

Petition for *Inter Partes* Review of
U.S. Patent No. 6,671,648 B2

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NINTENDO CO., LTD., and
NINTENDO OF AMERICA INC.,
Petitioners

v.

AMERICAN GNC CORPORATION,
Patent Owner

Case No. IPR2024-00668
U.S. Patent No. 6,671,648 B2
Issue Date: December 30, 2003

Title: Micro Inertial Measurement Unit

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 6,671,648 B2**

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List of Exhibits

Exhibit No.	Description of Document
1001	U.S. Patent No. 6,671,648 B2 to Hiram McCall, et al. (filed Oct. 22, 2001, issued Dec. 30, 2003) (“’648” or “’648 patent”)
1002	Declaration of Darrin Young, Ph.D.
1003	U.S. Patent No. 4,675,820 to Jeffrey T. Smith, et al. (filed Apr. June 14, 1984, issued June 23, 1987) (“Smith”)
1004	U.S. Patent No. 4,424,038 to Paul Tingleff, et al. (filed Apr. Jan. 31, 1980, issued Jan. 3, 1984) (“Tingleff”)
1005	U.S. Patent No. 6,058,778 to Tsiu Chiu Chan (filed October 24, 1997, issued May 9, 2000) (“Chan”)
1006	U.S. Patent No. 5,203,208 to Jonathan J. Bernstein (filed April 29, 1992, issued April 20, 1993) (“Bernstein”)
1007	Excerpts from J. David Irwin et al., <i>Introduction to Electrical Engineering</i> (1995) (“Irwin”)
1008	Excerpts from Shmuel Merhav, <i>Aerospace Sensor Systems and Applications</i> (1996) (“Merhav”)
1009	Japanese Patent Application JPH07313649A to Yuichiro Yamawaki et al. (filed May 27, 1994, published December 5, 1995)
1010	Certified English Translation of Exhibit 1009
1011	U.S. Patent No. 4,820,953 to Malcolm Saubolle et al. (filed November 23, 1987, issued April 19, 1989) (“Saubolle”)
1012	Excerpts from <i>IEEE Standard Dictionary of Electrical and Electronics Terms</i> (1996)
1013	U.S. Patent No. 5,396,797 to Rand H. Hulsing, II (filed December 8, 1992, issued March 14, 1995) (“Hulsing”)

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List of Exhibits

Exhibit No.	Description of Document
1014	U.S. Patent No. 5,841,537 to James H. Doty (filed August 11, 1997, issued November 24, 1998) (“Doty”)
1015	Prosecution history of U.S. Patent No. 6,671,648 B2
1016	Affidavit of Service in <i>American GNC Corp. v. Nintendo Co., Ltd et al.</i> , ECF No. 10, Case No. 2:23-cv-00302 TL (W.D. Wash.)
1017	Order on Motion to Dismiss in <i>American GNC Corp. v. Nintendo Co. Ltd. et al.</i> , ECF No. 38, Case No. 2:23-cv-00302 TL (W.D. Wash January 10, 2024)
1018	AGNC’s Opening Claim Construction Brief in <i>American GNC Corp. v. ZTE (USA) Inc. et al.</i> , ECF No. 111, Case No. 17:cv-00620-ALM-KPJ (E.D. Tex. February 21, 2018)
1019	AGNC’s Opening Claim Construction Brief in <i>American GNC Corp. v. Oneplus Technology (Shenzhen) Co., Ltd.</i> , ECF No. 55, Case No, 6:20-cv-00171-ADA (W.D. Tex. March 2, 2021)
1020	AGNC’s Opening Claim Construction Brief in <i>American GNC Corp. v. LG Electronics Inc. et al.</i> , ECF No. 92, Case No. 17-cv-0190-BAS-BLM (S.D. Cal. January 30, 2018)
1021	Declaration of Ingrid Hsieh-Yee, Ph.D.
1022	Additional pages from J. David Irwin et al., <i>Introduction to Electrical Engineering</i> (1995) (not included with EX1007)
1023	Additional pages from Shmuel Merhav, <i>Aerospace Sensor Systems and Applications</i> (1996) (not included with EX1008)

Petitioner respectfully requests institution of *inter partes* review (IPR) of claims 1 and 4 of U.S. Patent No. 6,671,648 B2 (“’648 patent”), as shown below.

I. MANDATORY NOTICES UNDER §42.8(A)(1)

A. Real Party-In-Interest Under §42.8(b)(1)

Nintendo Co., Ltd. and Nintendo of America Inc. (collectively, “Petitioner”) are the real parties-in-interest to this IPR petition.

B. Related Matters Under §42.8(b)(2)

The ’648 patent is the subject of the following pending litigation involving Petitioner: *American GNC Corporation v. Nintendo Co.*, No. 2:23-cv-00302-TL (W.D. Wash.). Petitioner was served on March 8, 2023. (EX1016.)

The ’648 patent was formerly the subject of the following actions, which did not involve Petitioner: *American GNC Corporation v. ZTE Corporation.*, No. 4:17-CV-00620 (E.D. Tex.) (terminated September 12, 2018), *American GNC Corporation v. ZTE Corporation.*, No. 2:17-cv-00107 (E.D. Tex.) (terminated September 5, 2017), *American GNC Corporation v. LG Electronics Inc.*, No. 2:17-cv-00119 (E.D. Tex.) (terminated June 17, 2017), *American GNC Corporation v. LG Electronics Inc.*, No. 3:17-01090 (S.D. Cal.) (terminated February 20, 2019), *American GNC Corporation v. GoPro, Inc.*, No. 3:18-cv-00968 (S.D. Cal.) (terminated November 6, 2018), *American GNC Corporation v. GoPro, Inc.*, No. 4:18-cv-06778 (N.D. Cal.) (terminated February 19, 2019), *American GNC*

Corporation v. OnePlus Technology (Shenzhen) Co., Ltd., No. 6:20-cv-00171 (W.D. Tex.) (terminated June 23, 2021).

C. Lead and Back-Up Counsel under §42.8(b)(3)

Petitioner provides the following designation of counsel.

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D. Service Information

This Petition is being served by Federal Express to the attorneys of record for the '648 patent, DAVID AND RAYMOND PATENT FIRM, 108 N. Ynez Ave., Suite 128, Monterey Park, CA 91754. This Petition is also being served on litigation counsel identified in the Certificate of Service. Petitioner consents to electronic service at the addresses provided above for lead and back-up counsel.

E. Power of Attorney

Filed concurrently per 37 C.F.R. § 42.10(b).

II. FEE PAYMENT

Petitioner requests review of two claims, with a \$41,500 payment.

III. REQUIREMENTS UNDER §§ 42.104 AND 42.108 AND CONSIDERATIONS UNDER §§ 314(A) AND 325(D)

A. Standing

Petitioner certifies that the '648 patent is available for IPR and that Petitioner is not barred or otherwise estopped.

B. Identification of Challenge

Petitioner requests institution of IPR based on the following grounds:

Ground	Claims	Basis under §103
1	1	Smith (EX1003), in view of Chan (EX1005), and Bernstein (EX1006)
2	4	Ground 1 Prior Art, in further view of Irwin (EX1007) and Merhav (EX1008)
3	1, 4	Tingleff (EX1004), in view of Chan and Bernstein
4	1, 4	Yamawaki (EX1009/1010), in view of Chan, Bernstein, and Saubolle (EX1011)

Submitted herewith the Declaration of Darrin J. Young (**EX1002**) (“Young”), a qualified technical expert. (EX1002, ¶¶1-9.)

C. §§314 and 325(d)

No basis exists under either §314(a) or §325(d) for discretionary denial.

§314(a): The *General Plastic* factors do not apply because Petitioner has not previously filed an IPR petition against the '648 patent. With respect to the *Fintiv* factors, the pending litigation is in early stages and no claim construction rulings have issued. A trial date has been set for May 19, 2025. Mindful of the Board's

limited resources, this Petition challenges only two claims, corresponding to the claims asserted in the litigation. To allay concerns regarding duplication of efforts, Petitioner provides a *Sotera* stipulation that, in the event of IPR institution, Petitioner will not pursue in district court any grounds of invalidity against the challenged claims that were or reasonably could have been asserted in IPR.

§325(d): None of the prior art cited in the grounds identified in **Part III.B** above was previously presented during prosecution.

IV. OVERVIEW OF THE '648 PATENT

A. Level of Ordinary Skill in the Art

A skilled artisan would have possessed a bachelor's degree in electrical engineering or similar degree, with two to three years of practical experience designing and/or implementing systems that include sensors for measuring movement, such as acceleration and rotational position. (EX1002, ¶¶12-15.) A skilled artisan could also have had more formal education and less practical experience, or vice versa. (*Id.*, ¶14.)

B. Specification Overview

The '648 patent states that it “relates to motion measurement, and more particularly to a motion inertial measurement unit in micro size that can produce highly accurate, digital angular increments, velocity increments, position, velocity, attitude, and heading measurements of a carrier[.]” ('648, 1:11-16.) The patent acknowledges that inertial measurement units (IMUs) were well-known, and

explains that an IMU “is employed to determine the motion of a carrier” by relying on “three orthogonally mounted inertial angular rate producers and three orthogonally mounted acceleration producers to obtain three-axis angular rate and acceleration measurement signals.” (*Id.*, 1:18-23.) The patent further provides examples of “conventional IMUs,” such as the Platform IMU and Strapdown IMU, which are used to obtain attitude and attitude rate measurements by employing angular rate producers and acceleration producers. (*Id.*, 1:28-44.)

