detail below, the pivoting function of side extending pivot contacts as represented by the specific embodiments of elements 404, can also be effectuated by elements projecting from the external hubs of two or more of wheels 30, or the side wall surfaces of cover 12 or other side peripheral structure of the cleaner 10. The transverse projection of such elements is determined with reference to their longitudinal position and the shape or footprint of the peripheral projection of the cleaner on the pool surface. For example, a side-projecting frictional pivot member located at the leading edge of a generally rectilinear cleaner will require less projection than a single member of FIG. 33 that is located midway between the ends of the cleaner.

In FIG. 41, both axles are mounted in slots 320 on one side of the unit so that the wheels adjacent the slots can slide up and down to be either parallel to the robot's longitudinal axis, or at an angle thereto, depending on the direction of movement of the cleaner. This arrangement produces the scanning pattern of FIG. 31B.

In the embodiment of FIG. 42, the axles swivel in larger slots 320 to achieve angular positioning of wheels to the robot's body in both extreme positions, but in symmetrical fashion, with a resulting scanning pattern as shown in FIG. 32B.

From the above description, it will be understood that when operating in a rectangular pool or tank, the embodiments shown in FIGS. 39-42 allow the robot to move parallel to the swimming pool's end walls, even when it travels other than perpendicular to the sidewalls. In other words, the correct scanning pattern does not require an angular change in the alignment of the robot's body caused

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by a forceful contact with a swimming pool wall as with the prior art. This is particularly important where a water jet propulsion means is employed, because as the filter bag accumulates debris in the jet propulsion system, the force of the water jet weakens and the force of impact lessens, so that the robot's body may not be able to complete the pivoting action required to put it into the correct position before it reverses direction. This is especially true in Gunite or other rough-surfaced pools in which a robot with even a clean filter bag may not be able to pivot into proper position because the resistance or frictional forces between the wheels and the bottom surface of pool may be too great to allow the necessary sideways sliding of the wheels before reversal of the propelling means occurs.

As shown in FIG. 43, one of the axles is mounted in slots 320 that permit it to move longitudinally at both ends. This longitudinal sliding motion is restricted by one or more repositionable guide pins 330. These pins allow the user to adjust the angular positioning of the axle to accommodate the width or other characteristics of the pool. By reversing the position of the pins on both left and right sides, the robot will follow a pattern which is similar to that shown in FIG. 35A. This method of operation will also unwind a twisted cable.

With further reference to FIG. 43, there are shown mounted on the ends of axles 32 or hubs of wheels 30 side projecting pivot member 200. These members serve the same function and can be constructed of materials as described with reference to side projecting members 404 as described in connection with FIG. 33, above. Pivot member 200 can be mounted on one or both sides of the cleaner 10 to engage the sidewall of the pool and cause the cleaner to pivot into that wall.

In FIG. 44, both axles are mounted in slots permitting longitudinal movement at both ends. This will allow the robot with proper positioning of the guide pins to advance in a relatively small circular pattern in one direction and in a slightly larger one in the other.

It is to be noted that the odd-numbered embodiments of FIGS. 31 to 44 illustrate devices which turn only one way when they make 90° pivoting turns, and that the embodiments of even-numbered FIGS. 31 to 44 turn both ways. Simply put, when the robot scans in an asymmetrical pattern, it turns either clockwise or counter-clockwise; when the robot scans in a symmetrical pattern, it turns in both directions. The two main categories in relation to their movements. Within these principal categories, there are variations where straight-line movements are replaced by curved paths, e.g., in FIG. 35B, or the two are combined, e.g., in FIG. 35A.

It is relatively easy to clean a rectangular pool in any systematic scanning manner as shown above, but it is more difficult to clean an irregularly-shaped pool. Applying the method and apparatus of the invention and using the guide pins set as described above, the robot can scallop a free form pool in a systematic manner as shown in FIG. 46.

FIG. 45 shows the six different arrangements in which each wheel 32 can be positioned. By pressing the appropriate pins 330 down or pulling them up, the wheel axle 30 can be placed in three stationary positions: outside, center and inside. It can also be placed in three sliding positions outside to inside; outside to center; and center to inside. Since there are four wheels, the total combination of positions of these wheels is 1296 (6 to the 4th power) which provides a total of 361 different scanning patterns.

In a particularly preferred embodiment employing a transverse axle 32 one-half inch in diameter, the axle supporting

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members 353 are provided with slots 320 extending 1.5 inches longitudinally to receive the axle in slidable relation. Each slot is provided with a central lock pin 330 which can optionally be withdrawn from the slot. This configuration provides a sufficiently large number of combinations and angular displacements of wheels and axles to cover essentially all of the sizes and shapes of pools in common use today. The flexibility of this embodiment gives the user the ability to select an optimum cleaning pattern for all types, sizes and shapes of pools.

The embodiment illustrated in FIG. 47 provides an apparatus and method that automatically switches the positions of two wheels when the scanning robot reaches the end of the pool. Unlike the embodiments described above that provided the robot with means by which to turn 90° clockwise or counter-clockwise, this embodiment allows the robot to maintain its orientation in a rectangular pool that is parallel with the swimming pool's walls. Using this embodiment, the power cord cannot become twisted or formed into tight coils. Moreover, a coarse surface having a high coefficient of friction does not adversely effect desired scanning patterns. The robot has two side plates 370 which are provided with horizontal slots 320 to hold the ends of transverse axle 32. Pivotaly mounted at pivot pin 353 on the inner side of the side plates and overlapping the horizontal slots are two identical guide plates 374, 374' each of which is provided with an L-shaped slot 355 in freely accommodate movement of axle 32. Two levers 356, each of which is pivotaly mounted at one of its ends concentrically with the pivot point of each of the guide plates. The other end of each lever 356 extends into a 45° slot 358 provided in slidably mounted transverse cross-bar 360, which cross-bar extends beyond the periphery of a side wall of housing 12 a distance that is sufficient to contact on adjacent pool wall. Each of said guide plates 354 is linked with its corresponding lever 356 through a spring 362, said spring being secured to pins 364 protruding from said guide plates and levers.

With respect to FIG. 48A, which is a view taken along line 48A—48A of FIG. 47, it can be seen that spring 362 is pulling guide plate 354 counter-clockwise holding the longer vertical leg of the upside down L-shaped slot in position for the wheel axle to slide freely.

With reference to FIG. 48B, which is a view taken along line 48B—48B of FIG. 47, it can be seen that spring 362 pulls corresponding opposite guide plate 354' clockwise, locking that end of wheel axle 32 into a forward stationary position relative to the opposite end of the axle.

During operation, as the cleaner approaches a pool side wall that is generally parallel to the longitudinal axis of the cleaner, the projecting end 360R of the slidably mounted cross-bar comes in contact with the swimming pool wall, and the bar slides to the left, as indicated FIG. 49. This horizontal movement of bar 360 is translated into a vertical or lifting force on levers 356 via the 45° slots 358 in bar 360. This results in the flipping of levers 356 to their opposite side. This movement causes springs 362 to pull their respective guide plates 354, 354' to the opposite position, locking the right end of the axle 32, while freeing up the left end. While this action on the left end of axle 32 is instantaneous, the right end is not locked in position until the robot reverses direction, at which time the right end of axle 32 slides into a trap provided by the short leg of L-shaped slot 355 in guide plate 354. Using this apparatus, the cleaner 10 continues to travel back and forth between the same end walls of the pool but over a different reverse path that is determined by the angular displacement of the wheels and/or axles, thereby assuring cleaning of the entire surface.

FIG. 50 illustrates another embodiment of the invention in which pool cleaner 10 is provided with a plurality of rolling cylindrical members in place of wheels. The long cylinder 500 is driven at one end by a flexible chain belt 510 at presses around sprocket 512 attached to an electric motor or water turbine drive shaft (not shown.) A pair of shorter rollers 502, 504 are mounted on transverse axle 506. As schematically illustrated, the right end of axle 506 is free to move longitudinally in slot 508 provided in axle support member 520. The use of a drive chain and spoked rollers allows for changing alignment of supporting axle 506, and eliminates problems of tensioning and resistance to movement associated with timing belts used by the prior art. A cleaner constructed in accordance with this embodiment will exhibit a scanning pattern similar to that of FIG. 32B.

FIG. 51 schematically illustrates a robot 10, which uses a pair of drive belts or chains 510a, 510b to power two cylindrical members 500, 501. The right end of axle 506 is free to move in slot 510 provided in axle support member 520 and the opposite end of axle is provided with a universal joint 522 which in turn is attached to a driven pulley or sprocket 512. The scanning pattern of this unit is also similar to the one shown in FIG. 32B.

With further reference to FIGS. 51 and 51, there are shown side projecting pivot members 202 secured to the exterior of side supporting member 520. Similarly, pivot members 202 can be secured to the opposite side, e.g., on housing 12, or other outboard supporting member to provide a point of frictional engage with a sidewall of the pool to effect a pivoting turn of the cleaner into the wall where it is properly oriented for eventual movement away from the wall, e.g., upon reversing of the cleaner's water jet or other drive means.

It will be understood that in the apparatus of FIGS. 31-44, the wheels mounted on transverse axles can be replaced with cylindrical roller members of the types illustrated in FIGS. 50 and 51.

In determining the optimum angular displacement of the axles and caster mounted wheels, it will be understood that the length of the longitudinal slots provide a practical limitation on the angle of the axle, while the caster axles can provide a greater angular displacement for the wheels. The angular displacement of the coaster wheel axles can be up from 20° to 45° from the normal and arc preferably up to 10°, the most preferred being up to about 5° from the zero, or normal line.

Auto-Reversal Sequence

One embodiment of the apparatus and method of the invention addresses problems associated with the immobilization of the cleaner. The electronic control means of the pool cleaner is programmed and provided with electrical circuits to receive a signal from at least one mercury switch of the type which opens and closes a circuit in response to the cleaner's movement from a generally horizontal position to a generally vertical position on the sidewall of the pool or tank. The use of mercury switches and a delay circuit to reverse the direction of the motor is well-known in the art. As will be understood by one of ordinary skill in the art, a pool cleaner can become immobilized by a projecting ladder or other structural feature in the pool so that its continuing progress or scanning to clean the remaining pool surfaces is interrupted. In accordance with the improvement of the invention, the electronic controller circuit for the motor is preprogrammed to reverse the direction of the motor automatically if no signal has been generated by the opening (or closing) of the mercury switch after a prescribed period of time. A suitable period of time for the auto-reversal of the pump or drive motor is about three minutes.

This sequence of program steps is schematically illustrated in the flow chart of FIG. 52, where the time clock begins to count-down a prescribed time period after the cleaner is activated. In a preferred embodiment, the timer can be manually set to reflect the user's particular pool requirements. Alternatively, the time clock can be factory-set for a period of from about 1.5 to 3 minutes. If the mercury switch changes position, the time clock stops its countdown and/or a delay circuit is activated to allow time for the cleaner to climb the sidewall of the pool, e.g., about 5-10 seconds. At the end of the delay period, the drive motor is stopped and/or reversed to move the cleaner down the wall. In the event the timer reaches the prescribed time period without receiving a signal from the mercury switch, a signal is transmitted to stop and/or reverse to drive motor. If the cleaner has been immobilized by an obstacle, this timed auto-reversing of the drive motor will move the cleaner away from the obstacle to resume its scanning or random motion cleaning pattern.

