JUDGE DANIELS

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04 CV 5492

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

AQUA PRODUCTS, INC.,

Plaintiff,

-against-

SMARTPOOL, INC.,
MAYTRONICS, INC.,
RICHARD HOLSTEIN, and
JOSEPH DYBROFSKY,

Defendants.

04 Civ. _____ (____)

COMPLAINT FOR INJUNCTIVE RELIEF AND DAMAGES FOR PATENT INFRINGEMENT (35 U.S.C. §§ 271 and 281), FOR CYBERPIRACY (15 U.S.C. § 1125(d)), FOR TRADEMARK INFRINGEMENT (15 U.S.C. § 1114), FOR FALSE DESIGNATION OF ORIGIN (15 U.S.C. § 1125(a)), FOR DILUTION OF AND INJURY TO BUSINESS REPUTATION (15 U.S.C. § 1125(c)) and N.Y.S. GENERAL BUSINESS LAW § 368.1), FOR THE USE OF FALSE OR MISLEADING DESCRIPTIONS OR REPRESENTATIONS OF FACT (15 U.S.C. § 1125(a)), FOR DECEPTIVE TRADE PRACTICES (N.Y. GEN. BUS. LAW §349), FOR FALSE ADVERTISING (N.Y. GEN. BUS. LAW § 350), AND FOR COMMON LAW UNFAIR COMPETITION

The plaintiff, Aqua Products, Inc. ("Aqua Products"), by its attorneys, Abelman, Frayne & Schwab, for its complaint against the defendants, Smartpool, Inc. ("Smartpool"), Maytronics, Inc. ("Maytronics"), Richard Holstein ("Mr. Holstein"), and Joseph Dybrofsky, ("Mr. Dybrofsky"), 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 and the New York Business Law, more particularly 15 U.S.C. § 1125(c) and N.Y.S. General Business Law § 368.1, 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), for engaging in deceptive trade practices in violation of § 349 of the New York General Business Law, for false advertising in violation of § 350 of the New York State General Business Law, and for related pendent acts of unfair competition.

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 Southern District of New York 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 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 Maytronics is and was at all relevant times a corporation organized under the laws of Israel, with offices at Kibbutz Yizre'el, Israel.

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

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

11. Upon information and belief, Mr. Dybrofsky is a principal owner and/or corporate officer of the corporate defendants, and has actively and knowingly aided and abetted in the commission of the infringing acts of the corporate defendants.

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

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

14. Upon information and belief, Smartpool is the alter ego of Messrs. Holstein and Dybrofsky, and all four defendants have cooperated in furtherance of the infringing acts complained of herein.

FACTS COMMON TO ALL CAUSES OF ACTION

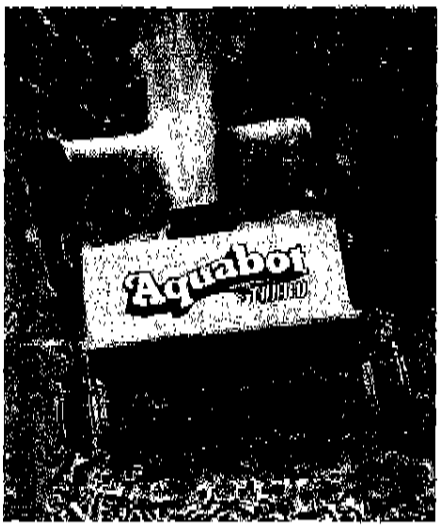
15. For over 20 years, Aqua Products has developed and sold the most comprehensive line of high quality, state-of-the art robotic pool cleaners for residential and commercial markets in nearly 40 countries.

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

17. Aqua Products is the owner of U.S. Patent Nº. 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.

18. Aqua Products is the owner of U.S. Patent Nº. 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.



19. For residential use, Aqua Products manufactures robotic pool cleaners identified by the trademarks Aquabot, Aquabot Pool Rover, Aquabot Pool Rover Plus, Aquabot Turbo (illustrated to the right), Aquabot Turbo Remote Control, Aquabot Turbo Solo Remote Control, Aquabot Plus Remote Control, Aquabot Ultra, Ultra, Viva, and Bravo.

20. 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.

21. 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.

22. 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.

23. The corporate defendants are examples of such companies. They have undertaken an entire 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.

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

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

26. When members of the public accesses a URL that incorporates one of Aqua Products' trademarks, such as the "aquabot2.com" URL, and is immediately forward to the Smartpool home page, they are likely to be confused and assume there is a connection, sponsorship or affiliation between Aqua Products and the defendants and their products.

27. The defendants have 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.

28. 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.

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

Aqua Products' Patents

30. The '613 patent, relates to water jet reversing propulsion and directional controls for automated swimming pool cleaners, issued on June 1, 2004. Figure 1 of the '613 Patent is illustrated to right.

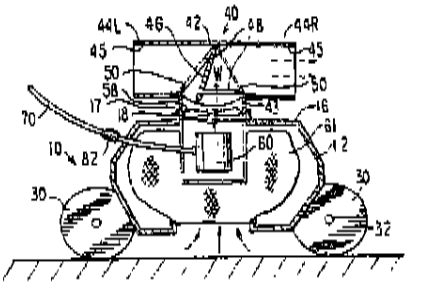


FIG.1

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

32. 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.

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

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

35. The '658 patent relates to 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.

36. 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.

Aqua Products's Trademarks

37. Aqua Products has sold its products in interstate commerce for over 20 years, and has prominently identified the same using the following trademarks (the "Aqua Products 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,
Bravo,
AquaMax,
AquaMax Junior HT,
AquaMax Junior Plus,
AquaMax BiTurbo,
AquaMax BiTurbo Remote Control,
UltraMax,
UltraMax Junior, and
Power Handi Vac.

38. 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.

39. 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.

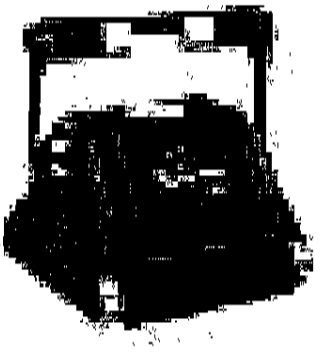
40. As a direct result of this usage, the unique and distinctive Aqua Products Trademarks are well-known, famous, are associated by the trade and public with Aqua Products, and represent a business and goodwill of significant and inestimable value to it.

41. Aqua Products is the owner of Federal Trademark Registration №. 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.

42. 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

43. The defendants manufacture, and/or sell, and/or induce others to use and sell pool cleaning products identified as the "Dolphin" and "Robo-Kleen" which, upon information and belief, embody the subject matter protected under the `613 Patent and '658 Patent. An illustration of the defendants' "Dolphin" branded pool cleaner is shown to the right.



44. Aqua Products has advised the defendants that the aforementioned products infringe the `613 Patent and '658 Patent, and have demanded that they cease the manufacture and sale of the products.

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

Defendants' Cyber-Piracy and Trademark Infringement

46. Recently, Aqua Products learned that the defendant Smartpool has systematically and maliciously registered the following Internet URLs (the "Infringing URLs"):

aquabot-storm.com",
"aquabot2.com",
"aquabotautomatlcpoolcleaner.com",
"aquabotbravo.com",
"aquabotcleaners.com",
"aquabotpoolrover.com",
"aquabotpoolroverplus.com",
"aquabotpoolvacuum.com",
"aquabotpoolvacuums.com",
"aquabotroboticpoolcleaner.com",
"aquabotrover.com",
"aquabotterminator.com",
"aquabotyurbopoolcleaner.com",
"aquabotultra.com",
"aquabotviva.com".

47. When any of the Infringing URLs are opened, the user is forwarded to Smartpool's home page at "http://www.smartpool.com/website/".

48. The defendants Smartpool, and Messrs. Holstein and Dybrofsky are using the Infringing URLs in interstate commerce without the permission, authority or consent of Aqua Products.

49. Upon information and belief, the Infringing URLs were obtained with the knowledge, consent, and sponsorship of the defendant Maytronics.

50. Upon information and belief, the defendants are using the Infringing URLs with actual knowledge of Aqua Products's

use, rights in, and registration of its well-known and famous Aqua Products Trademarks.

51. Upon information and belief, the registration of the Infringing URLs, and the forwarding of visitors to the Smartpool home page appropriates and infringes the Aqua Products Trademarks, and falsely suggests that defendants' services, products and website originate with, or are sponsored by Aqua Products, and that their services, products and website are in some way affiliated with Aqua Products.

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

Defendants' False Advertising

53. Recently, 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.

54. 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.

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

56. 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 SEEKING INJUNCTIVE AND MONETARY RELIEF

57. Aqua Products realleges paragraphs 1 through 56 as if fully set forth herein.

58. 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 Southern District of New York and elsewhere in the United States, in violation of the patent laws of the United States.

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

60. 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 Southern District of New York and elsewhere in the United States, and will continue to do so unless enjoined by this Court.

61. 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 Southern District of New York and elsewhere in the United States and will continue to do so unless enjoined by this Court.

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

63. 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.

64. On account of the defendants activities in this State, County and Southern District of New York, 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).

65. 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 SEEKING INJUNCTIVE AND MONETARY RELIEF

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

67. 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 '658 Patent, in the Southern District of New York and elsewhere in the United States, in violation of the patent laws of the United States.