Figure 1 below shows an IMU according to one embodiment:

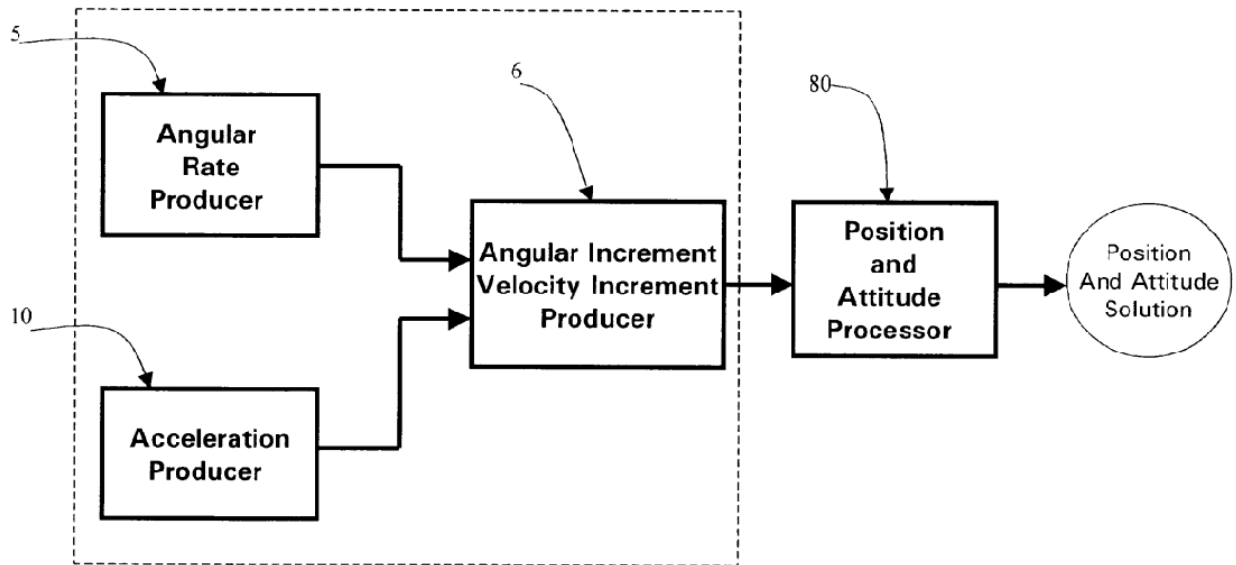


Figure 1

(’648, Fig. 1.)

The IMU above “comprises an angular rate producer 5 for producing three-axis (X axis, Y axis and Z axis) angular rate signals; an acceleration producer 10 for

producing three-axis (X-axis, Y axis and Z axis) acceleration signals; and an angular increment and velocity increment producer **6** for converting the three-axis angular rate signals into digital angular increments and for converting the input three-axis acceleration signals into digital velocity increments.” (’648, 6:61-7:3.) In one embodiment, “the output of the angular rate producer **5** and the acceleration producer **10** are analog voltage signals.” (*Id.*, 8:11-13.) Furthermore, “[t]he three-axis analog angular rate voltage signals produced from the angular producer **5** are directly proportional to carrier angular rates, and the three-axis analog acceleration voltage signals produced from the acceleration producer **10** are directly proportional to carrier accelerations.” (*Id.*, 8:13-18.)

V. CLAIM CONSTRUCTION

Petitioner has identified one issue of claim construction potentially relevant to the present Petition, *i.e.*, whether the claim 1 preamble is limiting. As fully explained in **Part VII.C.1** below, it is not. But even if the preamble is found to be limiting, it is still obvious over the cited prior art as explained in **Part VII.C**. Other than the issue involving the preamble, Petitioner does not believe any terms require express construction at this time.

VI. THE CHALLENGED CLAIMS ARE UNPATENTABLE.

A. Overview of the Grounds of Unpatentability

The challenged claims of the ’648 patent attempt to lay claim to inertial measurement units (IMUs) that were in widespread use and well-known decades

before the '648 patent was filed. It was well-known and admitted prior art in the '648 patent that IMUs existed that included gyroscopes and accelerometers to measure, respectively, the change of angular rate and the change in velocity along three axes (*e.g.*, X, Y, or Z axes). The IMU recited in the claims adds nothing of patentable significance to the admitted prior art.

Smith (EX1003), Tingleff (EX1004) and Yamawaki (EX1009/1010) all disclose IMUs remarkably similar to the one later claimed in the '648 patent, each having gyroscopes and accelerometers for the X, Y, and Z axes that output signals used to determine changes in angular rate and velocity. (EX1002, ¶¶47-51, 56-58, 61-64.) All grounds further cite to Chan (EX1005) and Bernstein (EX1006), in the event the preamble of claim 1 is found to be limiting. As explained in **Part VI.C.1** below, the preamble is not limiting but even if it was, Chan and Bernstein confirm that a “micro inertial measurement unit,” as recited in the preamble, was known. (EX1002, ¶¶67-68, 71, 94-97.) **Ground 4** cites to Saubolle (EX1008) to provide a motivation to combine with Yamawaki, and **Ground 2** cites Irwin (EX1007) and Merhav (EX1008), for dependent claim 4. (EX1002, ¶¶82-84, 74, 77-79.)

B. Date Qualification of Prior Art

Each of the relied-upon references qualifies as prior art under pre-AIA rules. Smith, Tingleff, and Bernstein qualify as prior art under at least §102(b) because they are patents that issued more than one year before the earliest application to

which the '648 patent claims priority. Chan qualifies as prior art under at least §102(e) because it issued from an application filed before the earliest application for the '648 patent. Irwin and Merhav qualify as prior art printed publications under at least § 102(b), as evidenced by their availability in public libraries. (EX1021, ¶¶18, 20-32 (Irwin), 33-45 (Merhav).)

Yamawaki qualifies as prior art under at least § 102(b) because it is a Japanese patent application published more than one year before the earliest application for '648 patent. Because Yamawaki (EX1009) was originally published in Japanese, Petitioner has provided a certified English translation (EX1010). All citations to Yamawaki below refer to the certified translation.

Petitioner has cited other documents (EX1012-1014), not to supply limitations missing from the prior art but to confirm the knowledge and understanding of a skilled artisan. These references nevertheless qualify as prior art because they were published before the earliest application for the '648 patent.

C. Ground 1: Claim 1 Is Obvious Over Smith in View of Chan and Bernstein.

1. Independent Claim 1

The preamble recites “[a] micro inertial measurement unit.”

The preamble is not limiting. The Federal Circuit has “long ruled that ‘a preamble is not limiting ‘where a patentee defines a structurally complete invention in the claim body and uses the preamble only to state a purpose or intended use for

the invention.”” *Arctic Cat Inc v. GEP Power Prods., Inc.*, 919 F.3d 1320, 1328 (Fed. Cir. 2019) (quoting *Catalina Mktg. Int'l, Inc. v. Coolsavings.com, Inc.*, 289 F.3d 801, 808 (Fed. Cir. 2002)). Here, the limitations in the body of claim 1, *i.e.*, limitations 1[a] through 1[c] addressed below, define a structurally complete invention comprising, respectively, an “**angular rate producer**,” “**acceleration producer**,” and “**angular increment and velocity increment producer**,” each fully reciting its respective components and purposes without relying on anything recited in the preamble. None of the claim limitations rely on the preamble to provide antecedent basis for any element of claim 1.

The preamble consists of five words, *i.e.* “[a] **micro inertial measurement unit**,” that merely recite the intended purpose or use of the invention. As in *Arctic Cat* and *Catalina*, which found preambles to be non-limiting that were more extensive than the preamble here, “deletion of the disputed phrase from the preamble... [would] not affect the structural definition or operation of the [invention] itself.” *Arctic Cat, supra*, 919 F.3d at 1329 (quoting *Catalina*, 289 F.3d at 810). Had Patent Owner written the preamble to simply recite “[a] **unit comprising**,” or “[a] **system comprising**,” that would have had no impact on the limitations in the body of the claim, and would not have made the invention described in the body of the claim less complete. (EX1002, ¶88.)

Patent Owner also did not rely on the preamble to distinguish prior art during

prosecution. The prosecution history, in fact, generated only a single Office Action rejection based on double-patenting grounds. (EX1015 at 0114-0125.) The Board should therefore hold that the preamble is not limiting.

Nevertheless, even if the preamble is limiting, it is rendered obvious by Smith, which discloses the claimed “**inertial measurement unit**” in view of Chan and Bernstein which render obvious a “**micro**” inertial measurement unit.

Starting with Smith, it discloses an “**inertial measurement unit**” that includes inertial sensor assembly (ISA) 12 and P1 processor 14, both depicted in Figure 1 below:

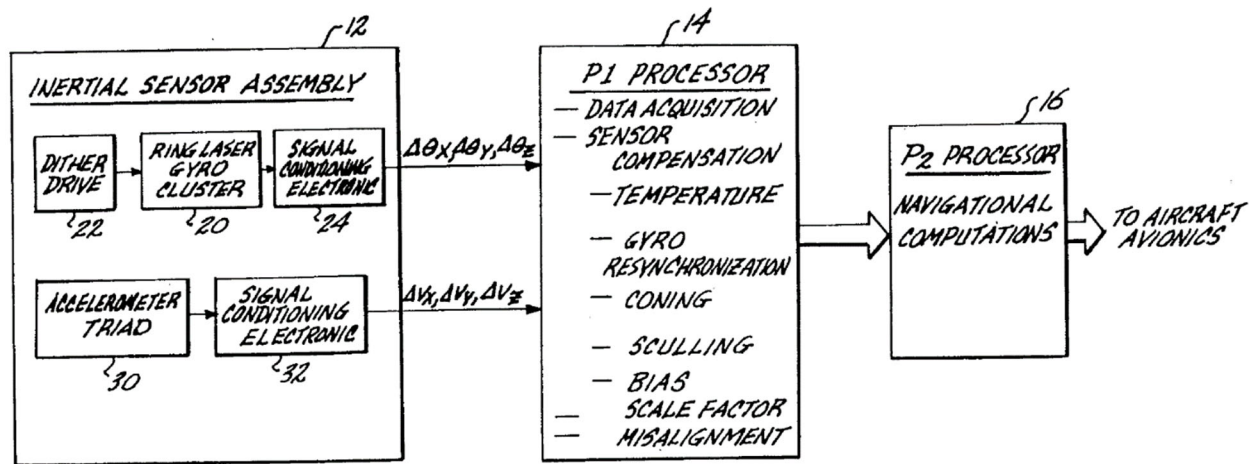


Fig. 1.