Power Shut-off

The method and apparatus of the invention also comprehends the use of a power shut-off circuit that is responsive to a signal or force that corresponds to a magnetic field. In one preferred embodiment, a magnet or magnetic material is formed as, incorporated in, or attached to a movable element that forms part of the cleaner, e.g., a non-driven supporting wheel or an auxiliary wheel that is in contact with the pool surface on which the cleaner is moving. One suitable device is a reed switch that is maintained in a closed position (e.g., passing power to the pump motor) so long as the adjacent magnet is moving past at a specified rotational speed, or rpm. If the rotation of the magnet stops, as when the cleaner's advance is stopped by encountering a sidewall of the pool, the reed switch opens and the power to the drive motor is interrupted. In a preferred embodiment, the circuit includes a reversing function so that the cleaner resumes movement in the opposite direction and the reed switch is closed to complete the power circuit until the unit again stops, e.g., at the opposite wall.

In a further specific and preferred embodiment of the invention, the cleaner is provided with an impeller that is rotatable in response to movement through the water. One or more of the impeller blades and/or mounting shaft is provided with or formed from a magnetic material. A sensor is mounted proximate the path of the moving magnet and an associated circuit is responsive to the signal generated by the sensor due to the movement, or absence of movement, of the magnet. In one preferred embodiment, the magnetic sensor circuit is incorporated in the cleaner IC device that electronically controls the pump motor, so that when the cleaner's movement is halted by a vertical side wall, the movement of the impeller and associated magnetic material also ceases and the sensor sends a signal through the circuit to interrupt power to the pump motor. After a predetermined delay period, the pump motor can be reactivated, in either the same or the reverse direction, to cause the unit to move away from the wall. The same circuit can be employed to control a drive motor that propels the drive train for wheel, track or roller mounted cleaners.

In another embodiment, the cleaner is provided with an infrared ("IR") light device that includes an IR source and sensor and related control circuit that is responsive to a static position of the cleaner adjacent a side wall of the pool or tank. When the returned IR light indicates a static position the circuit transmits a signal that results in the reverse movement of the cleaner.

In a further preferred embodiment, the electric or electronic controller circuit of the cleaner includes an "air

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sensor" switch that sends a signal or otherwise directly or indirectly interrupts the flow of water stream W when the sensor emerges from the water. In one preferred embodiment the sensor is a pair of float switches, one located at either end of the cleaner. When the cleaner climbs the vertical sidewall of the pool, and the end with the air sensor emerges from the water line, water drains from the float chamber and the switch is activated to either directly interrupt the flow of electrical power to the pump motor, or to send a signal to the IC controller to effect the immediate or delay interruption of power to the pump motor. The same sequence of events occurs during operation of an in-ground pool of the "beach" type design, where one end has a sloping bottom or side that starts at ground level. Once the forward end of the moving cleaner emerges from the water, the flow of water is interrupted for a brief time and then resumed in the opposite direction to propel the unit down the slope to continue its scanning pattern.

As will be understood from the preceding description, and from that which follows, this aspect of the invention comprehends various alternative means for interrupting the flow of the water jet. For example, if the pressurized water stream is delivered via hose 152 from a source external to the cleaner, e.g., the pool's built-in filter pump, an electromechanical bypass valve (not shown) located adjacent the hose fitting at the sidewall of the pool can be activated for a predetermined period of time to divert the flow of water from the hose directly into the pool. When the flow of water W is interrupted, the flap valve 46 of valve assembly 40 changes position and the cleaner reverses direction when the flow W is resumed.

As will be understood by one of ordinary skill in the art, the means of generating signals directed to the control circuit can also be combined. For example, an air sensor of the float type can be combined with, or fabricated from a magnetic material and installed proximate a magnetic sensor so that a change in position of the float when it is no longer immersed in water produces a signal in the magnetic sensor circuit.

The flow of water W can also be interrupted by a water-driven turbine timer having a plurality of pre-set or adjustable timing sequences. For example, a water-powered cam or step-type timer in combination with a by-pass or diverter valve located downstream is installed on the hose 152 from the external source of pressurized water. As water flows through the hose, the timer mechanism is advanced to a position at which the associated by-pass valve is actuated and the flow is diverted into the pool for a predetermined period of time. The turbine timer then advances to the next position at which the by-pass valve moves to the main flow position to redirect water to the cleaner, which now moves in the opposite direction. In this embodiment, the by-pass/diverter valve can comprise an adjustable pinch valve that compresses the hose to interrupt flow to cleaner 10.

In another preferred embodiment, the rpms of the pump and/or drive motor are monitored and if the rpm decreases below a certain minimum, as when the impeller is jammed by a piece of debris that escaped the filter, the power to the pump motor is interrupted. If the rpms exceed a maximum, as when the unit is no longer submerged and the motor is running under a no-load condition, the power is interrupted to both pump and drive motors. This will constitute an important safety feature, where the cleaner is turned on while it is not in the pool, either by inadvertence, or by small children playing with the unit.

We claim:

1. A self-propelled apparatus for cleaning the submerged sidewall and bottom surfaces of a pool in a predetermined scanning pattern, the apparatus comprising;

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- (a) a housing formed by a top wall and depending side walls;
- (b) reversible drive means for propelling the apparatus in opposite directions, which directions correspond generally to the longitudinal axis of the apparatus; and
- (c) a pair of wheels assembled to each of the opposite longitudinal ends of the apparatus, where the improvement comprises mounting each pair of wheels to transverse axes, the axes of the respective axes defining an angle that is acute to the longitudinal axis of the apparatus when the apparatus is moving in at least one direction.

2. The apparatus of claim 1, wherein one pair of wheels is mounted on a first transverse axle, and the first transverse axle forms an angle of between about 75° and 89° with the longitudinal axis of the apparatus.

3. The apparatus of claim 1 where the angle of one of the transverse axes is fixed.

4. The apparatus of claim 1, wherein at least one end of the transverse axes is free to move longitudinally within a predetermined range.

5. The apparatus of claim 4, wherein the angular range of movement of at least one of the axes is adjustable.

6. The apparatus of claim 4, wherein the range of movement is defined by the ends of a slot through which the axle passes.

7. The apparatus of claim 4, wherein the angular position of at least one of the axes is adjustable.

8. The apparatus of claim 7, which further comprises manually adjustable lock pins for controlling the range of movement of at least one end of the axle.

9. The apparatus of claim 7 which further comprises manually adjustable lock pins for controlling the range of movement of both ends of the axle.

10. A self-propelled robotic apparatus for cleaning the submerged sidewall and bottom surfaces of a pool in a predetermined scanning pattern, the apparatus comprising:

- (a) a housing formed by a top wall and depending side walls;
- (b) reversible drive means for propelling the apparatus in opposite directions, which directions correspond generally to the longitudinal axis of the apparatus; and
- (c) a pair of wheels assembled to each of the opposite longitudinal ends of the apparatus, where the improvement comprises mounting at least one of said pair of wheels at a fixed predetermined angle that is acute to the longitudinal axis of the apparatus when the apparatus is moving in at least one direction, whereby the adjacent trajectories defined by the apparatus moving across the bottom surface between opposing sidewalls cover substantially the entire bottom surface between said trajectories.

11. The apparatus of claim 10, wherein the angled pair of wheels are mounted on a transverse axle.

12. The apparatus of claim 10 where the angle of the axle upon which the wheels are mounted is manually adjustable to accommodate the dimensional characteristics of the pool to be cleaned.

13. A self-propelled robotic apparatus for cleaning the submerged sidewall and bottom surfaces of a pool in a predetermined scanning pattern, the apparatus comprising:

- (a) a housing formed by a top wall and depending sidewalls;
- (b) reversible drive means for propelling the apparatus in opposite directions, which directions correspond generally to the longitudinal axis of the apparatus; and

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(c) a pair of wheels assembled to each of the opposite longitudinal ends of the apparatus, where the improvement comprises mounting at least one of said pair of wheels on an axle that is moveable from the first position to a second position defining an angle that is acute to the longitudinal axis of the apparatus when the apparatus is moving in at least one direction, whereby the adjacent trajectories defined by the apparatus moving across the bottom surface between opposing sidewalls cover substantially the entire bottom surface between said trajectories.

14. The apparatus of claim 13, wherein both pairs of wheels are mounted on transverse axles that are moveable to positions that respectively define an angle that is acute to the longitudinal axis of the apparatus when the apparatus is moving in at least one direction.

15. The apparatus of claim 13, wherein the at least one pair of wheels are mounted on the same axle.

16. The apparatus of claim 13, wherein the angle defined by the axle in the second position is manually adjustable.

17. The apparatus of claim 13, wherein the first position of the axle is normal to the longitudinal axis of the apparatus.

18. A self-propelled apparatus for cleaning the submerged sidewall and bottom surfaces of a pool in a predetermined scanning pattern, the apparatus comprising:

- (a) a housing formed by a top wall and depending side walls;
- (b) reversible drive means for propelling the apparatus in opposite directions, which directions correspond generally to the longitudinal axis of the apparatus; and
- (c) a pair of wheels assembled to each of the opposite longitudinal ends of the apparatus, where the improvement comprises mounting to at least one end of the apparatus a pair of caster wheels, each of the caster wheels comprising an independently mounted axle mounted proximate the outboard side of the housing, each of the axles having a range of angular movement

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in a plane parallel to the surface being cleaned, the axes of the respective caster wheel axles defining an angle that is acute to the longitudinal axis of the apparatus when the apparatus is moving in at least one direction.

19. The apparatus of claim 18, wherein each of the axes of at least one pair of the wheels move through an arc that is intersected by a line that is normal to the longitudinal axis of the apparatus.

20. The apparatus of claim 18, wherein each of the independently mounted caster wheels on one end of the apparatus move through an angle of between about 75° and 89° with the longitudinal axis of the apparatus.

21. A self-propelled robotic apparatus for cleaning the submerged sidewall and bottom surfaces of a pool in a predetermined scanning pattern, the apparatus comprising:

- (a) a housing formed by a top wall and depending sidewalls;
- (b) reversible drive means for propelling the apparatus in opposite directions, which directions correspond generally to the longitudinal axis of the apparatus; and
- (c) a pair of wheels assembled to each of the opposite longitudinal ends of the apparatus, where the improvement comprises independently mounting each of a pair of caster wheels on one end of the apparatus, each of the caster wheels comprising an axle mounted proximate the outboard side of the housing, each of said axles being moveable from a first position to a second position through an arc that defines an angle acute to the longitudinal axis of the apparatus when the apparatus is moving in at least one direction, whereby the adjacent trajectories defined by the apparatus moving across the bottom surface between opposing sidewalls cover substantially the entire bottom surface between said trajectories.

