

CONFIDENTIAL ATTORNEY WORK PRODUCT

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

XINGMAI INNOVATION TECHNOLOGY (SUZHOU) CO., LTD.

D/B/A BEATBOT

Petitioner,

v.

AIPER GLOBAL PTE. LTD.

Patent Owner

Case No. PGR2026-00012

U.S. Patent No. 12,221,196

DECLARATION OF KATE CHENG, Ph.D., P.E.

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I, Kate Cheng, declare as follows:

I. ENGAGEMENT

1. I have been retained by Patent Owner Aiper Global PTE. Ltd. (“Patent Owner”) as an expert witness in a post-grant review (“PGR”) before the U.S. Patent Trial and Appeal Board (“PTAB”).

2. I have been engaged by counsel for Patent Owner Aiper Global Pte. Ltd. to provide independent technical opinions in this post-grant review of U.S. Patent No. 12,221,196, including in support of Patent Owner’s Response and Patent Owner’s Contingent Motion to Amend (substitute Claims 20–39). I have been asked to provide my opinions on the validity of Claims 1–19 (the “Challenged Claims”) of the ’196 Patent under 35 U.S.C. §§ 103 and 112(b) as challenged in the instituted grounds, on the technical soundness of the opinions of Petitioner’s declarant Dr. Cowan (EX1003), and on the written-description support, patentability, and definiteness of the proposed substitute claims.

3. My employer, Exponent, is being compensated at the rate of \$450 per hour for my time, which is Exponent’s standard hourly consulting rate for my time. This compensation is not contingent on my performance, my opinions, the outcome of this matter, or any other issues involved in or related to this matter. Neither Exponent nor I have a conflict of interest with respect to the Petitioner or Patent Owner.

4. I am over 18 years of age, I have personal knowledge of the facts stated in this declaration, and I could testify competently to them if asked to do so.

II. QUALIFICATIONS

5. My curriculum vitae is attached as Exhibit EX2004. To summarize my qualifications, I hold a Ph.D. in Mechanical Engineering from Northwestern University and a

B.S. in Mechanical Engineering from the California Institute of Technology. I am a licensed Professional Engineer in the State of Illinois.

6. My academic training included undergraduate and graduate coursework in fluid mechanics, thermodynamics, and control systems. As part of my graduate coursework, I developed various computational fluid dynamics (CFD) programs implementing a variety of numerical methods for simulating fluid-flow behavior. My doctoral dissertation involved mathematical modeling and experimental validation of complex manufacturing processes, including metal additive manufacturing and incremental sheet metal forming.

7. Throughout my education and professional career, I have developed substantial expertise in the analysis of computer-controlled electro-mechanical systems. My work routinely requires application of principles of fluid mechanics, thermodynamics, and controls. I have analyzed a wide variety of products and systems incorporating:

- a. Controllers: these would include, for example, embedded controllers, including those utilizing microcontrollers; ECU (engine control units); SCR (Selective Catalytic Reduction) dosing units; and various PLCs (programmable logic controllers).
- b. Sensors: these would include, for example, acoustic, optical, pressure, position, proximity, temperature, frequency, and acceleration sensors.
- c. Actuators: these would include, for example, motors, pumps, valves, hydraulic cylinders, and heating elements.

8. Among other applications, I have performed such analyses for automotive systems, industrial machinery, consumer products, transportation equipment, and robotic systems used in underwater surveying and manufacturing.

9. In many matters, I have evaluated how environmental conditions and control logic affect system performance and safety. I have examined topics including unintended brake actuation, engine emissions regulatory compliance, aftermarket lighting products for towing applications, railcar wheel bearing monitoring systems, algorithms concerning friction and regenerative braking, and the control of automated equipment (including an Autonomous Underwater Vehicle). I have also performed source code evaluations associated with these systems, including investigations of how timers, signal filters, state machines, PID (proportional-integral-derivative) parameter tunings, and feedback and feedforward control logic influence the behavior of the system. As part of my graduate studies, I also investigated how the sequencing and timing of manufacturing operations affect the material properties of finished products.

10. In performing such analyses, I routinely consider how real-world operating conditions affect system performance relative to idealized assumptions used during design, simulation, or testing. As part of my graduate work, I conducted experimental validation of computational model predictions at the Advanced Photon Source at Argonne National Laboratory in Illinois and the National Institute of Standards and Technology in Maryland. At Exponent, I have reviewed and compared software implemented in autonomous devices and embedded controllers against documentation, design specifications, operation manuals, patents, technical publications, and testing results. In doing so, I evaluate factors such as environmental variability, manufacturing tolerances, interactions between hardware and software, and other sources of variation that influence the performance of practical systems.

III. INFORMATION CONSIDERED

11. My opinions are based on my years of education, research, personal experience, professional experience, and my investigation and study of the '196 Patent, its prosecution

history, the documents identified in this declaration, and the following exhibits, in light of the general knowledge in the relevant art:

Exhibit	Description
1001	U.S. Patent No. 12,221,196 (“the ’196 Patent”)
1002	Prosecution file history for the ’196 Patent
1003	Declaration of Noah Cowan
1005	U.S. Patent Application Publication No. 2025/0146315, published May 8, 2025 to Wang et al. (“Wang”)
1009	U.S. Patent No. 11,946,282, issued April 2, 2024 to Zhang (“Zhang”)
1010	Certified Translation of Chinese Patent No. CN117738506, published March 22, 2024 to Guo et al. (“Guo”)
1012	U.S. Patent No. 11,803,193, issued October 31, 2023 to Zhao et al. (“Zhao”)
1013	International Patent Application No. PCT/US2007/063650 (published as WO 2007/106730), published September 20, 2007 (“Owen”)
1021	Plot and Code of Simulation for Airbag Inflation
1022	Chapter 9: “Timers” of <i>Programmable Logic Controllers</i> , 6th Edition, W. Bolton, published in 2015
2004	Curriculum vitae of Kate Cheng, Ph.D., P.E.
2005	Revised MATLAB code and simulation result

IV. LEGAL PRINCIPLES

12. I understand that the Petitioner alleges that certain claims are unpatentable because they were obvious under 35 U.S.C. §103 or indefinite under 35 U.S.C. §112(b).

A. Obviousness – 35 U.S.C. § 103

13. I am informed by counsel and understand that a patent claim is unpatentable as obvious under 35 U.S.C. § 103 if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious to a POSITA at the

relevant time. I understand the analysis considers the scope and content of the prior art, the differences between the prior art and the claims, the level of ordinary skill, and objective indicia of non-obviousness. I further understand that a party asserting obviousness must show a reason a POSITA would have combined or modified the references with a reasonable expectation of success; that a proposed modification that renders a reference inoperable for its intended purpose or changes its principle of operation weighs against obviousness; that a reference qualifies as analogous art only if it is from the same field of endeavor or reasonably pertinent to the inventor's problem; and that expert testimony offered without underlying facts or data may be given little or no weight (37 C.F.R. § 42.65(a)).

B. Indefiniteness – 35 U.S.C. § 112(b)

14. I am informed by counsel and understand that a claim is indefinite under 35 U.S.C. § 112(b) only if, read in light of the specification and prosecution history, it fails to inform a POSITA of the scope of the invention with reasonable certainty. I further understand that a claim limitation that does not use the word “means” is presumed not to be a means-plus-function limitation under § 112(f), and that the presumption is overcome only if the limitation fails to recite sufficiently definite structure to a POSITA; terms that connote a known class of structures to skilled artisans — even functionally named terms such as “unit” combined with structural context — are not means-plus-function limitations.

C. Written Description – 35 U.S.C. § 112(a)

15. I am informed by counsel and understand that a substitute claim is supported by the written description of the original disclosure under 35 U.S.C. § 112(a) if the original disclosure reasonably conveys to a POSITA that the inventors had possession of the claimed subject matter as of the filing date. I understand that the disclosure need not recite the claimed

subject matter verbatim for support to exist; that possession may be shown through the words, structures, figures, diagrams, and formulas of the original disclosure taken as a whole; and that the claims of the application as originally filed are themselves part of the original disclosure and may provide written description support for later-presented claims.

D. Patentability of Substitute Claims – 35 U.S.C. §§ 102, 103

16. I am informed by counsel and understand that, where a patent owner proposes substitute claims in a motion to amend, the petitioner bears the burden of proving that the proposed substitute claims are unpatentable. I understand that a substitute claim is anticipated under 35 U.S.C. § 102 only if a single prior art reference discloses, expressly or inherently, every limitation of the claim as arranged in the claim, and that obviousness under 35 U.S.C. § 103 is evaluated under the principles described in Section IV.A above, including the requirement that the party asserting obviousness articulate a reason that a POSITA would have combined or modified the references with a reasonable expectation of success. I further understand that a substitute claim that adds limitations narrowing the original claim does not enlarge the scope of the claims, and that amendments drawn from the original claims and original specification do not introduce new matter. I also understand that a specification is enabling if it teaches a POSITA how to make and use the claimed invention without undue experimentation, and that the need for routine experimentation does not defeat enablement.

V. THE RELEVANT TIMEFRAME FOR ANALYSIS

17. In performing this analysis, I have assumed that the priority date is July 26, 2024, the date of the earliest application in the chain leading to the '196 Patent. (EX1001, Face). I take no position at this time whether that is the correct priority date for any of the challenged claims.

My opinions would not change if the relevant date were instead the U.S. filing date of the application that issued as the '196 Patent, which is September 2, 2024.

VI. PERSON OF ORDINARY SKILL IN THE ART (“POSITA”)

18. I understand that a person of ordinary skill in the art (“POSITA”) is a hypothetical person who is presumed to be aware of pertinent art including knowledge in the art, thinks along conventional wisdom in the art, and is a person of ordinary creativity. I understand that this hypothetical POSITA is considered to have the normal skills and knowledge of a person in the technical field.

19. I understand that, in determining the level of ordinary skill of a POSITA, the following factors may be considered: (a) the levels of education and experience of persons working in the field; (b) the types of problems encountered in the field; and (c) the sophistication of the technology.

20. It is my opinion that, at the time of the invention, a person of ordinary skill in the art related to the technologies of the '196 Patent would have had an undergraduate degree in Mechanical Engineering, Electrical Engineering, or an equivalent field, or at least two years of experience in the design or analysis of robotic systems, control systems, sensor integration, or a similar field. This opinion is based on my understanding of the typical minimum qualifications of those working in the field at that time. Additional education can compensate for less experience and vice versa.

21. Based on this definition, I consider myself at least a POSITA as of this writing and at the time of the earliest filing date/priority date of the '196 Patent. I have conducted my analysis from the perspective of this person of ordinary skill in the art, as of that date. My opinions would not change if Petitioner's definition of a POSITA is adopted.

VII. CLAIM CONSTRUCTION

22. I understand that, in this proceeding, the claims are construed according to their ordinary and customary meaning, in light of the specification and prosecution history, as understood by a person of ordinary skill in the art at the time of the invention. Petitioner submits that the terms addressed in Grounds 5-6 and listed in the table below require construction.

Claim Language	Claims	Petitioner's Proposed Construction
"Sinking and floating control unit"	Claims 1-19	Subject to §112(f). EX1003, ¶¶76-86. Structure: an air-based buoyancy control assembly, described in FIG.3-5 and 6:66-8:5 of EX1001, and equivalents thereof.
"Waterline detection unit"	Claims 1-14	Subject to §112(f). EX1003, ¶¶92-98. Structure: a capacitive or ultrasonic sensor, described in FIG.1 and 5:58-6:17; 8:24-47 of EX1001, and equivalents thereof.
"Posture detection unit"	Claims 2, 13	Subject to §112(f). EX1003, ¶¶99-107. Structure: an IMU, described in FIG.1 and 9:29-57; 12:5-21 of EX1001, and equivalents thereof.
"Outlet water detection subunit"	Claims 5, 7-9, 12-14	Subject to §112(f). EX1003, ¶¶118-126. Structure: a capacitive or ultrasonic sensor, described in FIG.1 and 8:29-40 of EX1001, and equivalents thereof.
"Proximity waterline detection subunit"	Claims 6, 8	Subject to § 112(f). EX1003, ¶¶127-137. Structure: an ultrasonic sensor, described in FIG.1 and 8:29-47 of EX1001, and equivalents thereof.
"Inflation and deflation subunit"	Claims 7-9, 11-14	Subject to § 112(f). EX1003, ¶¶138-146. Structure: air pump, described in FIG.1,3-5 and 7:19-8:15 of EX1001, and equivalents thereof.

23. In my opinion, no claim term requires construction beyond its plain and ordinary meaning to a POSITA. Each of the disputed terms connotes concrete, well-understood structures when read in the context of the '196 Patent. I have addressed Grounds 5 and 6 later in this report.

24. According to the '196 Patent specification,

- a. The waterline detection unit 30 is described as including an outlet water detection subunit 301 and a proximity waterline detection subunit 302, which can be for example a capacitive sensor or ultrasonic ranging device, respectively (8:29-47).
- b. The posture detection unit can be, for example, an inertial sensor (IMU) (9:31-33).
- c. The inflation and deflation control unit 202 (part of sinking and floating control unit 20) is described in one embodiment as including a first and second air pump assembly 2021 and 2022. (7:19-21).