(Smith, Fig. 1.)

ISA 12 on the left “contains the positional sensors,” which include “a cluster of three ring laser gyros 20,” each of which is “mounted with its sensitive axis normal to one of three mutually orthogonal coordinate axes X, Y, and Z.” (Smith,

5:60-65.) ISA **12** also includes “accelerometer triad **30**,” which includes “three accelerometers, each having its sensitive axis aligned with one of the three mutually orthogonal coordinate axes X, Y, and Z.” (*Id.*, 6:15-18; EX1002, ¶90.)

Smith explains that the purpose of the ISA is to measure and output the changes in angular position and velocity along the X, Y, and Z axes:

Briefly, according to the invention, an inertial reference system comprises an inertial sensor assembly. The inertial sensor assembly includes gyros for producing asynchronous output signals $\Delta\theta_x$, $\Delta\theta_y$, and $\Delta\theta_z$ representative of the change in angular position of the inertial sensor assembly with respect to three mutually orthogonal coordinate axes X, Y, and Z, respectively. Also provided in the inertial sensor assembly are accelerometers for producing output signals ΔV_x , ΔV_y , and ΔV_z representative of the change in velocity of the inertial sensor assembly in the X, Y, and Z coordinate axes, respectively

(Smith, 3:7-18.)

The signals from ISA **12** are output to P1 processor **14**, shown in the middle of Figure 1 above. (Smith, 3:19-20.) P1 processor **14**, as explained in the discussion of limitation 1[c] below, includes gyroscope and accelerometer counters that accumulate and count $\Delta\theta$ and ΔV output values obtained from inertial sensor assembly **12**, over a period of time. (Smith, *e.g.*, 3:48-58, 4:29-37, 13:3-12, 13:26-39; EX1002, ¶¶117-121, 128-132.)

Smith thus discloses an “**inertial measurement unit**,” which includes inertial

sensor assembly (ISA) **12** and P1 processor **14**. (EX1002, ¶¶89-92.) Smith's disclosures are consistent with the '648 patent, which states that "three orthogonally mounted inertial angular rate producers and three orthogonally mounted acceleration producers with additional supporting mechanical structure and electronic devices are conventionally called an Inertial Measurement Unit (IMU)." ('648, 1:24-28.) The '648 patent further states that "an inertial measurement unit (IMU) is employed to determine the motion of a carrier." (*Id.*, 1:18-19.) This closely tracks the description in Smith as discussed above, which includes three gyros and accelerometers, mounted orthogonally along the X, Y, and Z axes, that determine the motion of a carrier (*e.g.* aircraft). (Smith, 5:62-65, 6:15-18; EX1002, ¶92.)

"Micro" Inertial Measurement Unit

The preamble further recites a "**micro inertial measurement unit.**" The '648 patent does not expressly define "**micro**" but makes clear that it includes at least known MEMS techniques. ('648, 2:15-51.) MEMS, which stands for Micro-Electro-Mechanical Systems, generally refers to a category of sensors and other components miniaturized using microfabrication techniques similar to those used to construct silicon-based integrated circuits such as microchips. (EX1002, ¶94.) The '648 patent acknowledges that MEMS angular rate sensors and accelerometers were known and commercially available. ('648, 2:25-51.)

Smith discloses that its IMU "may be constructed in a small enclosure"

(Smith, 2:57-58), but does not expressly disclose that it uses MEMS components. Nevertheless, a “**micro inertial measurement unit**” would have been obvious over Smith in view of **Chan** and **Bernstein**. As Chan explains:

Over the years, various microelectromechanical systems (“MEMS”) have arisen which require the necessity to sense temperature, pressure, strain, acceleration, rotation, infrared radiation, chemical properties of liquids and gases, and other physical inputs. Accordingly, various types of microsensors have been developed which receive analog and digital electrical inputs and also sense or measure these other physical inputs, e.g., acceleration, pressure, temperature, strain.

(Chan, 1:12-21 (emphasis added).) Chan further confirms that MEMS-based sensors were already well-known and had been used commercially, with applications including “aircraft monitoring systems for aircraft” that require “small, inexpensive, and reliable acceleration devices.” (*Id.*, 1:33-44.) Chan goes on to disclose an improved acceleration sensor capable of “sensing acceleration in a predetermined direction.” (*Id.*, 3:14-16.)

Turning next to gyroscopes, Bernstein describes micromechanical gyroscopes for measuring angular position along a particular axis. The Background of Bernstein states that “[m]icromechanical gyroscopes which are micromachined from a single silicon substrate are now well known in the art.” (Bernstein, 1:11-13.) Bernstein discloses “a micromechanical gyroscope including a mass symmetrically supported about both drive and sense axes, for detecting rotational movement about an input

axis.” (*Id.*, 1:48-51.) It would have been apparent and obvious that Bernstein discloses a “**micro**,” *e.g.*, MEMS-based, gyroscope. (EX1002, ¶97.)

Rationale and Motivation to Combine (Smith with Chan and Bernstein): It would have been obvious to combine Smith with Chan and Bernstein, predictably resulting in the IMU in Smith adapted to use micromechanical (MEMS-based) accelerometers and gyroscopes, for example, mounted on a printed circuit board using conventional techniques. (EX1002, ¶98.) The proposed combination could have been implemented in a number of straightforward ways. In one example, the accelerometers and gyroscopes in Smith would have been replaced with MEMS accelerometers and gyroscopes, which as confirmed in Chan, Bernstein, and the ’648 patent itself, were known and commercially available. (EX1002, ¶99.) This combination would have been straightforward because MEMS accelerometers and gyroscopes serve the same purposes and provide the same types of velocity and angular position information as non-micromechanical counterparts. (*Id.*; *see also* Bernstein, 2:57-59 (“The operation of the symmetrical, micromechanical gyroscope of the present invention is generally identical to that of prior art gyroscopes.”).)

Petitioner’s reliance on Chan and Bernstein does not depend on the particular details of their allegedly inventive accelerometers and gyroscopes, but on their general disclosures confirming that MEMS-based sensors for sensing acceleration and angular rotation were well-known. (EX1002, ¶99.) As the Background of ’648

patent acknowledges, “MEMS angular rate sensors and MEMS accelerometers are available commercially and have achieved micro chip-size and low power consumption[.]” (’648, 2:47-51.) Smith, Chan and Bernstein are analogous references in the same field as the ’648 patent of devices for measuring motion such as velocity and angular position, and would have been reasonably pertinent to problems facing the inventors. (EX1002, ¶100.)

A skilled artisan would have been motivated to adapt Smith to use MEMS accelerometers and gyroscopes in order to obtain the known benefits of MEMS sensors – reduced size, reduced weight, and reduced power consumption when compared to larger (non-micromechanical) components. (EX1002, ¶101.) This motivation is confirmed by the Background of the ’648 patent, which acknowledges that it was known that “MEMS... inertial sensors offer tremendous cost, size, and reliability improvements for guidance, navigation, and control systems, compared with conventional inertial sensors.” (’648, 2:11-14.)

This motivation is further supported by Smith, which explains that one objective of his invention was to provide an “improved inertial reference system may be constructed in a small enclosure and is designed to minimize the use of expensive components, thereby reducing overall cost.” (Smith, 2:56-59; *see also id.*, 22:35-39.) The use of MEMS accelerometers and gyroscopes would have allowed for construction of a smaller and reduced-cost IMU. (EX1002, ¶¶101, 103.)

The benefits of MEMS-based sensors would also have been applicable in the aviation context discussed in Smith. Chan explains that “[e]xamples of applications for microsensors for acceleration or accelerometers include... in-flight aircraft monitoring systems for aircraft,” which Chan identifies as an example of application that requires “small, inexpensive, and reliable acceleration devices.” (Chan, 1:33-38 (emphasis added).) Several other contemporaneous references from the 1990s further confirm the use of micromachined accelerometers and gyroscopes for use with aircraft. (EX1002, ¶102 (citing EX1013, 1:10-11, 1:36-39, 8:48-50 (disclosing micromachined devices used for measuring angular rate and acceleration in aircraft context) and EX1014, 1:15-36 (explaining that attitude heading reference system (AHRS) for aircrafts “utilize precision solid state inertial sensors,” including among other examples, “silicon micromachined accelerometers” and “micromachined quartz gyros, which are also commercially available.”).) A skilled artisan would thus have appreciated that the benefits of MEMS-based sensors would have applied to aircraft applications. (EX1002, ¶102.) This is also consistent with the Background of the ’648 patent mentioned above, which acknowledges that it was known that MEMS inertial sensors offer improved “guidance, navigation, and control systems, compared with conventional inertial sensors.” (’648, 2:12-15.)