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United States Patent [19]

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Porat

[45] **Date of Patent:** **Aug. 8, 2000**

[54] **APPARATUS AND METHOD OF OPERATION FOR HIGH-SPEED SWIMMING POOL CLEANER**

5,985,156 11/1999 Henkin et al. 134/167 R

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[57] **ABSTRACT**

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[52] **U.S. Cl.** **134/18; 134/22.1; 134/58 R; 134/167 R; 15/1.7; 210/143; 210/169**

[58] **Field of Search** **134/18, 22.1, 22.18, 134/57 R, 58 R, 167 R; 15/1.7; 210/143, 169**

An apparatus and method for cleaning the bottom and vertical side walls of a swimming pool, pond or tank employs a robotic, self-propelled cleaner having a protective housing of conventional design, the cleaner being operated at a primary cleaning speed as it traverses the surfaces to be cleaned and until the cleaner housing emerges from the water along a sidewall of the pool; thereafter the cleaner operates at a secondary drive speed that is relatively slower than the primary speed and the cleaner thereafter reverses direction and descends for a pre-determined period of time at the slower secondary speed in order to permit the air entrained under the housing to escape without destabilizing the cleaner during descent. After the predetermined period of time, the cleaner resumes operation at the more rapid primary speed until the cleaner housing once again emerges from the water's surface, after which the cycle is repeated.

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24 Claims, No Drawings

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**APPARATUS AND METHOD OF OPERATION
FOR HIGH-SPEED SWIMMING POOL
CLEANER**

FIELD OF THE INVENTION

The invention relates to automated, power-driven pool cleaners employed in the unattended cleaning of the bottom and side walls of swimming pools and tanks.

BACKGROUND OF THE INVENTION

Automated swimming pool cleaners have been developed for the cleaning of the bottom and side walls of pools by programming the electrically-powered cleaner to traverse the bottom of the pool in one direction, and climb the side wall of the pool that it encounters until the leading end of the cleaner emerges at the waterline of the pool. Thereafter, the drive mechanism is reversed which causes the pool cleaner to reverse direction and to descend the vertical side wall until it encounters the bottom of the pool, at which point it undergoes a transition to return to a generally horizontal position to again begin its traverse of the bottom of the pool. By means of various structural and/or electro-mechanical devices operated in response to a preprogrammed micro-processor controller, the pool cleaner can be made to traverse an ever-changing, but generally predictable pattern across the bottom and up and down the side walls of the pool in order to clean the entire bottom surface. The pool cleaner also traverses horizontally along the side wall of the pool to clean the so-called scum line that often forms at the waterline.

Pool cleaners of the prior art are designed to operate at a substantially continuous speed, whether they be driven by electric motors or water turbines. Minor variations in speed may occur at the transition zone where the pool cleaner moves from a generally horizontal position at the bottom of the pool to assume a vertical position on the side wall, and vice-versa. Other minor variations may be observed when the direction of travel of the pool cleaner is reversed, for example, when the pool cleaner begins its descent from the waterline along the side wall of the pool. Further minor variations between the speed at which the cleaner traverses the bottom of the pool and that at which it ascends and/or descends along the side wall due to gravitational effects which act upon the cleaner despite its neutrally buoyant design. However, these variations in speed are relatively minor and do not occur as a result of the preprogrammed operation of the cleaner and do not improve the functioning of the cleaner.

Swimming pool cleaners of the prior art operate at speeds in the range from about five feet per minute to ten feet per minute. Depending upon the size of the pool to be cleaned, the unit may have to be placed in operation for as long as six to eight hours to clean a large municipal or commercial swimming pool. The cleaning of larger pools must be done when the pool is not in use, generally overnight, over a weekend, or at other times when it is not convenient or economical to have maintenance personnel on duty to attend the cleaning of the pool. Although the power supply to the pool cleaner can be put on a timer, various circumstances can arise that will interfere with, or entirely interrupt the operation of the cleaner so that only a portion of the pool has been cleaned during the allocated cycle. For example, the floating power cord can become entangled, thereby disrupting the programmed cleaning pattern; the cleaner can become trapped in a corner, or against a ladder or other obstruction at the side of the pool.

In order to permit the pool cleaner to traverse the bottom of the pool and to ascend and descend the side walls of the pool during its cleaning operations, the pool cleaner is of

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substantially neutral buoyancy with respect to the water in the pool. Thus, variations in water density between fresh water and salt water pools must also be taken into account in the construction of pool cleaners for these different environments. For example, additional weights can be attached to the cover and/or base plate of a pool cleaner that is neutrally buoyant with respect to fresh water in order to adapt it for use in a salt water pool. As will be understood by one familiar with the art, when the pool cleaner ascends to the waterline to clean the wall surface at the scum line, a portion of the pool cleaner projects above the surface of the pool. Air enters the space between the cover and the base plate, and when the pool cleaner begins its descent along the wall, the air must be displaced by the water in order to maintain the designed neutral buoyancy of the cleaner. It has also been observed that when the pool cleaner is initially placed in the pool, the owner or maintenance personnel typically lowers the unit in a vertical position on the side wall and activates the power supply.

It has been found that when pool cleaners of the prior art are operated at higher speeds, the rapid descent from the waterline results in air becoming entrained in the space between the cover and base plate causing the cleaner to float away from its operating position and vertical alignment on the wall. If the air is not displaced, the cleaner will float at the surface of the pool; if the air is eventually displaced and the cleaner sinks to the bottom of the pool it can remain in an inoperable position with respect to the bottom of the pool, or if it does land upright on the bottom surface, its programmed pattern of operation will have been disrupted and areas of the pool will be left uncleaned.

It is therefore an object of the present invention to provide an apparatus and a method for increasing the speed at which the pool is cleaned, thereby reducing the overall operating time of the pool cleaner.

It is another object of the invention to provide a pool cleaner that operates at a speed that is significantly greater than that of commercially available pool cleaners of the prior art.

It is yet another object of the invention to provide a power-driven automated pool cleaner that will rapidly traverse the bottom and ascend the side walls of a pool and that will descend from the waterline while maintaining continuous operative cleaning contact with the side wall of the pool.

It is also an object of the invention to provide an apparatus and method for rapidly cleaning the side walls of pools a the scum line.

It is another important object of the invention to provide a pool cleaning apparatus that operates at speeds significantly greater than those of the prior art while maintaining its neutral buoyancy at all stages of its cleaning operations.

SUMMARY OF THE INVENTION

The above objects, as well as further advantages, are attained by providing an improved automated power driven pool cleaning apparatus for cleaning the bottom and side-walls of a pool comprising:

- (a) drive means for moving the cleaner in forward and reverse directions; and
- (b) control means associated with the drive means for operating the cleaner at a primary drive speed and at a secondary drive speed that is relatively slower than the primary drive speed when the cleaner begins to descend from the waterline at the side wall of the pool, where the drive means operates at the secondary speed for a predetermined operational period of time that is relatively short as compared to the time of operation at the primary speed.

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In the practice of one preferred embodiment of the invention, a pool cleaner having a cover and drive means for moving the cleaner in forward and reverse directions is provided with control means and with signal generating means which cooperate to cause the drive means to operate at a slower speed when the cleaner descends from the waterline at the side wall of the pool, thereby allowing any air entrained under the cover to be displaced by water as the cleaner descends in operational cleaning contact with the wall of the pool.

In a first preferred embodiment, the pool cleaner is provided with a preprogrammed microprocessor controller that causes the cleaner to operate upon activation at a relatively slower secondary drive speed for an initial predetermined period of time. The initial predetermined time is sufficient to permit the cleaner to release entrapped air when the unit is placed on the side wall at start-up. Thereafter, the controller causes the speed to increase to the more rapid primary drive speed. After the cleaner has traversed the bottom and ascended a side wall, it is again slowed to descend the side wall at the secondary drive speed.

The change in speed to a significantly slower speed for descending from the waterline can be in response to a signal generated upon the occurrence of a prior event. One such prior event can be the transition of the pool cleaner from a generally horizontal position on the bottom of the pool to a generally vertical position as it climbs the side wall of the pool. A signal can be generated by a switch that is activated in response to the change of orientation, for example, a mercury switch or a pendulum switch. Alternatively, a signal can be generated when the leading edge of the pool cleaner emerges from the surface of the water above the waterline, e.g., by the movement of a float switch.

The control signal is transmitted to a timer which in turn transmits a signal to the microprocessor that controls the speed and direction of the drive means. In a preferred embodiment, the pool cleaner moves horizontally along the side wall at the waterline in order to remove any scum and dirt that has accumulated there. The cleaner can traverse horizontally at the more rapid primary drive speed, or at the much slower secondary drive speed. However, at the preprogrammed time for descent from the waterline, the cleaner descends at the secondary drive speed or slower descending drive speed. It will be understood that the relatively slower secondary drive speed is determined empirically, or otherwise, to insure that any air entrained by operation of the cleaner at the waterline can be readily displaced as the cleaner descends along the wall to maintain substantially neutral buoyancy and operational cleaning contact by the cleaner on the wall.

In an especially preferred embodiment, the microprocessor controller is programmed to cause the drive means to operate at the slower secondary speed when the cleaner is initially activated. This is an important feature, since the person transferring the cleaner from its transporting cart at the edge of the pool is likely to grasp the cleaner by its handle and lower it into the pool in contact with the side wall. If the power switch is activated while the cleaner is at the surface of the pool, it will descend at the slower secondary speed which permits the entrained air to escape from under the housing or cover.

In this embodiment, the microprocessor controller is programmed to cause the drive means to operate at the secondary speed for a predetermined start-up period of time before operating at the faster primary drive speed. The predetermined start-up time period can be longer than, or about the same as the predetermined operational period of time. Depending upon the size and structural configuration of the cleaner housing, these time periods can be from about five seconds to about fifteen seconds.

In order to simplify the design and construction of the pool cleaner and the programming of the microprocessor

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controller in accordance with the objectives of the invention, the cleaner is adapted to operate at the slower secondary drive speed for a predetermined operational period of time that is sufficient to insure that any entrained air will be purged from the interior of the cover. This predetermined period of time can range from about 5 to about 15 seconds, and as explained above, is determined based upon the design and operation of the specific pool cleaner, including features such as the configuration of the cover, the position of the intake ports in the base plate, and the like.

In order to achieve the goal of more rapidly completing the cleaning of the pool, the time of operation at the more rapid primary drive speed should be maximized and the time of operation at the slower secondary drive speed or descending drive speed should be kept to a minimum. However, in order to provide a universally acceptable commercial machine, the predetermined operational period of time for operation at the secondary or descending drive speed must take into account varying dimensional features found in a range of pool designs. In any event, operation at the descending secondary drive speed can result in enhanced cleaning performance of the contacted surfaces.