25. Accordingly, a POSITA would understand each term to denote structure provided by the '196 Patent.

VIII. SUBJECT MATTER OF THE '196 PATENT

A. Background of the '196 Patent

26. The '196 Patent is generally directed to an underwater robot for cleaning swimming pools and, more specifically, to “a controllable sinking and floating swimming pool robot and a sinking and floating control method for a swimming pool robot” (EX1001, 1:8-11). Swimming pool robots, at the time of invention of the '196 Patent, were capable of “independently clean[ing] a bottom and wall surface of a swimming pool,” which provided an improvement over conventional manual cleaning methods. (EX1001, 1:19-22). However, autonomous swimming pool robots still suffered from inefficiencies related to transitioning between cleaning states, specifically transitioning from a bottom floor cleaning state to a water surface cleaning state. (EX1001, 1:23-27). These inefficiencies were the result of mechanisms these robots implemented to modulate buoyancy, which involved the swimming pool robot absorbing water to cause itself to sink to the bottom of the pool followed by subsequent drainage

to cause itself to float towards the surfaces of the pool. (EX1001, 1:27-33). The inventors of the '196 Patent sought to solve this problem through an improved buoyancy mechanism that moved away from a water-intake/discharge method in favor of a gas-intake/discharge method. (EX1001, 6:66-7:8).

27. As shown in Fig. 3 of the '196 Patent, reproduced below, the '196 Patent's pool robot includes a sinking and floating control unit 20:

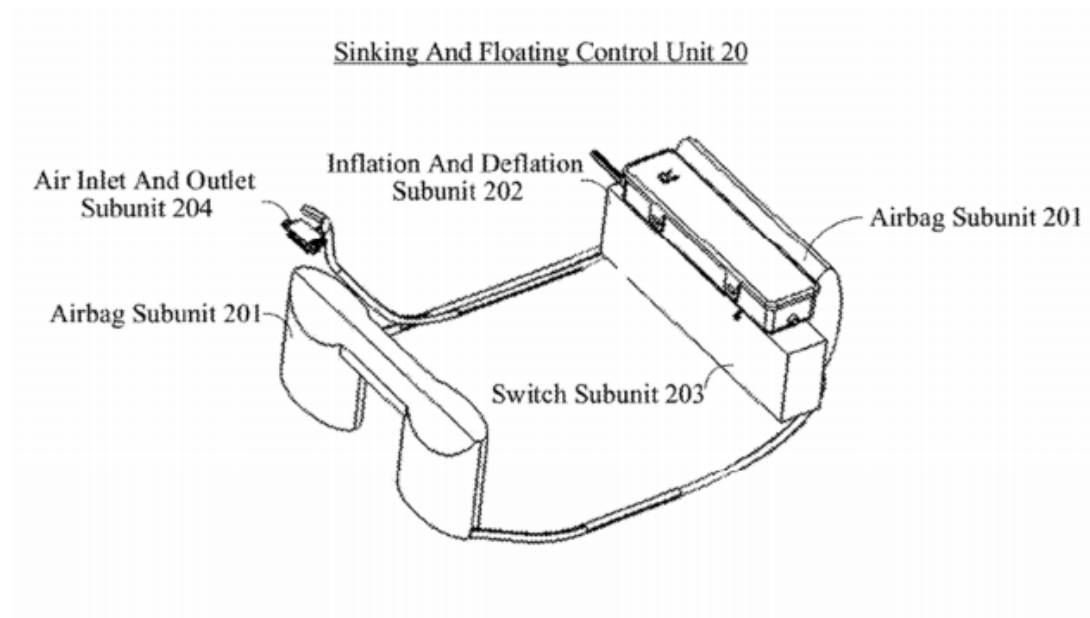


FIG. 3

EX1001, Fig. 3.

28. The sinking and floating control unit 20 includes components that cause the pool robot to transition between a plurality of states by selectively inflating and deflating airbag subunit 201 using air. (EX1001, 2:38-41 “the inflation and deflation subunit is controlled to start sucking air and the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state”, 3:10-13 “controlling the sinking and floating control unit to enter the sinking working state includes controlling the switch subunit to open and controlling

the inflation and deflation subunit to discharge air in the airbag subunit”). These plurality of states include a sinking working state, a floating working state, and a floating state.

29. In the sinking working state, the inflation and deflation subunit 202 is turned on to extract air from the airbag subunit 201, and the switch subunit 203 is turned on. (EX1001, 6:52-54). Air in the airbag subunit 201 is discharged through the inflation and deflation subunit 202, the switch subunit 203, and the air inlet and outlet subunit 204, “so that the volume of the airbag subunit 201 becomes smaller and the buoyancy of the swimming pool robot 1 is reduced to sink.” (EX1001, 6:52-59).

30. In the wall climbing state, the swimming pool robot has transitioned from cleaning the bottom of the pool to climbing along a side wall or slope toward the waterline. The robot’s posture changes “from a state parallel to the bottom surface of the swimming pool to a state parallel to the side wall of the swimming pool.” (EX1001, 9:38-40). As the robot climbs, the waterline detection unit 30 monitors the robot’s position relative to the waterline using the proximity waterline detection subunit 302 (which detects whether the robot is within a predetermined distance, such as 10-20 cm, from the waterline) and the outlet water detection subunit 301 (which detects whether at least a part of the robot has emerged from the water). (EX1001, 8:29-54).

31. In the floating working state, the inflation and deflation subunit 202 is turned on to suck air from outside, and the switch subunit 203 is turned on. (EX1001, 6:10-13, 6:40-43). Air from above the water level line enters the airbag subunit 201 through the air inlet and outlet subunit 204, the switch subunit 203, and the inflation and deflation subunit 202, “so that a volume of the airbag subunit 201 becomes larger and a buoyancy of the swimming pool robot 1 is increased to float.” (EX1001, 6:40-48).

32. In the floating state, the inflation and deflation subunit 202 and the switch subunit 203 are turned off. With both subunits closed, “the airbag subunit 201 is disconnected from the outside atmosphere, and the swimming pool robot 1 remains floating.” (EX1001, 6:48-52).

33. To transition between the states described above, the '196 Patent discloses a coordinated sequence of sensor-based triggers and control logic that govern transitions between states:

34. To transition from bottom cleaning to wall climbing, the robot includes a posture detection unit 40, which may be “configured by an inertial sensor,” that detects the posture of the swimming pool robot. (EX1001, 9:31-32). The main control unit 10 controls the waterline detection unit 30 to start detecting the positional relationship between the robot and the waterline “when posture detection results of the posture detection unit 40 meet a first predetermined condition (for example, changing from a state parallel to the bottom surface of the swimming pool to a state parallel to the side wall of the swimming pool).” (EX1001, 9:31-38). This posture change indicates the robot has transitioned from floor cleaning to wall climbing.

35. To transition from wall climbing to the floating working state, the waterline detection unit 30 monitors the robot's position relative to the waterline as the robot crawls along the side wall toward the water surface. (EX1001, 8:29-37). The waterline detection unit 30 includes two subunits: proximity waterline detection subunit 302 and outlet water detection subunit 301. (EX1001, 8:33-35). Proximity waterline detection subunit 302 is configured to detect whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline (for example, 10 cm to 20 cm). (EX1001, 8:40-44). This subunit “may be configured by an ultrasonic ranging device.” (EX1001, 8:45-47). Outlet water detection subunit 301 is configured to detect whether at least a part of the swimming pool

robot has come out of water. (EX1001, 8:35-37). This subunit “is configured by a capacitive sensor” or “an ultrasonic ranging device.” (EX1001, 8:38-40).

36. To transition from the floating working state to the floating state, the '196 Patent discloses one or more conditions that may cause the sinking and floating control unit to stop working and enter the stable floating state. These conditions are as follows:

37. Sensor-Based Shutoff: “[I]n response to the outlet water detection subunit 301 detecting that at least a part of the swimming pool robot 1 enters underwater again, the inflation and deflation subunit 202 and the switch subunit 203 are controlled to be closed.” (EX1001, 9:5-8).

38. Posture-Based Shutoff: “[I]n response to the posture detection unit 40 detecting that the posture of the swimming pool robot 1 meets a second predetermined condition (for example, changing from a state parallel to the side wall of the swimming pool to a state parallel to the bottom surface of the swimming pool), the inflation and deflation subunit 202 and the switch subunit 203 are controlled to be closed.” (EX1001, 9:41-47).

39. Timer-Based Shutoff: “[I]n response to ... the outlet water detection subunit 301 ... not detect[ing] that at least a part of the swimming pool robot 1 enters underwater again after the sinking and floating control unit 20 enters the floating working state for a predetermined time (for example, 40 seconds), the inflation and deflation subunit 202 and the switch subunit 203 are controlled to be closed.” (EX1001, 9:11-18).

B. Prosecution History and the Examiner’s Reasons for Allowance

40. During the prosecution of the '196 Patent, the Examiner allowed the filed claims with an express statement of reason for allowance over the cited prior art references (EX1002, p. 157):

The sinking and floating swimming pool robot and method are not shown or suggested in the prior art because of the use of a robot and method which include a sinking and floating control unit that is controlled to stop working after said unit enters a floating working state for a predetermined time.

41. As prior art references, the Examiner considered Korenfeld (US 11,124,982, “Pool Cleaner with Drive Motor Navigation Capabilities”), Tryber (US 11,274,462, “Controlling a Movement of a Pool Cleaning Robot”), and Henkin (US 5,985,156, “Automatic swimming pool cleaning system”).

C. Challenged Claims

42. Challenged claims 1-19 are recited in the table below:

Claim	Claim Language
1	[1pre] A controllable sinking and floating swimming pool robot, comprising: [1a] a sinking and floating control unit configured to control a swimming pool robot to float and sink; [1b] a waterline detection unit configured to detect a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located; and [1c] a main control unit configured to control a working state of the sinking and floating control unit, [1d] wherein the main control unit is capable of controlling the swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope; [1e] controlling the waterline detection unit to detect the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located; and [1f] controlling the sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot, [1g] wherein the sinking and floating control unit is controlled to stop working after the sinking and floating control unit enters the floating working state for a predetermined time.
2	[2a] The controllable sinking and floating swimming pool robot according to claim 1, further comprising a posture detection unit configured to detect a posture of the swimming pool robot, [2b] wherein the main control unit controls the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition.

Claim	Claim Language
3	The controllable sinking and floating swimming pool robot according to claim 1, wherein the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information, power information or swimming pool bottom environment information.
4	The controllable sinking and floating swimming pool robot according to claim 1, further comprising a distance measurement unit or a map storage unit, wherein the main control unit controls the swimming pool robot to find the nearest side wall or the nearest slope based on distance measurement results of the distance measurement unit or map data in the map storage unit.
5	The controllable sinking and floating swimming pool robot according to claim 1, wherein the waterline detection unit comprises an outlet water detection subunit configured to detect whether at least a part of the swimming pool robot has come out of water.
6	The controllable sinking and floating swimming pool robot according to claim 1, wherein the waterline detection unit further comprises a proximity waterline detection subunit configured to detect whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline.
7	[7a] The controllable sinking and floating swimming pool robot according to claim 5, wherein the sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit, [7b] wherein in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the inflation and deflation subunit is controlled to start sucking air and the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state.

Claim	Claim Language
8	[8a] The controllable sinking and floating swimming pool robot according to claim 5, wherein the sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit, [8b] wherein in response to the proximity waterline detection subunit detecting that the swimming pool robot has crawled to the distance less than or equal to the predetermined distance from the waterline, the inflation and deflation subunit is controlled to start sucking air, [8c] and in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state.
9	[9a] The controllable sinking and floating swimming pool robot according to claim 7, wherein the sinking and floating control unit further comprises an airbag subunit connected to the inflation and deflation subunit, wherein the airbag subunit is connected to or disconnected from outside atmosphere through the inflation and deflation subunit and the switch subunit, [9b] and wherein the sinking and floating control unit further comprises an air inlet and outlet subunit, wherein the switch subunit is connected to the outside atmosphere through the air inlet and outlet subunit.
10	The controllable sinking and floating swimming pool robot according to claim 1, wherein the main control unit is further capable of controlling the sinking and floating control unit to enter a sinking working state based on the operational requirement information of the swimming pool robot to realize a sinking of the swimming pool robot.
11	The controllable sinking and floating swimming pool robot according to claim 10, wherein the sinking and floating control unit comprises an inflation and deflation subunit, a switch subunit and an airbag subunit connected to the inflation and deflation subunit, controlling the sinking and floating control unit to enter the sinking working state comprises controlling the switch subunit to open and controlling the inflation and deflation subunit to discharge air in the airbag subunit.
12	[12a] The controllable sinking and floating swimming pool robot according to claim 7, wherein the inflation and deflation subunit comprises an air pump assembly, [12b] and the switch subunit comprises an electromagnetic valve assembly or a two-position three-way valve assembly.