A skilled artisan would have had at least a reasonable expectation of success and could have implemented the combination using conventional techniques without

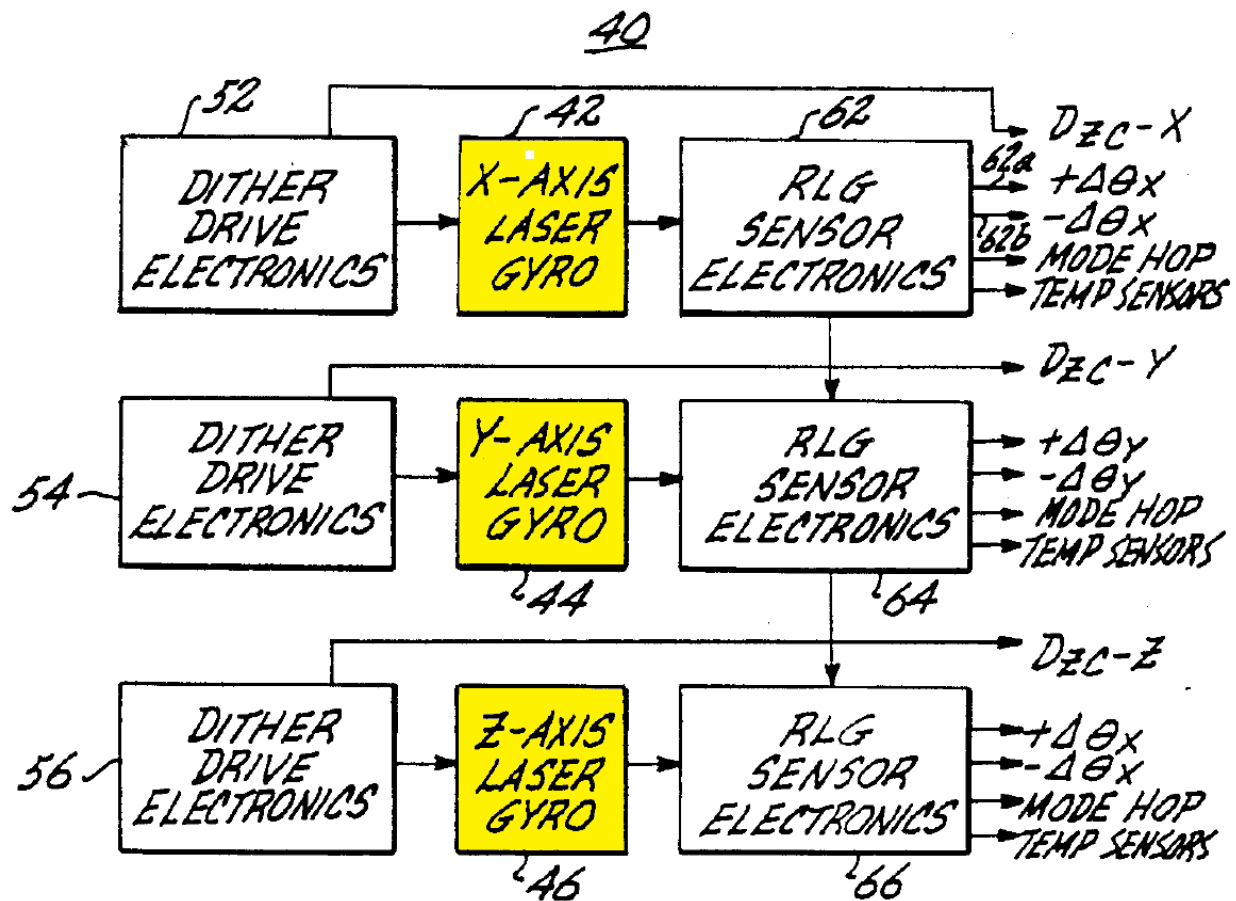
undue experimentation. (EX1002, ¶104.) As noted, the '648 patent itself acknowledges that MEMS inertial sensors were already commercially available. ('648, 2:25-46.) Although use of MEMS components would have required a change in the manufacturing processes of the IMU in Smith, and may have required a change to the signal conditioning electronics to interface the signals provided by the micromechanical replacement gyros and accelerometers, this would have been regarded as a routine implementation to a skilled artisan. (EX1002, ¶99.)

- (a) **“an angular rate producer comprising a X axis angular rate detecting unit which produces a X axis angular rate electrical signal, a Y axis angular rate detecting unit which produces a Y axis angular rate electrical signal, and a Z axis angular rate detecting unit which produces a Z axis angular rate electrical signal;” (1[a])**

Smith discloses **“an angular rate producer”** in the form of a set of three gyroscopes, each detecting the angular position of the inertial measurement unit along one of three axes and producing a corresponding electrical signal.

These gyroscopes are shown in Figure 2:

Fig. 2.



(Smith, Fig. 2 (partial figure; highlighting added).) Figure 2 shows “a cluster, indicated generally at 40, of three ring laser gyros 42, 44, 46, each having its sensitive axis aligned with one of three mutually orthogonal coordinate axes X, Y, and Z, respectively.” (*Id.*, 7:58-62 (highlighting added).) “Each ring laser gyro 42, 44, and 46 produces an output digital signal having a pulse repetition rate proportional to the rate of angular displacement of each gyro 42, 44, and 46 about its coordinate axis.” (*Id.*, 8:3-6 (highlighting added).)

Smith thus discloses “an angular rate producer,” which includes the three

gyroscopes above, thus **“comprising a X axis angular rate detecting unit which produces a X axis angular rate electrical signal, a Y axis angular rate detecting unit which produces a Y axis angular rate electrical signal, and a Z axis angular rate detecting unit which produces a Z axis angular rate electrical signal,”** *i.e.*, respectively, gyros 42, 44, and 46 that each detects angular displacement along the X, Y and Z axis, respectively, and generates an electrical signal proportional to the rate of angular displacement along that axis. The claimed **“electrical signal[s]”** are shown, in Figure 2 above, as the signals transmitted by gyros 42, 44, and 46 to RLG sensor electronics 62, 64, and 66, respectively. (EX1002, ¶¶107-108.) Petitioner’s mapping of this limitation to Smith is consistent with the specification of the ’648 patent, which confirms that “[c]onventional inertial angular rate producers include... Ring Laser Gyros (RLG)” (’648, 1:46-52), which are the type of gyroscopes disclosed in Smith. (EX1002, ¶108.)

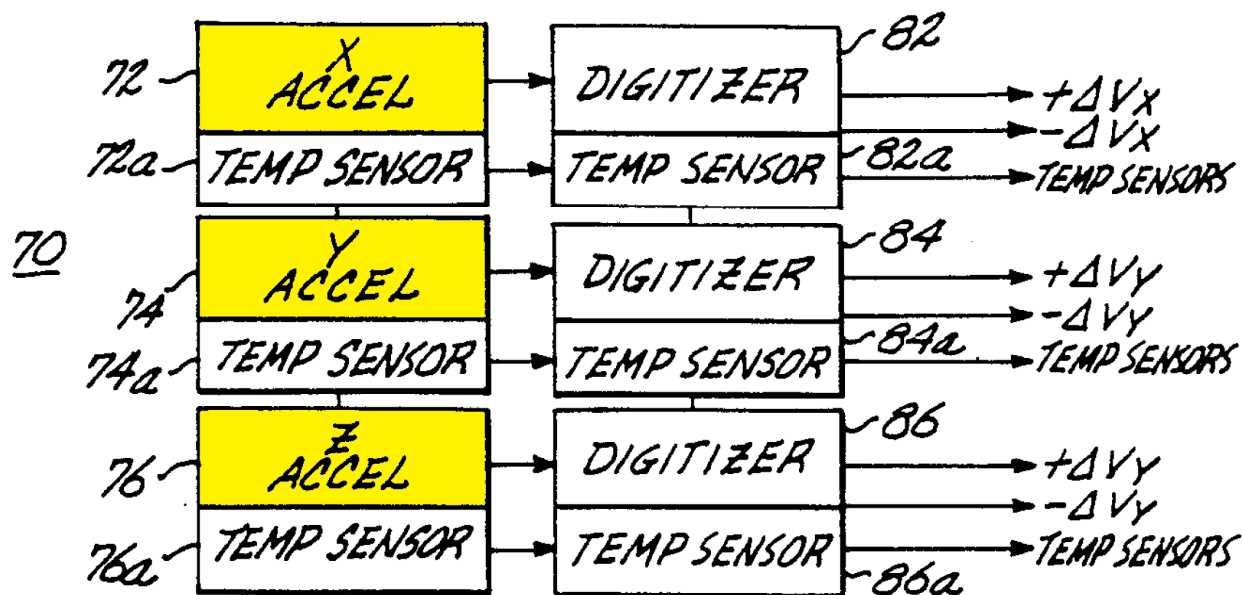
Moreover, to the extent the word **“micro”** in the preamble is limiting, as explained, it would also have been obvious for the ring laser gyros in Smith to have been replaced with micromechanical gyroscopes. (EX1002, ¶109.) Petitioner provided a full explanation of the rationale and motivation to adapt MEMS-based gyroscopes to Smith in the discussion of the preamble. (*Id.*, ¶¶98-104.)

- (b) **“an acceleration producer comprising a X axis accelerometer which produces a X axis acceleration electrical signal, a Y axis accelerometer which produces a Y axis acceleration electrical signal, and a Z axis**

accelerometer which produces a Z axis acceleration electrical signal; and” (1[b])

Smith also discloses “an acceleration producer” in the form of a set of three accelerometers, each detecting acceleration along one of three axes and producing an electrical signal.

These accelerometers are shown in the bottom half of Figure 2:



(Smith, Fig. 2 (partial figure; highlighting added).) Figure 2 above shows “an accelerometer triad, indicated generally at 70,” which “is comprised of three analog accelerometers 72, 74, 76, each having its sensitive axis aligned with one of the three mutually orthogonal coordinate axes X, Y, and Z, respectively.” (Smith, 8:43-48 (highlighting added).) “The analog accelerometers 72, 74, and 76 produce analog output signals corresponding to the rate of change of velocity of each accelerometer along its sensitive axis.” (*Id.*, 8:48-51 (highlighting added).)

Smith thus discloses “**an acceleration producer,**” which includes the three accelerometers shown above, thus “**comprising a X axis accelerometer which produces a X axis acceleration electrical signal, a Y axis accelerometer which produces a Y axis acceleration electrical signal, and a Z axis accelerometer which produces a Z axis acceleration electrical signal,**” *i.e.*, respectively, accelerometers **72**, **74**, and **76** that each detects acceleration (*i.e.*, change of velocity) along the X, Y and Z axis, respectively, and generates an analog electrical signal corresponding to the change of velocity along that axis. The claimed “**electrical signal[s]**” are shown, in Figure 2 above, as the signals transmitted by accelerometers **72**, **74**, and **76** to digitizers **82**, **84**, and **86**, respectively. (EX1002, ¶112.) And as explained above, to the extent the word “**micro**” in the preamble is limiting, it would also have been obvious for the accelerometers in Smith to have been replaced with MEMS accelerometers. (EX1002, ¶¶113, 98-104.)