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

69. 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 Southern District of New York and elsewhere in the United States, and will continue to do so unless enjoined by this Court.

70. 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 Southern District of New York and elsewhere in the United States and will continue to do so unless enjoined by this Court.

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

72. 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.

73. On account of the defendants activities in this State, County and Southern District of New York, 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).

74. 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 SEEKING INJUNCTIVE AND MONETARY RELIEF FOR CYBERPIRACY (15 U.S.C §1125(d))

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

76. 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.

77. 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.

78. By reason of the foregoing, the defendants have engaged in, and are continuing to engage in acts of cyberpiracy which are injuring the Aqua Products Trademarks, business and business reputation in violation of 15 U.S.C. § 1125(d).

79. By reason of the foregoing, Aqua Products is now and will continue 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.

80. On account of The defendants' activities in this State, County and Southern District of New York, 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 FOURTH CLAIM FOR INJUNCTIVE AND MONETARY RELIEF PURSUANT TO 15 U.S.C § 1114 FOR TRADEMARK INFRINGEMENT

81. Plaintiff realleges paragraphs 1 through 80 as if fully set forth herein.

82. The registration and use of the Infringing URLs is without the permission, consent or authorization of Aqua Products, gives 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.

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

84. 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.*

85. On account of the defendants' activities, the trade and public are likely and will continue to be confused, misled or deceived as to the source, origin or sponsorship of their website, services and products, and Aqua Products is now and will continue to suffer irreparable injury, including injury to its reputation and goodwill, for which Aqua Products has no adequate remedy at law.

86. On account of The defendants' activities in this State, County and Southern District of New York, 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 SEEKING INJUNCTIVE AND MONETARY RELIEF FOR FALSE DESIGNATION OF ORIGIN IN VIOLATION OF 15 U.S.C. § 1125(a)

87. Aqua Products realleges paragraphs 1 through 86 as if fully set forth herein.

88. The use of the Infringing URLs constitutes 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.

89. By reason of the foregoing, the trade and public are likely, and will continue to be confused, misled or deceived, and Aqua Products is now and will continue to suffer irreparable injury, including injury to its goodwill and reputation for which it has no adequate remedy at law.

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

91. On account of the activities of the defendants in this State, County and Southern District of New York, 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 INJURY TO BUSINESS REPUTATION AND DILUTION PURSUANT TO 15 U.S.C §1125(c) SEEKING INJUNCTIVE AND MONETARY RELIEF

92. Aqua Products realleges paragraphs 1 through 91 as if fully set forth herein.

93. The defendants' conduct is without the permission, consent or authorization of Aqua Products and has and is blurring and tarnishing the reputation of Aqua Products's unique, widely recognized, distinctive and famous Aqua Products Trademarks, thereby diminishing their value.

94. 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.

95. By reason of the foregoing, the defendants have engaged in, and are continuing to engage in acts which are injuring the business reputation and diluting and blurring the distinctive quality of the Aqua Products Trademarks in violation of the Trademark Act of the United States (15 U.S.C. § 1125(c)).

96. By reason of the foregoing, the trade and public are likely, and will continue to be confused, misled or deceived, and Aqua Products is now and will continue to suffer irreparable injury, including injury to its reputation and dilution of the distinctive quality of its Aqua Products Trademarks, for which it has no adequate remedy at law.

97. On account of the activities of The defendants in this State, County and Southern District of New York, 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 A SEVENTH CLAIM FOR RELIEF FOR UNFAIR COMPETITION UNDER SECTION 368.1 OF THE NEW YORK GENERAL BUSINESS LAW

98. Aqua Products realleges paragraphs 1 through 97 as if fully set forth herein.

99. This cause of action arises under section 368.1 of the New York State General Business Law, § 368.1.

100. The defendants' conduct is likely to injure the business reputation of Aqua Products and dilute the distinctive quality of the Aqua Products Trademarks.

101. The defendants' conduct is without the permission, consent or authorization of Aqua Products and creates a likelihood of injury to its public image and reputation, and a dilution of the distinctive quality of the Aqua Products Trademarks.

102. On account of the aforementioned activities of the defendants, 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 EIGHTH CLAIM SEEKING INJUNCTIVE AND MONETARY RELIEF FOR FALSE OR MISLEADING DESCRIPTIONS OR REPRESENTATIONS OF FACT IN VIOLATION OF THE LANHAM ACT (15 U.S.C. § 1125(a))

103. Plaintiff realleges paragraphs 1 through 102 as if fully set forth herein.

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

105. 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.

106. 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.

107. 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.

108. On account of the activities of the defendants in this State, County, and Southern District of New York, 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 A NINTH CLAIM SEEKING INJUNCTIVE AND MONETARY RELIEF FOR DECEPTIVE TRADE PRACTICES IN VIOLATION OF N.Y. GEN. BUS. LAW § 349

109. Plaintiff realleges paragraphs 1 through 108 as if fully set forth herein.

110. This cause of action arises under the New York State General Business Law, more particularly N.Y. Gen. Bus. Law § 349.

111. The Defendants' aforementioned conduct is false, misleading and constitutes the use of deceptive acts or practices in the conduct of business, trade or commerce and is misleading the public and injuring the good will and reputation of plaintiff in violation of §349 of New York State's General Business Law.

112. Upon information and belief, the defendants undertook the aforementioned conduct with full knowledge that it was misleading and with the intent to confuse, mislead and deceive consumers, and to unfairly compete with the plaintiff.

113. By reason of the foregoing, the plaintiff is now and will continue to suffer irreparable injury for which it has no adequate remedy at law.

114. On account of the activities of the defendants in this State, County, and Southern District of New York, 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 A TENTH CLAIM SEEKING INJUNCTIVE AND MONETARY RELIEF FOR FALSE ADVERTISING IN VIOLATION OF N.Y. GEN. BUS. LAW § 350

115. Plaintiff realleges paragraphs 1 through 114 as if fully set forth herein.

116. This cause of action arises under the New York State General Business Law, more particularly N.Y. Gen. Bus. Law § 350.

117. The defendants' Comparison Chart is materially misleading.

118. Upon information and belief, the defendants' distributed the Comparison Chart with full knowledge that it was misleading and with the intent to confuse, mislead and deceive consumers, and to unfairly compete with plaintiff.

119. By reason of the foregoing, the defendants have engaged in and are continuing to engage in acts which are misleading the public and injuring the good will and reputation of plaintiff in violation of the New York State General Business Law.

120. By reason of the foregoing, plaintiff is now and will continue to suffer irreparable injury for which it has no adequate remedy at law.

121. On account of the activities of the defendants in this State, County, and Southern District of New York, 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 A ELEVENTH CLAIM SEEKING INJUNCTIVE AND MONETARY RELIEF FOR UNFAIR COMPETITION IN VIOLATION OF THE COMMON LAW

122. Aqua Products realleges paragraphs 1 through 121 as if fully set forth herein.

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

124. The use of the Infringing URLs will mislead and confuse the public and trade, and create a likelihood of injury to Aqua Products' public image and reputation.

125. Upon information and belief, the trade and public are likely to attribute falsely 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.

126. By reason of the foregoing, the defendants have engaged in and are continuing to engage in acts of unfair competition in violation of the common law.

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

128. By reason of the foregoing, Aqua Products is now and will continue to suffer irreparable injury, including injury to its goodwill and reputation for which it has no adequate remedy at law.

129. On account of the activities of the defendants in this State, County, and Southern District of New York, 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 or the '658 Patent;

(ii) engaging in any other activity constituting an infringement of the '613 Patent or the '658 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 or the '658 Patent which were manufactured, distributed, sold or shipped by them and to reimburse their customers from whom said merchandise was recalled;

d. ordering that the Infringing URLs be preliminarily and permanently transferred to the plaintiff and/or forfeited;

e. ordering that 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, be preliminarily and permanently transferred to the plaintiff and/or forfeited;

f. 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;

g. directing that the defendants deliver to Aqua Product's 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 or the '658 Patent;

h. 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;

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

j. 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 he has 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;

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

l. 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 or the '658 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;

m. directing the defendants to account to Aqua Products for the defendants' unjustly received profits resulting from infringement of the '613 Patent or the '658 Patent;

n. 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.*;

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

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

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

Dated: July 14, 2004
New York, NY

ABELMAN FRAYNE & SCHWAB

Jeffrey A. Schwab (JS 9592)
Michael Aschen (MA 6336)
150 East 42nd Street
New York, NY 10017
(212) 949-9022

Counsel for plaintiff
Aqua Products, Inc.