Claim	Claim Language
13	The controllable sinking and floating swimming pool robot according to claim 7, wherein in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot enters underwater again and/or the posture detection unit detecting that the posture of the swimming pool robot meets a second predetermined condition, the inflation and deflation subunit and the switch subunit are controlled to be closed.
14	[14a] The controllable sinking and floating swimming pool robot according to claim 7, further comprising a water pump unit configured to pump liquid in the swimming pool where the swimming pool robot is located and discharge the liquid to drive the swimming pool robot, [14b] wherein a power of the water pump unit is changed after the sinking and floating control unit enters the floating working state or after the swimming pool robot climbs the side wall or the slope.
15	[15pre] A sinking and floating control method for a swimming pool robot, comprising: [15a] controlling a swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot, and enabling the swimming pool robot to crawl along the side wall or the slope; [15b] detecting a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located; [15c] controlling a sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot; and [15d] controlling the sinking and floating control unit to stop working after the sinking and floating control unit enters the floating working state for a predetermined time.
16	The sinking and floating control method for the swimming pool robot according to claim 15, wherein detecting the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located comprises: starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition.

Claim	Claim Language
17	The sinking and floating control method for the swimming pool robot according to claim 16, wherein the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information, power information or swimming pool bottom environment information.
18	The sinking and floating control method for the swimming pool robot according to claim 17, wherein controlling the sinking and floating control unit to enter the floating working state based on detection results to realize the floating of the swimming pool robot comprises: controlling the sinking and floating control unit to enter the floating working state in response to detecting that at least a part of the swimming pool robot has come out of water.
19	The sinking and floating control method for the swimming pool robot according to claim 17, further comprising: controlling the sinking and floating control unit to stop working in response to detecting that at least a part of the swimming pool robot enters underwater again and/or detecting that the posture of the swimming pool robot meets a second predetermined condition.

IX. OVERVIEW OF PRIOR ART IDENTIFIED BY PETITIONER

43. Petitioner's grounds rely on five references: U.S. Patent Application Publication No. 2025/0146315 ("Wang") (EX1005), U.S. Patent No. 11,946,282 ("Zhang") (EX1009), Chinese Patent No. 117738506 ("Guo") (EX1010), U.S. Patent No. 11,803,193 ("Zhao") (EX1012), and International Publication No. WO 2007/106730 ("Owen") (EX1013). Petitioner's grounds are summarized in the table below.

Ground	Claims Challenged	35 U.S.C. §	Reference(s)/Basis
1	1-7, 9-11, 13-19	103	Obviousness over Wang in view of Zhao and Owen
2	8, 12		Obviousness over Wang in view of Zhao, Owen, and Guo
3	1-6, 10, 14-17		Obviousness over Zhang in view of Zhao and Owen
4	1-8, 10-13, 15-19		Obviousness over Guo in view of Zhao and Owen
5	1-14	112(b)	Indefinite
6	4		Indefinite

44. A brief discussion of each prior art reference is provided in the following sections.

A. U.S. Pub. 2025/0146315 (“Wang”)

45. U.S. Patent Publication 2025/0146315 (“Wang”) titled “Cleaning Device” was filed on January 18, 2025, as a continuation-in-part of application No. PCT/CN2024/076040, filed on Feb. 5, 2024. (Wang, Face). As such, I understand Wang to be prior art to the ’196 Patent.

46. Wang is generally directed to a swimming pool cleaning device capable of switching between underwater and water surface cleaning modes (EX1005, Abstract). The cleaning device includes a mode switching member 510 that enables the device to transition between different operational states by adjusting forces applied in the vertical direction, including buoyancy adjustment (EX1005, ¶67). As shown in Fig. 6, reproduced below, Wang’s cleaning device includes a buoyancy adjustment assembly 511:

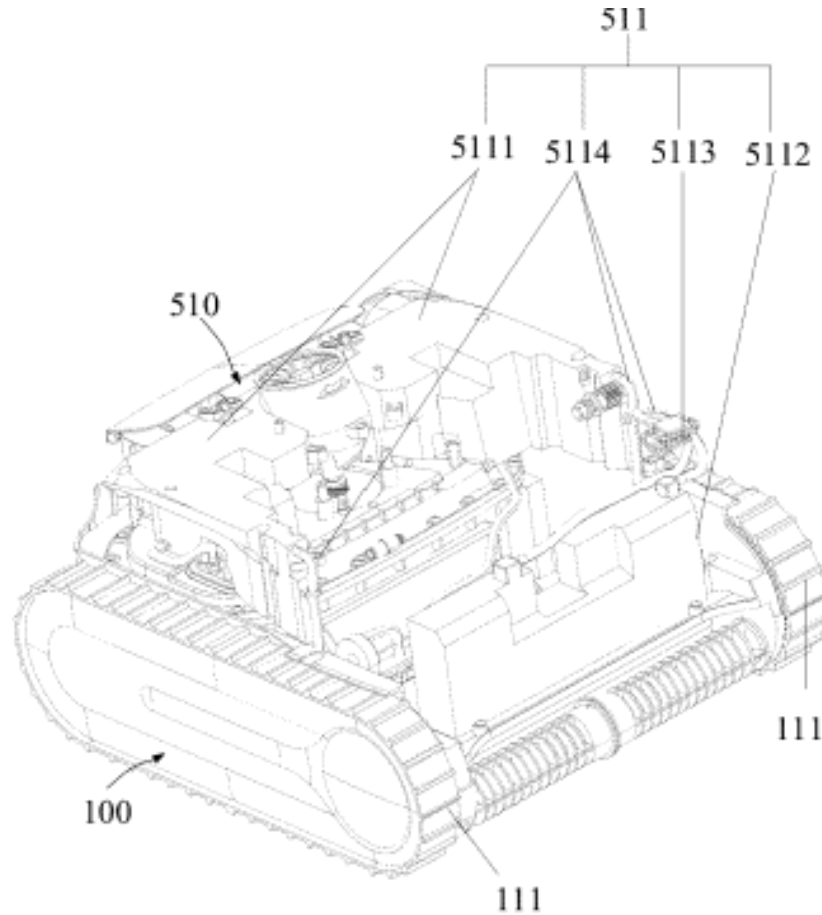


FIG. 6

EX1005, Fig. 6.

47. The buoyancy adjustment assembly includes a buoyancy cavity 5111, buoyancy cavity pump 5112, air inlet 5113, and connection duct 5114 (EX1005, ¶¶98-101). The buoyancy adjustment assembly is used by the cleaning device to transition between a plurality of motion states by selectively inflating and deflating the buoyancy cavity using gas (EX1005, ¶¶109-110). These motion states include a first motion state, a second motion state, and a third motion state. These three distinct motion states correspond to when the cleaning device is located at the bottom, side walls, and surface of a swimming pool respectively (EX1005, ¶0005). Wang defines these motion states as follows (EX1005, ¶0068):

*[A] **first motion state** is defined as a state in which the cleaning device 10 **moves on the bottom wall** 401, or an angle between the bottom wall 401 and an overall direction of the cleaning device 10 is less than 90° and the cleaning device 10 is away from the liquid surface 30...*

*A **second motion state** is defined as a state in which the cleaning device 10 **moves on the side wall** 402, or the overall direction of the cleaning device 10 is substantially parallel to the side wall 402...*

*A **third motion state** is defined as a state in which the cleaning device 10 **moves on the liquid surface** 30, or the cleaning device 10 is at least partially exposed at the liquid surface 30, or the cleaning device 10 is entirely located under the liquid surface 30 and close to the liquid surface 30...*

48. The motion states described above each require the cleaning device of Wang to maintain a different degree of buoyancy (i.e., net buoyant force). Wang discloses that to operate in the first motion state (at the bottom of a pool), the device must remain below neutral buoyancy (EX1005, ¶0120); then, to operate in the second motion state (clinging to the pool walls), the device must remain neutrally buoyant (EX1005, ¶0122); finally, to operate in the third motion state (at the surface of the water), the device must remain above neutral buoyancy (EX1005, ¶0122).

49. To switch between these three motion states, Wang discloses multiple embodiments wherein the cleaning device's buoyancy is adjusted via a "buoyancy adjustment assembly 511" comprising a "buoyancy cavity 5111" that is "configured to accommodate liquid and/or gas" such that the volume of liquid or gas in the cavity can be adjusted to modify the buoyancy of the cleaning device (EX1005, ¶0099). For an embodiment that "adjusts the buoyancy force by using gas," Wang describes that each motion state is associated with a different volume of gas in the buoyancy cavity 5111 (EX1005, ¶0122):

When the buoyancy cavity 5111 adjusts the buoyancy force by using gas, the volume of the gas in the buoyancy cavity 5111 is set to be a gas volume threshold, so that a balanced force is applied to the cleaning device 10 in the vertical direction. In this way, when the cleaning device 10 cleans the wall of the pool, the cleaning device 10 can be attached to the wall of the pool in the vertical direction and better clean the wall of the pool. When the cleaning device 10 is in the third motion state, there is a first volume of the gas in the buoyancy cavity 5111. When the cleaning device 10 is in the first motion state, there is a second volume of the gas in the buoyancy cavity 5111. The gas volume threshold is a value between the second gas volume and the first gas volume.

50. The table below provides a summary of the three motion states and three associated gas volumes:

Motion State	Location of Device	Gas Volume
First motion state	Bottom of pool	Second volume (below threshold)
Second motion state	Side walls of pool	Gas volume threshold
Third motion state	Surface of pool	First volume (above threshold)

51. Wang further discloses a first sensor that measures the device's vertical position ("or referred to as depth") that "may be, but is not limited to, a pressure sensor, an ultrasonic sensor, or an optical sensor" (EX1005, ¶0113). Based on the measurements captured by the first sensor, a processor 52 which "may be a micro-controller, an embedded processor..., an application-specific integrated circuit (ASIC), or the like" may adjust the volume of gas in the buoyancy cavity (EX1005, ¶0114). In this way, Wang discloses a controller that adjusts the volume of gas in the buoyancy cavity to achieve a desired depth. Wang further discloses a second sensor, which "may be an ultrasonic sensor," capable of detecting if the air inlet of the buoyancy cavity is exposed to air (EX1005, ¶0115), which is also used by the processor 52 to adjust the volume of gas in the buoyancy cavity (EX1005, ¶0117).

52. In addition to the first and second sensors, Wang discloses multiple sensors capable of detecting if the cleaning device is trapped, e.g., tangled by water plants at the bottom of the water (EX1005, ¶0232). Accordingly, Wang discloses the following sensors capable of sensing if the cleaning device is trapped: a gyroscope sensor capable of measuring the orientation of the device, an accelerometer capable of measuring the device's acceleration (which the processor uses to calculate position), a Time of Flight sensor capable of measuring changes in the cleaning device's position over time, and a sensor to monitor the drive motor current (EX1005, ¶¶[0256]-[0261]). Based on a combination of or individual sensors, the processor may determine if device is trapped (EX1005, ¶0262).

B. U.S. Pat. 11,946,282 (“Zhang”)

53. U.S. Patent No. 11,946,282 (“Zhang”) titled “Moving Devices Used in Liquid and Pool Cleaning Robots” was filed on July 17, 2023. (EX1009, Face). As such, I understand Zhang to be prior art to the '196 Patent.

54. Zhang is directed to a device for cleaning a swimming pool, including a buoyancy adjustment mechanism that enables the device to switch between underwater and water surface operation. (EX1009, Abstract). The moving device includes a body with a buoyancy cavity that can accommodate liquid and/or gas, and a buoyancy force adjustment member such as a pump that adjusts the volume of gas in the buoyancy cavity to control the device's buoyancy. (EX1009, 4:61-6:24). Zhang discloses that “a volume of the buoyancy cavity 1111 may be preset” and that the buoyancy cavity “may be made of a flexible material and/or a rigid material.” (EX1009, 5:8-10).

55. Unlike Wang, which discloses three distinct operational states, Zhang's moving device is configured to operate in two distinct states (referred to as “modes”): a first mode

wherein the moving device is “above the liquid surface” and a second mode wherein the cleaning device is “below the liquid surface.” (EX1009, 4:24-27). When the moving device is in the first of these modes, “at least a portion of the moving device 100 is above the liquid surface 200.” (EX1009, 4:34-35). In the second of these modes, “all of the moving device 100 is submerged below the liquid surface 200.” (EX1009, 4:32-33). To switch between these modes, Zhang’s moving device comprises “a mode switching member configured to achieve a position switching” that includes a “buoyancy force adjustment assembly configured to adjust a magnitude of the buoyancy force to which the moving device is subjected in the vertical direction.” (EX1009, Claim 1).

56. Zhang’s control system includes one or more sensors, comprising a first sensor “configured to determine the position of the moving device 100 in real time” and a second sensor “configured to detect in real time whether the air inlet of the buoyancy cavity 1111 is positioned in air.” (EX1009, 7:35-37, 8:15-18). The first sensor of Zhang’s moving device “may include, but is not limited to, a pressure sensor, an ultrasonic sensor, an optical sensor, etc.,” while the second sensor of the moving device “may include an ultrasonic sensor.” (EX1009, 7:42-44, 8:16). Zhang’s moving device further comprises a processor that “may be a microcontroller, an embedded processor, or an application specific integrated circuit (ASIC), etc.” (EX1009, 7:46-48). Zhang’s processor obtains detection results of whether or not the air inlet is located in the air, and when the air inlet is exposed to air, the buoyancy force adjustment member is controlled to increase the gas volume to switch the device from below the liquid surface to above the liquid surface (EX1009, 7:34-44, 8:13-36). Thus, Zhang discloses a processor-based controller for managing transitions between two distinct modes.