- (c) “**an angular increment and velocity increment producer, which is electrically connected with said X axis, Y axis and Z axis angular rate detecting units and said X axis, Y axis and Z axis accelerometers, receiving said X axis, Y axis and Z axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals from said angular rate producer and said acceleration producer respectively, wherein said X axis, Y axis and Z axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals are converted into digital angular increments and digital velocity increments respectively.**” (1[c])

Smith also discloses “**an angular increment and velocity increment**

producer,” which corresponds to the components and circuitry in Smith that receive and process the electrical signals from the gyroscopes and accelerometers (discussed for limitations 1 [a]-1 [b] above), to convert them into the claimed digital increments. These components are shown in Figure 1:

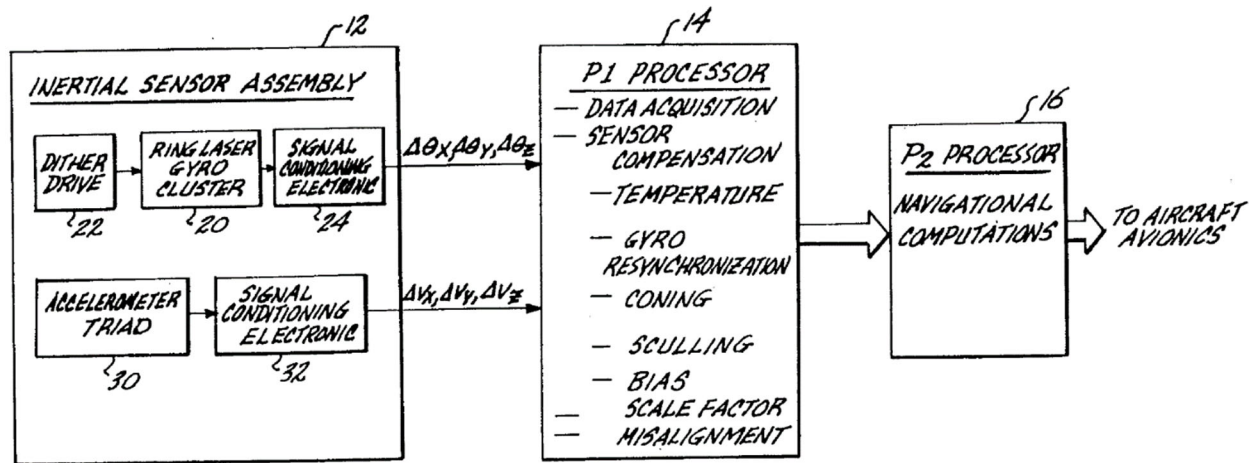


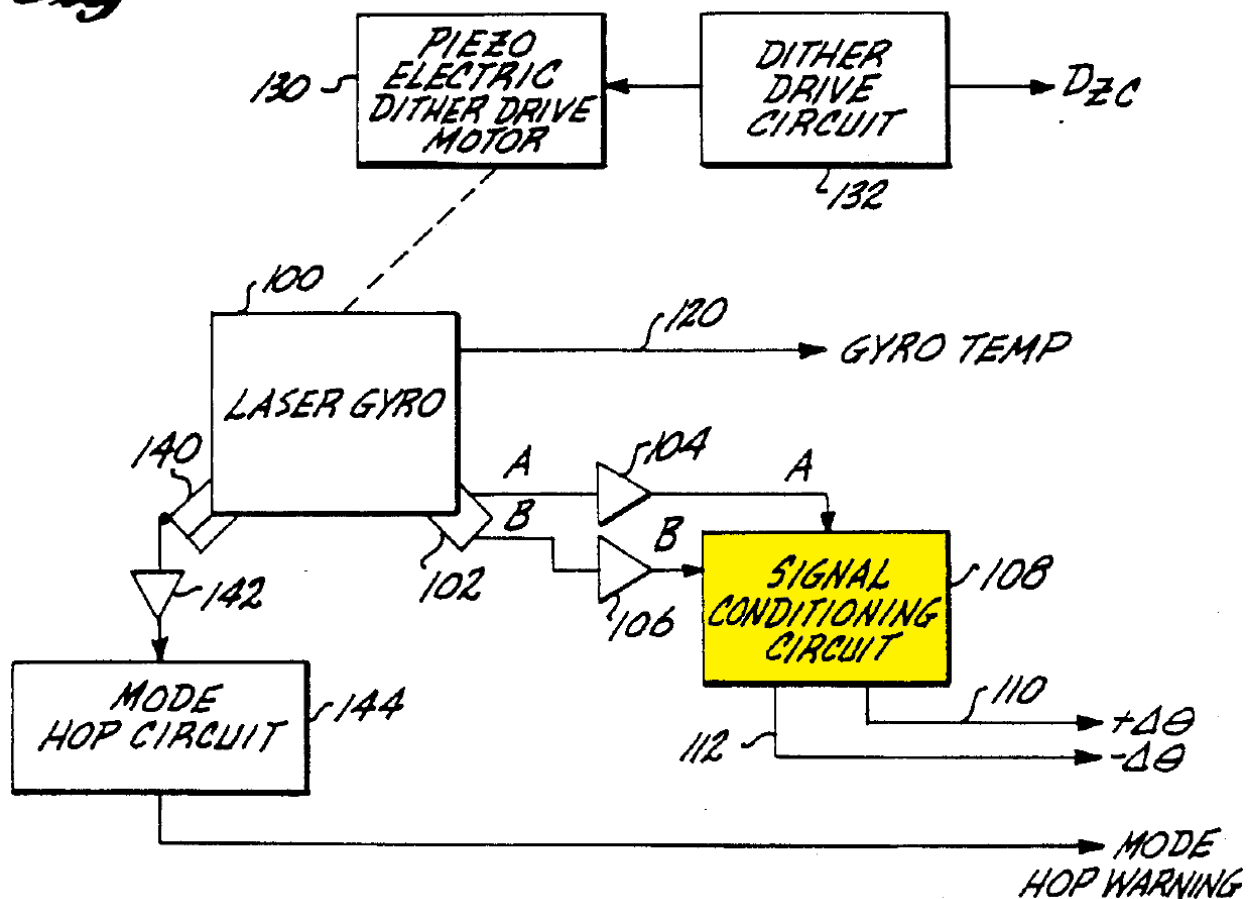
Fig. 1.

(Smith, Fig. 1.)

As discussed below, the claimed “**angular increment and velocity increment producer**” in Smith includes signal conditioning electronics **24** and **32** for the gyroscopes and accelerometers (shown within inertial sensor assembly **12** above), and further includes P1 processor **14** (shown in the middle of Figure 1 above), which accumulates and stores angular and velocity increments ($\Delta\theta$ and ΔV) for the X, Y, and Z axes. Claim 1 recites conversion of the electrical signals from the gyroscopes and accelerometers into “**digital angular increments**” and “**digital velocity increments,**” respectively, so Petitioner will address each below.

Starting with “**digital angular increments**”, Figure 1 above shows ring laser gyro cluster 20, as discussed for limitation 1[a], which includes “**said X axis, Y axis and Z axis angular rate detecting units.**” Figure 1 shows gyro cluster 20 electronically connected to signal conditioning electronics 24. (Smith, 6:9-11.) The signal conditioning electronics are further shown in Figure 3:

Fig. 3.

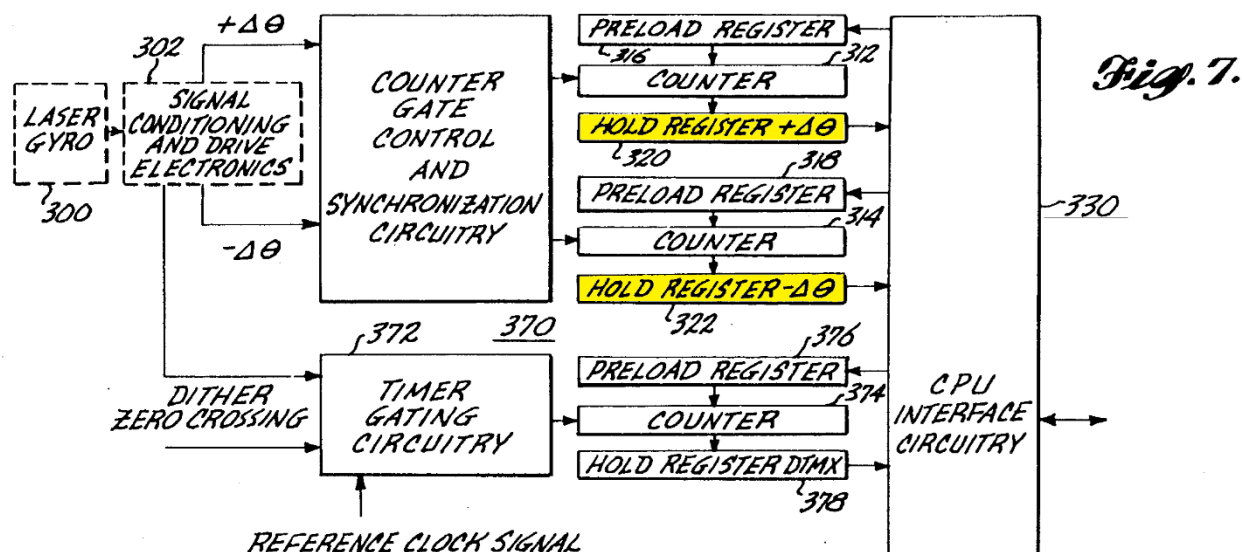


(Smith, Fig. 3 (highlighting added).)

Figure 3 shows “a detailed block diagram illustrating a ring laser gyro and its associated dither drive and output processing circuits.” (Smith, 9:7-9.) Gyro 100 produces “output signal A representative of clockwise rotation of the laser gyro, and

an output signal B representative of counterclockwise laser gyro rotation.” (*Id.*, 9:19-22.) “Signal-conditioning circuit **108** processes the A and B input signals to produce, on a first output line **110**, a signal $+\Delta\theta$ having a pulse repetition rate proportional to the clockwise angular rotation rate of the laser gyro **10** [sic; **100**] in its sensitive axis. On a second line **112**, the signal-conditioning circuit **108** produces an output signal $-\Delta\theta$ having a pulse repetition rate proportional to the counterclockwise angular rotation rate of the laser gyro **100** in its sensitive axis.” (*Id.*, 9:25-33 (highlighting added).) Although Figure 3 shows signal-conditioning electronics for a single gyroscope **100**, these electronics are provided for all three gyroscopes, resulting in three sets of $+\Delta\theta$ and $-\Delta\theta$ signals for the X, Y, and Z axes, *i.e.*, $+\Delta\theta_x$, $-\Delta\theta_x$, $+\Delta\theta_y$, $-\Delta\theta_y$, $+\Delta\theta_z$ and $-\Delta\theta_z$. (*Id.*, 8:3-28, Figs. 1-2; EX1002, ¶116.)

