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.

PGR2026-00012

U.S. Patent No. 12,221,196 B1

PATENT OWNER'S RESPONSE PURSUANT TO 37 C.F.R. § 42.220

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2001	Hugh Young and Roger Freedman, *University Physics with Modern Physics* (14th ed. 2016). (previously filed)
2002	*Oxford Dictionary of Computing* (6th ed. 2008). (previously filed)
2003	Declaration of Kate Cheng, Ph.D., P.E.
2004	Curriculum Vitae of Kate Cheng, Ph.D., P.E.
2005	Revised Matlab code and simulation result of Dr. Kate Cheng

I. INTRODUCTION

Patent Owner Aiper Global Pte. Ltd. ("Patent Owner") submits this Response under 37 C.F.R. § 42.220 to the Petition for post-grant review of U.S. Patent No. 12,221,196 B1. The Board instituted trial on six grounds. The record is now materially different from the one before the Board at institution: it includes the declaration of Dr. Kate Cheng (EX2003), whose analysis of Petitioner's technical theory — and of the simulation on which Dr. Cowan's inherency opinion rests (EX1021) — exposes defects that the preliminary record could not. On the full record, Petitioner cannot establish unpatentability of any challenged claim by a preponderance of the evidence. Concurrently with this Response, Patent Owner files a contingent motion to amend under 37 C.F.R. § 42.221. That motion is fully contingent: it does not concede the unpatentability of any original claim, and each substitute claim is to be considered only if the corresponding original claim is held unpatentable. *Lectrosonics*, Paper 15, at 4.

Petitioner's § 103 case reduces to a single proposition: that a skilled artisan designing a sensor-governed, submersible cleaning robot would borrow a blind countdown timer from a household air-mattress pump and let it override the robot's own sensors. The complete record refutes that proposition in three independent ways. First, the inherency theory fails on its own terms: Dr. Cowan's time-equals-volume model rests on assumptions — an airbag starting empty, a static back-pressure, an

invariant pump — that contradict both the references and the operating physics, and no preset time reliably yields a target volume across real cycles. Second, no reason to combine exists outside hindsight: each reference already solves pump shutoff with sensors; the only motivation Petitioner offers (overinflation) is one the references either already guard against or solve with well-known sensor-based alternatives. Third, Petitioner never explains how its combinations would actually be engineered — which criteria, which states, which transitions — and conclusory integration testimony cannot substitute for that explanation. The § 112(b) grounds fail for a more basic reason: the challenged "unit" terms name concrete, well-understood classes of hardware, as Petitioner's own constructions concede.

Ground	**Claims**	**Basis**	**Prior Art/Reasoning**
1	1-7, 9-11, 13-19	§ 103	Wang in view of Zhao and Owen
2	8, 12	§ 103	Wang in view of Zhao, Owen, and Guo
3	1-6, 10, 14-17	§ 103	Zhang in view of Zhao and Owen
4	1-8, 10-13, 15-19	§ 103	Guo in view of Zhao and Owen
5	1-14	§ 112(b)	Indefinite ("main control unit")
6	4	§ 112(b)	Indefinite ("distance measurement unit")

At trial, Petitioner bears the burden of proving unpatentability by a preponderance of the evidence. 35 U.S.C. § 326(e); *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015). The institution decision

was a preliminary threshold determination on an incomplete record; the Board's final decision must rest on the full trial record, which now includes the declaration of Dr. Kate Cheng, Ph.D., P.E. (EX2003). *TriVascular, Inc. v. Samuels*, 812 F.3d 1056, 1068 (Fed. Cir. 2016).

Petitioner cannot carry its burden. All of the prior-art grounds (Grounds 1–4) rely on Owen, which is non-analogous art to the claimed invention—making all of those grounds improper for an obviousness challenge. Each ground also fails on its merits: Wang's "gas volume threshold" is a neutral-buoyancy wall-cleaning set-point that Wang routinely exceeds, not a time-based shutoff; Petitioner's inherency theories rest on a constant-flow-rate assumption that Petitioner's own expert contradicts; Zhang's control is purely sensor-based; and Guo's sealed closed-loop gas circulation makes Petitioner's overinflation rationale physically inapplicable. And the Petition's indefiniteness arguments are contradicted by its own claim construction and prior-art arguments.

Concurrently and solely as a contingent measure, Patent Owner files a Contingent Motion to Amend under 37 C.F.R. § 42.221 proposing substitute claims 20–38, to be considered only if the Board finds a corresponding original claim unpatentable. This Response addresses the patentability of the *original claims only*; the patentability of the substitute claims is addressed in the Motion to Amend. 37

C.F.R. § 42.6(a)(3). The contingent motion is not a concession as to any original claim.

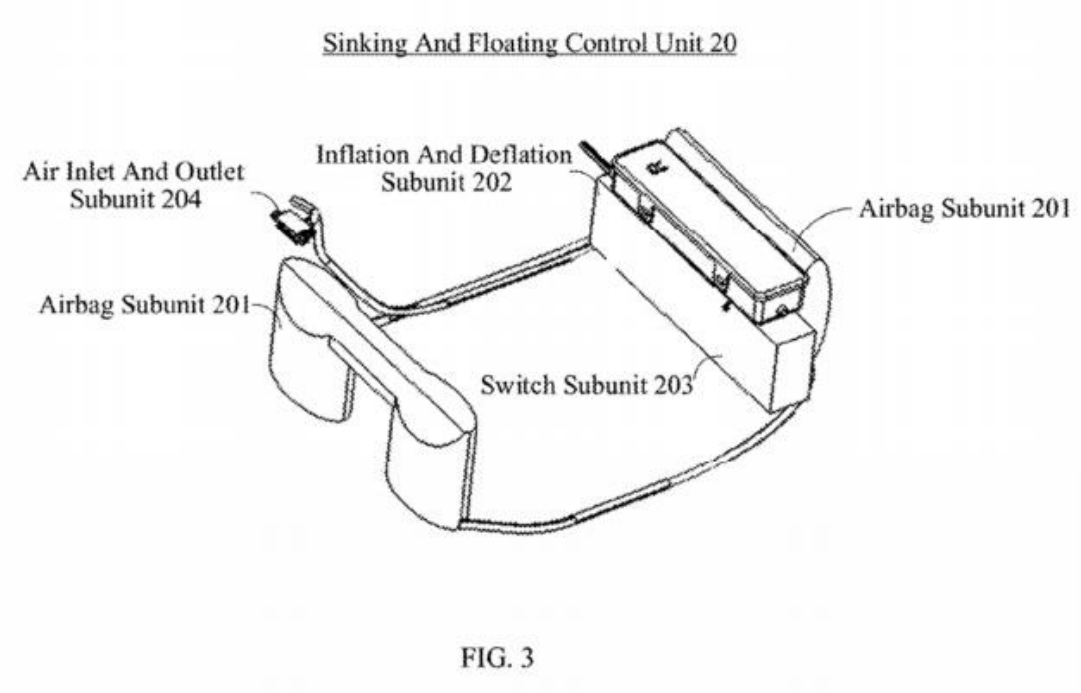
II. OVERVIEW OF THE ’196 PATENT

The ’196 patent addresses a recurring operational challenge in autonomous pool cleaning: a robot that traverses the pool floor and walls must periodically come back to the surface — to be retrieved, to reposition, or to complete its cycle — and must do so quickly, reliably, and without operator involvement. 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, the current state of 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 the buoyancy mechanisms these robots implemented, which involved the swimming pool robots 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 patent solves this problem with a robot whose buoyancy is actively orchestrated by an on-board control architecture: a sinking and floating control unit changes the robot’s buoyancy state; a waterline detection unit senses the robot’s

position relative to the water surface; and a main control unit sequences the two — directing the robot to a side wall, initiating ascent, monitoring the robot's relationship to the waterline, and stopping the sinking and floating control unit after a predetermined time once the floating working state is achieved. EX1001, 6:31-59, 9:5-30.

FIG. 3, reproduced below, illustrates the architecture, the '196 patent's pool robot includes a sinking and floating control unit 20:



EX1001, FIG. 3.

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.

Sinking Working State: In this 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.

Wall Climbing State: In this 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.

Floating Working State: In this 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 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.

Floating State: In this 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.

Transitioning between States: The '196 patent describes a coordinated set of sensor-driven triggers and control logic governing the transitions among these states:

Transition from Bottom Cleaning to Wall Climbing (First Predetermined Condition): 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.

Transition from Wall Climbing to Floating Working State: As the robot crawls along the side wall toward the water surface, the waterline detection unit 30 monitors the robot's position relative to the waterline. 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, 9:40-44. 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.

Transition from Floating Working State to 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:

> **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.
>
> **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.
>
> **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.

A. Prosecution History and the Examiner's Reasons for Allowance

The Examiner allowed the claims with an express statement of reasons for allowance: the claimed 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." EX1002, p.157. The Examiner considered Korenfeld (US 11,124,982) (waterline-angle detection and wall crawling), Tryber (US 11,274,462) (water-ballast tank with compressed gas cylinder), and newly cited Henkin (US 5,985,156) (fluid-jet movement between pool bottom and waterline), and found that none discloses the claimed time-based shutoff. Id. The Petition is an effort to backfill that admitted gap with Owen, a non-analogous household pump reference. Patent Owner recites the Examiner's stated reason as background only; it does not concede that this distinction is the sole basis of patentability, and the challenged claims are patentable for each of the independent reasons set forth below.