C. U.S. Pat. 11,803,193 (“Zhao”)

57. U.S. Patent No. 11,803,193 (“Zhao”) titled “Pool Cleaning Robot Automatic Docking” was filed on January 3, 2023. (EX1012, Face). As such, I understand Zhao to be prior art to the ’196 Patent.

58. Zhao is directed to an automatic docking method for pool cleaning robots that enables the robot to autonomously navigate to the nearest pool wall, climb to the water surface, and maintain dynamic balance at the waterline for user retrieval. (EX1012, Abstract). The alleged invention addresses the problem of user inconvenience: traditional pool robots are heavy and require manual pulling or use of cables or hooks to retrieve, which can damage the robot. (EX1012, 1:24-35). Zhao’s robot uses ultrasonic sensors positioned on the front, rear, left, and right sides to measure distances to pool walls, and a gyroscope to detect posture changes. (EX1012, 4:6-17, 5:3-14). Zhao’s robot comprises a controller that “can be, for example, a central processing unit (CPU), or a micro processor.” (EX1012, 3:42-44). This controller is “electrically coupled” to the gyroscope and ultrasonic sensors and is used to execute Zhao’s automatic docking method. (EX1012, 1:62-65, 1:66-2:5).

59. Upon receiving a docking instruction, the robot determines the closest wall, navigates to it, climbs the wall, and maintains dynamic balance at the water level. (EX1012, 4:62-5:2). If the user does not retrieve the robot within a “predetermined time period,” the robot “retreats to underwater” to continue cleaning (EX1012, 8:24-42). Further, while Zhao’s automatic docking method comprises multiple operational modes related to navigation and cleaning (e.g., a “wall climbing mode” and a “pool bottom turn mode”), Zhao does not disclose adjusting the buoyancy of a cleaning robot to switch between these modes. (EX1012, 6:25, 7:13).

D. Chinese Pat. CN117738506 (“Guo”)

60. Chinese Patent No. CN117738506 (“Guo”) titled “Swimming Pool Cleaning Robot” was filed on January 23, 2024. (EX1010, Face). As such, I understand Guo to be prior art to the ’196 Patent.

61. Guo is directed to a swimming pool cleaning robot with a floating and diving assembly that enables the robot to transition between underwater and surface operation (EX1010, Abstract). Unlike Wang and Zhang, which draw air from the external atmosphere through an air inlet, Guo discloses a sealed internal gas circulation system in which “the driving cabin 131 [of the swimming pool cleaning robot 100] serves as the gas source for the airbag 122 [of floating and diving assembly 120]” (EX1010, ¶56). When the robot needs to surface, the inflation/deflation device draws gas from the sealed driving cabin into the airbag; when the robot needs to dive, the inflation/deflation device discharges gas from the airbag back into the driving cabin. (EX1010, ¶34 and ¶48). This fixed-mass system means there is a maximum possible gas volume that is transferred between compartments within the robot. This gas circulation configuration leverages the pool cleaning robot’s fixed cabin volume to store compressed gas thereby “allowing for better control of the overall volume of the swimming pool cleaning robot 100, making its body more compact and its movement in water more agile, while also reducing costs.” (EX1010, ¶56).

62. Guo further discloses a pool cleaning robot comprising multiple airbags and inflation/deflation devices wherein the inflation/deflation of each airbag can be controlled individually to enable “more precise control of the gas content in each airbag 121, and thus more precise control of the ascent or descent speed of the underwater cleaning robot.” (EX1010, ¶39).

Guo's pool cleaning robot further comprises a "mainboard" (i.e., a printed circuit board). (EX1010, ¶52).

E. Int'l Pub. WO 2007/106730 ("Owen")

63. International Patent Publication No. WO 2007/106730 ("Owen") titled "Pump for Inflatable Objects with Automatic Shutoff Timing Mechanisms" was filed on March 9, 2007. (EX1013, Face). As such, I understand Owen to be prior art to the '196 Patent.

64. Owen is directed to a pump for inflating household inflatable objects, particularly an air mattress. (EX1013, 1:11-17). Owen addresses the problem that prior art pumps require user attention during inflation (EX1013, 1:17-19):

Until now, however, these pumps generally require the user to hold an inflate or deflate button until the respective inflation or deflation has completed.

65. Owen's solution is a timer-based automatic shutoff that allows a user to start a furniture inflation process without requiring the user to remain with the pump as the furniture inflates (EX1013, 2:1-2):

The pump includes a timer that operates the pump after activation for a set period of time before automatically shutting off the pump.

66. Owen also discloses that "a pressure sensor (not shown) can be supplied that shuts the pump off automatically once a certain PSI (pounds per square inch) level is reached," and that both the timer and pressure sensor may operate together as a "failsafe mechanism." (EX1013, 4:11-31).

67. Further, Owen discloses a "setting selector knob" that allows a user to specify the desired "firmness level" (i.e., air pressure) of an inflatable object wherein the "the pressure sensor will shut off the motor once the desired pressure, corresponding to the chosen setting 34,

is reached.” (EX1013, 6:1-10). To achieve the desired automatic shutoff behavior, Owen’s pump for inflatable household objects comprises a controller in “electrical communication” with a timer, a pressure sensor, and the motor of the pump. (EX1013, 9:19-25).

X. RESPONSE TO PETITIONER’S INVALIDITY GROUNDS

A. Lack of motivation to combine references

1. All Grounds: Owen is from a disparate field of invention than the ’196 Patent

68. With regards to Ground 1-4, Petitioner seeks to combine Owen with Wang, Zhang, Zhao, and/or Guo.

69. As described in the prior art summary section above, Owen discloses that instead of requiring a user to “hold an inflate or deflate button” for an inflatable support system such as an inflatable mattress, its invention can automatically shut off the pump “after a set period of time once it is activated.” (EX1013, 1:17-23, 4:7-10). Such a control scheme can be categorized as open-loop control.

70. Open-loop control is often used when the use of a sensor has been deemed unnecessary, insufficient, or infeasible. For example, a shutoff timer for a toaster is an example of open-loop control because the shutoff transition is not based on any measurement or sensing of the toast or toaster; instead, the timer is initialized based on user input.

71. Closed-loop control, in contrast, is often used when there is need for feedback from a sensor to account for a dynamic environment. For example, a thermostat with ON-OFF control of a heating element exercises closed-loop control. In this example system, the thermostat constantly measures the temperature of the environment through sensors. If the sensed temperature falls below a specified threshold, the controller can transition the heater from

OFF to ON. If the sensed temperature rises above a specified threshold, the controller can transition the heater from ON to OFF. In this way, the controller is able to react to the dynamics of heat transfer into and out of its environment.

72. A POSITA would recognize that an autonomous pool robot encounters a more dynamic and uncertain environment than an inflatable mattress. The inflatable mattress of Owen remains stationary, both horizontally and vertically; does not need to accommodate a dynamic environment; and does not have to perform any navigation or cleaning tasks. As a result, Owen discloses an embodiment that does not require a sensor that measures volume or pressure, and it does not disclose requiring multiple types of sensors. A predetermined timer for shutting off the pump would not account for user or environmental interference during the inflation or deflation process.

73. On the contrary, a POSITA would recognize that an autonomous pool robot described in the '196 Patent is tasked with performing navigational tasks in a more complex environment, both horizontally across the bottom or surface of the pool, or vertically with respect to the walls of the pool. An autonomous pool robot must react to information sensed from a variety of sensors that indicate its horizontal and vertical position. These sensors include information with respect to depth below the waterline and/or whether certain parts of the robot are clear of the waterline, and potentially sensors that indicate posture or inclination. The autonomous pool robot must also make decisions on how to control different actuators. These actuators include drive or propulsion systems that allow the robot to move along a surface as well as buoyancy-control systems. In Owen, the initiation of the inflation or deflation of Owen's inflatable mattress is always initiated by the user, whereas an autonomous pool robot must automatically sense and react to a dynamic environment.

74. As part of the motivation analysis, I considered whether Owen, which pertains to an inflatable mattress pump with an automatic shutoff timer, is analogous art to the '196 Patent or the other asserted prior art. In my opinion it is not. The '196 Patent's field of invention is pool-based, autonomous cleaning robots, whereas Owen's field of invention is interior land-based, user-operated inflatable objects. A POSITA designing a control system that involves control of an autonomous pool robot would not look to Owen.

2. All Grounds: Lack of specificity in how to integrate software disclosed in prior art references

75. With regards to Ground 1-4, Petitioner seeks to combine the control systems of the identified prior art using generic language such as “integrate,” “incorporate,” and “substitution.” For example (Petition at 19-20):

*A POSITA implementing Zhao's system would find it obvious and advantageous to **incorporate Wang's three-state motion control** (bottom cleaning, wall cleaning, surface cleaning) to achieve complete cleaning coverage. EX1003, ¶263. Conversely, a POSITA implementing Wang's design would naturally **adopt Zhao's ultrasonic wall-finding logic** to automate the initiation of wall climbing. Id. Both combinations produce predictable benefits—greater autonomy, stability, and cleaning efficiency. Id.*

*A POSITA would also have been motivated to **combine Zhao's posture-based triggering with Wang's waterline-detection and buoyancy-control mechanisms** since both address the same control problem—automated, sensor-driven coordination between posture change detection and buoyancy adjustment. EX1003, ¶322. Combining these systems would yield a more efficient, fully automated control process: upon detecting a change to a vertical posture, the controller activates waterline monitoring and initiates buoyancy adjustment, seamlessly transitioning the robot from bottom cleaning to wall climbing and then to surface cleaning. Id.*

76. Petitioner and Dr. Cowan do not explain *how* different software features will be integrated. The behavior of a control system is highly dependent on the implemented logic, including how inputs and internal variables are used and their relationship to one another. For example, the choice of whether to use the “AND” versus the “OR” operator in a control decision, whether and which actions are performed concurrently vs sequentially, or how states are defined and what transitions are allowed between them can all greatly impact and define system behavior.

77. Because there are many ways to integrate software elements, a POSITA would require additional implementation details, for instance, to incorporate a “three-state motion control” into a control scheme that originally only had one state or even two states. For context, state machines are computational models within a control system that describe distinct internal operational states or modes. State machines require the definition of specific criteria and events that cause the transition from one particular state to another; otherwise, no transition is allowed between those two particular states. Adding additional states to the state machine or modifying the conditions required to transition between states can result in substantial changes to the system’s behavior and functionality. The impact of such a modification must be clarified with respect to existing states, existing state transitions, new states, and new state transitions. The program must additionally define separately for each state what calculations and control actions to perform for the full set of possible inputs. As such, a POSITA would need to carefully consider the impact of modifying a system’s state machine prior to making such a modification, which Petitioner and Dr. Cowan have not detailed.

78. Many of Petitioner’s combinations rely on the implementation of timers. However, a POSITA would require additional implementation details, for instance, to

incorporate timers into a control scheme that originally did not have timers. Petitioner cites a textbook chapter on timers to explain that “timer-based control of pumps and motors was standard practice in industrial automation.” (Petition at 35). That textbook chapter shows three different types of timer triggers (on-delay, off-delay, and pulse), different ways to link timers to outputs (in parallel or in sequence, potentially using multiple cascading timers), and timers that retain their value when paused. As I will explain in Section X.B.1, the system behavior can vary depending on when Petitioner’s proposed predetermined shut-off timer is programmed to start counting. Introducing a timer into an existing control architecture is not a trivial substitution, especially if said timer is used to modify conditions or introduce new conditions for switching between operational states.

79. If a timer were to be introduced into the state machine logic of an existing control system, both the specific conditions in which the timer is initiated, stopped, and reset in addition to the state transitions that occur as a result of the timer reaching a given value must be considered. The modification of any one of these can result in substantial changes to a system’s behavior and functionality. For example, initiating a timer upon reaching a target depth may produce substantially different behavior than initiating the timer when initiating buoyancy adjustment. Accordingly, a POSITA would not simply add a timer to an existing buoyancy-control scheme without carefully evaluating how the timer interacts with the system’s existing states, transitions, and sensor-based control mechanisms, which Petitioner and Dr. Cowan also have not detailed.

80. In my experience with control systems, it is also common for state machines to include “fault” states such that the system transitions into a fault state upon detection of abnormal operating conditions or unintended system behavior. Fault states are included such that

a system can recover from a detected fault and return to nominal operation without incurring damage to the system or operating the system outside of acceptable operating conditions. For example, the detection of water in the air inlet of a pool cleaning robot may trigger a transition to a fault state wherein the air pump is configured to deactivate to avoid damaging the system. The system may not be able to “recover” or transition out of this state until a new criterion is met. Subsequently, modifying a control system by adding new operational states, timers, sensors, or transition conditions requires detailed consideration of both the system’s nominal operating states and how such modifications interact with fault detection and recovery logic. A change that appears straightforward when considering only nominal operation may require substantial revisions to the fault detection and recovery logic to ensure that the overall system continues to operate safely and reliably. For this reason, a POSITA would not simply add additional operational states, sensors, timers, or transition conditions to an existing control system without carefully evaluating the impact of such a modification on both the system’s nominal behavior and fault-recovery behavior, which Petitioner and Dr. Cowan have not analyzed.