Figure 7 of Smith, shown in part below, shows these $+\Delta\theta$ and $-\Delta\theta$ signals from gyroscope **300** output to P1 processor **14**, where they are then accumulated over a period of time to produce counts of the $+\Delta\theta$ and $-\Delta\theta$ signals stored in hold registers **320** and **322**:



(Smith, Fig. 7 (partial figure shown; highlighting added).)

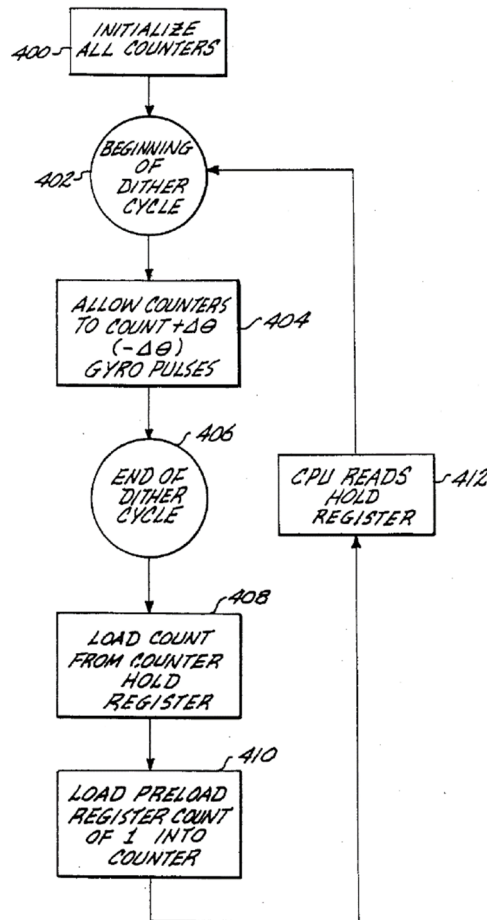
Figure 7 shows $+\Delta\theta$ and $-\Delta\theta$ signals output from signal conditioning electronics 302 for a gyro 300 (at the top left) to counter gate control and synchronization circuitry, which is further connected to counters 312 and 314. The counter gate control and synchronization circuitry and counters are part of P1 processor 14. (Smith, 5:14-16 (“FIG. 7 is a detailed block diagram illustrating the arrangement of counter banks used in the P1 processor[.]”), 3:46-47, 10:36-38.)

The counters in Smith are straightforward and easily understood. The term “counter” in electronics generally refers to logic circuits for counting how many signals of a particular type are received during a period of time. (EX1002, ¶118.) Here, the $+\Delta\theta$ and $-\Delta\theta$ signals received from signal conditioning electronics 302 represent the rate of angular displacement information from the gyroscope *at a particular point in time*. (*Id.*) To further determine the change of angular displacement *over time*, the counters in Figure 7 count the number of pulses in the

$+\Delta\theta$ and $-\Delta\theta$ signals that are received, over a predetermined time interval, and then store the accumulated counts in hold registers **320** and **322**. (Smith, 3:48-54, 6:35-38 (“Inasmuch as the gyro and accelerometer-produced signals are digital in nature, the data acquisition function of the P1 processor **14** involves the accumulation and storage of the input pulses over periodic cycles.”).) As shown in Figure 7 above, hold register **320** stores the accumulated counts of the $+\Delta\theta$ signals, and hold register **322** stores the accumulated counts of the $-\Delta\theta$ signals, received during the predetermined time interval. (EX1002, ¶118; Smith, 14:7-16.)

Figure 8 provides a more detailed description of how the counters perform the process of accumulating and counting $+\Delta\theta$ and $-\Delta\theta$ signals:

Fig. 8.



(Smith, Fig. 8.)

As Figure 8 shows, accumulation of $+\Delta\theta$ and $-\Delta\theta$ signals starts at the beginning **402** and completes at the end **406** of a dither cycle. (Smith, *e.g.*, 2:15-18, 3:48-52, 14:7-13.) During this period, “the counters, such as counters **312**, **314** [in Figure 7 above] are allowed to count their corresponding $+\Delta\theta$ and $-\Delta\theta$, respectively, gyro pulses at block **404**.” (*Id.*, 14:7-11 (emphasis added).) At the end of dither cycle **406**, “the accumulated counts in the counters **312**, **314** are loaded into the corresponding hold registers **320**, **322** [of Figure 7] respectively, at block **408**.” (*Id.*, 14:13-16 (highlighting added; emphasis added).)

In plain English, the process in Figure 8 counts the number of pulses of the

$+\Delta\theta$ signal and the number of pulses of the $-\Delta\theta$ signal received over a predetermined time period (*i.e.* dither cycle), and then stores those accumulated counts in hold registers **320** and **322**, respectively. (EX1002, ¶121.) This accumulation takes place with respect to all three gyros, and thus, generates $+\Delta\theta$ and $-\Delta\theta$ counts for the X, Y, and Z axes. (Smith, *e.g.*, 10:39-54, Fig. 5 (**202** (X axis), **204** (Y axis), **206** (Z axis)).)

Smith thus discloses “**an angular increment ... producer, which is electrically connected with said X axis, Y axis and Z axis angular rate detecting units... receiving said X axis, Y axis and Z axis angular rate electrical signals... from said angular rate producer,**” *i.e.*, the signals received from the three gyroscopes from the X, Y, and Z axes as discussed above, which are “**converted into... digital angular increments,**” *i.e.*, the accumulated $\Delta\theta$ counts for each of the X, Y, and Z axes produced by the counters.

These accumulated counts qualify as “**digital angular increments.**” The term “**increments**” has not been construed in the litigation, but in three prior litigations involving the ’648 patent against three other companies, Patent Owner consistently argued that “**digital angular increments**” and “**digital velocity increments**” should take their plain and ordinary meaning or be construed as “changes in [angle]/[velocity] expressed digitally.” (EX1018, 019-020; EX1019, 026-027; EX1020, 014-015.) The defendants in each of those cases (not Petitioner) argued that these phrases instead should be construed as “accumulated changes in

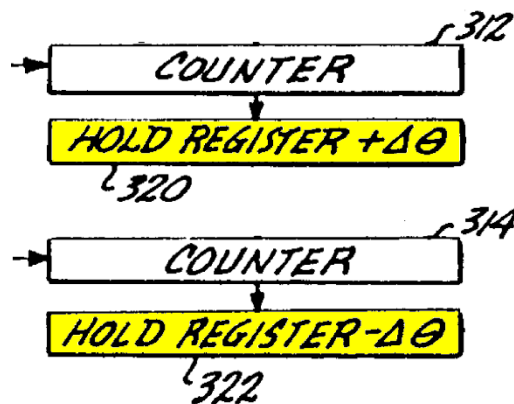
[angle]/[velocity] over a predetermined time interval expressed in digital form.”

(*Id.*) No claim construction rulings occurred in those prior litigations.

Nevertheless, in order to streamline the Board’s consideration of the prior art, Petitioner for purposes of this IPR only adopts Patent Owner’s prior litigation construction of the claimed increments. *E.g.*, *Glux Visual Effects Tech (Shenzhen) v. Ultravision Techs*, IPR2020-01052, Paper 28, p.33 (PTAB Nov. 17, 2021) (“*Western Digital* states, and we agree, that ‘37 C.F.R. § [42.]104(b)(3) does not require [a p]etitioner to express its subjective agreement regarding correctness of its proffered claim constructions or to take ownership of those constructions,’ such as in a district court proceeding.” (citation omitted)). Patent Owner argued in the prior litigations that the term “increment” was a known term that referred to an amount of change from a prior value. (EX1018, 019-020.)

Smith nevertheless satisfies both of the constructions from the prior litigations, or any other reasonable construction.

This is because the accumulated counts of the $+\Delta\theta$ and $-\Delta\theta$ signals, for example stored in registers 320 and 322 (shown in Figure 7 partially at right), represent angular position changes over a period of



time. This is clear from the $\Delta\theta$ notation used in Smith, with delta (Δ) being a standard symbol representing change, and theta (θ) a standard symbol representing

angle. (EX1002, ¶124; *see also* Smith, *e.g.*, 3:8-13 (“... signals $\Delta\theta_x$, $\Delta\theta_y$, and $\Delta\theta_z$ [are] representative of the change in angular position of the inertial sensor assembly with respect to three mutually orthogonal coordinate axes X, Y, and Z, respectively.”) (emphasis added).) The $+\Delta\theta$ and $-\Delta\theta$ accumulated counts stored in registers 320 and 322 therefore represent the change in angular rate of a gyroscope during the predetermined time interval. (EX1002, ¶124.) For example, Smith explains that a “net” $\Delta\theta$ value, which the P1 processor can readily compute by a “simple subtraction” of the accumulated $+\Delta\theta$ count in 320 from the accumulated $-\Delta\theta$ count in 322 as discussed above (Smith, 15:1-6), which “represents change of [angular] displacement rates for each gyro at a different point in time.” (Smith, 15:10-13 (emphasis added); *see also id.*, 14:65-15:7; EX1002, ¶124.)