III. SUMMARY OF REFERENCES IDENTIFIED BY PETITIONER

Petitioner builds its four obviousness grounds from 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). Each reference is summarized in turn below.

A. Wang, EX1005

Wang concerns a pool-cleaning device that can switch 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:

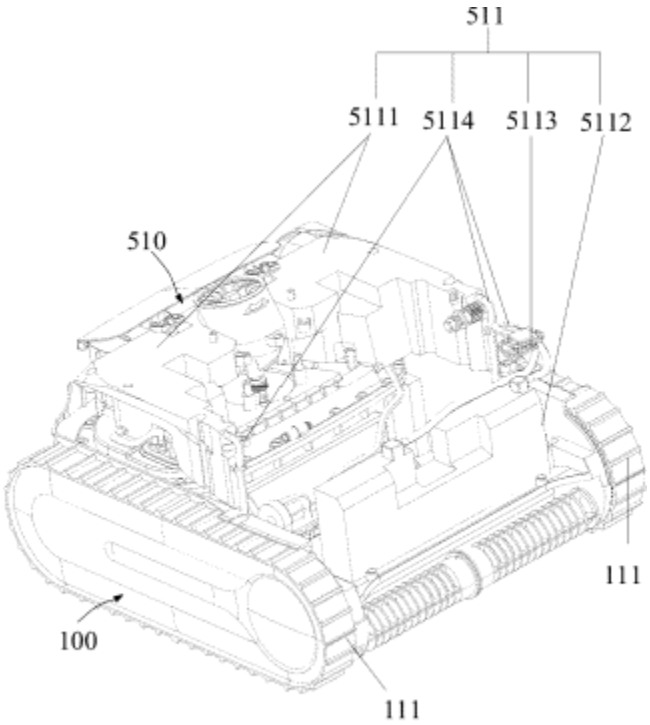


FIG. 6

EX1005, FIG. 6.

The buoyancy adjustment assembly includes a buoyancy cavity 5111, buoyancy cavity pump 5112, air inlet 5113, and connection duct 5114. EX1006, ¶¶98-101. The buoyancy cavity 5111, together with the buoyancy cavity pump 5112,

forms a buoyancy adjustment part that causes 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.

First Motion State (Bottom Cleaning): Wang defines the first motion state 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." EX1005, ¶68. Wang further explains that "the cleaning device 10 is away from the liquid surface 30 may be understood as that the cleaning device 10 cleans the bottom of the pool or performs an action underwater." EX1005, ¶68. In this state, the cleaning device performs underwater cleaning. EX1005, ¶69.

Second Motion State (Wall Cleaning): Wang defines the second motion state 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." EX1005, ¶68. In this state, "the cleaning device can clean a pool wall or a waterline." EX1005, ¶70.

Third Motion State (Surface/Floating): Wang defines the third motion state 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." EX1005, ¶68. In this state, the cleaning device performs water surface cleaning. EX1005, ¶69.

Wang establishes a relationship between the motion states and gas volumes in the buoyancy cavity. Wang discloses that "[w]hen 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." EX1005, ¶122. Wang further explains that "[w]hen 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." EX1005, ¶122. Wang therefore establishes the following relationship:

Motion State	**Location**	**Gas Volume**	**Buoyancy Effect**
First motion state	Bottom of pool	Second volume (lowest)	Negative (sinks)
Second motion state	Pool wall	Gas volume threshold (intermediate)	Neutral (clings to wall)

Third motion state	Water surface	First volume (highest)	Positive (floats)

The express relationship is defined as: **Second volume < Gas volume threshold < First volume**. EX1005, ¶122. The gas volume threshold creates "a balanced force ... in the vertical direction" so that the cleaning device "can be attached to the wall of the pool in the vertical direction and better clean the wall of the pool." EX1005, ¶122. This neutral buoyancy allows the robot to cling to the wall during the second motion state without floating off or sinking.

Wang also discloses the sensor suite that supervises these state transitions: a first sensor that measures the device's vertical position or depth, a second sensor that detects whether the air inlet is above the liquid surface, and additional sensors capable of detecting whether the device is trapped. EX2003, ¶¶51-52. Wang's motion-state control is thus sensor-supervised from end to end.

B. Zhang, EX1009

Zhang describes a movable swimming-pool cleaning device that includes 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. Zhang's control system is sensor-based: the processor obtains detection results of whether 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.

Zhang's control system is likewise processor-based: a first sensor determines the position of the moving device, and a processor manages the transitions between modes as a feedback controller. EX2003, ¶56.

C. Guo, EX1010

Guo describes a pool-cleaning robot whose floating and diving assembly 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, ¶19, ¶34, ¶48, ¶52, ¶56. This closed-loop system means the total gas volume is finite and simply transfers between compartments within the robot.

Because Guo circulates a fixed mass of gas between the cabin and the airbag, there is a maximum possible gas volume, and Guo discloses no operating states or state transitions at all. EX2003, ¶¶61, 117.

D. Zhao, EX1012

Zhao concerns an automatic docking method by which a pool-cleaning robot can 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/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. 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. Importantly, Zhao's timer is for docking/retrieval timeout—not for stopping a buoyancy control unit.

E. Owen, EX1013

Owen, by contrast, describes a pump for inflating household inflatable objects—principally 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"). 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"). 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.

Owen further provides a "setting selector knob" by which the user specifies a desired firmness level for the mattress, and Owen nowhere describes a processor or controller. EX2003, ¶¶67, 73.

IV. LEVEL OF ORDINARY SKILL IN THE ART

No material dispute separates the parties' definitions of the person of ordinary skill in the art for purposes of the issues in this trial. A POSITA at the relevant time would have held at least a bachelor's degree in mechanical engineering, electrical

engineering, or a comparable discipline, with two to three years of experience designing electro-mechanical consumer products or robotic systems — additional education substituting for experience and vice versa. EX2003, ¶20. Patent Owner's analysis does not change under either party's articulation, and Dr. Cheng has applied this level of skill throughout her analysis. EX2003, ¶¶20-21.

V. OWEN IS NOT ANALOGOUS ART

A reference may properly support an obviousness determination under 35 U.S.C. § 103 only if it qualifies as analogous art to the claimed invention. In re Bigio, 381 F.3d 1320, 1325 (Fed. Cir. 2004). A reference is analogous art if (1) it is from the same field of endeavor as the claimed invention regardless of the problem addressed, or (2) it is reasonably pertinent to the problem faced by the inventor. *Id.* Petitioner bears the burden of establishing that Owen is analogous with reasoned, evidence-supported analysis. Netflix, Inc. v. DivX, LLC, 80 F.4th 1352, 1358-59 (Fed. Cir. 2023). Owen fails both prongs.

A. Owen Is Not From the Same Field of Endeavor as the Claimed Invention

The "same field of endeavor" inquiry for analogous art focuses primarily on what the reference itself discloses. Bigio, 381 F.3d at 1325. The '196 patent "relates to the field of underwater robots, and in particular to a controllable sinking and floating swimming pool robot and a sinking and floating control method for a

swimming pool robot." EX1001, Abstract, 1:8-11. Owen, on the other hand, discloses various embodiments "directed to a pump for inflatable support systems having a mechanism for automatically shutting off the pump after inflation." EX1013, 1:30-32. These fields are completely different. As Petitioner's expert opined, the fields are "household bedding [i.e., Owen's air mattress] versus aquatic robotics [i.e., the claimed invention]." EX1003, ¶293.

Petitioner acknowledges that Owen's field is not directed to aquatic robots (as Petitioner's expert broadly characterizes the claimed invention's field). Petition, 24 ("Owen's embodiment concerns an inflatable mattress, it *explicitly applies to 'an inflatable mattress* **or other inflatable object**.'") (italics added, bold text in the original). The Petition's emphasis of "other inflatable object" does not magically convert Owen's *land-based* pump for a household mattress into an aquatic/underwater robot, let alone a controllable sinking and floating swimming pool robot and a sinking and floating control method for a swimming pool robot.

Moreover, the Petition (at 24) stretches the meaning of "other inflatable object" to "a broader technical field encompassing control of air pumps, bladders, and automatic shutoff mechanisms," which is misplaced and mischaracterizes the field of the claimed invention (i.e., underwater robots, particularly controllable sinking and floating swimming pool robots and a sinking and floating control method for a swimming pool robot).

The Petition goes so far as to allege that the differences between "household bedding [i.e., an air mattress] versus aquatic robotics—is superficial." Pet. at 24; EX1003, ¶293. In doing so, the Petition relies on Dr. Cowan to bridge the large gap between the '196 patent's complex automated underwater technology and a "household" air mattress. He incredulously compares the differences between Owen and the claimed invention as the difference between a toothbrush reference and a hairbrush reference. EX1003, ¶293.