81. The Petition and Dr. Cowan’s declaration do not address how the integration of additional operating states, sensors, or timers would be made. Instead, the Petition and Dr. Cowan point to disparate references and merely recite that a combination would be “obvious to integrate” or a “routine substitution” without explaining how the references would actually be combined. In my opinion, this lack of specificity is an independent deficiency in each of Grounds 1 through 4.

B. Ground 1: Wang in view of Zhao and Owen does not render claims 1-7, 9-11, and 13-19 obvious

82. As explained in Section X.A.1, a POSITA would not be motivated to combine Wang and/or Zhao with Owen. As explained in Section X.A.2, Dr. Cowan has not provided specificity in how to integrate the hardware and software of the different references. Further, it is my opinion that Wang in view of Zhao and Owen does not render Claims 1-7, 9-11, and 13-19 obvious for at least the reasons below.

1. No motivation to combine: Incorporating Owen's timer into Wang and/or Zhao would interfere with Wang and/or Zhao's control system, and there are alternate methods of achieving said motivation

83. Petitioner asserts that “integrating Owen’s timer circuit into Wang’s buoyancy-control framework would have been a routine substitution of known control methods, achieving the same predictable result—safe, consistent buoyancy, reduced cost and complexity, and protection against overinflation.” (Petition at 22).

84. As described in Section IX.A, Wang discloses a first sensor that measures the device’s vertical position (“or referred to as depth”) that “may be, but is not limited to, a pressure sensor, an ultrasonic sensor, or an optical sensor” (EX1005, ¶0113) and a second sensor capable of detecting if the air inlet of the buoyancy cavity is exposed to air. (EX1005, ¶0115). Based on the measurements captured by the sensors, the processor 52 adjusts the volume of gas in Wang’s buoyancy cavity to achieve a predetermined depth. (EX1005, ¶0114). Given that Wang’s processor adjusts the volume of gas in the buoyancy cavity (by actuating the pumps) based on a measured depth or sensed waterline, Wang discloses the use of a position-based controller. Meanwhile, Zhao leverages position-based control to adjust a pool cleaning robot’s horizontal distance from pool walls and dock at the waterline. Zhao discloses ultrasonic sensors and a

gyroscope that measure the pool cleaning robot's position, orientation, and distance from nearby pool walls, and a controller that uses these measurements to determine the closest pool wall, steer the robot toward that wall, and control wall-climbing behavior until the robot reaches the water level. (EX1012, 5:3-14, 6:16-60). Thus, like Wang, Zhao discloses a position-based control system that receives position measurements from sensors and adjusts the operation of the robot to achieve a desired position. Petitioner describes the combination of Wang and Zhao as providing a "unified, sensor-driven control architecture in which Zhao provides feedback for wall detection and Wang provides actuation for wall climbing" and addressing the problem of "automated, sensor-driven coordination." (Petition at 19-20).

85. However, Dr. Cowan does not provide sufficient specificity as to how a POSITA would incorporate Owen's shut-off timer into the control logic of Wang. Since Dr. Cowan uses the term "substitution" (EX1003, ¶286), he appears to suggest replacing a pump shut-off criterion based on input from sensors, as described by Wang and/or Zhao, with a shut-off criterion based on a predetermined time, as described by Owen, for the purpose of preventing overinflation. However, he does not specify when the timer should begin to count. I will analyze two scenarios that Dr. Cowan appears to suggest for when the countdown timer should start.

86. In one approach, Wang's inflation pump could be configured to deactivate at a predetermined time after the initiation of pumping. Dr. Cowan appears to suggest this by assuming a zero initial airbag volume in his simplified airbag model. As I will explain in Section X.B.2, Dr. Cowan's model relationship between airbag volume and time does not account for environmental and operational factors, including temperature and battery state of charge (and also depth if the initial airbag volume is zero). Without input from sensors, the cleaning device would not receive information on whether or not it has reached its target position (distance from

the waterline) or if it is close to an overinflated volume. The cleaning robot would risk not being able to reach the pool surface before the pumps shut off, or else overinflating the airbags.

Therefore, following this approach could result in several issues including overshoot or undershoot of the target depth, and greater power consumption or battery usage than without the delay timer. Petitioner and Dr. Cowan have not addressed these potential problems with the combination that would interfere with the control system.

87. In another approach, Dr. Cowan may be suggesting that Wang's inflation pump could be configured to deactivate at a predetermined time after a target depth threshold or a sensed waterline condition is achieved. As I will explain in Section X.B.2, Dr. Cowan's model assumption of an initial airbag volume of zero is inconsistent with an approach wherein the cleaning device begins to inflate only after reaching a target depth threshold or a sensed waterline condition is achieved. In addition, neither Wang nor Zhao discloses stopping pumps once a target depth threshold or sensed waterline condition is achieved. Zhao only discloses "maintaining dynamic balance at the water level." (EX1012, 6:25-30). If Petitioner argues that Wang and/or Zhao inherently disclose or render obvious stopping pumps once a target depth threshold or sensed waterline condition is achieved, Petitioner has not explained why a POSITA would consider a modification that would amount to delaying the pump shut-off by a predetermined time after the target depth or sensed waterline condition had already been reached. Delaying the pump shut-off appears to contradict the stated motivation of preventing airbag overinflation.

88. In my opinion, a POSITA would not be motivated to replace pump shut-off criteria based on input from sensors with a shut-off criteria based on a predetermined time for the purpose of preventing overinflation. A POSITA would recognize that introducing a timer-based

control strategy to Wang or Zhao's existing position-based controllers would offer little benefit at the risk of performance degradation. Since Wang already discloses depth and waterline sensors, a POSITA would find that commanding pumps to stop when a predetermined depth is reached or the airbag inlet is above the waterline is more likely to prevent airbag overinflation than commanding pumps to stop after a predetermined time.

89. Dr. Cowan asserts that "the motivation to adopt a timer-based cutoff would have been reinforced by the practical engineering goals of reducing cost, simplifying control logic, and preventing overpressure or motor wear." (EX1003, ¶286). I disagree that this modification would simplify control logic, since Wang is already using sensor-based control to control buoyancy. Dr. Cowan has not explained how such a modification would simplify control logic, or how adopting a timer-based cutoff would reduce cost.

90. Moreover, Dr. Cowan's assertion that "Wang identifies the operational goal—achieving a gas volume threshold sufficient for buoyancy—but does not specify a control mechanism for safely and consistently terminating inflation" is inconsistent with Wang's disclosure of a position-based controller. (EX1003, ¶285). As discussed above, Wang discloses a control strategy wherein a pool device's buoyancy is adjusted based on sensor measurements to achieve a desired depth or sensed waterline condition. A POSITA would recognize that Wang's disclosure of a control strategy wherein sensor measurements are used to control buoyancy adjustment already implements a mechanism for safely and consistently terminating inflation once a target depth is achieved without the aforementioned risk of performance degradation.

91. If a POSITA were concerned with airbag overinflation or excess battery consumption (EX1003, ¶464), there are many solutions that would not cause the deficiencies discussed above. For instance, airbag pressure can be monitored directly with a pressure sensor

and shut off the pump at a predetermined pressure threshold. Owen discloses such a pressure sensor. As another example, Petitioner acknowledges that Wang discloses a one-way inlet valve in one embodiment, which allows liquid to be pumped out of the buoyancy cavity when the inlet is submerged. (Petition at 33-34; EX1005, ¶0109). Petitioner also references a one-way valve disclosed by Guo that “open[s] to discharge gas from the airbag into the driving cabin.” (Petition at 103; EX1010 Guo, ¶0014). A POSITA would understand that a passive pressure-relief valve could be used to prevent overinflation by opening at a predetermined pressure threshold. To address excess battery consumption, the pump motor current could be monitored and the pump stopped after a predetermined threshold of calculated power consumption. Petitioner offers no reason why, among these alternatives, a POSITA would select a predetermined timer.

92. In my opinion a POSITA would not have combined Wang and/or Zhao with Owen for the reason of preventing overinflation or excess battery consumption.

2. Element [1g] and [15d]: No predetermined relationship between time and volume in Wang and/or Zhao

93. Limitation [1g] recites: “the sinking and floating control unit is controlled to stop working after the sinking and floating control unit enters the floating working state for a predetermined time.” Limitation [15d] recites: “controlling the sinking and floating control unit to stop working after the sinking and floating control unit enters the floating working state for a predetermined time.”

94. Regarding claim limitations [1g] and [15d], Petitioner states that the gas-volume threshold disclosed by Wang would be understood by a POSITA to “inherently corresponds to a predetermined-time inflation control to prevent overfilling or mechanical failure.” (Petition at 35-36). To support this, Dr. Cowan models the volume (V) of the airbag as a function of

volumetric flow rate (Q) and time (t) with the equation below (Petition at 21-22; EX1003, ¶¶271-274):

$$V \approx Q \times t$$

95. To implement this model, Dr. Cowan's MATLAB simulation assumes the following:

- The initial airbag volume is zero (0 L), reaches a pre-determined gas volume threshold of 1.75 L, and asymptotically grows toward a maximum volume of 2.75 L.
- Backpressure follows an exponential growth curve solely as a function of the current volume in the airbag, with assumed constants k , V_{scale} , and V_{slack} . Dr. Cowan appeared to model backpressure solely as a function of the instantaneous volume of the airbag, the airbag material, and the geometry of the airbag. I note that Dr. Cowan has not provided a pressure or volume limit at which he considers the airbag to be overinflated and prone to mechanical damage.
- Volumetric flow rate (Q) is inversely related to backpressure, with assumed constants $Q_{nominal}$ and P_{max} .

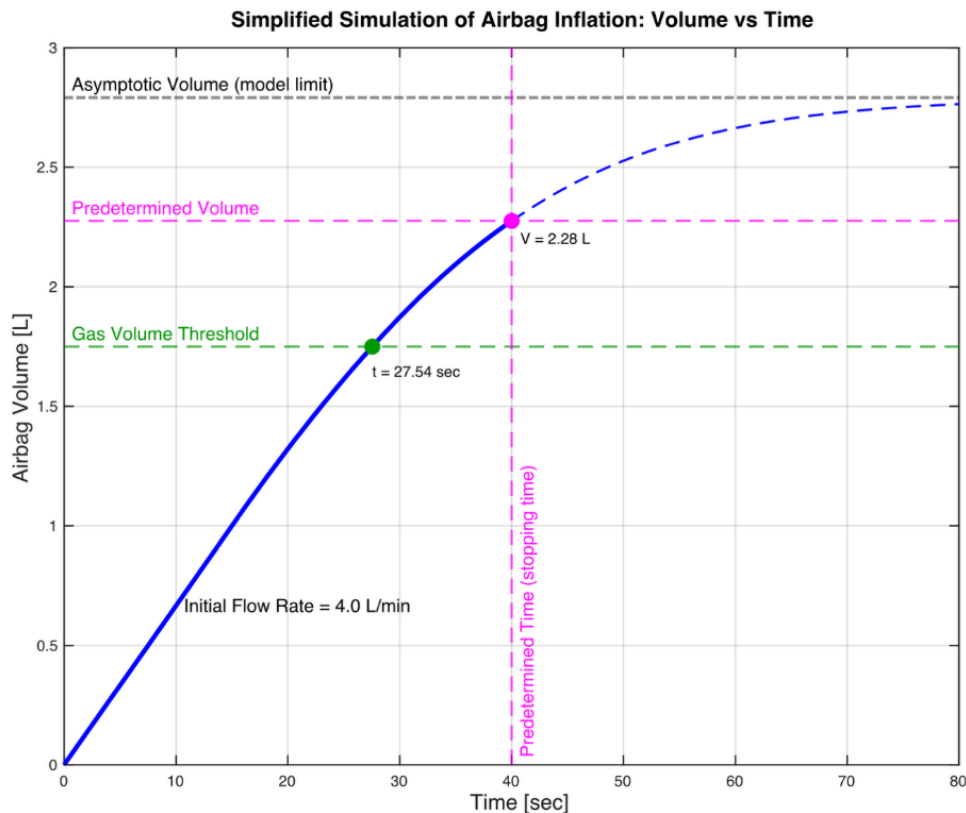


Fig. 1 of Exhibit 1021

96. Setting aside whether his chosen model constants are realistic, Dr. Cowan's chosen initial zero airbag volume is inconsistent with Wang's disclosures. First, a zero airbag volume would require that the airbag contains no air at all, which is difficult to achieve without specialized equipment. Second, Wang discloses that its buoyancy cavity 5111 inflates when near the pool surface, when its air inlet 5113 is above the liquid surface. (EX1005, ¶0114). This is consistent with a transition from the second motion state (cleaning device located on the side walls of the pool) to the third motion state (cleaning device located on the surface of the pool).