The accumulated counts of the $+\Delta\theta$ and $-\Delta\theta$ signals for the X, Y, and Z axes thus disclose “**angular increments**” under any of the proposed constructions from the prior litigations, or any other reasonable construction. Alternatively, the claimed “**angular increments**” can be mapped to the “net” $\Delta\theta$ value determined by a subtraction involving the $+\Delta\theta$ and $-\Delta\theta$ counts, which the P1 processor CPU can determine as discussed above. (Smith, 14:65-15:13.) The claimed “**angular increments**” are thus satisfied by either (1) the $+\Delta\theta$ and $-\Delta\theta$ accumulated counts, or (2) the “net” $\Delta\theta$, discussed above, for all three axes. (EX1002, ¶124.) These angular increments are also “**digital**” because the accumulated counts are stored in memory

(e.g., hold registers **320** and **322**) that is accessible to the CPU. (EX1002, ¶125 (citing Smith, 6:35-38, 13:8-16).)

Turning to the claimed “**digital velocity increments**,” a similar analysis applies. Figure 1 of Smith above shows accelerometer triad **30**, discussed extensively for limitation 1[b], which includes “**said X axis, Y axis and Z axis accelerometers.**” Figure 1 also shows accelerometer triad **30** electronically connected to signal conditioning electronics **32**, which generate a digital output signal. (Smith, 6:24-26, 10:5-17.) More specifically, “[t]he analog accelerometers **72, 74, and 76** produce analog output signals corresponding to the rate of change of velocity of each accelerometer along its sensitive axis,” which are “converted to digital signals by corresponding digitizers **82, 84, and 86.**” (*Id.*, 8:48-53.) This is shown in Figure 4, which shows a more detailed view of the signal conditioning electronics for a particular accelerometer **150**, which include digitizer **152**:

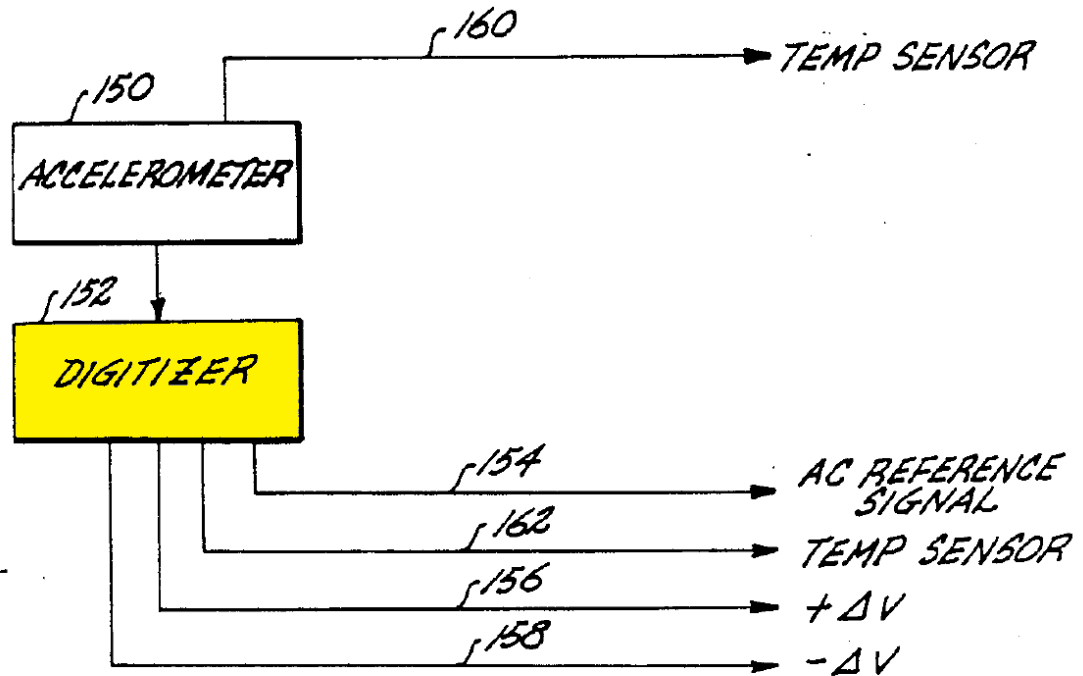


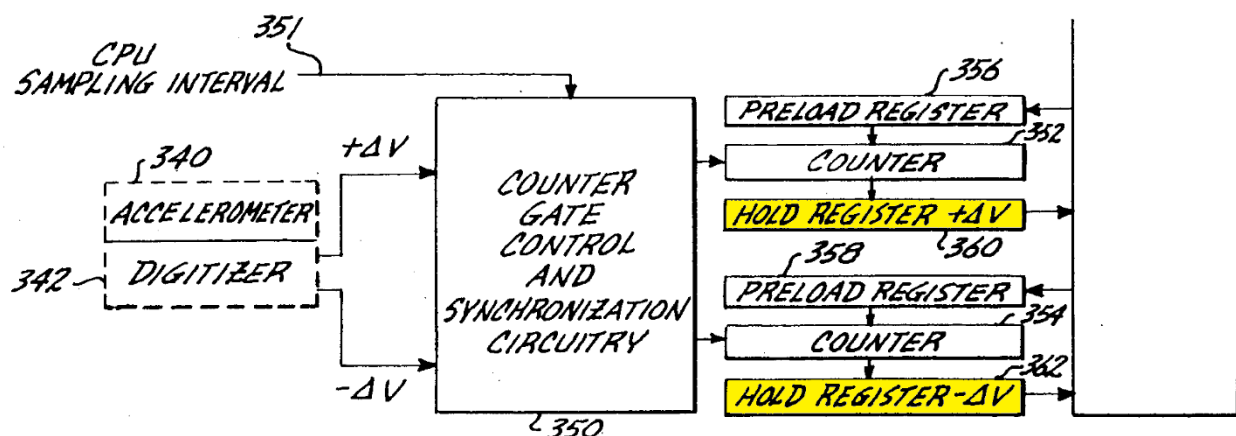
Fig. 4.

(Smith, Fig. 4 (highlighting added).)

Figure 4 shows an analog accelerometer **150** and digitizer **152**. “The digitizer **152** processes the analog output signal from the accelerometer **50** [sic; **150**], as well as an input AC reference signal on a line **154** to produce a pair of output signals $+\Delta V$ and $-\Delta V$.” (Smith, 10:6-9 (highlighting added).) “The $+\Delta V$ signal is a digital signal having a pulse repetition rate proportional to acceleration of the accelerometer **150** in a reference positive direction along its sensitive axis. The $-\Delta V$ signal has a pulse repetition rate proportional to acceleration of the accelerometer **150** in a reference negative direction along its sensitive axis.” (*Id.*, 10:10-15.) This process takes place for all three accelerometers, resulting in output of three sets of $+\Delta V$ and $-\Delta V$ signals for the X, Y, and Z axes, *i.e.*, $+\Delta V_x$, $-\Delta V_x$, $+\Delta V_y$, $-\Delta V_y$, $+\Delta V_z$ and $-\Delta V_z$. (*Id.*, 8:54-

64, Figs. 1-2; EX1002, ¶127.)

The bottom half of Figure 7 below shows that these digitized $+\Delta V$ and $-\Delta V$ signals (with respect to one accelerometer 340) are output to P1 processor 14, which accumulates them over a period of time to store digital $+\Delta V$ and $-\Delta V$ increment signals in hold registers 360 and 362:



(Smith, Fig. 7 (partial figure; highlighting added).)

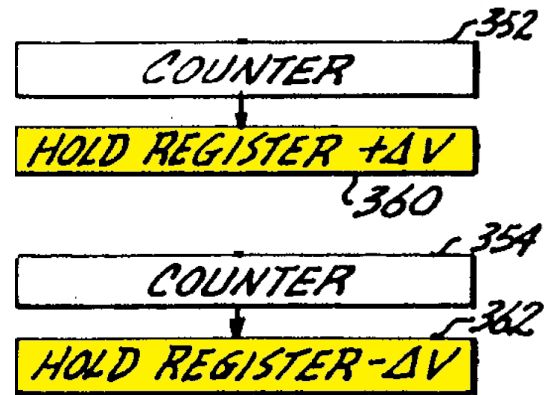
The process here is similar to the one discussed above for the gyroscopes. Figure 7 above shows the $+\Delta V$ and $-\Delta V$ signals from digitizer 342 for a particular accelerometer 340 (at left) output to counter gate control and synchronization circuitry, connected to counters 352 and 354, which are part of P1 processor 14. (Smith, 5:14-16, 13:26-29, 10:36-38.) The purpose of the counters here is substantially the same as the counters for the gyroscopes discussed above. (EX1002, ¶129.) To determine the change of velocity *over time*, the counters in Figure 7 receive and count the number of pulses of the $+\Delta V$ and $-\Delta V$ signals, over a period of time, and then store the accumulated counts in hold registers 360 and 362 as

shown above. (*Id.*; *see also* Smith, 4:29-35, 13:27-45.)

Figure 10 provides a more detailed description of how the counters perform the process of accumulating $+\Delta V$ and $-\Delta V$ signals. (Smith, Fig. 10, 14:53-59.) For purposes of this Petition, the process is substantially similar to the process in Figure 8 discussed above. The accumulation process in Figure 10 counts the number of pulses of the $+\Delta V$ signal and the number of pulses of the $-\Delta V$ signal received over a predetermined time period (*i.e.*, sampling interval), and then stores those accumulated counts in hold registers 360 and 362, respectively. (EX1002, ¶¶131-132; Smith, 14:53-59.) And like the gyroscopes discussed above, the accumulation of $+\Delta V$ and $-\Delta V$ signals takes place with respect to all three accelerometers, and thus, for the X, Y, and Z axes, generating $+\Delta V$ and $-\Delta V$ accumulated counts for the X, Y, and Z axes. (Smith, *e.g.*, 10:39-54, Fig. 5 (202 (X axis), 204 (Y axis), 206 (Z axis))).)

Smith thus discloses “a **velocity increment producer, which is electrically connected to ... said X axis, Y axis and Z axis accelerometers, receiving... said X axis, Y axis and Z axis acceleration electrical signals from... said acceleration producer,**” *i.e.*, the analog signals received from the three accelerometers with respect to the X, Y, and Z axes discussed above, which are “**converted into... digital velocity increments,**” *i.e.*, the accumulated ΔV counts for each of the X, Y, and Z axes produced by the counters.