Moreover, Dr. Cowan cites to no evidence for his conclusions on this issue, which is a clear instance of "gap filling." This is improper. *Xerox Corp. v. Bytemark, Inc.*, IPR2022-00624, Paper 9, p. 15 ("Dr. Jones does not cite to any additional supporting evidence or provide any technical reasoning to support his statement. Thus, the cited declaration testimony is conclusory and unsupported, adds little to the conclusory assertion for which it is offered to support, and is entitled to little weight. *See* 37 C.F.R. § 42.65(a) ('Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.')").

In addition, the Patent Office's classification system confirms that the claimed invention and Owen are in different fields. Specifically, the international patent classifications for the '196 patent are:

International Patent Classification	**Description**
B63G 8/24	Underwater vessels adapted for special purposes, e.g. unmanned underwater vessels; Equipment specially adapted therefor, e.g. docking stations — unmanned autonomously operating
B25J 3/00	Manipulators of leader-follower type, i.e. both controlling unit and controlled unit perform corresponding spatial movements
B63G 8/00	Underwater vessels adapted for special purposes, e.g. unmanned underwater vessels; Equipment specially adapted therefor, e.g. docking stations
E04H 4/16	Self-propelled cleaners
G05D 1/467	Control of position or course in three dimensions for movement inside a confined volume, e.g. indoor flying
G05D 105/10	Specific applications of the controlled vehicles for cleaning, vacuuming or polishing
G05D 107/00	Swimming pools

EX1001, cover page section (51); B63G 8/24 (2006.01), B25J 3/00 (2006.01), B63G 8/00 (2006.01), E04H 4/16 (2006.01), G05D 1/467 (2024.01), G05D 105/10 (2024.01), G05D 107/00 (2024.01).

As can be seen, these classifications similarly indicate that the claimed invention's relevant field pertains to controllable underwater vessels adapted for special purposes including autonomous control for cleaning and/or vacuuming, which is consistent with the '196 patent's description of the field as shown above. Owen is unrelated to any of these. Indeed, Owen's international patent classification

is A47C 27/08 (EX1013, cover page section (51)), which corresponds to "Fluid mattresses of pneumatic type with non-manual inflation, e.g. with electric pumps." A47C 27/08 (2006.01). Accordingly, Owen is not from the same field of endeavor as the '196 patent, failing the first *Bigio* test.

B. Owen Is Not Reasonably Pertinent to the Particular Problem with which the Inventor Is Involved

Owen fares no better under the second *Bigio* test, which asks whether the prior art is "reasonably pertinent" to the problem confronting the inventor. Bigio, 381 F.3d at 1325. Nothing in Owen is "reasonably pertinent" to the claimed invention. The '196 patent describes the limitations of the prior art at the time as: "The existing sinking and floating control method for the swimming pool robots realizes floating or sinking by changing a quality of the swimming pool robots themselves through water absorption and drainage, and *the whole sinking and floating process takes a long time, resulting in a decrease in the working efficiency of the swimming pool robots*." EX1001, 1:27-34 (emphasis added).

In other words, the inventors of the '196 patent sought to provide a solution to conventional swimming pool robots that controlled their buoyancy by absorbing water to sink and draining water to float, i.e., "changing a quality of the swimming pool robots themselves through water absorption and drainage." *Id.* This water-intake/discharge approach was slow because absorbing and then subsequently draining water, enough to cause the robot to sink and float, takes significant time,

thereby decreasing the robot's working efficiency. The improvement provided by the '196 patent is a change from a water-intake/discharge buoyancy control system to a gas-intake/discharge buoyancy control system. This shift enabled a much faster transition between sinking and floating states because, as a POSITA understands, air is far less dense than water and can be moved more quickly. EX2001, 370 (Table 12.1 Densities of Some Common Substances showing air having a density of 1.20 kg/m^3 and water having a density of 1.00×10^3 kg/m^3).

Owen's inventors sought to solve a completely different problem; namely, providing a means that allows a user to start a furniture inflation process without requiring the user to remain with the pump as the furniture inflates. EX1013, 1:16-23. For example, Owen provides: "Pumps are known in the art and are used to inflate items of furniture such as air mattresses and beds, which usually contain at least one air bladder. Until now, however, these pumps generally require the user to hold an inflate or deflate button until the respective inflation or deflation has completed. Other pumps may require that the inflation or deflation process be terminated by manually pressing a switch or knob on the pump, else the pump motor would continue to pump and possibly burn out. In either case, *a user cannot simply begin the inflation or deflation process and leave the pump unattended to let the process finish*." EX1013, 1:16-23 (emphasis added).

A POSITA seeking faster buoyancy control for an autonomous underwater robot would have no logical reason to consult air-mattress inflation technology. The problems are unrelated: one concerns autonomous robotic state management in an underwater environment; the other concerns freeing a user from babysitting a household appliance. From a controls perspective, Owen is an open-loop device—its timer runs blind precisely because a sensor was deemed unnecessary for an attended household appliance—whereas the '196 patent, Wang, Zhang, Zhao, and Guo all employ closed-loop, sensor-supervised control suited to a dynamic underwater environment. EX2003, ¶¶70-73. Owen's timer exists simply because the user leaves and is not there to stop the inflation; the '196 patent's timer exists to: (1) make the floating and sinking more efficient and (2) protect the device's hardware by using a better mechanism (air-intake/discharge v. water-intake/discharge). The inventors of the claimed invention were not concerned about removing a user-interaction (Owen's problem) because they were addressing a problem that was occurring with devices that were already automated in the first place.

Owen therefore is not "reasonably pertinent" to the problem the '196 patent's inventors confronted, and it fails the second *Bigio* test as well.

Dr. Cheng confirms from an engineering perspective that the design environments—submerged autonomous operation, hydrostatics, waterline sensing, and sealed-hull constraints versus dry, user-attended appliance operation—do not

overlap in a way that would lead a POSITA from one to the other. EX2003, ¶¶64-65, 72-74. Therefore, Owen is not analogous art to the claimed invention of the '196 patent and therefore is not proper prior art for the Petition's obviousness challenges in Grounds 1–4. Because each of Grounds 1–4 relies on Owen, each fails at the threshold.

VI. CLAIM CONSTRUCTION

The Phillips standard governs claim construction in this proceeding. 37 C.F.R. § 42.200(b); Phillips v. AWH Corp., 415 F.3d 1303 (Fed. Cir. 2005) (en banc). Only terms in controversy need be construed, and only to the extent necessary. Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co., 868 F.3d 1013, 1017 (Fed. Cir. 2017).

A. Petitioner's § 112(f) Constructions Are Incomplete and Should Not Be Adopted

Petitioner alleges that each of "sinking and floating control unit," "waterline detection unit," "posture detection unit," "outlet water detection subunit," "proximity waterline detection subunit," and "inflation and deflation subunit" are subject to § 112(f). However, Petitioner fails to provide a proper construction under this section. Notably, Petitioner only identifies the alleged structure for each limitation without specifying the corresponding function. As a result, Petitioner's proposed claim constructions are incomplete and should not be adopted. Properly

construed under Phillips, each of these terms designates structure: each is defined in the claims and specification by its physical components (airbags, pumps, valves, capacitive sensors, ultrasonic ranging devices) and objective operational characteristics. EX1001, 6:31-59; 8:29-54; Figs. 2B, 7; EX2003, ¶¶26-40.

B. "main control unit" (claims 1–14) — Not Means-Plus-Function

Because the claims do not recite "means," a rebuttable presumption arises that § 112(f) does not apply. *Williamson v. Citrix Online, LLC*, 792 F.3d 1339, 1349 (Fed. Cir. 2015) (en banc). The presumption stands: unlike bare nonce words such as "module" or "element," "control unit" has a well-established structural meaning to engineers in robotics and embedded systems, denoting a processor, microcontroller, or equivalent control circuitry. EX2002, 112 (Oxford Dictionary of Computing); EX2003, ¶¶26-40, 146-147; *Dyfan, LLC v. Target Corp.*, 28 F.4th 1360, 1365-67 (Fed. Cir. 2022); *Zeroclick, LLC v. Apple Inc.*, 891 F.3d 1003, 1008 (Fed. Cir. 2018). The claims reinforce that structural character by reciting the unit's inputs (operational requirement information; detection results), outputs (state commands; sensor activation), and interconnection with the other claimed structural units. *Apple Inc. v. Motorola, Inc.*, 757 F.3d 1286, 1299-1301 (Fed. Cir. 2014). The drawings confirm it: FIG. 2B—"a schematic diagram illustrating cross-sectional components" of the robot—depicts main control unit 10 as a discrete physical component positioned within the robot body, and the specification treats its "position" as a

design variable ("the position and the number of each component in FIG. 2B are only exemplary"). Drawings form part of the written description. Vas-Cath Inc. v. Mahurkar, 935 F.2d 1555, 1565 (Fed. Cir. 1991). Petitioner itself concedes that, absent § 112(f), the term "would at most refer to a generic processor/controller performing the recited functions." Pet., 114.