EXHIBIT 1

US006742613B2

(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

(56) **References Cited**

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

FOREIGN PATENT DOCUMENTS

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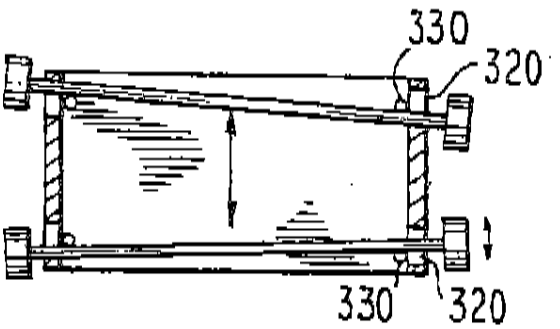
* cited by examiner

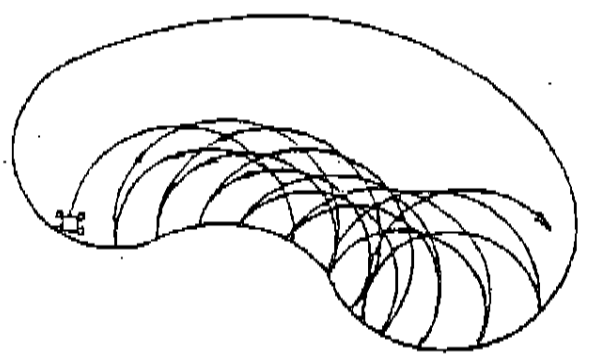
Primary Examiner—David Dunn
(74) *Attorney, Agent, or Firm*—Abelman, Frayne & Schwab

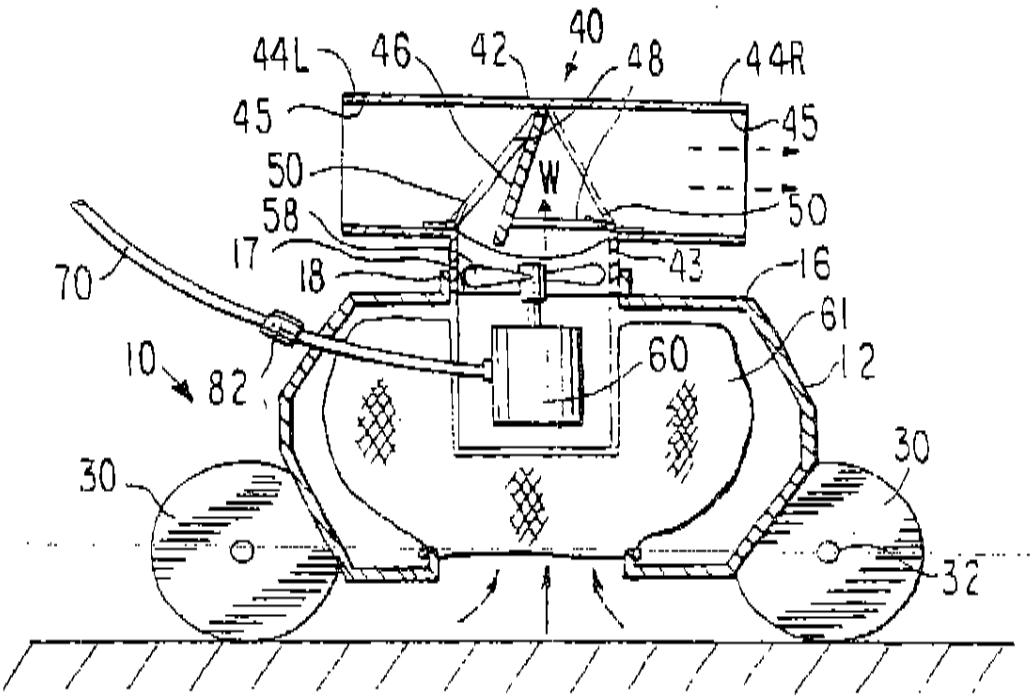
(57) **ABSTRACT**

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






44L
46
42
40
48
44R
45
45
50
W
50
58
17
18
43
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70
61
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60
12
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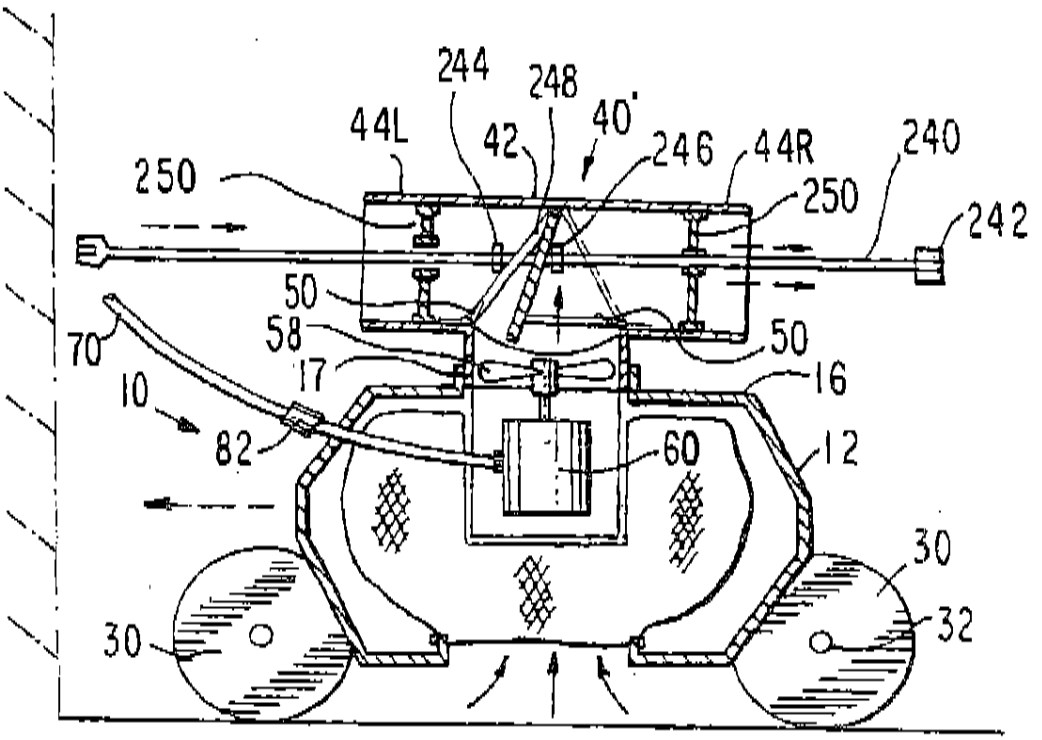
32

FIG.1

FIG. 1A


244
248
40
44L
42
246
44R
240
250
250
242
50
58
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70
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16
10
82
60
12
30
30
32