A further advantage of operating the pool cleaner at the more rapid primary drive speed at the waterline is to enhance the ability of the pool cleaner to turn the corner of the pool, i.e., to move from one wall surface to an intersecting wall surface at the corner of the pool. This enhanced cornering ability results from the greater momentum and traction achieved at the faster primary drive speed.

DESCRIPTION OF PREFERRED EMBODIMENTS

A pool cleaner having drive means comprised of a DC electric motor attached through pulleys and drive belts to a pair of transverse cleaning brushes is provided with a preprogrammed microprocessor controller that is adapted to move the pool cleaner on the bottom of the pool at a primary drive speed of about 30 ft. per minute. A mercury switch is affixed beneath the cover of the cleaner and electrically connected to a timer associated with the microprocessor. In a preferred embodiment, the timer is integrated into the microprocessor controller. When the pool cleaner is placed in an operational position on the bottom of the pool, the mercury switch is in an open position. When the pool cleaner is in an operational or vertical position on the side wall of the pool, the mercury switch moves with respect to the cover and transmits a signal that is received by the timer.

The cleaner continues to ascend the side wall and upon reaching the waterline begins to move horizontally along the side wall to scrub the scum line. In the preferred embodiment, the timer operates for a random period of time which can be for about 10 to about 30 seconds before stopping and reversing the drive means to cause the cleaner to descend the sidewall at the slower secondary drive speed. As the cleaner starts its descent, air from under the cover is displaced by water and the cleaner maintains operational contact with the side wall.

The cleaner completes its descent from the sidewall and begins to traverse the bottom of the pool at the secondary drive speed. After the preprogrammed period of light seconds, the timer transmits a signal to the microprocessor controller which cause the DC motors to increase to the primary drive speed to about 30 feet/second which is about twice the secondary speed. The pool cleaner rapidly traverses the long dimension of the pool bottom, ascends the wall to the waterline, move horizontally along the waterline for a randomly determined time of about seven seconds, after which the DC motors are stopped and reversed to cause the drive means to move the cleaner down the side wall at the secondary drive speed of about twelve to fourteen

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feet/second, and thereafter to assume a different course in traversing the bottom of the pool.

I claim:

1. A method of operating a power-driven pool cleaner to clean the bottom and side walls of a pool or tank, the method comprising the steps of

- (a) providing a pool cleaner having a cover, drive means for moving the cleaner in forward and reverse directions and a timer;
- (b) activating the pool cleaner while the cleaner is in operating position in the pool;
- (c) causing the pool cleaner to traverse the bottom of the pool in a forward direction at a primary drive speed until the cleaner encounters a side wall of the pool;
- (d) causing the pool cleaner to ascend the side wall of the pool to the waterline of the pool;
- (e) generating a control signal when the cleaner is in a vertical orientation on the side wall of the pool;
- (f) activating the timer in response to the control signal;
- (g) changing the drive speed of the pool cleaner to a secondary drive speed that is relatively slower than the primary drive speed while the cleaner is at the waterline of the pool;
- (h) operating the cleaner for a predetermined operational period of time at the secondary drive speed;
- (i) causing the cleaner to descend the side wall of the pool at the secondary speed, whereby any air entrained under the cover is displaced as the cleaner descends in contact with the side wall; and
- (j) changing the drive speed of the pool cleaner after the predetermined operational period of time to the primary drive speed.

2. The method of claim 1 comprising the further steps of:

- (k) causing the pool cleaner to traverse the bottom of the pool and ascend a side wall of the pool at the primary drive speed;
- (l) changing the speed of the pool cleaner to the secondary drive speed while the cleaner is at the waterline and operating the cleaner for the predetermined operational period of time at the secondary drive speed;
- (m) causing the cleaner to descend the side wall at the secondary drive speed;
- (n) changing the drive speed of the pool cleaner after the predetermined period of time to the primary drive speed; and
- (o) repeating steps (c) through (n).

3. The method of claim 1 comprising the further steps of: upon activation of the pool cleaner, operating the pool cleaner drive means at the secondary drive speed for a predetermined start-up period of time; and

at the end of the predetermined start-up period of time operating the drive means at the primary drive speed.

4. The method of claim 1 where the predetermined start-up and operational periods of time are sufficient to permit the cleaner to descend from the waterline of the pool to the bottom of the pool.

5. The method of claim 1 where the predetermined start-up and operational periods of time are substantially the same.

6. The method of claim 1 where the first and second predetermined periods of time are each from about 5 to about 15 seconds.

7. The method of claim 4 where the pool cleaner operates at the primary speed to advance along the side wall of the pool at the waterline.

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8. The method of claim 4 where the pool cleaner operates at the secondary drive speed after the cleaner reaches the waterline of the pool.

9. The method of claim 1 where the direction and speed of the drive means are varied by a preprogrammed micro-processor.

10. The method of claim 8 where the microprocessor includes the timer.

11. The method of claim 1 where the control signal is generated by a control signal switch.

12. The method of claim 11 where the control signal switch moves with respect to the cleaner housing.

13. The method of claim 12 where the control signal switch is a mercury switch.

14. The method of claim 1 where the primary drive speed from about three to about five times faster than the secondary drive speed.

15. The method of claim 1 where the primary drive speed is from about twenty-four feet per minute to about thirty-six feet per minute.

16. The method of claim 1 where the secondary drive speed is predetermined to permit air entrained under the cover to be displaced while the cleaner maintains contact with the side wall of the pool being cleaned.

17. An improved method for cleaning the bottom and side walls of a swimming pool or tank using a power-driven pool cleaner, the method comprising:

- (a) placing the pool cleaner in a horizontal operative position on the bottom of the pool;
- (b) causing the pool cleaner to traverse the bottom of the pool at a primary speed in the range from about twenty-four to about thirty-six feet per minute;
- (c) causing the pool cleaner to move horizontally along the waterline of the pool or tank;
- (d) causing the cleaner to descend from the waterline of the pool at a secondary speed that is less than the primary speed, the rate of descent at the secondary speed being sufficient to permit displacement of any entrained air in the pool while maintaining the pool cleaner in cleaning contact with the side wall of the pool.

18. The method of claim 17 where the secondary speed is in the range of from about four to about fifteen feet per minute.

19. The method of claim 17 where the pool cleaner is operated at the secondary speed for a predetermined operational period of time.

20. The method of claim 19 where the predetermined operational period of time is from about 5 to about 10 seconds.

21. The method of claim 17 where the commencement of the operation of the cleaner at the secondary speed is in response to a change in the orientation of the cleaner from a generally horizontal to a generally vertical position.

22. The method of claim 17 where the commencement of the operation of the cleaner at the secondary speed is in response to a control signal generated when a portion of the cleaner emerges from the water at the waterline of the pool.

23. The method of claim 21 where the pool cleaner commences operation at the secondary speed after a predetermined delay period of time following the change in orientation from a generally horizontal to vertical position.

24. The method of claim 19 which further comprises operating the pool cleaner at the primary speed after the predetermined operational period of time.

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(12) **United States Patent**
Porat

(10) **Patent No.:** **US 6,758,226 B2**
(45) **Date of Patent:** **Jul. 6, 2004**

(54) **MOTION DETECTION AND CONTROL FOR AUTOMATED POOL CLEANER**

(75) **Inventor:** Joseph Porat, North Caldwell, NJ (US)

(73) **Assignee:** Aqua Products Inc., Cedar Grove, NJ (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by days.

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(52) **U.S. Cl.** 134/56 R; 134/58 R; 134/172; 134/166 R; 134/167 R; 15/1.7

(58) **Field of Search** 15/1.7; 134/56 R; 134/57 R; 58 R; 172, 198, 166 R, 167 R

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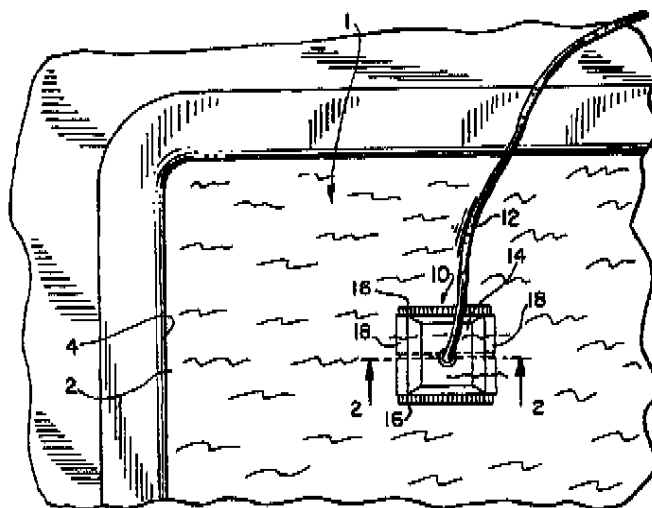
Primary Examiner—Frankie L. Stinson

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(57) **ABSTRACT**

An automated power-driven pool cleaning apparatus is provided with a motion translating member that contacts the surface being cleaned, an associated signal transmitter and a sensor that is connected to the pool cleaner's programmed electronic control device, or chip, so that when the cleaner is moving, the mtrm moves the signal transmitter past the sensor thereby providing an intermittent signal. When the cleaner stops moving, no intermittent signal is received and after a predetermined period of time, the control device causes the cleaner's drive means to move the cleaner in a different direction.