When the position of the cleaning device 10 meets a preset condition, the processor 52 may control the buoyancy adjustment part to increase the volume of the

buoyancy cavity 5111. The preset condition may be that the position of the cleaning device 10 is higher than a preset height. [...]

The processor 52 may determine that the air inlet 5113 of the cleaning device 10 is above the liquid surface 30, the processor 52 may control the buoyancy cavity pump 5112 to drain the liquid from the buoyancy cavity 5111, and air may enter the buoyancy cavity 5111 through the air inlet 5113, to increase the volume of the gas in the buoyancy cavity 5111

97. Therefore, when the cleaning device begins inflation, the buoyancy cavity should be at or near the gas volume threshold and not at zero volume. If the airbag is at zero volume, the cleaning device would sink to the bottom of the pool. Since Dr. Cowan assumes that the gas volume threshold is 1.75 L, then even according to his model the “predetermined time” between the start of inflation and his “predetermined volume” cannot be 40 seconds, but much closer to 12.5 seconds.

98. If Dr. Cowan is asserting that the cleaning device can transition directly from the first motion state (cleaning device located on the bottom of the pool) to the third motion state (cleaning device located on the surface of the pool), there are several challenges as well.

99. First, Dr. Cowan has not explained how the buoyancy adjustment assembly 511 would be able to intake air when the air inlet 5113 is at the bottom of the pool. If air inlet 5113 is not above the waterline, there could be intake of liquid instead of gas, which would not increase the buoyancy and potentially damage the equipment. Rather, Wang’s disclosure of a transition directly from the first motion state to the third motion state is associated with “when the buoyancy cavity 511 adjusts the buoyancy force by using liquid, the buoyancy cavity 5111 may be a rigid cavity having a confined space.” (EX1005, ¶0121).

100. Second, if the cleaning device begins at the bottom of the pool, then the time it takes for the cleaning device to surface would depend on the depth of the pool at the time of operation. At a fixed buoyancy, the surfacing time would increase as the depth of the pool increases. To model the surfacing time, Dr. Cowan would also have to adjust his current model to account for hydrostatic pressure. Hydrostatic pressure applied to the airbag increases as water depth increases, and therefore Dr. Cowan's assumption that backpressure only depends on current airbag volume no longer holds.

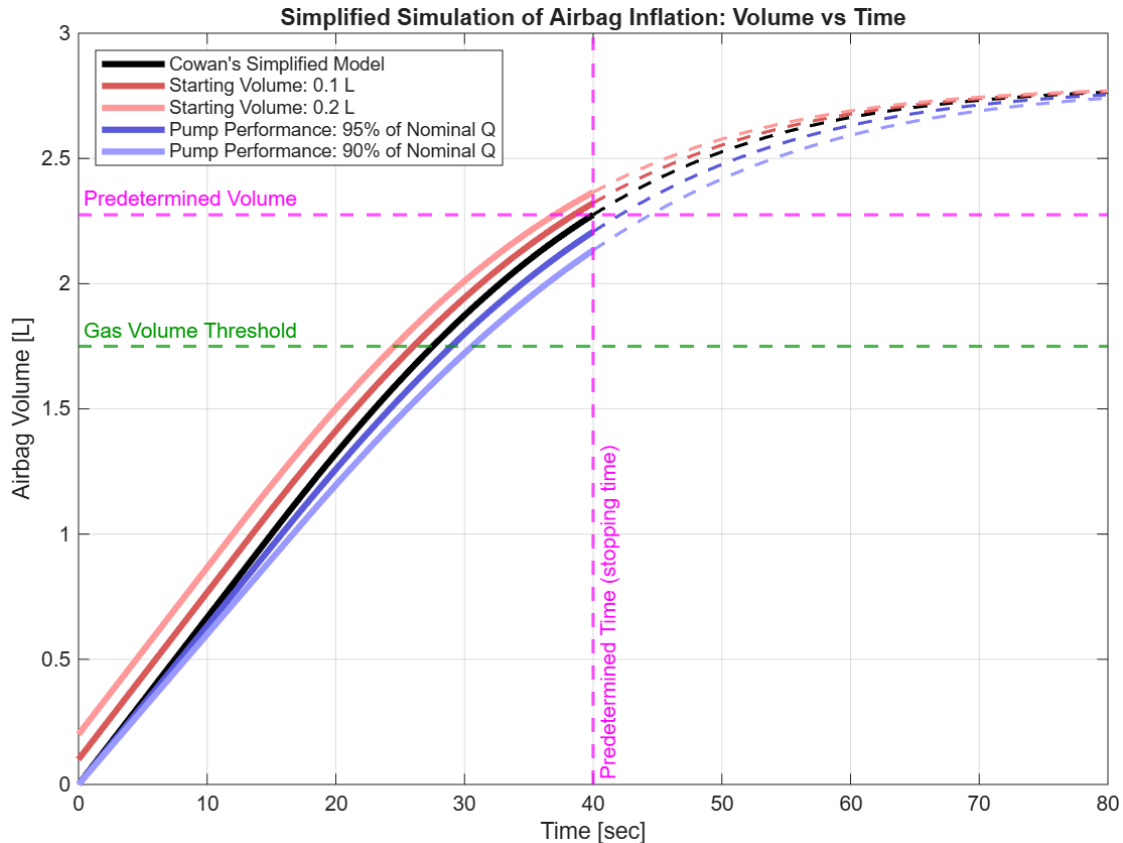
101. Aside from the aforementioned inconsistencies with Wang, Dr. Cowan's overly simplified model does not account for environmental factors that may alter the volume of the airbag across different inflation-deflation cycles. Dr. Cowan asserts that "All key parameters—pump flow rate, airbag compliance, desired buoyancy volume—are measurable and stable, allowing straightforward determination of a safe and effective inflation time" (EX1003, ¶288), but he has not considered the effects of many other disturbances in the environment that will cause the relationship between airbag volume and time to change.

102. For instance, after several cycles of inflation and deflation without explicit volume control, the initial airbag volume at the start of each cycle may vary due to leaks and equipment wear that adds up over time. For example, using Dr. Cowan's simplified airbag volume model and the parameters therein (EX 1021), if an airbag starts with an initial volume of 0.2 L (i.e., the airbag was not completely deflated at the onset of inflation) rather than zero L, the airbag will inflate to Dr. Cowan's 1.75 L "Gas Threshold Volume" approximately 3 seconds faster.

103. The volumetric flow rate Q may also drop below nominal Q throughout the life cycle of the cleaning device. The actual volumetric flow rate Q , which depends on the efficiency

of the pump, may be reduced by leaks that develop over time or due to dust or water in the pumping system, or lowered as the state of battery charge (for certain motor types) depletes. Considering a pump system with a volumetric flow rate derated to 90% of a pump's nominal volumetric flow rate Q and using Dr. Cowan's simplified airbag model and the parameters therein (EX 1021), the airbag will inflate to Dr. Cowan's 1.75 L "Gas Threshold Volume" approximately 3 seconds slower than a system with a nominal volumetric flow rate.

104. The impact of the initial volume of the airbag at the onset of inflation and the actual volumetric flow rate of the pump on the inflation time of an airbag is shown in the figure below, based on a revised MATLAB simulation. (EX2005). As shown in this figure, variations in either the starting volume of the airbag or the pump's actual volumetric flow rate can lead to variations in the airbag volume at Dr. Cowan's predetermined time duration. Subsequently, these parameters introduce uncertainty that can interfere with a predetermined pump shut-off timer.



EX2005, p. 5.

105. In addition to the initial airbag volume and actual volumetric flow rate, Dr. Cowan's model does not account for temperature. Air expands at higher temperatures and compresses at lower temperatures, so if the air inside the airbag undergoes temperature changes due to heat transfer from the pool water and robotic components, the volume of the airbag may change even after inflation has concluded. For example, using Dr. Cowan's nominal model and the parameters therein (EX1021), and assuming the airbag has inflated to the volume corresponding to Dr. Cowan's predetermined 40-second pump shutoff time, if the water temperature of the pool is 30°C compared to an ambient air temperature of 15°C at a pressure of 101.3 kPa (e.g., a heated pool on a cool day), the volume of air in the airbag may increase by roughly 3% as the enclosed air warms according to the ideal gas law. This calculation relies on

the ideal gas law equation $\frac{P_a V_a}{T_a} = \frac{P_b V_b}{T_b}$, where P is the absolute pressure of the gas, V is the volume of the gas, and T is the temperature of the gas (the subscripts “a” and “b” refer to a first and second state respectively). Using Dr. Cowan’s equation for backpressure (EX1021) and a first state gas volume and temperature at the predetermined 40-second time, the above equation can be applied to solve for a second state gas volume of the airbag after a temperature change.

106. In practice, there are additional uncertainties that would interfere with a predetermined shut-off timer, such as debris that would prevent the cleaning device from surfacing or component failures. These uncertainties are exacerbated if, according to Dr. Cowan’s model, there is a relatively short window of time between the gas volume threshold and his predetermined volume. All of these multiple sources of uncertainties can combine into a significant amount of uncertainty with respect to a short, predetermined time window.

107. Even if an improved version of Dr. Cowan’s model were validated by experiment for a single inflation process, there is too much variability between inflation-deflation cycles for a POSITA to rely on the measured relationship between volume and time in a single cycle. A predetermined time may not correspond to the same volume across different inflation-deflation cycles. A POSITA would not consider a predetermined inflation time to be a “safe and effective inflation time” that would “run long enough to achieve buoyancy but would stop before risking overinflation or damage to the airbag.” Such a control scheme is insufficiently robust to the environmental and operational conditions that can occur in practice, and in my opinion a POSITA would not replace the existing sensor-based control of Wang with a predetermined-time shutoff.

108. In my opinion, because Wang in view of Zhao and Owen does not render obvious claim limitations [1g] and [15d] for at least this reason, Wang in view of Zhao and Owen does not render obvious Claims 1-7, 9-11, and 13-19.

3. Element [1g] and [15d]: Concerns regarding overinflation cannot be addressed by Wang's gas volume threshold

109. Regarding claim limitations [1g] and [15d], Petitioner also states that “a POSITA would understand [Wang's] gas volume threshold to “inherently require... the pump to stop after a predetermined time to prevent overinflation or airbag damage.” (Petition at 34). Petitioner points to Dr. Cowan's simplified airbag volume model as a means of selecting a “predetermined inflation time that ensures the airbag exceeds the minimum buoyancy requirement (the “Gas Volume Threshold”) while remaining below its pressure limit. As previously discussed, Dr. Cowan has not provided a pressure or volume limit at which he considers the airbag to be overinflated and prone to mechanical damage.

110. A POSITA would not understand Wang's gas volume threshold to *require* the pump to stop after a predetermined time to prevent overinflation or airbag damage. For example, Wang discloses both depth and waterline sensors (the first and second sensors in EX1005, ¶¶0113-0117). If the cleaning device uses sensor-based control to control the airbag gas volume that depends on depth or waterline sensors, the pumps could be commanded to stop when a predetermined depth is reached or the airbag inlet is above the waterline, rather than being commanded to stop based on a predetermined time.

111. Wang's gas volume threshold would also not inform a POSITA of a particular predetermined airbag volume at which the shut-off criteria should occur. Because the cleaning device must have a first gas volume (above the gas volume threshold) in order to surface to the

top of the pool, the gas volume threshold merely establishes a lower bound for the volume of the airbag in the third motion state, not an upper bound for preventing overinflation.

112. In my opinion, because Wang in view of Zhao and Owen does not render obvious claim limitations [1g] and [15d] for at least this reason, Wang in view of Zhao and Owen does not render obvious Claims 1-7, 9-11, and 13-19.

4. Element [1g] and [15d]: Zhao teaches away from stopping the sinking and floating control unit after floating for a predetermined time

113. Zhao discloses that if the user does not retrieve the robot within a “predetermined time period,” the robot “retreats to underwater” to continue cleaning. (EX1012, 8:24-42). Since Zhao’s timer causes the robot to “retreat underwater,” the termination of the timer is not used to stop the buoyancy control unit but instead to return to underwater operation rather than stopping the sinking and floating control unit. Therefore, contrary to the language of element [1g] and [15d], which requires the sinking and floating control unit to stop after a predetermined time, Zhao teaches using a predetermined timing criterion for initiating operation of the sinking and floating control unit.

114. In my opinion, because Wang in view of Zhao and Owen does not render obvious claim limitations [1g] and [15d] for at least this reason, Wang in view of Zhao and Owen does not render obvious Claims 1-7, 9-11, and 13-19.

5. Element [2b] and Claim 16: No disclosure of starting waterline detection unit in response to posture meeting a first predetermined condition

115. Limitation [2b] recites: “wherein the main control unit controls the waterline detection unit to start detecting the positional relationship in response to the posture meeting a

first predetermined condition.” Claim 16 includes: “starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition.”

116. Petitioner asserts that “[w]hen the gyroscope confirms that the robot is substantially parallel to the wall, the controller activates the waterline-detection function.” (Petition at 37). On the contrary, neither Wang, Zhao, nor Owen discloses starting waterline detection in response to a posture meeting a first predetermined condition, as opposed to maintaining continuous waterline detection. Petitioner provides no explanation of the motivation or steps required to make this modification. As I have explained in Section X.A.2, the way that states are defined and what transitions are allowed between them can greatly impact and define system behavior. Petitioner generally has not described with any specificity how the existing control system of this combination would operate.