FIG. 1B

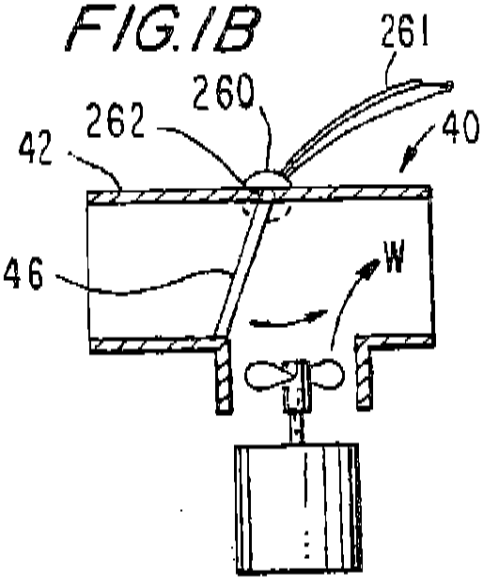

261
260
262
42
40
46
W

FIG. 2

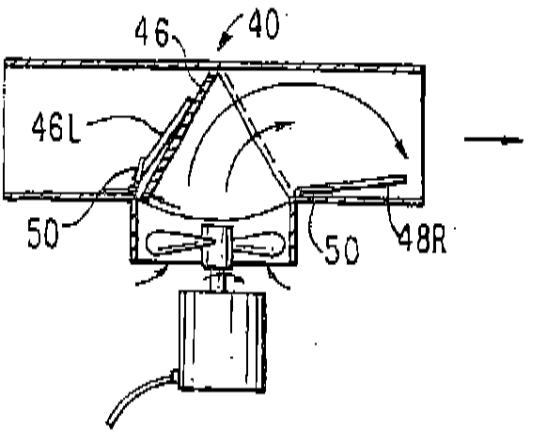


FIG. 3

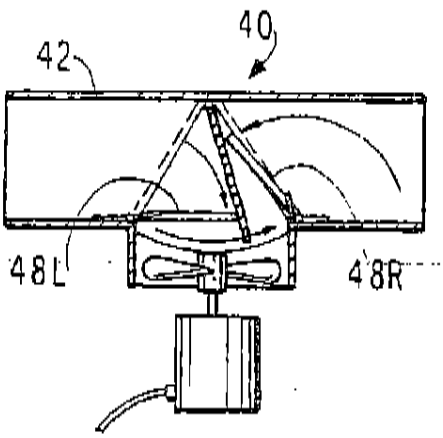


FIG. 4

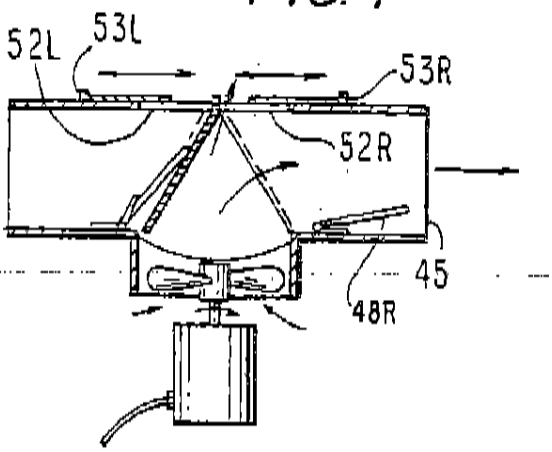


FIG. 5

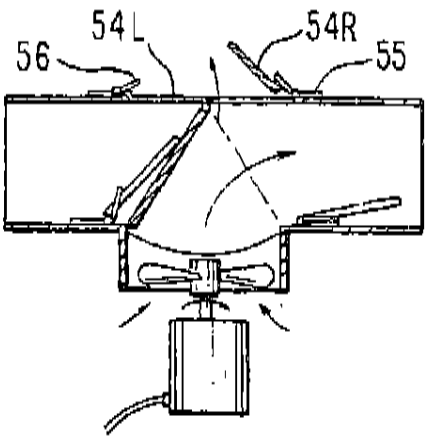


FIG. 6

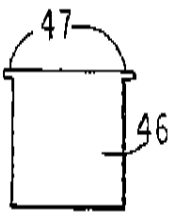


FIG. 7

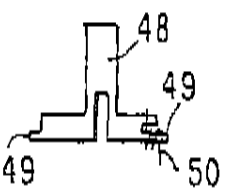


FIG.8

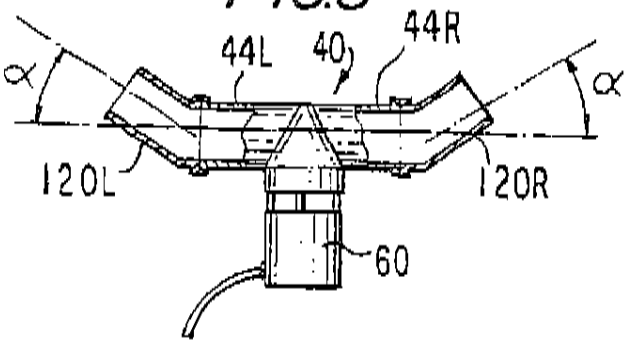


FIG.9

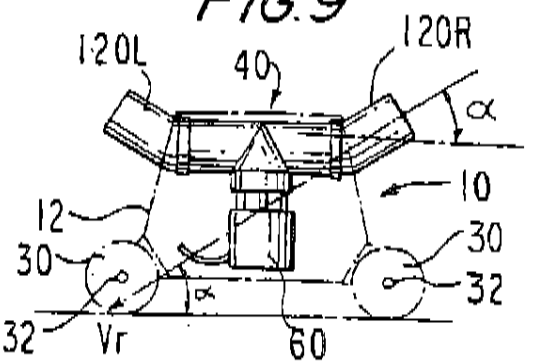


FIG.10

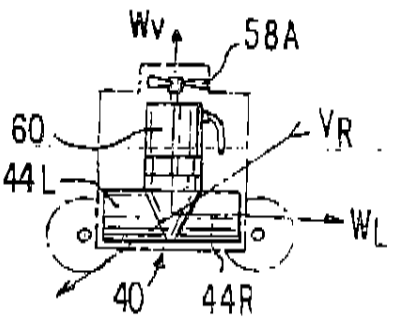


FIG.11

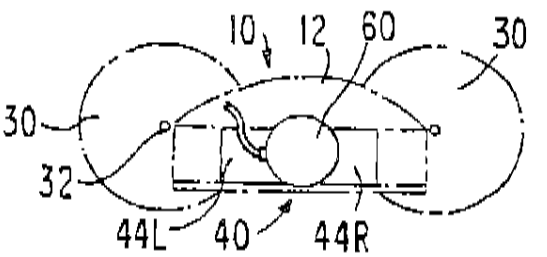


FIG.12

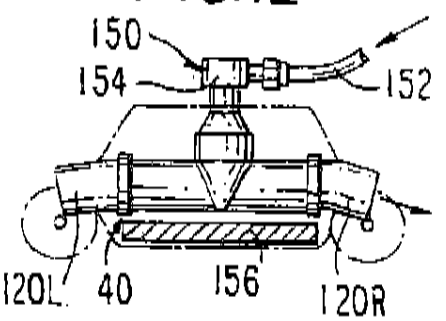


FIG.12A

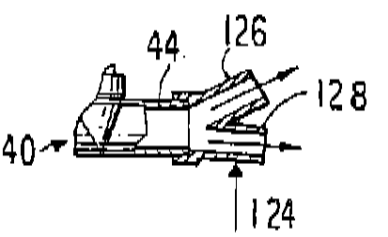


FIG.13