27 Claims, 5 Drawing Sheets



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FIG. 1

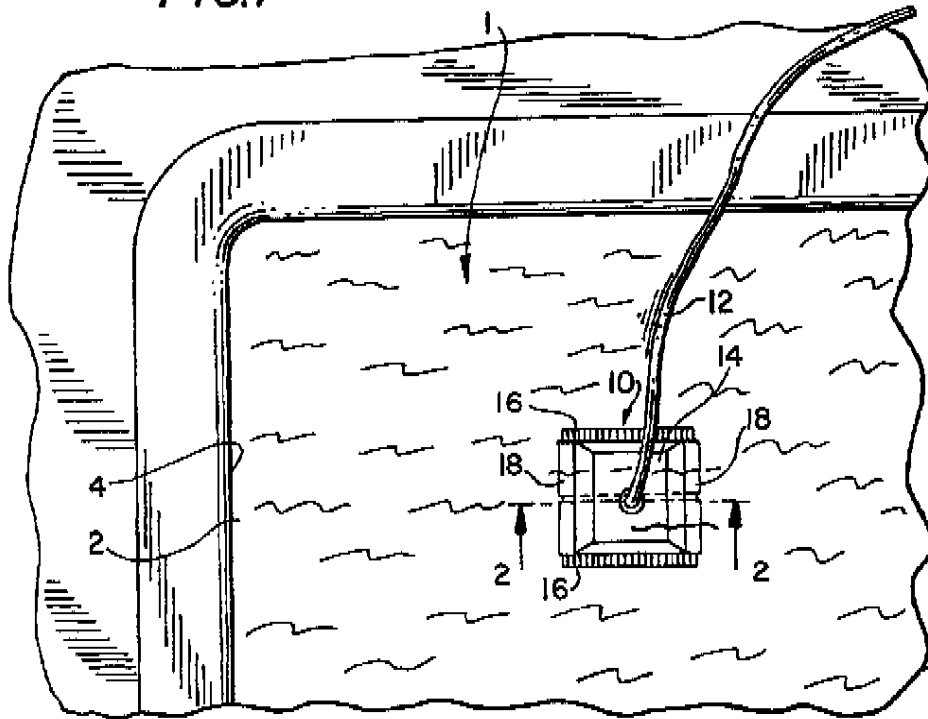
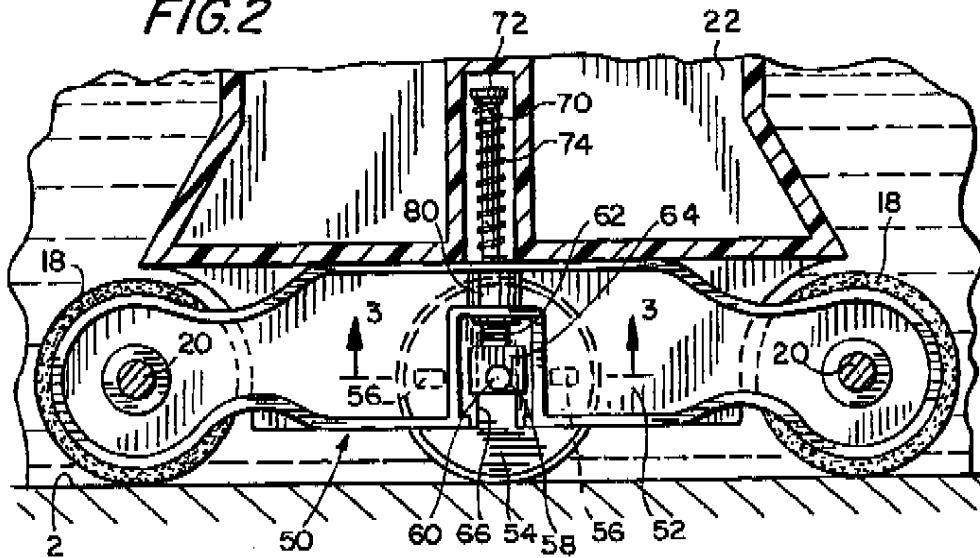


FIG. 2



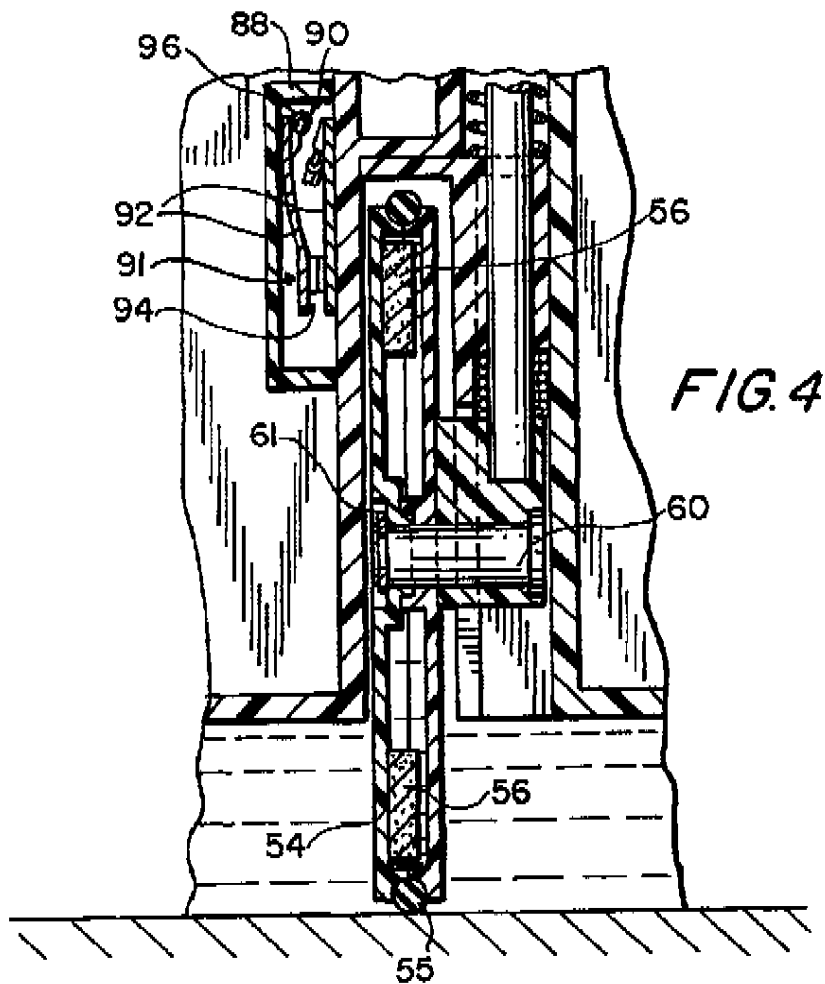
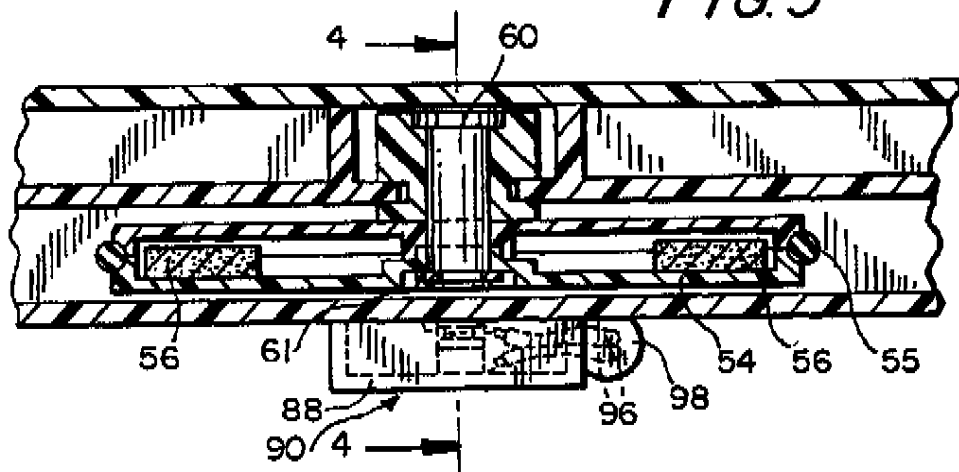
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FIG. 3



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FIG. 5

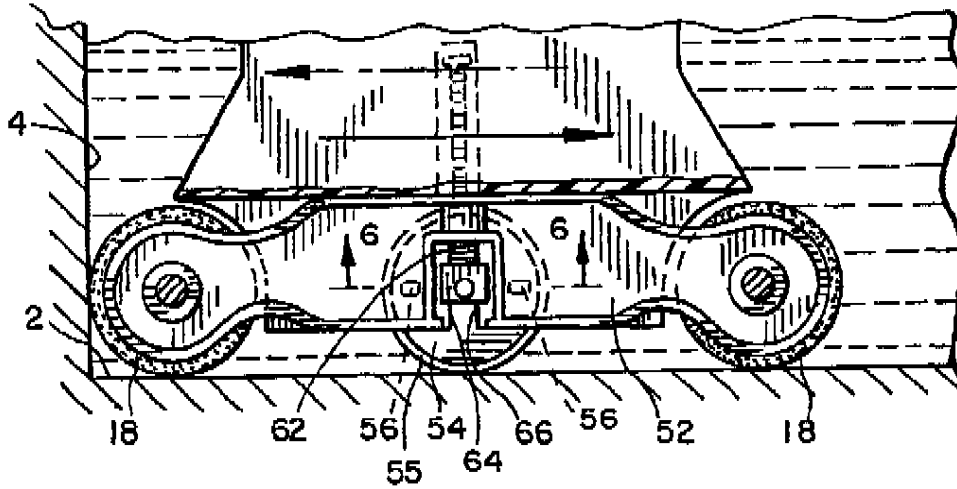


FIG. 6

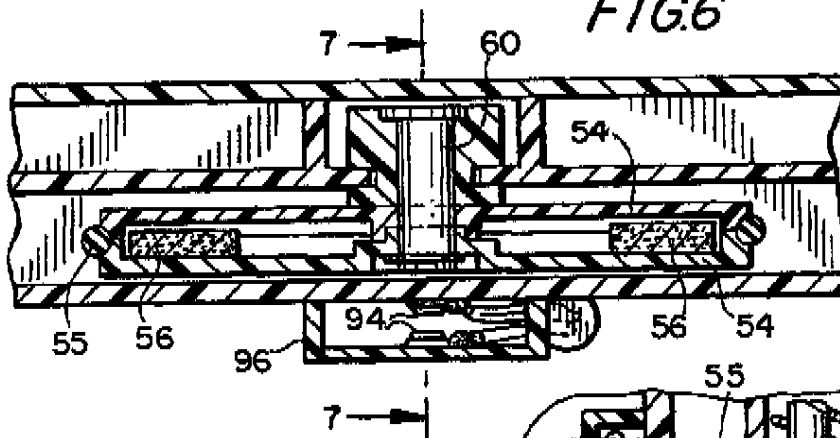
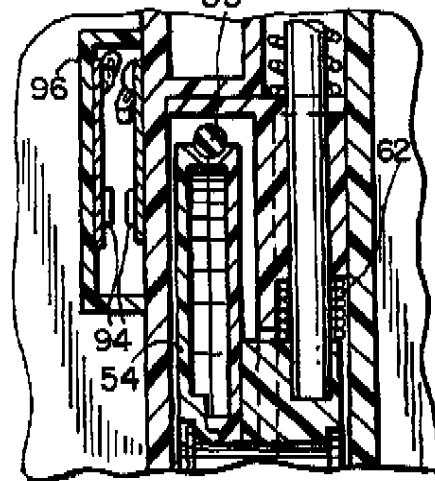