C. "distance measurement unit" (claim 4) — Not Means-Plus-Function

"Distance measurement unit" denotes a known class of ranging sensor hardware to a POSITA. The specification discloses the unit's complete operating procedure—the robot "rotates once in situ" to detect the distances L1–L4 to each side wall and select the nearest, EX1001, Fig. 7—and configures the adjacent, functionally analogous waterline subunits with ultrasonic ranging devices, EX1001, 8:38-40, 8:45-47, confirming the ranging-sensor context in which a POSITA reads the term. EX2003, ¶¶164-166.

D. "predetermined time" (claims 1, 15)

The term "predetermined time" carries its plain and ordinary meaning—a time duration fixed in advance of the floating working state's commencement, exemplified as 40 seconds. EX1001, 9:11-18. It is a temporal criterion—not a gas-volume, pressure, or other physical-quantity set-point. This distinction is dispositive of Petitioner's reliance on Wang's "gas volume threshold" and Zhang's "preset" volume, as shown below.

All remaining terms may take their plain and ordinary meaning. *See Phillips v. AWH Corp.*, 415 F.3d 13030 (Fed Cir. 2005) (en banc).

VII. GROUND 1: PETITIONER HAS NOT ESTABLISHED BY A PREPONDERANCE OF THE EVIDENCE THAT CLAIMS 1-7, 9-11 AND 13-19 ARE OBVIOUS OVER WANG, ZHAO AND OWEN

As discussed above, Owen is non-analogous art to the claimed invention of the '196 patent. For this reason alone, Ground 1 is deficient. Nevertheless, should the Board consider Owen analogous, the Petition still fails on multiple accounts as addressed below.

A. Wang Fails to Disclose Limitation [1g]

Petitioner alleges that Wang alone discloses this limitation. Pet., 34-36. Petitioner's arguments are flawed for at least the following reasons:

1. Petitioner Mischaracterizes Wang's "Gas Volume Threshold"

Petitioner fundamentally mischaracterizes Wang's "gas volume threshold." Wang discloses three motion states with corresponding gas volumes:

Motion State	**Gas Volume**
First motion state (bottom cleaning) [EX1005, ¶68]	Second volume (low gas, negative buoyancy) [EX1005, ¶122]
Second motion state (wall cleaning) [EX1005, ¶68]	Gas volume threshold (neutral buoyancy) [EX1005, ¶122]

Third motion state (floating) [EX1005, ¶68]	First volume (high gas, positive buoyancy) [EX1005, ¶122]

Wang expressly discloses that "[t]he gas volume threshold is a value between the second gas volume and the first gas volume." EX1005, ¶122. The gas volume threshold provides "a balanced force ... in the vertical direction" so that "the cleaning device can be attached to the wall of the pool in the vertical direction and better clean the wall of the pool." EX1005, ¶122. Accordingly, Wang's gas volume threshold corresponds to neutral buoyancy for *wall climbing*. But limitation [1g] recites the "floating working state," meaning that the robot is floating and therefore has a positive buoyancy—neutral buoyancy for wall climbing (Wang) is not positive buoyancy for floating (limitation [1g]).

2. Wang Routinely Exceeds the Gas Volume Threshold

Petitioner alleges that a "POSITA would understand that this 'gas volume threshold' inherently requires the pump to stop operating after a predetermined time to prevent overinflation or damage to the buoyancy cavity." Pet., 34. This is entirely incorrect as Wang expressly states that the gas volume threshold is routinely exceeded. EX1005, ¶122 ("The gas volume threshold is a value between the second gas volume and the first gas volume."), ¶68 ("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"), ¶68 ("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."), ¶122 ("When the cleaning device 10 is in the third motion state, there is a first volume of the gas in the buoyancy cavity 5111"), ¶122 ("When the cleaning device 10 is in the first motion state, there is a second volume of the gas in the buoyancy cavity 5111."). Wang's floating state (third motion state) requires a first volume, which Wang expressly states is a gas volume greater than the gas volume threshold. If the pump stopped at the gas volume threshold (as Petitioner's inherency theory suggests), the robot would only achieve neutral buoyancy for wall climbing and would not be able to achieve a gas volume sufficient to enter the floating working state as required by limitation [1g].

Even the graph relied upon by Dr. Cowan shows that the threshold is exceedable:

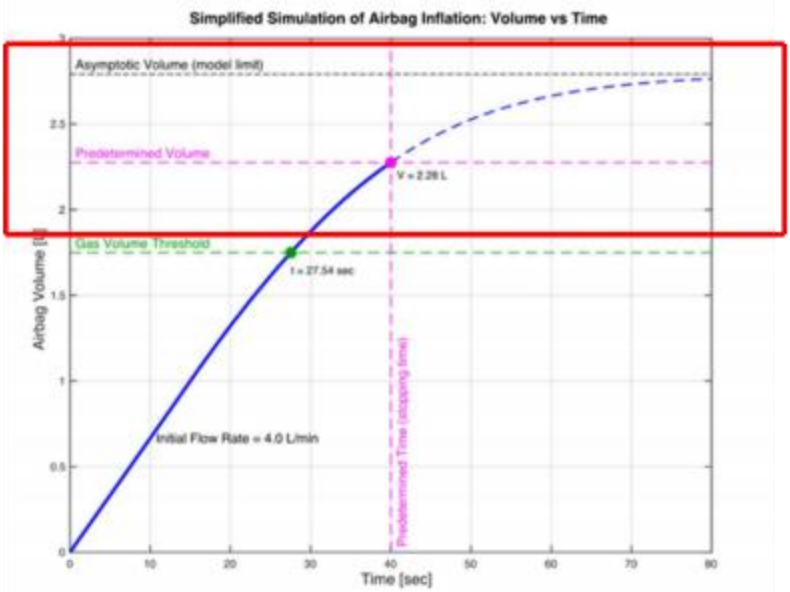


Fig. 1 of EX1021

EX1003, ¶274 (red box added).

Moreover, the gas volume threshold certainly is not used to "prevent overinflation or damage to the buoyancy cavity" since the gas volume threshold is exceeded every time the robot transitions from the wall climbing state to the floating state. EX1005, ¶122 ("The gas volume threshold is a value between the second gas volume and the first gas volume."), ¶281 ("The first motion state or the third motion state may be a state of the filtering assembly 710 when the cleaning device 10 cleans the bottom of the pool or the water surface" and "The first motion state or the third motion state is different from the second motion state"), ¶122 ("When the cleaning device 10 is in the third motion state, there is a first volume of the gas in the buoyancy cavity 5111"), ¶122 ("When the cleaning device 10 is in the first motion state, there is a second volume of the gas in the buoyancy cavity 5111."). Therefore, because Wang's "gas volume threshold" does not necessarily result in the pump

stopping operation as alleged by the Petition, Petitioner's inherency argument must fail. In re Rijckaert, 9 F.3d 1531, 1534 (Fed. Cir. 1993) ("The fact that a certain result or characteristic ***may occur*** or be present in the prior art is not sufficient to establish the inherency of that result or characteristic.") (emphasis added); *see also PAR Pharm., Inc. v. TWi Pharms., Inc.*, 773 F.3d 1186, 1195-96 (Fed. Cir. 2014).

3. Petitioner Uses Flawed Model with Incorrect Assumptions in Its Inherency Argument

Petitioner further alleges that Wang's "gas volume threshold" inherently requires the pump to stop operating after a predetermined time because, according to Dr. Cowan, "for a pump operating at a roughly constant flow rate (Q), the inflated volume (V) increases linearly with time (t) – $\mathbf{V \approx Q \times t}$." Pet., 21; EX1003, ¶¶271-272. Dr. Cowan cites to *no evidence* for his conclusions on this issue, which is another clear instance of improper "gap filling." *Xerox Corp.*, IPR2022-00624, Paper 9, p. 15 ("Dr. Jones does not cite to any additional supporting evidence or provide any technical reasoning to support his statement. Thus, the cited declaration testimony is conclusory and unsupported, adds little to the conclusory assertion for which it is offered to support, and is entitled to little weight. *See* 37 C.F.R. § 42.65(a) ('Expert testimony that does not disclose the underlying facts or data on which the opinion is based is entitled to little or no weight.')"). Petitioner then concludes that "a POSITA would readily select a predetermined inflation time that ensures the airbag exceeds the minimum buoyance requirement (the 'Gas Volume Threshold')

while remaining below its pressure limit." Pet., 35. Patent Owner respectfully disagrees.

First, Petitioner's argument fails because it is based on an assumption that the flow rate for an underwater robot is constant ("constant flow rate (Q)" in the above equation). Petitioner's theory does not, however, account for backpressure, water temperature, ambient temperature, and depth of the robot in the water. For example, a POSITA would understand that pump flow rate varies with backpressure, i.e., as the buoyancy cavity inflates, internal pressure increases which results in a reduction of pump flow rate. Dr. Cowan acknowledges that backpressure results in a non-constant flow rate, but chooses to ignore this in his discussion at paragraphs 273-274. EX1003, ¶272 ("As the airbag nears its maximum capacity, the internal pressure rises due to membrane tension and hydrostatic head. This increased back-pressure causes the pump's effective flow rate to decay toward zero"). Taken together, Petitioner's theory assumes a deterministic relationship between time and volume that only exists in rare and ideal conditions. EX2003, ¶¶95-98.