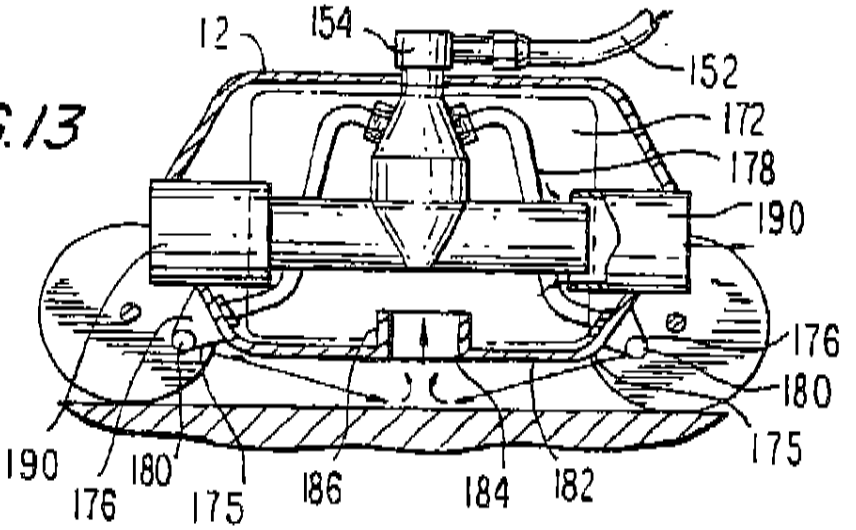


FIG.14

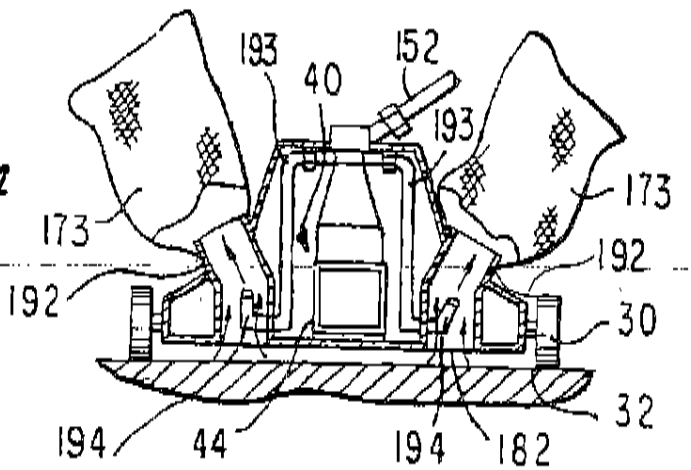


FIG.15

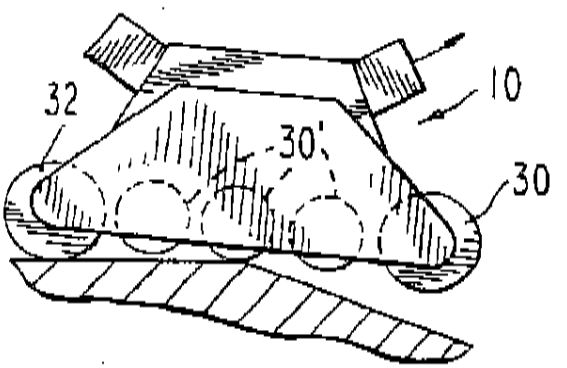


FIG. 16

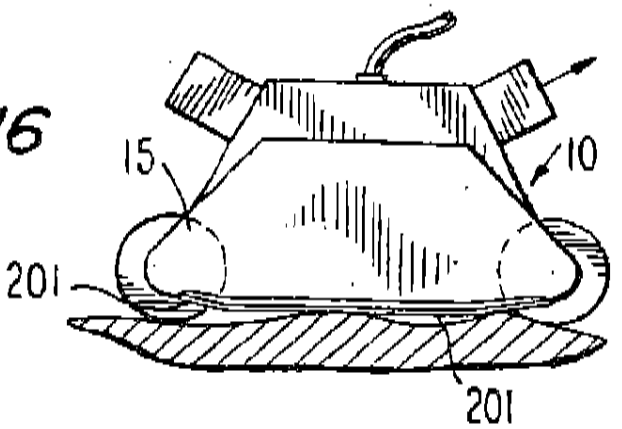


FIG. 17

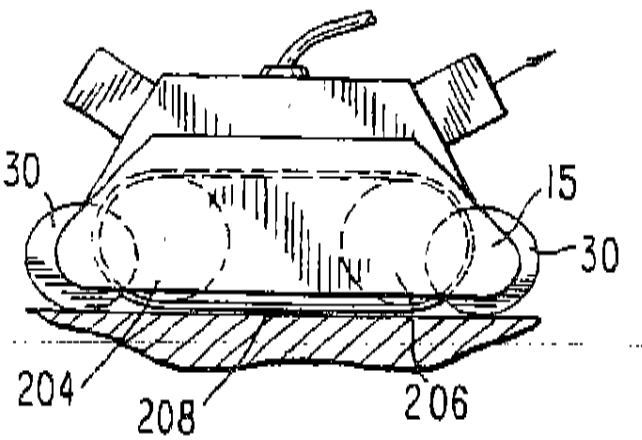


FIG. 18

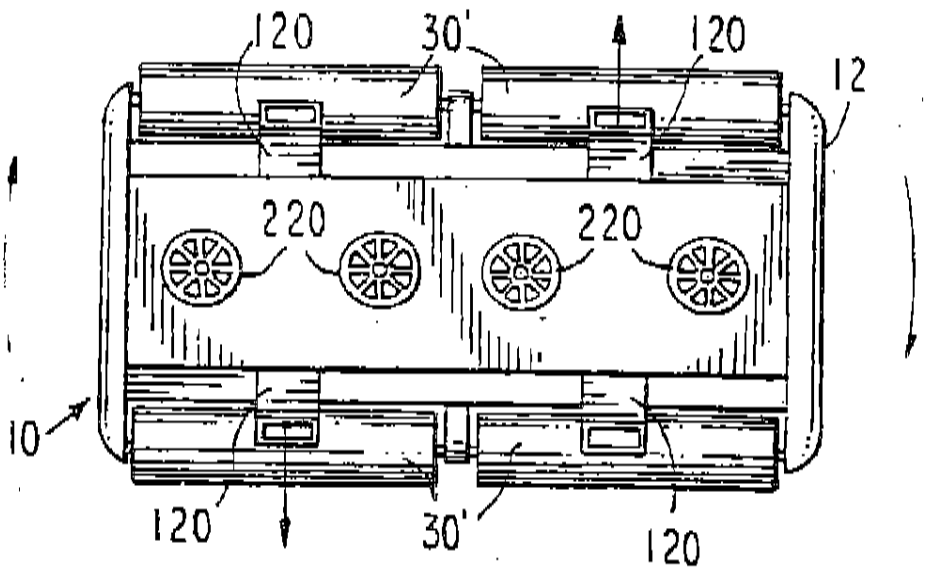


FIG. 21

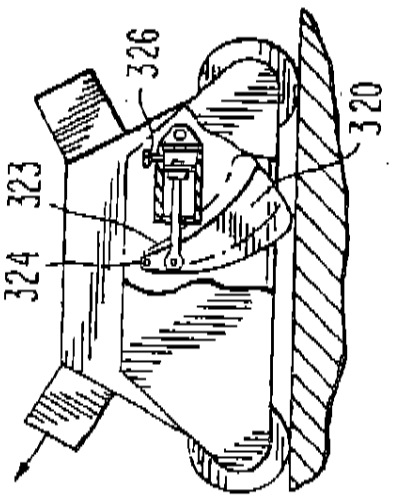


FIG. 19
PRIOR ART

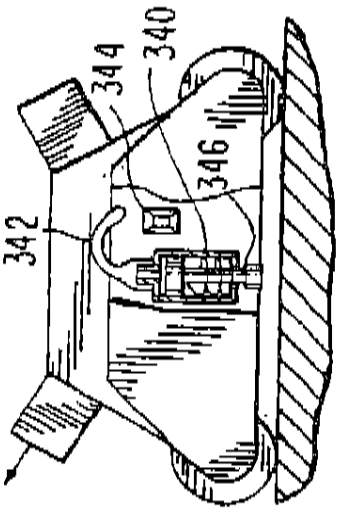


FIG. 20

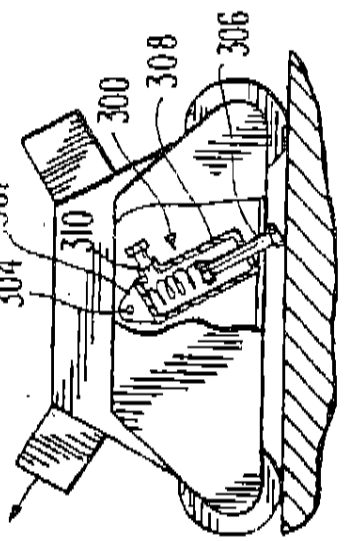


FIG. 22

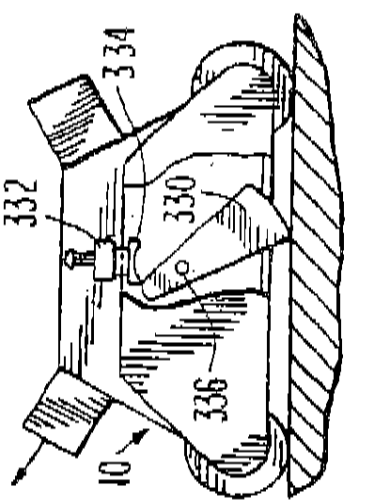


FIG. 24
PRIOR ART

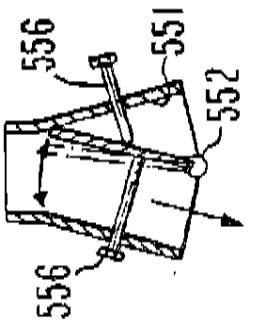


FIG. 26

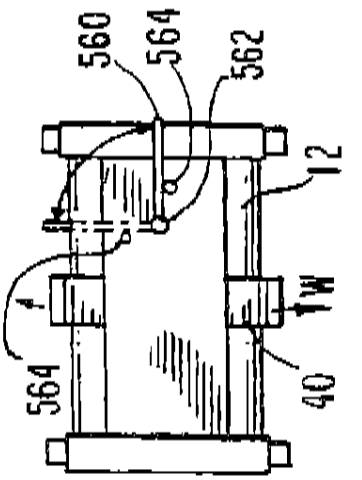


FIG. 23

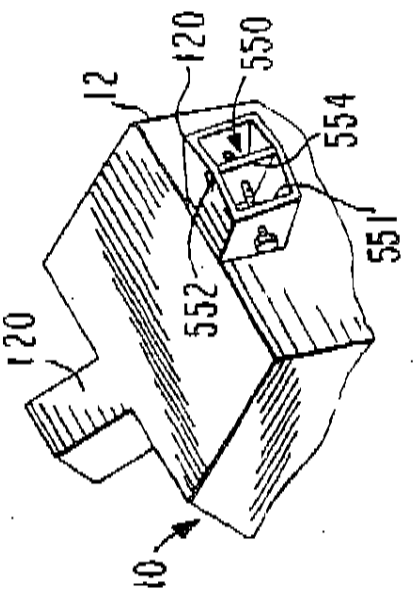
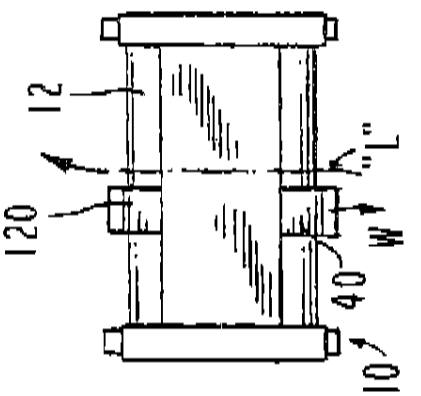