117. In my opinion, Wang in view of Zhao and Owen does not render obvious claim limitation [2b] and Claim 16 for at least this reason.

C. Ground 2: The addition of Guo does not render obvious Claims 8 and 12

119. Claims 8 and 12 depend from Claim 1. Petitioner adds Guo to the combination of Wang, Zhao, and Owen in order to attempt to address Claims 8 and 12.

120. Because Ground 2 adds Guo to the Wang, Zhao, and Owen combination already addressed in Ground 1, my opinions with respect to Ground 1 apply equally to the underlying combination in Ground 2. The addition of Guo does not cure those deficiencies. Guo does not describe a predetermined relationship between time and volume and does not disclose any states or state transition logic relevant to the predetermined pump shut-off. Further, as explained below, Guo's sealed internal gas circulation system is not readily combined with Wang.

121. With regards to Ground 2, Petitioner seeks to combine Guo with Wang, Zhao, and Owen. However, a POSITA would not be motivated to combine Guo with any of these references. Firstly, Dr. Cowan asserts that one motivation for combining Guo and Owen is to avoid overinflation of Guo's airbag (EX 1003, ¶619):

Given this relationship, a POSITA would readily appreciate that a predetermined inflation time can be selected to deliver the target gas volume necessary to achieve buoyancy in Guo's robot while remaining safely below the airbag's structural or pressure limit.

122. As discussed above in Section IX.C, Guo discloses a cabin-airbag circulation system wherein a finite mass of gas is transferred between a pressurized cabin compartment and an airbag to adjust the buoyancy of the swimming pool cleaning device. Given that Guo's system contains a fixed mass of gas, Petitioner and Dr. Cowan have not explained why a POSITA would expect the enclosed cabin-airbag circulation system to experience an overinflation problem. For

this reason, a POSITA considering Guo may not expect overinflation to be a problem for their specific system.

123. Further, Guo's fixed-mass design is incompatible with the variable volume inflation-deflation units of Wang and Zhang. The buoyancy cavities of Wang and Zhang are configured to be inflated via an air inlet that communicates with the atmosphere, thereby allowing the volume of gas within the buoyancy cavity to increase or decrease during operation. (EX1005, ¶¶0117-0118; EX1009, 8:13-36). In contrast, Dr. Cowan explains that, in Guo, "the driving cabin 131 of the swimming pool cleaning robot 100 serves as the gas source for the floating and diving assembly 120," such that gas is transferred between the driving cabin and the airbag during ascent and descent. (EX1003, ¶406, quoting EX1010, ¶0034). Thus, Guo adjusts buoyancy by redistributing a fixed quantity of gas within a closed system, whereas Wang and Zhang adjust buoyancy by changing the quantity of gas contained within the buoyancy cavity with gas from the atmosphere. Guo's closed-system buoyancy system is not readily combined with Wang's (or Zhang's) open-system buoyancy system

124. To this end, a POSITA would recognize that incorporating Guo's fixed-mass gas circulation architecture into Wang's buoyancy control system would require substantially redesigning Wang's inflation and deflation system rather than simply substituting one known component for another. Dr. Cowan does not explain how Guo's fixed-mass gas circulation architecture would be integrated into the externally supplied, variable-volume buoyancy cavities of Wang or Zhang. Accordingly, a POSITA would not be motivated to combine Guo with Wang or Zhang.

D. Ground 3: Zhang in view of Zhao and Owen does not render claims 1-6, 10, and 14-17 obvious

125. As explained in Section X.A.1, a POSITA would not be motivated to combine Zhang and/or Zhao with Owen. As explained in Section X.A.2, Dr. Cowan has not provided specificity in how to integrate the hardware and software of the different references. Further, it is my opinion that Zhang in view of Zhao and Owen does not render Claims 1-6, 10, and 14-17 obvious for at least the reasons below.

1. No motivation to combine: Incorporating Owen's timer into Zhang and/or Zhao would interfere with Zhang and/or Zhao's control system, and there are alternate methods of achieving said motivation

126. A POSITA would not have combined Zhang and/or Zhao with Owen for reasons similar to my discussion of Petitioner's stated motivation to combine for Ground 1. Petitioner asserts that "[i]ntegrating Owen's timer-based control into Zhang's buoyancy system would have been a straightforward and predictable design choice, allowing for precise, energy-efficient inflation control in a battery-powered submersible cleaner. The resulting buoyancy actuator would inflate only as needed to adjust position, or lift the cover, then automatically stop—avoiding overpressure, conserving power, and improving reliability." (Petition at 59).

127. Like Wang and Zhao, Zhang discloses a position-based control system that receives position measurements from sensors and adjusts the operation of the robot to achieve a desired position. Zhang discloses a processor that controls the buoyancy force adjustment member in response to measurements from a first and second sensor, respectively a depth and waterline sensor. (EX1009, 7:34-44, 8:13-36). Therefore, Zhang discloses sensor-based control of its buoyancy force adjustment member.

128. Similar to his treatment of Ground 1, Dr. Cowan uses the term “substitute” when he describes the combination of references: “substituting Owen’s control logic into Zhang’s airbag embodiment.” (EX1003 ¶467). Dr. Cowan does not provide sufficient specificity as to how a POSITA would incorporate Owen’s shut-off timer into the control logic of Zhang, since he does not specify when the timer should begin to count (see discussion at Section X.B.1). In addition, if a POSITA were concerned with airbag overinflation (EX1003, ¶452), there are many solutions that would not cause the deficiencies caused by adding a delay timer to the sensor-based control disclosed by Zhang.

129. In my opinion a POSITA would not have combined Zhang and/or Zhao with Owen for the reason of preventing overinflation or excess battery consumption.

2. Element [1g] and [15d]: No predetermined relationship between time and volume in Zhang and/or Zhao

130. Similar to Petitioner’s assertions regarding Wang’s gas volume threshold, Petitioner asserts that Dr. Cowan’s simplified airbag volume model could be used to shut off the pump after a predetermined time for Zhang given that “the volume of the buoyancy cavity can be preset”. (Petition at 68).

131. However, as I explained in my analysis regarding Dr. Cowan’s overly simplified model, there are environmental and operational uncertainties that Dr. Cowan has not considered that would interfere with a predetermined shut-off timer. Furthermore, even if an improved version of Dr. Cowan’s model were validated by experiment for a single inflation process, there is too much variability between inflation-deflation cycles for a POSITA to rely on the measured relationship between volume and time in a single cycle. In my opinion, a POSITA would not replace the existing sensor-based control of Zhang with a predetermined-time shutoff.

132. In my opinion, because Zhang in view of Zhao and Owen does not render obvious claim limitations [1g] and [15d] for at least this reason, Zhang in view of Zhao and Owen does not render obvious Claims 1-6, 10, and 14-17.

3. Element [1g] and [15d]: Zhao teaches away from stopping the sinking and floating control unit after floating for a predetermined time

133. Zhao discloses that if the user does not retrieve the robot within a “predetermined time period,” the robot “retreats to underwater” to continue cleaning. (EX1012, 8:24-42). Since Zhao’s timer causes the robot to “retreat underwater,” the termination of the timer is not used to stop the buoyancy control unit but instead to return to underwater operation rather than stopping the sinking and floating control unit. Therefore, contrary to the language of element [1g] and [15d], which requires the sinking and floating control unit to stop after a predetermined time, Zhao teaches using a predetermined timing criterion for initiating operation of the sinking and floating control unit.

134. In my opinion, because Zhang in view of Zhao and Owen does not render obvious claim limitations [1g] and [15d] for at least this reason, Zhang in view of Zhao and Owen does not render obvious Claims 1-6, 10, and 14-17.

4. Element [2b] and Claim 16: No disclosure of starting waterline detection unit in response to posture meeting a first predetermined condition

135. Petitioner asserts that “[a] POSITA would recognize that for Zhang’s robot to execute these sequential actions, it needs to sense that the robot’s posture satisfies a specific condition (i.e., the transition from bottom cleaning to wall climbing) and in response initiate other sensing operations such as depth measurement and air-intake control.” (Petition at 70). Petitioner also asserts that “[w]hen the robot determines it has changed from the horizontal

bottom to the vertical wall—i.e., when the posture meets the first predetermined condition—Zhao initiates its climbing and docking sequence, which necessarily includes detecting its positional relationship relative to the waterline.” (Petition at 71, citing to EX1003, ¶¶644-645).

136. Neither of these disclosures teaches starting waterline detection unit in response to posture meeting a first predetermined condition, as opposed to maintaining continuous waterline detection. Petitioner provides no explanation of the motivation or steps required to make this modification. As I have explained in Section X.A.2, the way that states are defined and what transitions are allowed between them can greatly impact and define system behavior. Petitioner generally has not described with any specificity how the existing control system of this combination would operate.

137. In my opinion, Zhang in view of Zhao and Owen does not render obvious claim limitation [2b] and Claim 16 for at least this reason.

E. Ground 4: Guo in view of Zhao and Owen does not render claims 1-8, 10-13, and 15-19 obvious

139. As explained in Section X.A.1, a POSITA would not be motivated to combine Guo and/or Zhao with Owen. As explained in Section X.A.2, Dr. Cowan has not provided specificity in how to integrate the hardware and software of the different references. Further, it is my opinion that Guo in view of Zhao and Owen does not render Claims 1-8, 10-13, and 15-19 obvious for at least the reasons below.

1. No motivation to combine: Overinflation does not apply to Guo and incorporating Owen's timer into Zhao would interfere with Zhao's control system

140. A POSITA would not have combined Guo and/or Zhao with Owen for reasons similar to my discussion of Petitioner's stated motivation to combine for Ground 1. Petitioner asserts that "[i]ntegrating Owen's timer control into Guo's buoyancy assembly would prevent overinflation and maintain safe pressure limits, while Zhao's timing and feedback logic would coordinate the floating and sinking sequence." (Petition at 83).

141. However, as explained in Section X.C.1, Guo's cabin-airbag circulation system has a fixed mass of gas, and therefore Petitioner and Dr. Cowan have not explained why a POSITA would expect the enclosed cabin-airbag circulation system would experience an overinflation problem. For this reason, a POSITA considering Guo may not expect overinflation to be a problem for their specific system.

142. Petitioner admits that "Guo does not specify the control logic," and indeed in Guo there is no disclosure of whether Guo uses closed-loop control, open-loop control, and/or a state machine to control the buoyancy assembly. Therefore Petitioner appears to suggest "integrating Owen's timer" into "Zhao's timing and feedback logic." However, I have already addressed how

Zhao discloses a position-based control system, and how Dr. Cowan does not provide sufficient specificity as to how a POSITA would incorporate Owen's shut-off timer into the control logic of Zhao, since he does not specify when the timer should begin to count (see discussion at Section X.B.1).

143. In my opinion a POSITA would not have combined Guo and/or Zhao with Owen for the reason of preventing overinflation or excess battery consumption.

2. Element [1g] and [15d]: No predetermined relationship between time and volume in Guo and/or Zhao

144. Similar to Petitioner's assertions regarding Wang's gas volume threshold, Petitioner asserts that Dr. Cowan's simplified airbag volume model could be used to shut off the pump after a predetermined time. (Petition at 93).

145. However, as I explained in my analysis regarding Dr. Cowan's overly simplified model, there are environmental and operational uncertainties that Dr. Cowan has not considered that would interfere with a predetermined shut-off timer. Furthermore, even if an improved version of Dr. Cowan's model were validated by experiment for a single inflation process, there is too much variability between inflation-deflation cycles for a POSITA to rely on the measured relationship between volume and time in a single cycle. In my opinion, a POSITA would not replace the existing sensor-based control of Zhao, in combination with Guo, with a predetermined-time shutoff.

146. In my opinion, because Guo in view of Zhao and Owen does not render obvious claim limitations [1g] and [15d] for at least this reason, Guo in view of Zhao and Owen does not render obvious Claims 1-8, 10-13, and 15-19.

3. Element [1g] and [15d]: Zhao teaches away from stopping the sinking and floating control unit after floating for a predetermined time

147. Zhao discloses that if the user does not retrieve the robot within a “predetermined time period,” the robot “retreats to underwater” to continue cleaning. (EX1012, 8:24-42). Since Zhao’s timer causes the robot to “retreat underwater,” the termination of the timer is not used to stop the buoyancy control unit but instead to return to underwater operation rather than stopping the sinking and floating control unit. Therefore, contrary to the language of element [1g] and [15d], which requires the sinking and floating control unit to stop after a predetermined time, Zhao teaches using a predetermined timing criterion for initiating operation of the sinking and floating control unit.

148. In my opinion, because Guo in view of Zhao and Owen does not render obvious claim limitations [1g] and [15d] for at least this reason, Guo in view of Zhao and Owen does not render obvious Claims 1-8, 10-13, and 15-19.