In addition, Dr. Cowan's simulation assumes the airbag begins with zero volume (EX1021; EX1003, ¶¶271-274), an assumption contrary to the references themselves. In Wang, the airbag is partially inflated throughout normal operation — Wang's control matches the airbag volume to a gas volume threshold during wall cleaning and adjusts it about that set-point — so each surfacing cycle begins from a

substantial, non-zero, and cycle-dependent volume, not from the empty airbag Dr. Cowan's simulation assumes. That starting volume is itself uncertain from cycle to cycle: air may leak over repeated inflation-deflation cycles, the air mass is not perfectly known after many cycles, and temperature changes the gas volume even at rest. Even a model validated by experiment for a single run therefore could not establish that a preset time corresponds to a particular volume in the next cycle. EX2003, ¶¶101-104, 107.

Dr. Cheng's analysis quantifies these defects on Dr. Cowan's own framework. Dr. Cowan's MATLAB simulation assumes that the airbag starts at zero volume, reaches a predetermined gas volume threshold of 1.75 L, and grows asymptotically toward a 2.75 L maximum, with back-pressure following an exponential growth curve and the pump's volumetric flow rate inversely related to back-pressure (declining from nominal flow toward zero at maximum pressure), as reproduced below. EX2003, ¶¶94-95.

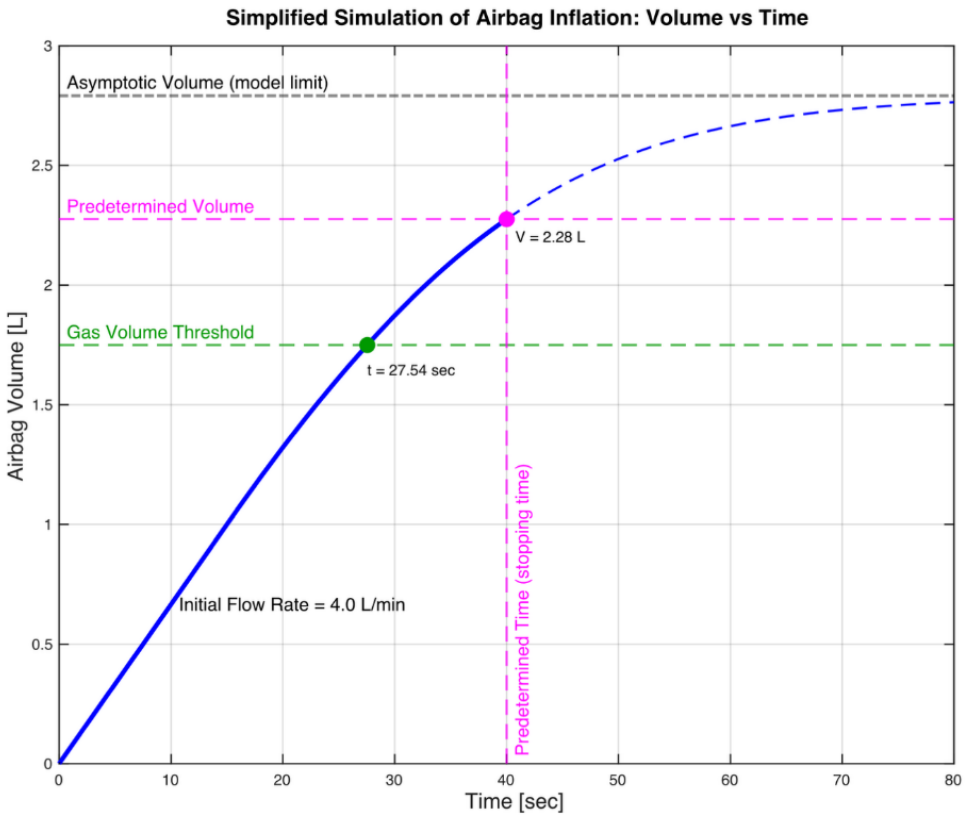
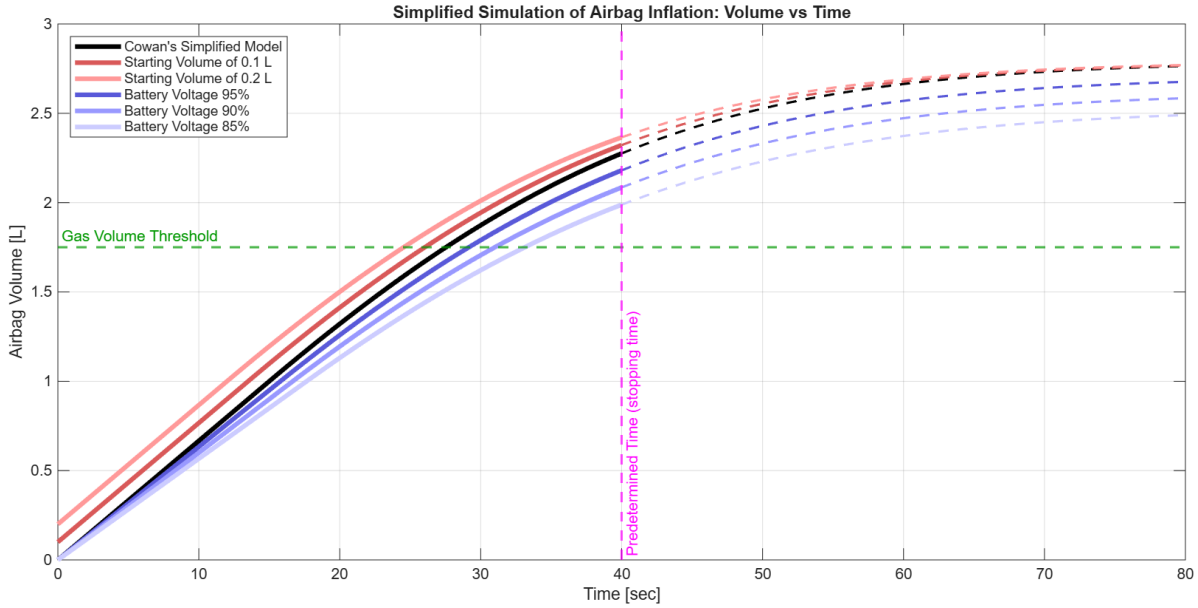


Fig. 1 of Exhibit 1021

The zero-initial-volume assumption is inconsistent with Wang itself — a device whose airbag held no air would rest at the bottom of the pool, and Wang's device begins each surfacing cycle at or near the gas volume threshold, not at zero. EX2003, ¶¶96-97. Real inflation-deflation cycles undermine those assumptions further. Across cycles, the inputs Dr. Cowan treats as fixed are not fixed. The starting volume of the airbag varies from cycle to cycle due to leaks and equipment wear. The pump's actual flow rate likewise degrades below its nominal value over the life of the device. EX2003, ¶¶101-103. Dr. Cheng's revised MATLAB simulation (EX2005) shows the consequence: *variations in either the starting volume or the*

actual flow rate produce substantially different inflation times for the same target volume, as shown below. EX2003, ¶104.



EX2005, p. 5; EX2003, ¶104.

Temperature effects and practical uncertainties compound the variability. EX2003, ¶¶105-106. A preset time therefore cannot reliably correspond to any particular gas volume across operating conditions, and the inherency theory underlying limitation [1g] fails on Dr. Cowan's own model.

Dr. Cheng's analysis also confirms that Dr. Cowan's model omits the compressibility of the air already in the airbag, the hydrostatic head at the inflation depth, battery-voltage effects on pump flow, and temperature effects on delivered volume, and that his simulation rests on an unrealistic vacuum initial state and an idealized membrane model — so that, across realistic operating conditions, reaching

any specified volume does not reliably occur at a predetermined time. EX2003, ¶¶95-101.

Dr. Cheng quantifies these effects using Dr. Cowan's own simplified model and parameters (EX1021): an airbag that begins a cycle with just 0.1 L of residual air—rather than the empty airbag Dr. Cowan assumes—reaches his 1.75 L "Gas Threshold Volume" approximately 1.5 seconds early. EX2003, ¶102. Because pump speed and flow for the brushed direct-current motors commonly used in small pumps fall linearly with applied voltage, a battery at 90% of nominal voltage reaches the same threshold approximately 3.5 seconds late. EX2003, ¶103. Dr. Cheng's figure shown below (EX2005) illustrates how these two parameters alone *decouple airbag volume from any predetermined time*. EX2003, ¶104. Temperature compounds the problem: under the ideal gas law, pool water 15°C warmer than the ambient air expands the enclosed air by roughly 5% even after inflation concludes. EX2003, ¶105. Debris that impedes surfacing and ordinary component variation add still further uncertainty, which the short window between the gas-volume threshold and Dr. Cowan's predetermined volume only magnifies. EX2003, ¶¶106-107.

Accordingly, neither Dr. Cowan's model nor any single-run measurement can carry Petitioner's burden on limitation [1g], and a POSITA would not incorporate a predetermined-time shutoff into these systems. EX2003, ¶¶88, 107.