FIG. 7



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FIG. 8

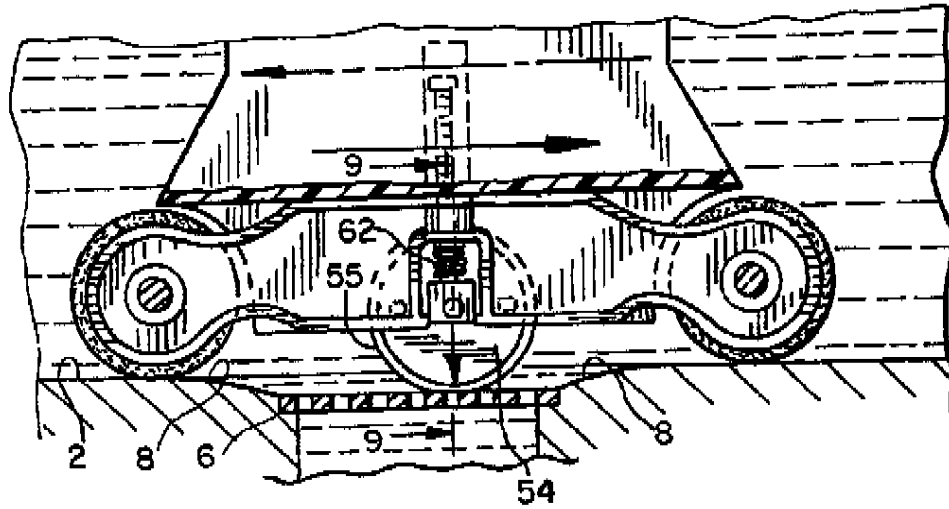


FIG. 9

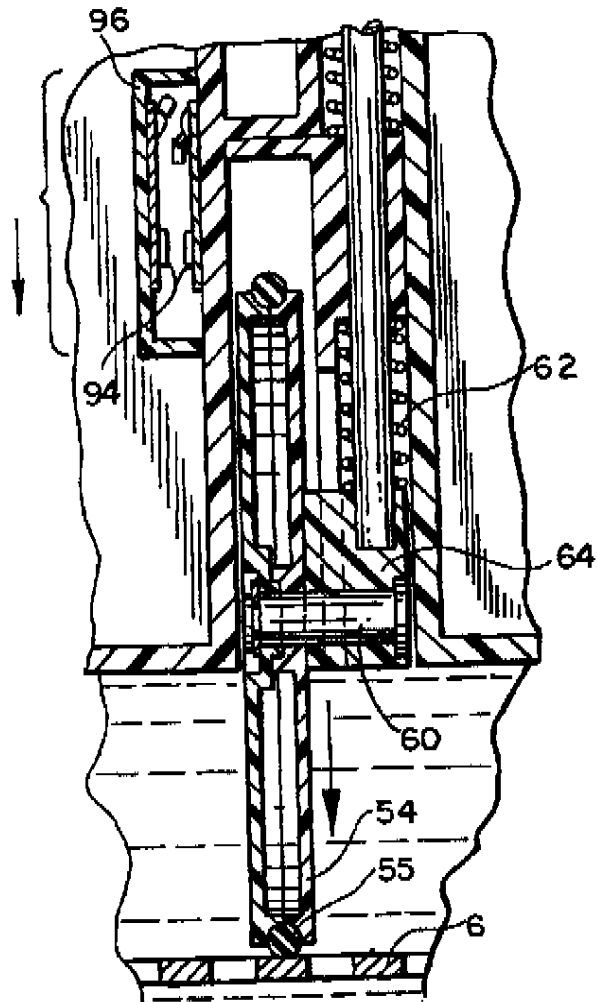
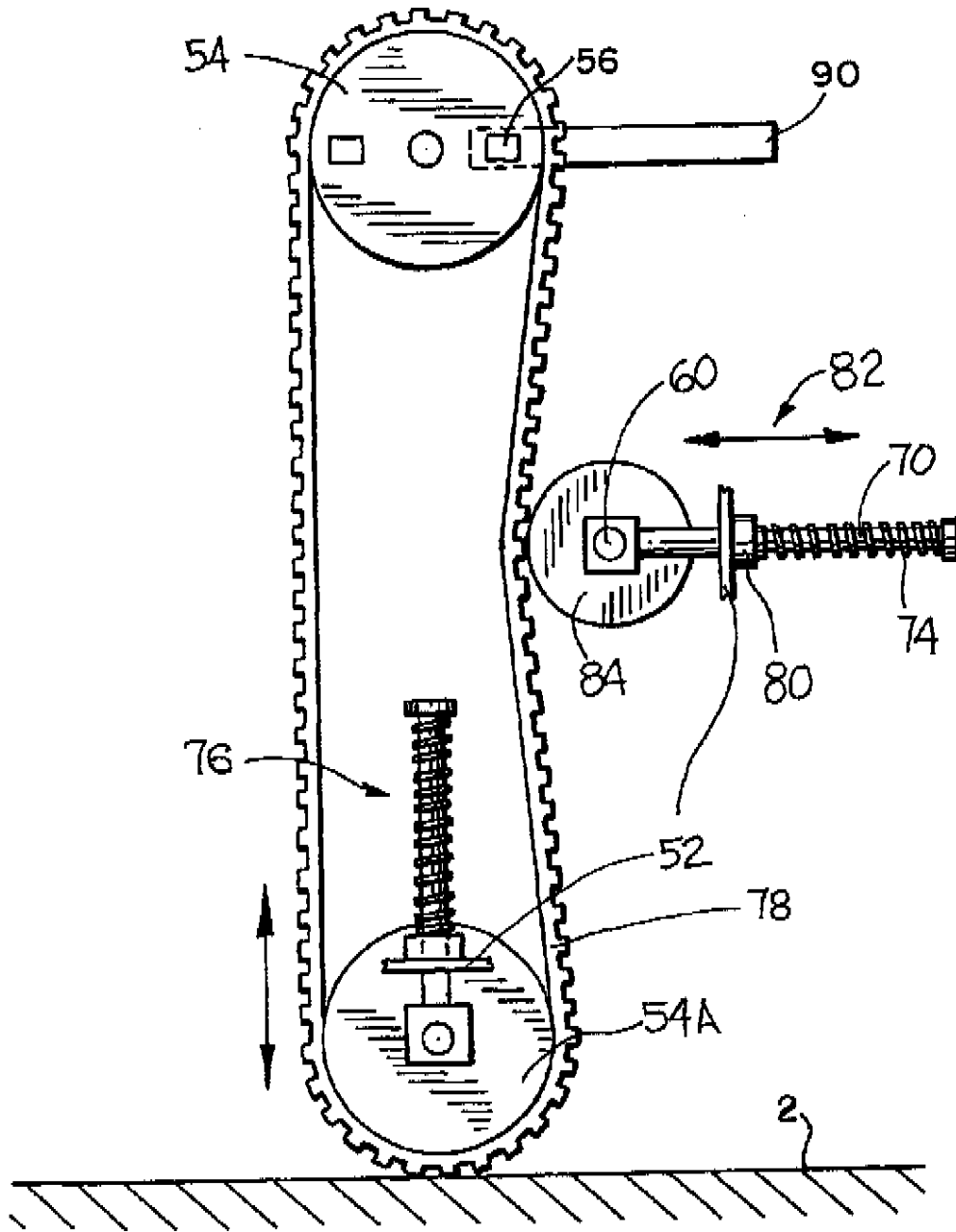


FIG. 10



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MOTION DETECTION AND CONTROL FOR AUTOMATED POOL CLEANER

This application is a continuation-in-part of U.S. Ser. No. 09/285,020 filed Apr. 1, 1999, now U.S. Pat. No. 6,299,699. 5

FIELD OF THE INVENTION

The invention relates to motion detection and control systems for automated, power-driven pool and tank cleaning apparatus. 10

BACKGROUND OF THE INVENTION

Automated, power-driven pool and tank cleaners have been provided with programmable circuit control devices to provide random and/or regular patterns of movement of the apparatus. The purpose of these devices is to maximize the probability that the apparatus will cover the entire bottom wall surface during the cleaning operation. Some pool cleaners are designed and programmed accordingly for cleaning the generally vertical side walls, as well as the bottom wall of the pool or tank. 15 20

Control devices are known that produce a change in direction after a predetermined period of time. Other control devices respond to signals generated by mercury switches that change with the orientation from horizontal to vertical, or when a projecting rod, proximity device, or the like senses that the apparatus is adjacent a wall. 25

These prior art methods and apparatus for controlling the direction of movement do not take into account the possibility that the apparatus may be stopped by an obstacle, or that much of the directional cycle may be spent with the apparatus stalled in a corner or other pool contour. 30

It is therefore an object of this invention to provide a method and apparatus for determining whether the apparatus is actually moving across a wall surface that is to be cleaned or whether the relative movement of the apparatus has stopped and, in the event that relative movement has ceased, to thereafter cause the apparatus drive means to move the apparatus in a different direction. 35 40

It is a further object of the invention to provide a method and apparatus for detecting the relative motion of the apparatus that are responsive to changes in the contour of the surface being cleaned. 45

SUMMARY OF THE INVENTION

The above objects and other advantages are obtained by the method and apparatus of the invention which comprehends providing an automated power-driven pool cleaning apparatus which includes a programmable control device for directing the movement of the apparatus with elements comprising: 50

- a motion translating member ("mtm") mounted for contacting the surface of the wall being cleaned, said motion translating member moving as said apparatus moves across the wall;
 - a signal transmitter for transmitting signals in accordance with movement of said motion translating member; and
 - a sensor mounted to receive signals from said signal transmitter and for providing an output indicative of signals received to the control device, 60
- wherein the programmable control device is programmed to alter the direction of movement of said apparatus when the output of said sensor indicates that said apparatus has not moved within a prescribed period of time. 65

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In accordance with the method of the invention for controlling movement of an automated power-driven pool cleaning apparatus, the apparatus comprising a programmable control device for directing movement of the apparatus, the method comprising the steps of:

- providing a motion translating member mounted on the apparatus for contacting the surface of the wall being cleaned, the motion translating member including at least one signal transmitter that moves as the apparatus moves across the wall;
- providing a sensor mounted on the apparatus to receive signals from the signal transmitter;
- transmitting signals from the signal transmitter in relative to the accordance with movement of the motion translating member;
- outputting from the sensor to the programmable control device, an output signal that is indicative of signals received from the signal transmitter by the sensor; and
- changing a direction of movement of the apparatus under control of the programmable control device when the output indicates that the apparatus has not moved within a prescribed period of time. 5 10 15 20

The motion translating member can take the form of a wheel, a continuous belt or other element that extends from the body of the pool cleaner apparatus to contact the wall that is being cleaned. The mtm is mounted so that it moves freely as the apparatus traverses the bottom and/or side walls of the pool. The mtm stops moving when the apparatus stops moving, e.g., when the apparatus encounters an obstacle, a vertical sidewall (if the cleaner is designed only to clean the bottom wall), or the surface of the water when on a side wall. As will be explained in more detail below, when the mtm stops for a pre-determined period of time, an associated signal transmitter ceases to transmit an intermittent signal to a nearby sensor, and the program of the electronic control device causes the drive means to stop and then to reverse the direction of the cleaner. 25 30 35 40

The mtm is preferably mounted to extend downwardly beneath the body of the cleaner, between the drive means and in a position where it is protected from side impact. 45

The mtm can be in the form of a wheel that is mounted on an axle, which in turn is mounted for vertical displacement in response to a biasing force that urges the mtm into contact with the wall below the apparatus. Thus, the portion of the mtm in contact with the wall moves in response to depressions, e.g., recessed drains, or to raised areas and other irregularities typically found on the walls of a pool and which do not impede the progress of the apparatus in the pursuit of its cleaning program. 50

The mtm can take the form of an endless belt or track, one or more of the supporting pulleys or sprockets of which is mounted as described above to assure that the portion of the belt extending below the apparatus maintains contact with the surface being cleaned. The mechanism for this embodiment can include one or more idler rollers to provide the necessary tension and expansion for the belt. 55

The mtm is provided with at least one signal transmitter that is mounted for movement with the mtm. The signal transmitter can take the form of one or more permanent magnets, each of which emanates a separate magnetic force field; a point source of light; one or more apertures that permit the passage of light from a fixed light source adjacent the mtm; or other equivalent devices which will be apparent to those of ordinary skill in the signal generation, control and detection art. 60 65

A sensor is positioned proximate the mtm to receive and respond to the signal from the transmitter. The sensor is also

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in communication with the programmed control device. In a preferred embodiment, the sensor is hard-wired to the device. However, infrared and short range radio transmission technology can be utilized to link the sensor and the control device.