FIG. 25



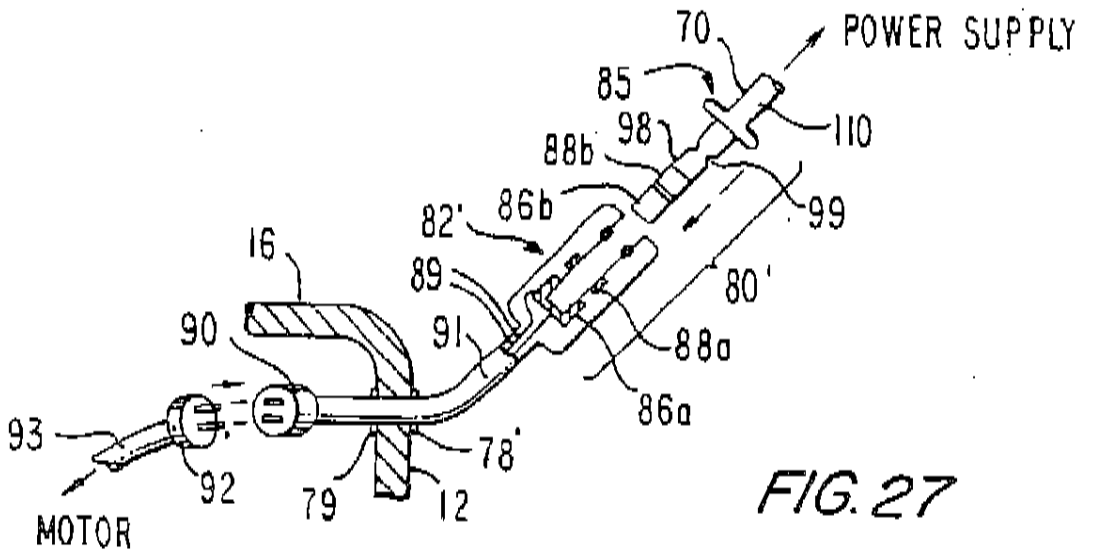

70
POWER SUPPLY
85
98
110
88b
99
82'
86b
16
89
80'
90
91
88a
86a
93
78'
92
79
12
MOTOR

FIG. 27

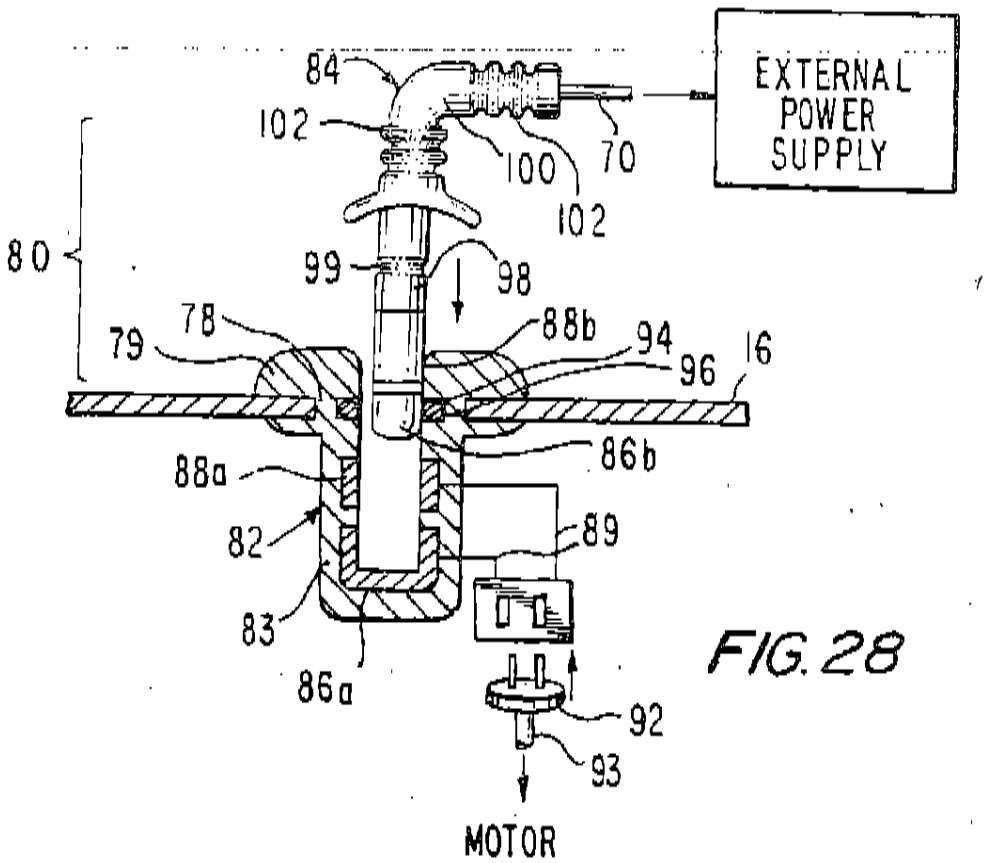

84
EXTERNAL POWER SUPPLY
102
100
70
102
80
99
98
79
78
88b
94
96
16
88a
86b
82
89
83
86a
92
93
MOTOR

FIG. 28

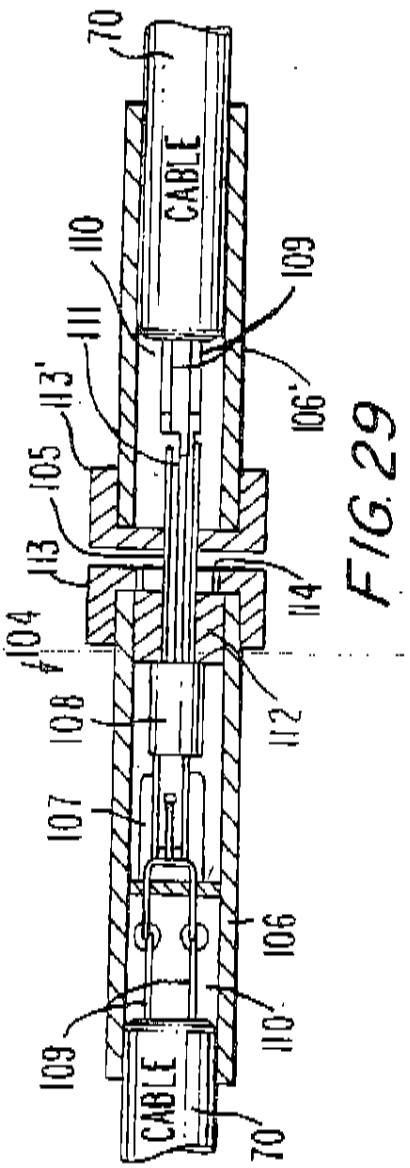

70
CABLE
110
111
109
113'
106'
105
113
114
104
108
112
107
106
110
109
CABLE
70

FIG. 29

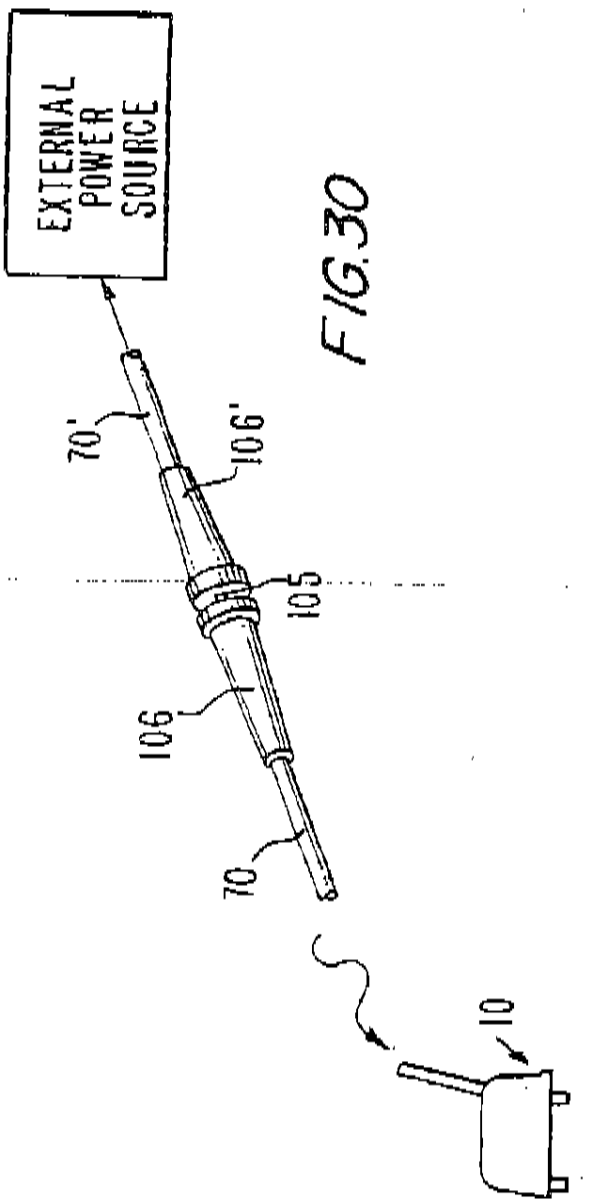

EXTERNAL POWER SOURCE
70'
106'
105
106
70
10

FIG. 30

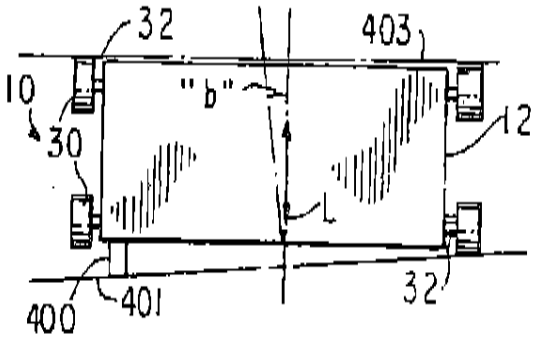


FIG. 31
PRIOR ART

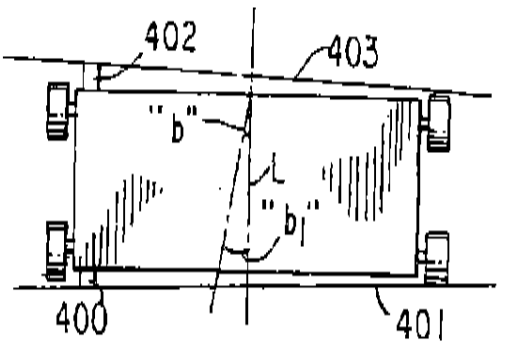


FIG. 32A
PRIOR ART

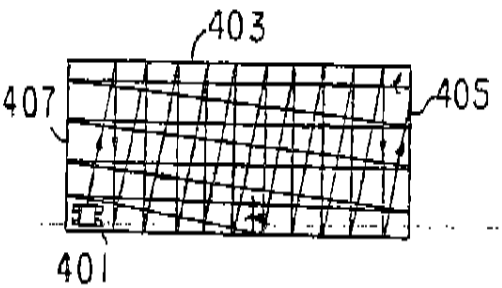


FIG. 31B

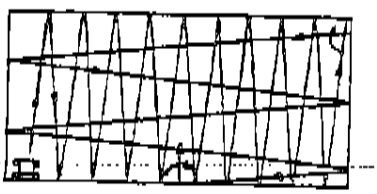


FIG. 32B

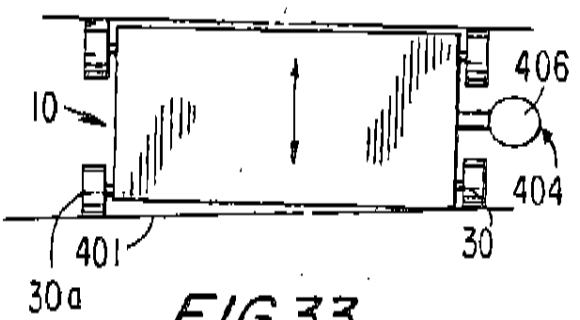


FIG. 33

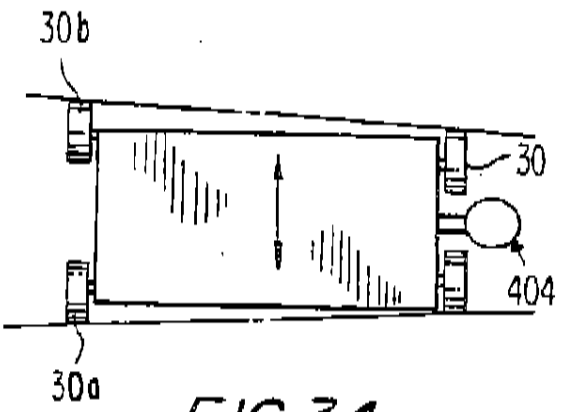


FIG. 34

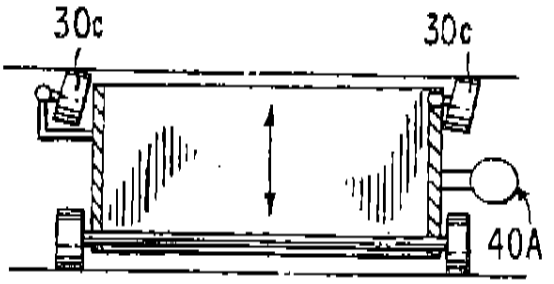