Accordingly, for at least the foregoing reasons, Petitioner has failed to show that Wang discloses limitation [1g].

In addition, no asserted reference discloses the claimed two-state structure at the surface: a floating working state, in which the pump operates to establish buoyancy, followed by a distinct floating state, in which the inflation and deflation subunit and the switch subunit are closed and the robot simply floats. Wang discloses no sealed, pump-off floating configuration distinct from the pump-on state; and Zhao affirmatively teaches away, instructing that after the device reaches its surface position and its retrieval window expires, it deflates and returns underwater — the opposite of maintaining a closed, stable floating state. EX1012, 8:24-42; EX2003, ¶¶113-114. The combinations therefore fail to disclose the claimed state structure regardless of the timer dispute. This structure is what limitation [1g] claims: the main control unit stops the working state of the sinking and floating control unit after the predetermined time — a transition out of the floating working state into the configuration the specification calls the floating state. EX1001, 9:11-18, 9:26-30. A combination that never discloses the destination state cannot disclose the claimed transition to it. EX2003, ¶¶32, 36.

B. Wang in View of Owen Fails to Disclose Limitation [1g]

In the alternative, Petitioner alleges that Wang in view of Owen discloses this limitation. Pet., 34-36. As discussed above, Owen is non-analogous art to the ’196

patent. For this reason alone, Petitioner's reliance on Wang in view of Owen is deficient. Nevertheless, should the Board consider Owen analogous art, Petitioner's arguments are similarly flawed.

Petitioner alleges that "[i]ntegrating Owen's timer circuit into Wang's buoyancy-control framework would have been a routine ***substitution*** of known control methods." Pet., 22. Petitioner does not expressly state what Owen's timer circuit would replace, as Wang discloses no volume or pressure sensor at all — only depth and air-inlet-exposure sensing. EX1005, ¶¶0113, 0115. But given the context, it appears that Petitioner's position is that Owen's timer circuit would replace Wang's gas-volume threshold. Even that position is underspecified: the pump might be configured to stop a preset time after pumping begins, or a preset time after a depth or position threshold is reached—materially different designs with different failure modes—and neither the Petition nor Dr. Cowan says which is intended. EX2003, ¶¶85-87. Pet., 22 ("a POSITA would recognize that Wang's gas-volume threshold corresponds to a predetermined-time inflation control to prevent overfilling and maintain safety"); Pet. at 34.

As discussed above, Wang's gas-volume threshold is used to maintain the robot in a wall climbing position—*not a floating working state*. Owen fails to compensate for this deficiency. Owen's countdown runs from a *user's button press* on an appliance with *no floating working state*, no waterline sensing, and no robotic

state machine—mapping it onto the claimed state-triggered shutoff is hindsight reconstruction using the claims as a roadmap. *In re NTP, Inc.*, 654 F.3d 1279, 1299 (Fed. Cir. 2011).

Accordingly, at best, substituting Owen's timer circuit for Wang's gas-volume threshold would only result in a timer that activates when Wang's robot enters a *climbing state* and *must be exceeded* for Wang's robot to subsequently *transition from the climbing state to the floating state*. But this teaching fails to compensate for Wang's deficiencies, meaning that the combination does not render limitation [1g] obvious.

In addition, Wang's architecture already contains a complete volume-based control paradigm; a POSITA would view superimposing a blind countdown as fighting Wang's set-points—stopping the pump before the first volume is reached (stranding the device below the surface state) or after it is exceeded—rendering Wang's control principle inoperative or changing its principle of operation. *In re Ratti*, 270 F.2d 810, 813 (CCPA 1959); EX2003, ¶¶85-88. Nor does the Petition explain how the combined logic would behave at the boundaries—whether the timer criterion combines with Wang's sensor criteria conjunctively, disjunctively, or sequentially, or how the combined state machine would detect and recover from fault conditions, as such systems commonly must. EX2003, ¶¶77-80.

Further, Petitioner alleges that "Owen discloses timer circuits that run a pump for a **predetermined time** and then automatically shut it off—preventing overinflation or motor damage." Pet., 35-36. This is a wrong allegation, because the actual motivation in Owen to use a timer is to ensure *adequate inflation* rather than *preventing overinflation*. *See*, EX1013, 3:22-28 ("in one type of inflatable mattress 12, it may take 60 seconds to adequately inflate the mattress 12. In this case, the circuit board is programmed to run the pump for at least 60 seconds before shutting it off.)

Even assuming, *merely for argument and without conceding*, Petitioner's premise that a POSITA would be concerned with overinflation, a timer is only one of several well-known solutions — and not the natural one for feedback-controlled systems. Pet. at 34. A POSITA could monitor airbag pressure directly with a pressure sensor, monitor pump motor current and stop at a maximum-current threshold, or rely on a passive pressure-relief valve of the very kind Wang already discloses. EX1005, ¶0109; EX2003, ¶¶83, 86. Moreover, Wang's gas volume threshold would not even inform a POSITA of any particular predetermined airbag volume at which such a shut-off criterion should trigger. EX2003, ¶0111. Petitioner never explains why, among these familiar alternatives, a POSITA would select a blind countdown that conflicts with the references' own sensor-based control — the hallmark of hindsight reconstruction. *See Ortho-McNeil Pharm., Inc. v. Mylan Labs., Inc.*, 520

F.3d 1358, 1364 (Fed. Cir. 2008) (obviousness requires more than a choice made from numerous possible solutions absent a reason to select the claimed one).

Petitioner's combination theory also fails for lack of any explanation of how the references would actually be integrated. Adding new hardware and new shutoff criteria to an existing control scheme requires answering, at minimum: whether the added criteria combine conjunctively, disjunctively, or sequentially, and in what order; whether new controller states are added, how each is defined, and how transitions between states are defined; how the combined logic avoids overshooting or undershooting buoyancy targets; and how the system recovers from faults — integrations of this kind can drive a controller into unanticipated states from which it cannot recover. EX2003, ¶¶75-81, 83-85, 77-80. The Petition's recitals that integration would be "obvious" or a "routine substitution" answer none of these questions, and conclusory expert testimony to the same effect is entitled to little weight. 37 C.F.R. § 42.65(a). This deficiency applies to each of Grounds 1-4. *See ActiveVideo Networks, Inc. v. Verizon Commc'ns, Inc.*, 694 F.3d 1312, 1327 (Fed. Cir. 2012) (rejecting as "generic" and "fraught with hindsight bias" expert testimony that components could be combined without explaining how); *Pers. Web Techs., LLC v. Apple, Inc.*, 848 F.3d 987, 994 (Fed. Cir. 2017) (obviousness requires explanation of "how the combination of the two references was supposed to work").

Therefore, independent claims 1 and 15 are not shown obvious under Ground 1. Accordingly, dependent claims 2–7, 9–11, 13, 14, and 16–19 are patentable for at least the same reasons as stated above for the independent claims 1 and 15, and for additional features recited therein.

For example, Claims 2 and 16 require that the main control unit control the waterline detection unit to ***start detecting*** the positional relationship in response to the posture meeting a first predetermined condition. No asserted reference discloses or suggests such limitation of holding waterline detection in abeyance and initiating it upon a machine-detected posture condition. EX2003, ¶¶116-117, 135-137, 149-151.

Wang's sensing arrangement operates as an ongoing input to its buoyancy and motion-state logic; and nowhere in Wang describes a dormant detection function that is activated in response to a detected posture condition. EX1005, ¶¶0113-0114, 0120, 0256. The Petition merely asserts that Wang's device "begins detecting" upon the posture change without identifying any disclosure in Wang that a detection operation is **initiated** at that time, and Dr. Cowan's supporting testimony (EX1003, ¶¶303-322) is offered without citation to any underlying fact or data and is entitled to little or no weight. 37 C.F.R. § 42.65(a). Pet., 39-41.

Zhao (EX1012) does not supply the missing relationship. Zhao's gyroscope and ultrasonic sensors operate together during its docking routine, and Zhao

describes monitoring distance and posture during the approach and climb. Zhao does not describe holding waterline detection in abeyance and commencing it upon a posture criterion. EX1012, 4:6-17, 5:3-14, 8:24-42. A general statement that a docking operation "necessarily includes" detecting is not an enough disclosure of the claimed **condition-based initiation** step. EX1003, ¶¶316-317.

For example, Claim 13 requires closing the inflation and deflation subunit and the switch subunit in response to re-entry detection and/or the posture second predetermined condition. Petitioner's combination supplies neither triggering mechanism. While it was alleged in the Petition that Wang's gyroscope can detect a posture change, Wang does not disclose closing or stopping inflation based on such posture change. Pet., 47-48; EX1005, [0120]. In addition, Owen's timer consults no triggering sensor at all. EX1013, 2:1-2, 4:11-31. Zhao's retrieval timer neither closes a buoyancy control unit nor responds to re-submersion detection. EX1012, 8:24-42. EX2003, ¶¶90-92.

Therefore, Petitioner has not established by a preponderance of the evidence that claims 1-7, 9-11 and 13-19 are unpatentable under Ground 1.