When the apparatus is moving, one or more signal transmitters mounted in the mtm will provide an intermittent signal to the sensor as it moves past the sensor. In turn, the sensor communicates this data to the control device. When the apparatus stops, as by having its movement interrupted by an obstacle, no intermittent signal is received by the sensor. After a prescribed period of time, the control device program causes the drive means to reverse or otherwise change the direction of movement of the apparatus.

The control device is programmed to process a continuous signal from the transmitter to the sensor in the same manner as no signal. Thus, if the mtm stops so that a magnet, or light source, or light-transmitting aperture is providing a continuous signal to the sensor for more than the predetermined interval, the apparatus will be reversed.

The use of the apparatus and method of the invention provides an inexpensive and reliable solution to the problem of maintaining a continuous pattern of movement for the apparatus. Placement of the mtm inboard and beneath the body of the cleaner minimizes its exposure to damaging impacts, both in and out of the pool. The number of moving parts is minimal, their assembly and mode of operation is straight-forward, and they can be made from known materials to assure long-term use without failure.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and other advantages will become apparent from the detailed description of the invention, particularly when read in conjunction with the attached drawings in which like elements are referred to by the same numeral and where

FIG. 1 is a top plan view of a portion of a pool in which a pool cleaner is operating;

FIG. 2 is a side elevational view, partly in section showing a preferred embodiment of the motion sensing apparatus of the invention;

FIG. 3 is a bottom sectional view taken along section line 3-3 of FIG. 2;

FIG. 4 is a sectional end view taken along section line 4-4 of FIG. 3;

FIG. 5 is a side elevational view similar to FIG. 1 schematically illustrating the method of the invention for changing the direction of the cleaner;

FIG. 6 is a partial section bottom view taken along line 6-6 of FIG. 5;

FIG. 7 is partial elevational view taken along line 7-7 of FIG. 6;

FIG. 8 is a side elevational view similar to FIG. 1 illustrating the method of operation of the invention when the cleaner passes over a section of uneven wall;

FIG. 9 is partial elevational end view taken along line 9-9 of FIG. 8; and

FIG. 10 is a side elevational view schematically illustrating another embodiment of the invention.

Preferred embodiments of the invention will be described with reference to the attached drawings in which FIG. 1 is a plan view of swimming pool 1 having a bottom wall 2 and side walls 4, across which is moving a power-driven, automated pool cleaner referred to generally as 10. Pool cleaner power cord 12 provides a low voltage current from a remote

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power source (not shown) to power the drive means contained in housing 14 that move drive means 16 attached to cleaning brushes 18 that contact the wall surface of the pool being cleaned. The pool cleaning apparatus 10 also includes a programmable control device, i.e., a computer chip, which is pre-programmed with a routine for controlling the drive means to accomplish a predetermined pattern of movement that is intended to clean the entire bottom wall surface, as well as the side walls if the apparatus is so designed and constructed. For the purpose of this description, the embodiment will be limited generally to a pool cleaner that is adapted to cleaning the bottom wall of a pool or tank. The design and manufacture of the programmable control device for the pool cleaning apparatus is within the skill of the art.

DESCRIPTION OF PREFERRED EMBODIMENTS

As noted above, the pool cleaner 10 moves in a pattern under the control of a programmable control device, such as a computer chip, which directs its movement across the bottom and/or side walls of the pool or tank. The control device itself is conventional, but it receives specified signals and is programmed to respond thereto in accordance with the present invention to achieve new and unobvious results. In particular, the mtm is provided with means for indicating to the control device both when the mtm, and hence the pool cleaner 10, is moving normally, i.e. as intended, and also when the pool cleaner 10 has not moved for at least a prescribed period of time. Accordingly, when the pool cleaner 10 has stopped, e.g., against a side wall, or when it should not have stopped, e.g., against an obstacle, the control device can take action by changing the direction of movement of the pool cleaner 10 to get it moving again.

In a preferred embodiment illustrated in FIGS. 2-9, the wheel 54 embodying the mtm is provided with two rare earth permanent magnets 56 of the type known to produce a strong localized magnetic force field. As shown in FIG. 2, the two magnets 56 are advantageously mounted equidistant from each other at diametrically opposed positions at the periphery of the wheel 54 so as to rotate with the wheel 54. The magnets 56 can be mounted conveniently in corresponding recesses at the periphery of the wheel 54 and held in place with a water and chemical resistant epoxy compound or other known potting composition.

This preferred embodiment uses two magnets 56 spaced apart such that the magnetic field proximate to each magnet 56 is substantially greater than the magnetic field adjacent the wheel 54, but distant from the magnets 56, e.g., halfway between the magnets 56 around the periphery of the wheel 54. The spacing is determined such that the difference between the two magnetic field strengths can be detected by a sensor assembly 90 including a sensor such as reed switch 91. As best seen in FIGS. 3, 4, 7 and 9, the sensor assembly 90 is mounted in a waterproof housing 88 formed on a wall of support 52 and located facing the rotating wheel 54. The reed switch 91 itself is a conventional element including two opposed arms 92 each carrying a contact 94. In its conventional operation, when the reed switch 91 is not in the presence of a magnetic field of a defined strength, the arms 92 with the contacts 94 thereon stand separated by a gap. However, in the presence of a suitable magnetic field, the arms 91 are drawn together until the contacts 94 meet to close a circuit including the reed switch 91 and thereby provide an output on electrical leads 96 to the programmable control device.

In the illustrated embodiment, the magnetic field experienced by the reed switch 91 increases and decreases twice

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with each rotation of the wheel 54. As the wheel 54 rotates to bring one of the magnets 56 proximate to the reed switch 91, as shown in FIG. 4, the magnetic field increases to bring the contacts 94 together to close the circuit. However, after another quarter turn of the wheel 54, both magnets 56 are 5
distanced from the reed switch 91 and the magnetic field at the reed switch 91 decreases to allow the arms 92 to separate, opening the circuit as shown in FIG. 7. Thus, as the pool cleaner 10 moves normally across the pool wall, the reed switch 91 will receive a strong magnetic field twice at 10
regular intervals for each complete rotation of the wheel 54. Each strong magnetic field is a signal transmitted from the respective magnet 56 in accordance with movement of the wheel 54 to be received by the reed switch 91. As a result, the reed switch 91 opens and closes at these intervals, 15
thereby generating an output indicative of the signals received by the reed switch 91. If such signals (sufficiently high magnetic fields in this embodiment) continue to be received at these intervals, then the wheel 54, and hence the pool cleaner 10, is moving normally and the output of the reed switch 91 will so indicate. 20

However, if these signals are not generated at the expected intervals, some misoperation of the pool cleaner 10 is happening. In particular, and assuming that no element of the pool cleaner has malfunctioned, if no signal is generated over the interval, then the wheel 54 is not rotating normally to bring one of the magnets 56 timely into proximity with the reed switch 91. This situation may arise if, for example, the pool cleaner 10 is trapped in a corner of the pool or blocked by an object that has fallen into the pool. To detect this situation, a prescribed time period is set during which at least one signal should be transmitted from the signal transmitter carried by wheel 54 to the reed switch 91. Advantageously, this time period is longer than the expected interval between signals, to allow for a brief interruption in motion. In a preferred embodiment, with wheel 54 being 3 inches in diameter and the pool cleaner 10 moving at a conventional speed, the prescribed time period can be 5 seconds. If the output from the reed switch 91 to the programmable control device does not include an indication that a high magnetic field signal was received by the reed switch 91 for 5 seconds, then the output also indicates that the pool cleaner 10 has not moved within this prescribed period of time. 25

It is possible that the pool cleaner 10 will stop moving with one of the magnets 56 proximate to the reed switch 91, so that the high magnetic field signal is constantly received by the reed switch 91 and the contacts 94 remain closed in constant contact. The output of the reed switch 91 under this condition also indicates that the pool cleaner 10 has not moved within the prescribed period. 30

When the programmable control device receives an output indicating that the pool cleaner 10 has not moved within the prescribed period, it can take corrective action. Advantageously, this includes changing the direction of movement of the pool cleaner 10 from the direction it had before it stopped. If the direction is reversed, this enables the pool cleaner 10 to back away from an obstacle or out of a corner, and the pattern of movement can then be resumed. 35

If the change in direction of movement still fails to bring about movement of the wheel 54 and thereby indicating movement of the pool cleaner 10, the wheel 54 may be jammed with debris. In such case, a fall-back error operation can be used, such as shifting to a standard routine for the pool cleaning pattern. This change in pattern would be obvious to the individual responsible for the maintenance of the pool and operation of the pool cleaner 10, who is then 40

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alerted to a condition that must be corrected. In this way, any problem with the operation of the wheel 54 will result in the disabling of that particular part of the program with a transition to a standard program such as that well known in the art. 45

While the above-discussed embodiment employs two magnets 56, it will be understood that more magnets or only one magnet can be used instead. However, it is necessary that the number of magnets be chosen in consideration of the size of the wheel 54 so that the magnetic field changes sufficiently as the wheel 54 rotates to cause the reed switch to open and close.