FIG. 35

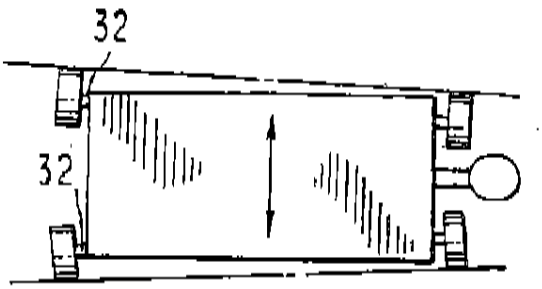


FIG. 36

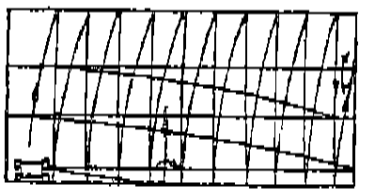


FIG. 35A

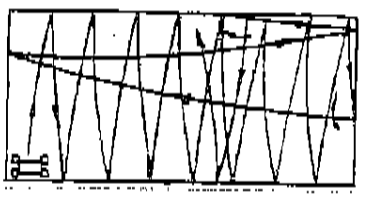


FIG. 35B

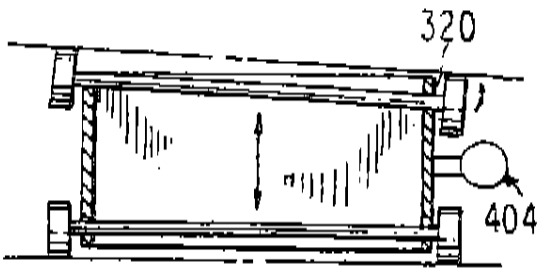


FIG. 37

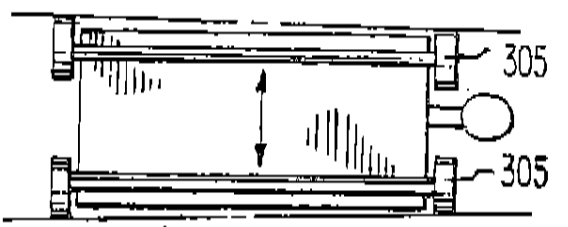


FIG. 38

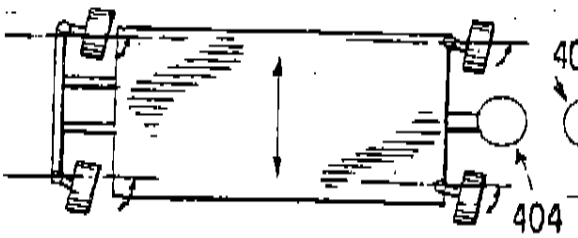


FIG. 39

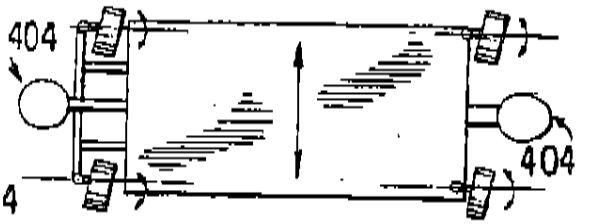


FIG. 40

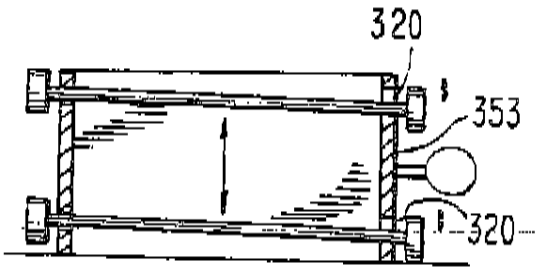


FIG. 41

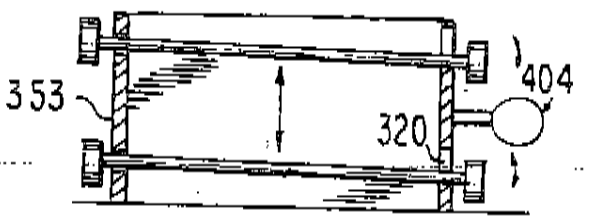


FIG. 42

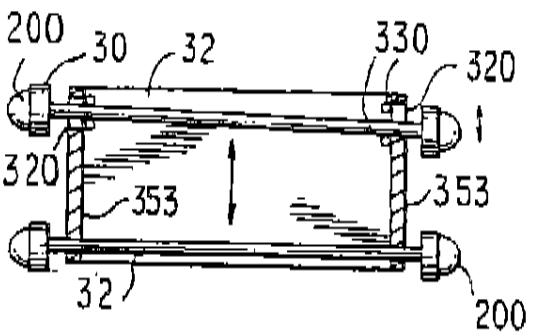


FIG. 43

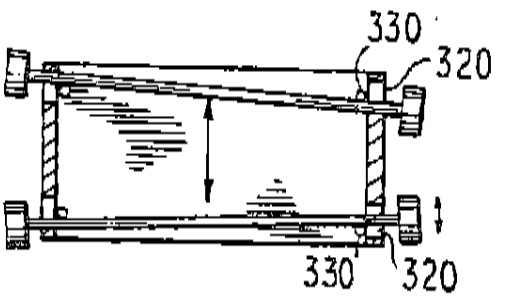


FIG. 44

FIG.45

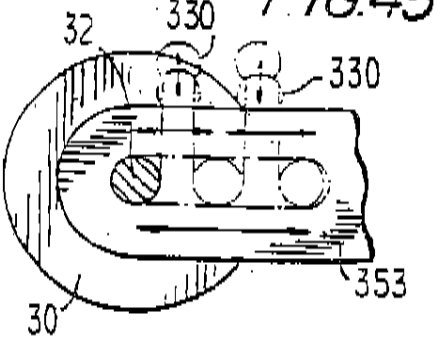


FIG.46

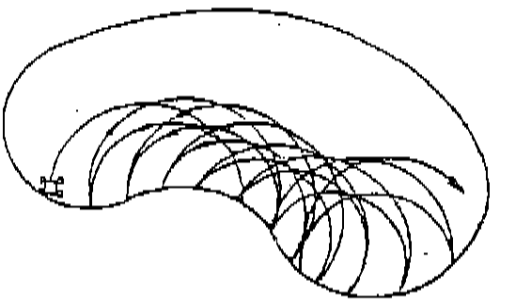


FIG.47

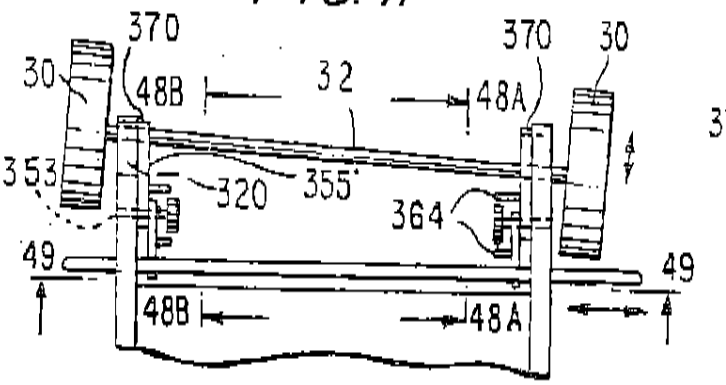


FIG.48A

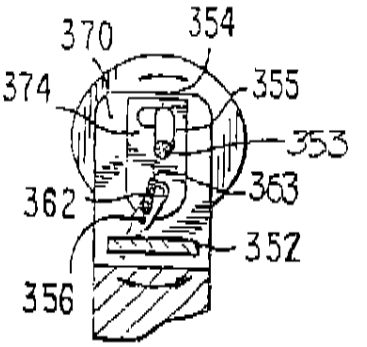


FIG.48B

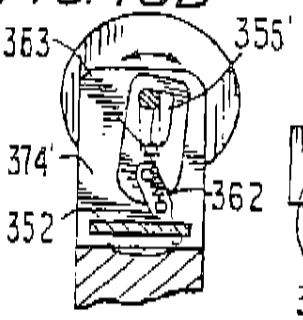
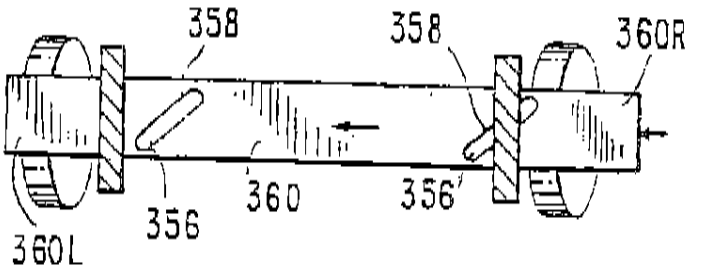