VIII. GROUND 2: PETITIONER HAS NOT ESTABLISHED BY A PREPONDERANCE OF THE EVIDENCE THAT CLAIMS 8 AND 12 ARE OBVIOUS OVER WANG, ZHAO, OWEN AND GUO

Claims 8 and 12 are ultimately dependent on independent claim 1. By nature of this dependency, Ground 2 is deficient for reasons similar to Ground 1. Guo, added only for the features of dependent claims 8 and 12, does not remedy the base combination's failure to disclose limitation [1g] or the improper reliance on non-analogous Owen, and Petitioner does not contend otherwise. Therefore, Petitioner has not carried its burden on Ground 2.

Moreover, because Ground 2 adds Guo to the same Wang-Zhao-Owen combination addressed in Ground 1, the deficiencies established there — the failure of the inherency theory, the delay-timer analysis, the absence of the claimed floating state, and the integration-specificity failure — apply equally to Ground 2's underlying combination, where the addition of Guo cures none of them. EX2003, ¶¶120-124.

As to claims 8 and 12 specifically, the alleged combination of the cited references in Ground 2 also fails on the merits.

Claim 8 requires a two-stage entry into the floating working state: (1) the inflation and deflation subunit starts working in response to the proximity waterline detection subunit detecting that the robot has crawled to within the predetermined distance from the waterline, and (2) the switch subunit is controlled to open in response to the outlet water detection subunit detecting emergence. EX1001, 8:56-9:4. Operating the inflation subunit while the switch subunit remains closed and the

robot is submerged develops a pressure differential across the switch subunit and prepares the gas path so that air is admitted rapidly upon emergence, directly serving the '196 patent's fast-transition objective. EX1001, 1:27-34; EX2003, ¶¶24, 31. No asserted reference discloses beginning inflation upon proximity detection before emergence: Wang's inflation is governed by its buoyancy-state logic and discloses no proximity-triggered pre-inflation, EX1005, ¶¶0113-0120; Guo discloses no waterline-proximity sensing at all; and Owen has no sensors.

Claim 12 requires an electromagnetic valve or a two-position three-way valve as the switch subunit. This is concrete controlled-valve hardware that neither Guo's sealed circulation nor Wang's passive one-way valve (disclosed only in its liquid-adjustment embodiment, EX1005, ¶¶0109-0111) provides. EX2003, ¶¶119, 122-124.

Therefore, Petitioner has not established by a preponderance of the evidence that claims 8 and 12 are unpatentable under Ground 2.

IX. GROUND 3: PETITIONER HAS NOT ESTABLISHED BY A PREPONDERANCE OF THE EVIDENCE THAT CLAIMS 1-6, 10, AND 14-17 ARE OBVIOUS OVER ZHANG, ZHAO AND OWEN

Regarding limitation [1g], Petitioner relies on Zhang's statement that "a volume of the buoyancy cavity 1111 may be preset" to argue that Zhang discloses a volume threshold that inherently requires the pump to stop working after a predetermined time to prevent overinflation or damage to the buoyancy cavity. Pet.,

68. Using this as a backdrop, Petitioner relies upon the same assumption that Zhang discloses a constant flow rate of gas to achieve the "preset volume." Pet., 68.

First, a preset volume of the cavity *itself* does NOT mean a preset volume of gas in the cavity. Zhang explicitly states that: "[t]he *volume of the gas* in the buoyancy cavity 1111 may be *adjusted* by the buoyancy force adjustment member …" and "the *volume of gas* and/or liquid inside the buoyancy cavity 1111 *can be adjusted* by a movement of the piston assembly inside the buoyancy cavity 1111." EX1009, 5:59-60; 6:36-38 (emphasis added.).

Second, the above theory fails because Dr. Cowan himself admits the formula's critical limitation that the flow rate of gas is not constant throughout the inflation process because of backpressure. EX1003, ¶453 ("A POSITA would understand that when an airbag is filled by a pump operating at a constant volumetric flow rate (Q), and while back-pressure remains low (i.e., the bag is still compliant and far below its geometric or pressure limit), the volume (V) of the airbag grows roughly linearly with time (t)"), ¶454 ("As the airbag nears its maximum capacity, the internal pressure rises due to membrane tension and hydrostatic head. This increased back-pressure causes the pump's effective flow rate to decay toward zero, and consequently, the airbag's volume asymptotically approaches a limiting value rather than increasing indefinitely.").

Accordingly, because Petitioner has not shown that flow rate is constant, time does not reliably correspond to volume as alleged in the Petition. Pet. at 68. As a result, a predetermined time cannot reliably achieve a predetermined volume as alleged by the Petitioner because the time-volume relationship is non-linear and varies with pressure conditions. The same real-world uncertainties that defeat the inherency theory in Ground 1—cycle-to-cycle initial-volume drift, battery-voltage droop for the brushed direct-current motors common in small pumps, temperature effects on the enclosed air, and debris or component variation—apply with equal force to this ground. EX2003, ¶¶101-107; EX2005. EX1003, ¶67 ("A POSITA would understand that when an airbag such as that disclosed by Guo is filled by a pump operating at a constant volumetric flow rate (Q), and while back-pressure remains low (i.e., the bag is still compliant and far below its geometric or pressure limit), the volume (V) of the airbag grows ***roughly linearly*** with time (t)."), ¶68 ("As the airbag nears its maximum capacity, the internal pressure rises due to membrane tension and hydrostatic head. This increased back-pressure causes the pump's effective flow rate to decay toward zero"). Petitioner's proposed combination of Zhang and Owen therefore fails for at least this additional reason.

Moreover, Zhang's control is affirmatively sensor-based: the processor acts when the air inlet is detected to be exposed to air. EX1009, 7:34-44; 8:13-36. That closed feedback loop already accomplishes shutoff when the target condition is

sensed, leaving no problem for Owen's user-convenience timer to solve; a POSITA would view superimposing a blind timer on Zhang's sensor logic as introducing a failure mode—premature or delayed shutoff contradicting the sensed state—not an improvement. EX2003, ¶¶127, 129-132.

Petitioner's generic motivation, untethered to Zhang's actual architecture, cannot sustain the combination. *ActiveVideo Networks, Inc. v. Verizon Commc'ns*, Inc., 694 F.3d 1312, 1328 (Fed. Cir. 2012). Dr. Cheng further explains that in depth-based control a post-target countdown promotes overinflation and battery waste while a pre-target countdown promotes undershoot, and in waterline-based control the timer cannot even start until the inlet is detected out of water — at which point the pump should simply stop. EX2003, ¶¶127, 132.

In addition, the floating-state deficiency detailed in Ground 1 applies equally here: Zhang discloses no sealed, pump-off floating state distinct from the pump-on floating working state, so the claimed two-state structure is absent from the Zhang-based combination as well. EX2003, ¶¶91-92.

Further, the motivation deficiencies detailed in Ground 1 apply with equal force to this combination: Owen is not analogous art to submerged autonomous cleaning robots (EX2003, ¶¶125-126); the overinflation rationale fails because a POSITA concerned with overinflation had familiar sensor-based alternatives — pressure sensing, pump-current monitoring, or a relief valve — and Petitioner offers

no reason to select a blind countdown (EX2003, ¶¶129, 131); and the Petition never explains how Owen's timer would actually be integrated into Zhang's sensor-affirmative control scheme (EX2003, ¶126).

The cycle-variability analysis of Ground 1 likewise applies to Zhang: Zhang's device begins each surfacing cycle at a non-zero, environmentally dependent airbag volume, so no preset time reliably corresponds to a target volume. EX2003, ¶131.

As such the combination of Zhang, Zhao and Owen fails to teach at least limitation [1g].

Therefore, independent claims 1 and 15 are not shown obvious under this Ground. Accordingly, the dependent claims are patentable for at least the same reasons stated above for the independent claims 1 and 15, and for additional features recited therein. For example, claims 2 and 16 are also patentable for the reasons stated under Ground 1.

As such, Petitioner has not established by a preponderance of the evidence that claims 1-6, 10, and 14-17 are unpatentable under Ground 3.

X. GROUND 4: PETITIONER HAS NOT ESTABLISHED BY A PREPONDERANCE OF THE EVIDENCE THAT CLAIMS 1-8, 10-13 AND 15-19 ARE OBVIOUS OVER GUO, ZHAO AND OWEN

First, regarding limitation [1g], Petitioner alleges that "Guo itself notes that the airbag material … requires protection against puncture," citing EX1010, ¶37,

and therefore "a POSITA would have found it obvious to control the inflation/deflation device so that, once the robot entered a floating state, the system would automatically stop after a predetermined amount of time to prevent overinflation and material stress." Pet., 93. This completely mischaracterizes Guo. Instead, Guo's Paragraph 37 states that the airbag is protected from ***being punctured by foreign objects*** through the use of a protective sleeve positioned over the airbag. EX1010, ¶37 ("A protective cover … is sleeved over the airbag 121…. Since the material of the airbag 121 is relatively soft, the protective cover can effectively prevent the airbag 121 from being punctured by foreign objects.").