Furthermore, while the above-discussed embodiment employs magnets as a signal transmitter and a reed switch as a sensor, other signal transmitter/sensor combinations can be used. For example, the signal transmitter can be constructed as a light emitting element that intermittently transmits light and the sensor can then be a photoelectric cell. In a preferred embodiment, the photoelectric cell is mounted on the wall of support 52 in place of the reed switch 91 and the light element includes a modified version of wheel 54 and a light source fixed on the pool cleaner at a position opposed to the photoelectric cell. The modified wheel includes at least one portion that transmits light and at least one portion that blocks passage of light so that rotation of the modified wheel interrupts light received by the photoelectric cell from the light source. Accordingly, as the modified wheel rotates, the photoelectric cell receives light signals transmitted from the modified wheel and provides an output indicative of the signals received. This output contains the same information as the output in the previously-discussed embodiment and can be used by the programmable control device in the same way. As will be understood by one skilled in the art, the light emitted can be in the visible spectrum, including from a laser source, or in the non-visible spectrum. 50

In an especially preferred embodiment that will be described with reference to FIG. 9, the wheel 54 is so mounted in the supporting assembly 50 that it can be withdrawn sufficiently from the pool cleaner housing that the mounting clip 61 is exposed for removal from wheel axle 60 to thereby permit the wheel to also be dismounted from the axle. Removal of the wheel may be necessary to replace the traction surface 55, a wheel bearing (not shown), or the entire wheel. In the embodiment, slide block 64 can be displaced from channel 66 by pulling on the exposed rim of wheel 54 until cap 72 on shaft 70 completely compresses rebound spring 74. After the wheel has been replaced on axle 60, rebound spring 74 expands to raise shaft 70 and associated slide block 64 into channel 66 until block 64 encounters the resisting opposite force of biasing spring 62. As will be understood by one of ordinary skill in the art, shaft 70 can be short-ended and spring 74 omitted to provide a limited degree of vertical movement to slide block 64, and thereby to axle 60 and wheel 54. However, it will also be understood that such an arrangement will necessitate the disassembly of major components of the cleaner should it become necessary to replace the wheel. 55

In a preferred embodiment illustrated in FIGS. 2-9, wheel 54 is provided with at least two rare earth permanent magnets 56 of the type known to produce a strong magnetic force field. The magnets can conveniently be mounted in corresponding recesses in the region of the wheel between the axle bearing and periphery and held in place with a water and chemical resistant epoxy compound or other known potting composition. The plurality of magnets are mounted equidistant from each other, a pair preferably mounted at diametrically opposed positions. 60

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As best shown in FIGS. 3, 4, 7 and 9, a sensor assembly 90, in the form of a reed switch 91 is mounted in a waterproof housing 88 formed on a wall of support 52 and proximate rotating wheel 54. In this embodiment, the proximity of one of the magnets 54 to switch 91 will cause arms 92 to move relatively closer to each other until contacts 94 meet to close the circuit; if the magnet moves away from the switch, the field is reduced and the contacts 94 part opening the circuit. As best shown in FIG. 3, electrical leads 96 contained in cable 98 are attached to the cleaner's programmable control device, e.g., a computer chip (not shown), which has been programmed to maintain the directional movement of the drive means so long as an intermittent signal is received from the reed switch 91. In the event that the contacts 94 remain open or closed for a period of time that exceeds the predetermined, programmed time period, e.g., five seconds, the control device will alter the direction of movement of the cleaning apparatus.

It will also be understood that when the drive means is a continuous belt, one of the pulleys or sprockets can be constructed in the same manner as the wheel of FIG. 2. Its rotational movement will be caused by the passage of the belt, so long as the cleaner is moving normally in its cleaning pattern.

Other constructions can be employed without departing from the general method and apparatus of the invention described above. A further embodiment is illustrated schematically in FIG. 10 where the motion translating member 54 containing magnets 56 is displaced from the surface of the pool wall to an alternative position on the interior of the pool cleaner housing. The sensor 90 is positioned proximate wheel 54 in accordance with the embodiment described above in connection with FIGS. 2-9. The linear movement of the pool cleaner is translated to a rotational motion by auxiliary wheel 54A which is linked to wheel 54 by belt 78. The belt extends below the cleaner body 22. In the embodiment illustrated in FIG. 10, belt 78 is in contact with surface 2 and wheels 54 and 54A are preferably configured as pulleys or sprockets. Alternatively, the belt 78 can be recessed in a groove in the surface of the wheels 54 and 54A, or fixed to ride on a contiguous concentric portion formed for that purpose, in which case the rim of wheel 54A will contact surface 2 directly.

In order to assure appropriate tension in the belt 78, an idler wheel assembly 82 can be provided with idler wheel 84 urged into contact with the surface of belt 78 intermediate wheels 54 and 54A. The idler wheel provides for the tensioning of the belt when the spring-mounted lower sprocket moves from its customary position in order to accommodate irregularities in the wall being cleaned. The mounting of idler wheel assembly 82 and its component parts are comparable to that previously described and will be well known to those of ordinary skill in the art.

In the method of operation of the embodiment of FIG. 10, movement of the pool cleaner causes belt 78 to advance thereby rotating wheels 54 and 54A. Should wheel 54A experience a change in its vertical position with respect to the housing frame member 52, the idler wheel 84 will move in order to maintain the necessary tension to keep belt 78 in rotational contact with wheel 54. As and when the pool cleaner stops moving, belt 78, or auxiliary wheel 54A, will also stop moving. Absent the rotational force of belt 78, wheel 54 and magnets 56 will also cease their rotational movement. Sensor 90 will communicate this condition to the programmable control device and the predetermined change in the directional movement of the cleaner's drive mechanism will be effected by whatever mechanical means are provided for this purpose.

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In yet a further variation on this embodiment, belt 78 can be provided with transmitters in the form of a plurality of magnetic elements (not shown) that are spaced apart along the length of the belt. The magnetic elements can be molded into the body of the flexible polymeric belt 78, or attached to its surface, e.g., in recesses. As the belt passes the sensor 90, or ceases its movement, the same effect is achieved as described in the earlier embodiments, with the direction of movement of the pool cleaner being altered.

As will be apparent from the above described embodiments, numerous other changes to the specific structure employed to effect the translation of the linear movement of the cleaner into a rotational movement, which rotational movement results in the corresponding movement of a signal transmitter past a sensor that detects the absence and/or periodic presence of the transmitter in order to determine whether the cleaner is actually moving with respect to the surface of the pool, or such relative movement has ceased, regardless of whether the cleaner drive means is still activated. Such movement can also be translated by one or more gear sets attached to wheels, rollers, belts or other traction devices that will consistently move without slipping to reliably indicate when the cleaner is moving with respect to the wall of the pool that is being cleaned.

The foregoing description of a preferred embodiment and best mode of the invention known to applicants at the time of filing the application has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and obviously many modifications and variations are possible in the light of the above teaching. The embodiment was chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims that follow.

I claim:

1. An automated power-driven pool cleaning apparatus utilized for cleaning the surface of a bottom or side wall of a pool or tank and including a programmable control device for directing movement of said apparatus across the wall, said apparatus comprising:

a motion translating member mounted for contacting the surface of the wall being cleaned, said motion translating member moving as said apparatus moves across the surface;

a signal transmitter for transmitting signals in accordance with movement of said motion translating member; and a sensor mounted to receive signals from said signal transmitter and for providing an output indicative of signals received to the programmable control device, which is programmed to change a direction of movement of said apparatus when the output of said sensor indicates that said apparatus has not moved within a prescribed period of time,

wherein said signal transmitter is responsive to normal movement of said motion translating member to transmit at least one signal during each unit of time equal in duration to the prescribed period of time, and wherein the output of said sensor indicates that said apparatus has not moved within the prescribed period of time when no signal is received by said sensor within the prescribed period of time.

2. The apparatus of claim 1, wherein the output of said sensor indicates that said apparatus has not moved within the

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prescribed period of time when a signal is constantly received by said sensor for the prescribed period of time.

3. The apparatus of claim 1, wherein said motion translating member includes a wheel mounted for rotation on an axis transverse to the direction of movement of said apparatus.

4. The apparatus of claim 3 wherein a portion of said wheel in contact with the surface of the wall is provided with a traction surface.

5. The apparatus of claim 4, wherein said traction surface is a polymeric material having a high coefficient of friction.

6. The apparatus of claim 1, wherein said motion translating member includes a wheel that rotates as said apparatus moves across the wall, said signal transmitter being mounted on said wheel to move as said wheel rotates.

7. The apparatus of claim 6, wherein said signal transmitter is mounted to rotate with said wheel.

8. The apparatus of claim 7, wherein said signal transmitter is mounted on said wheel at a periphery of said wheel.

9. The apparatus of claim 7, wherein said sensor is mounted on said apparatus at a position where said sensor receives or does not receive a signal from said signal transmitter in dependence upon a rotational position of said wheel.

10. The apparatus of claim 9, wherein said sensor is mounted on said apparatus at a position that said signal transmitter is alternately proximate to and distanced from as said wheel rotates, said sensor receiving a signal from said signal transmitter when said signal transmitter is proximate to said sensor, and said sensor not receiving a signal from said signal transmitter when said signal transmitter is distanced from said sensor.

11. The apparatus of claim 10, wherein said signal transmitter includes at least one permanent magnet mounted at said periphery of said wheel.

12. The apparatus of claim 11, wherein said sensor includes a reed switch that moves between an open and a closed position in dependence upon whether said at least one permanent magnet is proximate to or distanced from said reed switch.

13. The apparatus of claim 12, wherein said wheel is sized such that said at least one permanent magnet is proximate to said reed switch at least once during each unit of time equal in duration to the prescribed period of time during normal movement of said motion translating member to transmit at least one signal, and wherein the output of said sensor indicates that said apparatus has not moved within the prescribed period of time when no signal is received by said sensor within the prescribed period of time.

14. The apparatus of claim 13, wherein the output of said sensor indicates that said apparatus has not moved within the prescribed period of time when a signal is constantly received by said sensor for the prescribed period of time.

15. The apparatus of claim 12, wherein said signal transmitter includes at least two permanent magnets mounted at said periphery in diametrically opposed relation to each other.

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16. The apparatus of claim 1, further comprising a support assembly for urging said motion translating member into contact with the surface of the wall being cleaned.

17. The apparatus of claim 16, wherein said support assembly comprises a spring-biased shaft mounted for movement in a direction generally normal to the surface of the wall being cleaned, whereby said motion translating member is maintained in contact with irregularities in the surface.

18. The apparatus of claim 17, wherein said support assembly includes a mounting bracket for receiving said spring-biased shaft and a bearing surface for said motion translating member.

19. The apparatus of claim 18, wherein said motion translating member is a wheel and said bearing surface is an axle.

20. The apparatus of claim 18, wherein said motion translating member is a continuous flexible belt and said bearing surface comprises a plurality of rotationally-mounted pulleys.

21. The apparatus of claim 1, wherein said signal transmitter comprises a light element for intermittently transmitting light to said sensor.

22. The apparatus of claim 21, wherein said light element is responsive to normal movement of said motion translating member to transmit light to said sensor at least once during each unit of time equal in duration to the prescribed period of time, and wherein the output of said sensor indicates that said apparatus has not moved within the prescribed period of time when no light from said light element is received by said sensor within the prescribed period of time.

23. The apparatus of claim 22, wherein the output of said sensor indicates that said apparatus has not moved within the prescribed period of time when light from said light element is constantly received by said sensor for the prescribed period of time.

24. The apparatus of claim 21, wherein said light element includes a light source and means for intermittently transmitting light from said light source to said sensor.

25. The apparatus of claim 24, wherein said light source is fixed and said means for intermittently transmitting comprises at least one portion of said motion translating member that transmits light in spaced relation to at least one portion of said motion translating member that blocks passage of light, such that movement of said motion translating member interrupts light received by said sensor from said light source.

26. The apparatus of claim 1, wherein said signal transmitter is a light source and said sensor is a photoelectric cell.

27. The apparatus of claim 1, wherein the prescribed time is about five seconds.

* * * * *