4. Element [2b] and Claim 16: No disclosure of starting waterline detection unit in response to posture meeting a first predetermined condition

149. Petitioner asserts that “[a]lthough Guo does not explicitly describe control logic linking posture detection to waterline detection, a POSITA would understand that waterline-related detections necessarily occur after a posture change is detected and the robot enters a wall-climbing state, providing feedback for the control unit to initiate buoyancy adjustment and transition to surface cleaning.” (Petition at 95). Petitioner also asserts that “Dr. Cowan explains that once the [Zhao] robot detects a change from a horizontal bottom-cleaning posture to a vertical wall-climbing posture (i.e., the first predetermined condition), the robot initiates its

docking and climbing sequence, which necessarily requires detecting its positional relationship relative to the waterline.” (Petition at 96, citing to EX1003, ¶¶644-645).

150. Neither of these disclosures teaches starting waterline detection unit in response to posture meeting a first predetermined condition, as opposed to maintaining continuous waterline detection. Petitioner provides no explanation of the motivation or steps required to make this modification. As I have explained in Section X.A.2, the way that states are defined and what transitions are allowed between them can greatly impact and define system behavior. Petitioner generally has not described with any specificity how the existing control system of this combination would operate.

151. In my opinion, Guo in view of Zhao and Owen does not render obvious claim limitation [2b] and Claim 16 for at least this reason.

F. Ground 5: A POSITA would understand a “main control unit” to have corresponding definite structure

153. Claim [1c] recites “a main control unit configured to control a working state of the sinking and floating control unit.” Petitioner asserts that a “main control unit” is defined solely by its function without disclosing any structural detail (Petition at 112), but also that “[i]f the Board declines to apply § 112(f), “main control unit” would at most refer to a generic processor/controller performing the recited functions” (Petition at 113).

154. In my experience, a POSITA would understand that a control unit in a consumer product device that can be configured to monitor sensors, control actuators, and effectuate state changes is a microcontroller or similar device. Microcontrollers are well known in industry and can be chosen from catalogs based on engineering and cost requirements. A POSITA would understand that the structure associated with a microcontroller would include the following: a processor, memory, connection points for sensors and actuators, a printed circuit board (PCB) and other associated circuitry.

155. A POSITA would understand that the '196 Patent's description of a control unit that controls the motion of an autonomous swimming pool cleaning robot that performs the following actions (monitoring, controlling actuators, and effectuating state change) is consistent with a microcontroller:

- a. Claim limitation [1d]: “controlling the swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope,”
- b. Claim limitation [1e]: “controlling the waterline detection unit to detect the positional relationship between the swimming pool robot and the waterline of the

liquid surface of the swimming pool where the swimming pool robot is located;
and”

- c. Claim limitation [1f]: “controlling the sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot.”

156. Petitioner’s asserted prior art references confirm this understanding. Wang, Zhang, Zhao, and Guo all disclose a control unit consistent with a microcontroller that controls an autonomous pool robot. Wang discloses a processor 52 which “may be a micro-controller, an embedded processor [], an application-specific integrated circuit (ASIC), or the like” (EX1005, ¶0114). Zhang also discloses a processor that “may be a microcontroller, an embedded processor, or an application specific integrated circuit (ASIC), etc.” (EX1009, 7:46-48). Zhao includes a controller that “can be, for example, a central processing unit (CPU), or a micro processor” (EX1012, 3:42-44). Guo’s pool cleaning robot comprises a “mainboard” (i.e., a printed circuit board (PCB)) (EX1010, ¶52).

157. For the reasons given in my claim construction discussion above, “main control unit” connotes known structural detail (a microcontroller or similar programmable control device) to a POSITA. In my opinion, Claims 1-14 inform a POSITA of their scope with reasonable certainty.

158. Moreover, even if the “main control unit” were treated as a means-plus-function limitation, the specification discloses the algorithm, logic, and/or sequence in which the main control unit 10 performs each recited function. In one embodiment (see EX1001, Fig. 6), the ’196 Patent discloses that the pool robot rotates to measure distances L1–L4 and selects the nearest side wall (EX1001, 11:31-41, Fig. 7), climbs the side wall (EX1001, 10:17-40), begins

waterline detection in response to the posture detection unit sensing the first predetermined condition (EX1001, 9:31-38), commands the inflation and deflation subunit and the switch subunit to enter the floating working state upon waterline or proximity detection (EX1001, 8:29-54, 9:1-8), and stopping or closing the subunits upon detection of re-submersion, posture change, or expiration of the predetermined timer (EX1001, 9:5-18, 9:41-47). The main control unit 10 is configured to control each component of the swimming pool robot 1 above (EX1001, 5:58-6:17), where the structure of each subunit is also described in the specification (see Section VII). A POSITA would recognize these disclosures as an understandable algorithm, logic, and/or sequence for the recited operations.

G. Ground 6: A POSITA would understand a “distance-measurement unit” to have corresponding definite structure

160. Claim 4 recites “a distance measurement unit or a map storage unit, wherein the main control unit controls the swimming pool robot to find the nearest side wall or the nearest slope based on distance measurement results of the distance measurement unit or map data in the map storage unit.” Petitioner asserts that a “distance measure[ment] unit” is defined solely by its function without any definite structure (Petition at 114-115), but also that “[i]f the Board declines to apply § 112(f), “distance measurement unit” should at most be construed to mean “a device that measures a distance between the robot and a surrounding object” (Petition at 116).

161. The '196 Patent discloses a distance measurement unit 50. The distance measurement unit is described below (EX1001, 9:58-61):

The distance measurement unit 50 performs distance measurement to control the swimming pool robot 1 to find the nearest side wall or slope in response to the operational requirement information of the swimming pool robot 1.

162. The specification discloses a rotational measurement procedure in which the swimming pool robot rotates approximately 90 degrees between four measurements to obtain distances L1 through L4 (EX1001, Fig. 7 and 11:31-47). The swimming pool robot then uses the smallest distance L4 to move to the nearest side wall.

163. The '196 Patent also discloses a proximity waterline detection subunit 302 that is “configured to detect whether the swimming pool robot 1 has crawled to a distance less than or equal to a predetermined distance from the waterline” which may be “configured by, for example, an ultrasonic ranging device.” (EX1001, 8:40-47).

164. A POSITA would understand that a distance measurement unit can be an ultrasonic ranging device, similar to one embodiment of the proximity waterline detection subunit. A POSITA would understand that an ultrasonic ranging device can be used to detect the distance between the swimming pool robot to the side wall and the distance between the swimming pool robot to the surface of the pool. This is consistent with the '196 Patent's disclosure of a measurement procedure that requires rotation to measure the distance in different directions.

165. In general, a POSITA would understand that a distance measurement unit can be a ranging sensor that can operate underwater, including an ultrasonic sensor. A POSITA would understand that there are other types of ranging sensors, including light-based ranging sensors that would allow the swimming pool robot to measure distance underwater.

166. For the reasons given in my claim construction discussion above, "distance measurement unit" connotes known definite structure (an ultrasonic ranging device or similar ranging sensor) to a POSITA. In my opinion, Claim 4 informs a POSITA of its scope with reasonable certainty.

**XI. OPINIONS IN SUPPORT OF THE CONTINGENT MOTION TO AMEND
(SUBSTITUTE CLAIMS 20–39)**

168. I have reviewed proposed substitute Claims 20–39 as set forth in Patent Owner’s Contingent Motion to Amend. The proposed substitutes to independent Claims 1 and 15 are detailed below:

- a. Substitute Claim 20 amends Claim 1 by adding Claim 2’s “posture detection unit configured to detect a posture of the swimming pool robot,” and the requirement that “the main control unit controls the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition.”
- b. Substitute Claim 35 amends Claim 15 by adding Claim 16’s disclosure that “detecting comprises starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition.”

169. The proposed substitute dependent claims provide the following additional limitations over the original claims below, in addition to proposing Claims 25 and 28 (substitutes for Claims 6 and 8) where “distance from the waterline” is changed to “distance below the waterline.”

- c. Claim 21 (substitute for Claim 2): “the posture detection unit is configured by an inertial sensor” and “the first predetermined condition comprises the posture of the swimming pool robot changing from a state parallel to a bottom surface of the swimming pool to a state parallel to the side wall of the swimming pool.”
- d. Claim 24 (substitute for Claim 5): “the outlet water detection subunit is configured by a capacitive sensor or an ultrasonic ranging device.”

- e. Claim 27 (second substitute for Claim 7): “in response to the outlet water detection subunit not detecting that at least a part of the swimming pool robot enters underwater again after the sinking and floating control unit enters the floating working state for the predetermined time, the inflation and deflation subunit and the switch subunit are controlled to be closed.”
- f. Claim 36 (substitute for Claim 16): “wherein the detecting comprises starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition.”

170. I have been asked to evaluate the amended claims with respect to whether they have written description support, are patentable over the art of record, and whether they are definite and enabled. I have applied the legal principles provided to me in Sections IV.A through IV.D.

171. First, it is my opinion that the amended claims have written description support. Each added limitation appears in the original '196 Patent. I have independently verified each of these added limitations against the cited disclosure. In my opinion a POSITA would understand the inventors possessed the claimed subject matter as of the filing date. The specification and figures of Application No. 18/822,334 as filed (EX1002) are the same in all relevant respects as those of the '196 Patent, and my citations refer to EX1001 merely for convenience.

- a. Substitute Claim 20, 21, 35, and 36: the “posture detection unit configured to detect a posture of the swimming pool robot,” “the posture detection unit is configured by an inertial sensor,” “the main control unit controls the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition,” and “the first predetermined

condition comprises the posture of the swimming pool robot changing from a state parallel to a bottom surface of the swimming pool to a state parallel to the side wall of the swimming pool” are disclosed at 9:29-47.

- b. Substitute Claim 24: “the outlet water detection subunit is configured by a capacitive sensor or an ultrasonic ranging device” is disclosed at 8:33-40.
- c. Substitute Claim 27: “in response to the outlet water detection subunit not detecting that at least a part of the swimming pool robot enters underwater again after the sinking and floating control unit enters the floating working state for the predetermined time, the inflation and deflation subunit and the switch subunit are controlled to be closed” is disclosed at 9:10-18.

172. Second, it is my opinion that the amended claims are patentable over the art of record. Both independent claims 20 and 35 describe how the waterline detection unit “start[s] detecting the positional relationship in response to the posture meeting a first predetermined condition.” The implication is that before the posture meets the first predetermined condition, the waterline detection unit is not detecting the positional relationship. From an engineering standpoint, the amended claimed sequencing of initiating waterline detection only after meeting a predetermined posture condition is a feature that refines the pool robot’s control states and state transition logic. The ’196 Patent affirms that “by starting each component of the sinking and floating control unit in stages according to detection results of the positional relationship, more accurate floating and sinking control can be realized.” (EX1001, 10:55-62).

173. None of the asserted references or references cited by the Examiner suggests initiating a waterline detection measurement in response to a predetermined posture condition. The asserted references also do not describe state transitions that are initiated by a

preconditioned posture condition. As described in Section IX, the asserted prior art describe various sensors, but do not describe initiating a waterline detection measurement in response to a predetermined posture condition. The asserted prior art also describe actions caused when preconditions are met by sensor measurements such as depth or waterline detection, but none of them connect a predetermined posture condition to the initiation of a waterline detection unit. For example, Wang describes that “when the position of the cleaning device 10 meets a preset condition, the processor 52 may control the buoyancy adjustment part to increase the volume of gas in the buoyancy cavity 5111.” (EX1005, ¶0114). Zhang describes that “when the position of the moving device 100 meets a preset condition, the processor may control the buoyancy force adjustment member to increase the volume of the gas in the buoyancy cavity 1111.” (EX1009, 7:55-58). Guo does not explicitly describe sensors. Owen describes a pressure sensor but does not describe a different sensor that can initiate once the pressure sensor has reached a predetermined threshold.

174. Zhao describes a gyroscope that measures the “angle and a rising height of the pool cleaning robot”, which “cause[s] the pool cleaning robot to enter a wall climbing mode” and later “maintaining dynamic balance at the water level [that] can include sensing that the pool cleaning robot reaches the water level through sensors.” (EX1012, 6:21-28). However, there is no disclosure of Zhao’s water level sensors remaining at idle before the gyroscope has met a predetermined posture condition.

175. Third, it is my opinion that the amended claims are definite and enabled. A POSITA would understand the scope of each substitute claim with reasonable certainty. The substitute claims contain language that is provided in the specification and include specific sensors, as well as descriptions of specific thresholds and sequencing of control decisions.

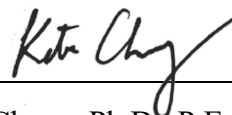
XII. CONCLUDING STATEMENTS

176. In summary, it is my opinion that the Challenged Claims of the '196 Patent are not rendered obvious by the grounds raised by Petitioner; that the terms challenged under 35 U.S.C. § 112(b) inform a POSITA of the scope of Claims 1-14 and Claim 4 with reasonable certainty; and that proposed substitute Claims 20-39 have written description support, are patentable over the art of record, and are definite and enabled.

177. In signing this declaration, I understand that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in this case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

178. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: August 10, 2026

By: 
Kate Cheng, Ph.D., P.E.