Second, Petitioner alleges that because Guo emphasizes "precise control of gas content" in each airbag, a timer is inherently required. Pet., 93. This again is a mischaracterization of Guo and does not meet the requirements for showing inherency. Guo's disclosure of "more precise control of the gas content in each airbag" refers to having individually controlled airbags rather than multiple airbags connected to a single inflation/deflation device. EX1010, ¶39 ("each airbag 121 is individually connected to an inflation/deflation device 122, and each inflation/deflation device 122 independently controls the inflation or deflation of each airbag 121. This allows 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."). In other words, the precision referenced by Petitioner comes from

independent control of each airbag so that the speed of the robot can be controlled better.

Third, Guo discloses a sealed internal gas circulation system that operates differently from open-air inflation systems. In particular, in Guo, the air comes from the ***sealed driving cabin*** inside the robot and not from the external atmosphere. EX1010, ¶19 ("Compared with the prior art, in the swimming pool cleaning robot of the present disclosure, the airbag is connected to the driving cabin via the inflation/deflation device, and the driving cabin of the swimming pool cleaning robot serves as the gas source for the floating and diving assembly."), ¶19 ("When it is necessary to control the robot to surface, the inflation/deflation device draws gas from the driving cabin into the airbag. When it is necessary to control the robot to dive, the inflation/deflation device discharges gas from the airbag into the driving cabin."). Therefore, Guo implements a closed-loop system in which gas is transferred between the airbag and the sealed driving cabin. This closed-loop system is fundamentally different from an open-air system that Owen employs for air mattress inflation. Moreover, Petitioner's alleged risk of Guo's airbags overinflating is not feasible due to the existence of a finite amount of gas in Guo's closed-loop gas circulation system. Because no additional gas is created, the amount of gas inside Guo's system is finite. Therefore, Guo's system is not prone to overinflation like Owen's open-air mattress system.

The Owen-related deficiencies detailed in Ground 1 apply equally here: Owen is not analogous art; the alleged overinflation motivation of Owen is unavailable on Guo's own architecture; sensor-based alternatives foreclose any reason to select a countdown; and the Petition supplies no integration specifics for adding Owen's timer to Guo's sealed circulation. EX2003, ¶¶61-65, 69-72, 83, 86.

Petitioner also alleges that "Zhao teaches that the robot ascends to the surface, detects its floating position, **maintains balance at the waterline for a predetermined time**, and then submerges to resume cleaning." Pet., 94. But maintaining balance at the waterline for a predetermined time at best means floating (in a floating state) for a predetermined time, which is different from inflating (in the floating working state) for a predetermined time. As discussed above, the pump-off "floating state" is distinct from the pump-on "floating working state." Unlike limitation [1g] that uses a predetermined time to transition from the "floating working state" to another state (e.g. the "floating state"), Zhao uses a predetermined time to transition from the "floating state" to a "sinking working state." *See*, EX1012, 6:28-31 ("when the pool cleaning robot stays for more than a predetermined time period, the timing is stopped and the pool cleaning robot moves to underwater"). Therefore, Zhao cannot remedy the deficiencies of Guo and Owen.

Dr. Cheng confirms by conservation of mass that the total gas in Guo's sealed system is fixed—the airbag cannot receive more gas than the driving cabin holds—

so the runaway-overinflation risk motivating Owen's timer cannot arise in Guo's architecture. EX2003, ¶¶122-124, 140. A motivation premised on a problem the primary reference cannot experience is no motivation at all. *Polaris Indus., Inc. v. Arctic Cat, Inc.*, 882 F.3d 1056, 1069 (Fed. Cir. 2018). The integration-specificity deficiency identified in Ground 1 applies with equal force to Ground 4's proposed combination. EX2003, ¶¶75-85.

As such the combination of Guo, Zhao and Owen fails to teach at least limitation [1g].

Therefore, independent claims 1 and 15 are not shown obvious under this Ground. Accordingly, the dependent claims are patentable for at least the same reasons stated above for the independent claims 1 and 15, and for additional features recited therein. For example, claims 2, 13 and 16 are also patentable for the reasons stated under Ground 1; and claims 8 and 12 are also patentable for the reasons stated under Ground 2.

As such, Petitioner has not established by a preponderance of the evidence that claims 1-8, 10-13, and 15-19 are unpatentable under Ground 4.

XI. GROUND 5: PETITIONER HAS NOT ESTABLISHED BY A PREPONDERANCE OF THE EVIDENCE THAT CLAIMS 1-14 ARE INDEFINITE

Petitioner alleges that "main control unit" is a means-plus-function limitation under § 112(f) and that the specification does not adequately describe its structure. Pet., 112. This argument fails because "control unit" has a well-established structural meaning in the field of robotics and embedded systems.

"Control unit" connotes definite structure. Unlike abstract nonce words such as "module," "mechanism," or "element," the term "control unit" has concrete structural meaning to engineers working in robotics. See, e.g., EX2002, 112 (definition of "control unit"). A POSITA would immediately understand "control unit" to refer to a processor, microcontroller, or equivalent control circuitry. EX2003, ¶¶26-40, 154-156. The asserted references confirm this understanding: each implements its control functions with the same familiar class of hardware — processors, memory, connection points for sensors and actuators, and associated circuitry. EX2003, ¶¶154-156.

Further, Petitioner concedes 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." Pet., 114. This admission is fatal to the indefiniteness argument. If a POSITA understands "main control unit" to mean a processor or controller, then the term does connote structure. Petitioner cannot simultaneously argue that "main control unit" is structureless while admitting that a POSITA would understand it to mean a processor.

Indeed, Petitioner applies exactly that processor construction throughout Grounds 1–4, mapping the processors of Wang, Zhang, and Guo onto the term without difficulty. A term consistently applied by Petitioner, its expert, and the asserted references informs a POSITA of the claim scope with reasonable certainty. *Nautilus, Inc. v. Biosig Instruments, Inc.*, 572 U.S. 898, 910 (2014); cf. Intel Corp. v. Qualcomm Inc., 21 F.4th 801, 813 (Fed. Cir. 2021). And even if § 112(f) applied, claims 1–14 would remain definite because the specification discloses the step-by-step operational logic—the algorithm—by which main control unit 10 performs each recited function: rotating in situ to measure distances L1–L4 and selecting the nearest wall, EX1001, 11:31-41, Fig. 7; triggering waterline detection upon the posture detection unit sensing the first predetermined condition, EX1001, 9:31-38; commanding the inflation and deflation subunit and switch subunit into the floating working state upon outlet-water or proximity detection, EX1001, 8:29-54; 9:1-8; and closing both subunits upon re-entry detection, posture change, or expiry of the predetermined time, EX1001, 9:5-18; 9:41-47. An algorithm may be disclosed "in any understandable terms including as a mathematical formula, in prose, or as a flow chart." *Finisar Corp. v. DirecTV Grp., Inc.*, 523 F.3d 1323, 1340 (Fed. Cir. 2008). Petitioner cannot have it both ways: a term definite enough to map onto the prior art's controllers for purposes of obviousness is definite enough to inform a POSITA of its scope. EX2003, ¶¶156-158.

XII. GROUND 6: PETITIONER HAS NOT ESTABLISHED BY A PREPONDERANCE OF THE EVIDENCE THAT CLAIM 4 IS INDEFINITE

Petitioner alleges that "distance measurement unit" is a means-plus-function limitation under § 112(f) and that the specification does not adequately describe its structure. Pet., 114. This argument fails for the same reasons as Ground 5: "distance measurement unit" connotes definite structure to a POSITA, particularly when viewed in light of the teachings of the '196 patent.

Further, the intrinsic record confirms the structural character of the term. The specification discloses the distance measurement unit's complete operating procedure: the unit "performs distance measurement to control the swimming pool robot 1 to find the nearest side wall or slope," with the robot "rotat[ing] once in situ" to detect the distances L1–L4 between the robot and each side wall and selecting the nearest. EX1001, Fig. 7. The specification further configures the functionally analogous ranging subunits of the same robot with "an ultrasonic ranging device." EX1001, 8:38-40; 8:45-47. A POSITA in the field of robotics and autonomous systems reading the '196 patent would understand a "distance measurement unit" to refer to the well-known sensing devices disclosed therein (e.g., an ultrasonic ranging device). EX2003, ¶¶164-166.

XIV. CONCLUSION

For each of the foregoing reasons, Petitioner has not carried its burden of proving any challenged claim unpatentable by a preponderance of the evidence. Patent Owner respectfully requests that the Board confirm the patentability of claims 1–19 of the ’196 patent. Should the Board nonetheless find any original claim unpatentable, Patent Owner respectfully refers the Board to its concurrently filed contingent motion to amend.

Date: August 11, 2026

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CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that this Patent Owner's Response complies with the type-volume limitation of 37 C.F.R. § 42.24(b) because it contains 12,431 words, excluding the parts of the paper exempted by 37 C.F.R. § 42.24, within the 18,700-word limit applicable to responses to post-grant review petitions.

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 42.6(e) and 42.205, the undersigned certifies that on Date: August 11, 2026 a complete copy of the foregoing Patent Owner's Response and all supporting exhibits were served electronically on the following Petitioner's counsel of record:

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