FIG.49



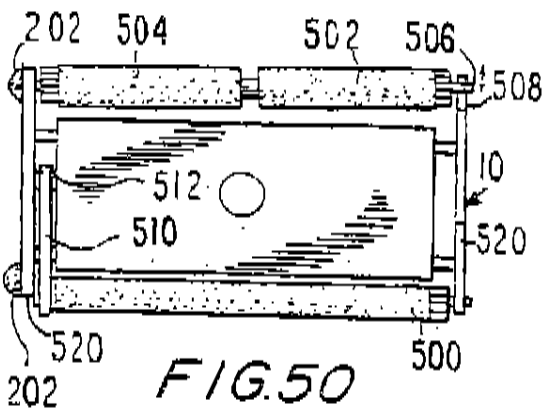


FIG.50

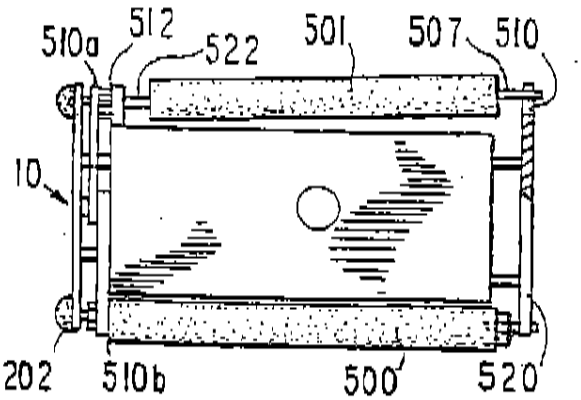


FIG.51

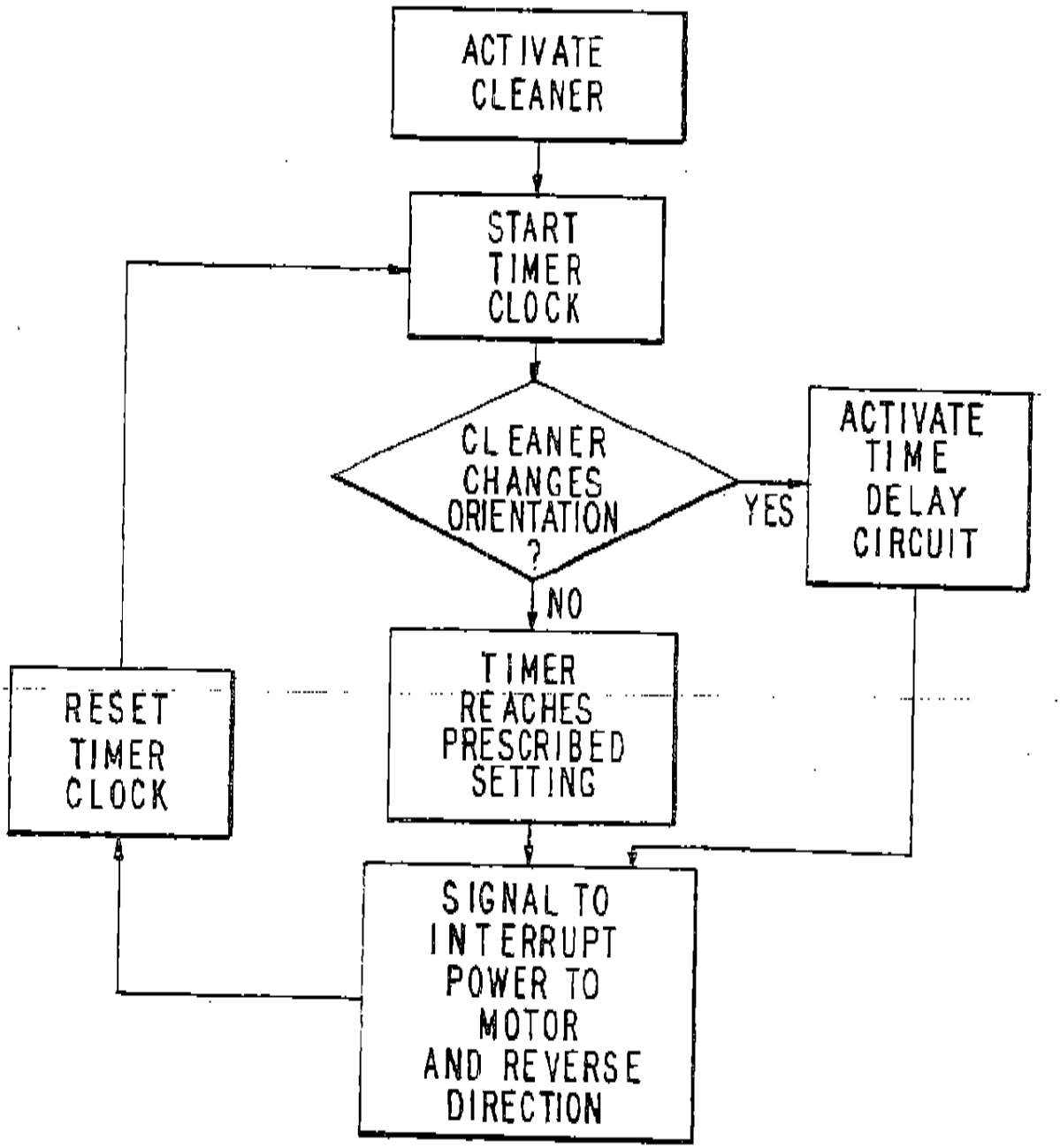

ACTIVATE CLEANER
START TIMER CLOCK
CLEANER CHANGES ORIENTATION ?
YES
ACTIVATE TIME DELAY CIRCUIT
NO
TIMER REACHES PRESCRIBED SETTING
RESET TIMER CLOCK
SIGNAL TO INTERRUPT POWER TO MOTOR AND REVERSE DIRECTION

FIG. 52

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

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 preprogrammed 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 direct, 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

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

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

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 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 axes 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:

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 aside 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 form 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;

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

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 "T"-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 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 lefthand 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 solidoid **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

on or off the vertical or angled side wall of a pool. As shown in FIG. **9**, the projected resultant vector Ar 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 "Ar" 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 **58**A creates a downward force, which when coupled with the horizontal or transnational jet force emitted from discharge conduit **44**R or **44**L 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 transnational 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 **120**R, **120**L 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 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. **12**A 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 transnational 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 course 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 sidewalls 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

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 the 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 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-circulator 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.

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 **86***a* and **88***a* 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 **86***b* and **88***b* that are adapted to be received in sliding contact with corresponding elements **86***a* and **88***a* 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 dielectrical material, through which are passed a pair of electrically conductive wires (not shown) from power cord **70** that terminate, respectively, at conductors **86***b* and **86***b*. 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 cleaned.

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. **31**A and **32**A 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. **31**A, 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 **30***a* 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 **30***a*, **30***b* 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 embodiments 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 **30***c* 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 **30***c* 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 to the axis "L", and vice versa. The scanning pattern would be as illustrated in FIG. **35B**.

In the embodiment of FIG **36**, the transverse axles **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 on 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

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 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. **35**A. 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. **35**B, or the two are combined, e.g. in FIG. **35**A

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 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**. Pivotally 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** to freely accommodate movement of axle **32**. Two levers **356**, each of which is pivotally 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. **48**A, which is a view taken along line **48**A—**48**A 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. **48**B, which is a view taken along line **48**B—**48**B 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 **360**R 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 spoket 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. **32**B.

FIG. **51** schematically illustrates a robot **10**, which uses a pair of drive belts or chains **510***a*, **510***b* 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. **32**B.

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 are 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

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:

(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 axles, the axes of the respective axles 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 axles is fixed.

4. The apparatus of claim **1**, wherein at least one end of the transverse axles 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 axles 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 axles 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

(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 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 axles 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.

* * * * *

EXHIBIT 2

US006099658A

United States Patent [19]

Porat

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

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

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[57] ABSTRACT

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.

24 Claims, No Drawings

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 microprocessor 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

substantially neutral bouyancy 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 sidewalls 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.

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 corer -o 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

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 descent 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 ar 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

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.

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 microprocessor.

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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