These digital signals $+\Delta V$ and $-\Delta V$ for each of the X, Y, and Z axes qualify as “**digital velocity increments**,” as claimed, because they represent accumulated changes in velocity over a predetermined time interval expressed in digital form. This is because the accumulated signals $+\Delta V$ and $-\Delta V$, for example stored in registers **360** and **362** (shown partially at right), represent



changes in the velocity of the inertial measurement unit. This is clear from the ΔV notation used in Smith, with delta (Δ) being a standard symbol representing change, and V representing velocity, consistent with disclosures in Smith. (EX1002, ¶135; Smith, *e.g.*, 3:13-18 (“... signals ΔV_x , ΔV_y , and ΔV_z [are] representative of the change in velocity of the inertial sensor assembly in the X, Y, and Z coordinate axes, respectively.”) (emphasis added).) Smith further explains that a net ΔV value, which a CPU can compute based on the difference between the accumulated $+\Delta V$ count in hold register **360** and the accumulated $-\Delta V$ count in hold register **362**, “produces a resultant acceleration count ΔV .” (Smith, 20:67-21:2.)

Smith thus discloses “**velocity increments**” because the accumulated $+\Delta V$ and $-\Delta V$ counts represent changes in velocity over a predetermined time interval. Alternatively, the claimed “**velocity increments**” can be mapped to the net ΔV value determined by a subtraction involving the $+\Delta V$ and $-\Delta V$ counts, which the P1

processor CPU can determine as discussed above. (*Id.*, 20:65-21:2.) The claimed “**velocity increments**” can thus be satisfied by either (1) the $+\Delta V$ and $-\Delta V$ accumulated counts, or (2) the net ΔV , discussed above, for all three axes. (EX1002, ¶135.) These velocity increments are also “**digital**” because, as noted, the signals from the accelerometer digitizers are digital and the accumulated counts are stored in memory (*e.g.*, hold registers **360** and **362**) accessible by the CPU. (EX1002, ¶136 (citing Smith, 6:35-38, 13:34-45).) It therefore would have been obvious that the “**velocity increments**” in Smith are expressed digitally. (EX1002, ¶136.)

Additionally, to the extent the word “**micro**” in the preamble is limiting, under the proposed combination, therefore, the IMU in Smith would have been adapted to receive and process signals from MEMS gyroscopes and accelerometers to produce the claimed digital angular and velocity increments. (EX1002, ¶138.)

D. Ground 2: Claim 4 Is Obvious Over Ground 1 Prior Art, in Further View of Irwin and Merhav.

1. **Claim 4: “A micro inertial measurement unit, as recited in claim 1, wherein said X axis, Y axis and Z axis angular rate electrical signals produced from said angular producer are analog angular rate voltage signals directly proportional to angular rates of a carrier carrying said micro inertial measurement unit, and said X axis, Y axis and Z axis acceleration electrical signals produced from said acceleration producer are analog acceleration voltage signals directly proportional to accelerations of said vehicle.”**

Claim 4 does little more than recite limitations that would have been basic knowledge. (EX1002, ¶¶74, 140-141.) It was well-known and basic knowledge that

an analog signal is a signal whose amplitude (typically measured by voltage) represents the information the signal is intended to convey. (EX1002, ¶140.) As explained in **Irwin (EX1007)**, in an analog signal, “the amplitude of the signal represents the information at every point in time.” (*Id.*, § 7.3, p.240.)

Almost all observable nature is analog, with continuously varying parameters such as temperature, pressure, light intensity, etc. Therefore, many systems receive as their input an analog signal representing an analog parameter. The electronic signal generally originates from a sensor or transducer which provides an analog signal proportional to the parameter. Table 7.1 provides a partial list of analog parameters that various types of electronic sensors can measure.

(Irwin, § 7.3, p.242 (emphasis added).) Among the examples listed in Table 7.1 referenced above are “[a]cceleration” and “[r]otation.” (*Id.*, Table 7.1, p.241.) Although Irwin uses “amplitude” to describe the information carried by an analog signal, it was well-known that the amplitude of an analog signal is typically measured in volts. (EX1002, ¶140; *see also* Irwin, *e.g.*, at pp. 242-243; *see also*, *e.g.*, *id.*, p.243 (“Assume the voltage signal from an electric guitar is 20 millivolts in amplitude...”)) (emphasis added); *see also* EX1022, pp. xviii-xix.)

Irwin therefore confirms that it would have been obvious for an acceleration or rotation sensor to have provided an analog voltage signal proportional to the measured acceleration or rotation. (EX1002, ¶140.) It therefore would have been obvious that the “**electrical signals**” produced from the angular producer and the

acceleration producer in Smith have included “**analog voltage signals directly proportional to,**” respectively, the angular rotation and acceleration of the aircraft carrying the gyroscopes and accelerometers. (EX1002, ¶¶141, 149-150.) Chan and Bernstein further confirm that the claimed proportionality also applies to MEMS-based sensors. (Bernstein, 2:57-59, 3:3-5 (“The operation of the symmetrical, micromechanical gyroscope of the present invention is generally identical to that of prior art gyroscopes... The voltage required to rebalance the gyroscope about the X axis is the measured output of the gyroscope, and is proportional to the input rate.”), Chan, 1:40-43 (“Many of the known [MEMS] accelerometers... are analog and measure or sense an electrical current that varies with frequency or amplitude of acceleration.”).)

This is consistent with Smith, which states that “[t]he analog accelerometers 72, 74, and 76 produce analog output signals corresponding to the rate of change of velocity of each accelerometer along its sensitive axis.” (Smith, 8:48-51 (emphasis added).) Smith further confirms, in describing digital signals output after analog-to-digital conversion, that “[t]he $+\Delta V$ signal is a digital signal having a pulse repetition rate proportional to acceleration of the accelerometer 150 in a reference positive direction along its sensitive axis. The $-\Delta V$ signal has a pulse repetition rate proportional to acceleration of the accelerometer 150 in a reference negative direction along its sensitive axis.” (*Id.*, 10:10-15 (emphasis added).) It would have

been obvious that the analog signals provided by the accelerometers in Smith, which are directly used to generate the “proportional” digital ΔV signals, would also have been proportional to the measured acceleration. (EX1002, ¶142.)

With respect to gyroscopes, Smith states that “[e]ach ring laser gyro produces a first output signal $+\Delta\theta_x, +\Delta\theta_y, +\Delta\theta_z$, having a pulse repetition rate proportional to the rate of angular displacement of the ring laser gyro in a reference clockwise direction and a second output signal $-\Delta\theta_x, -\Delta\theta_y, -\Delta\theta_z$, having a pulse repetition rate proportional to the rate of angular displacement of the ring laser gyro in a reference counterclockwise direction.” (Smith, 3:37-44 (emphasis added).) Although Smith suggests that the signals output by the ring laser gyroscopes are digital, this does not present a non-obvious distinction. (EX1002, ¶144.)

As explained in **Merhav** (EX1008), ring laser gyroscopes generate analog signals (*e.g.* sinusoidal outputs) before generating pulse signals. (EX1002, ¶¶78-79, 144-145 (citing Merhav, pp. 377 & 381).) Merhav explains that in a ring laser gyroscope, angular rate is measured based on the interaction between “a pair of collocated, closed path clockwise and counterclockwise light beams.” (Merhav, § 8.0, p.377.) “Their interaction causes interference, which manifests itself as fringes resulting from the corresponding changes of the wavelengths and oscillating frequencies. These changes are proportional to the inertial angular rate.” (*Id.*) Merhav further explains that “[t]he intrinsic readout is by counting the pulses due to

the fringes,” which “constitutes a natural interface with the digital processor and computer.” (*Id.*) But Merhav further explains that, *before* these pulses are output by a ring laser gyroscope, an analog signal, *e.g.*, a sinusoidal signal, is generated:

As the intensity fringes cross a diode, a corresponding sinusoidal signal is generated. Two diodes are required in order to determine whether Ω is clockwise or counter-clockwise. The diodes are placed at 90° with respect to each other in the coordinates of the fringe angle ζ . With this arrangement, it is possible to determine which of the two diodes precedes the other. Digital pulse conditioning and logic convert the sinusoidal outputs into a train of pulses whose frequency is directly proportional to Ω and whose accumulated count represents the angle θ .

(Merhav, p.381 (emphasis added).) A skilled artisan would have understood that the sinusoidal signal generated by the ring laser circuitry constitutes an analog signal. (EX1002, ¶145.) Merhav therefore confirms that it would have been obvious that ring laser gyroscopes, such as the ones used in Smith, would have generated analog signals proportional to the detected angular rates. (*Id.*)

Gyroscopes that generate analog output were common; for example Tingleff discussed for **Ground 3** uses gyroscopes that produce analog signals and require other components to perform analog-to-digital conversion. (EX1002, ¶146.) As Irwin explains, “[a]most all observable nature is analog,” such that an “electronic signal generally originates from a sensor... which provides an analog signal proportional to the parameter,” which as Irwin notes, includes the “[r]otation”

parameter. (Irwin, § 7.3, p.241-42 (emphasis added).) The decision between a gyroscope that outputs a digital or analog signal would have been nothing more than a routine implementation detail to a skilled artisan. (EX1002, ¶146.)

Rationale and Motivation to Combine (Ground 1 Prior Art with Irwin and Merhav): It would have been obvious that the “**angular rate electrical signals**” and “**acceleration electrical signals**” produced by the IMU for the X, Y, and Z axes in Smith would have included analog voltage signals proportional to the measured rotation and acceleration. With respect to gyroscopes, conversion of analog signals into digital would have been performed, under the proposed combination, as part of the function of the angular increment producer of limitation 1[c] above, for example, using digital pulse conditioning logic as described in Merhav. (EX1002, ¶147; Merhav, p.381.) Irwin and Merhav are analogous references in the field of sensor technology for detecting movement such as acceleration and rotation, and would have been reasonably pertinent to problems facing the inventors. (EX1002, ¶147.)

With respect to the accelerometers and gyroscopes in Smith, a skilled artisan would have been motivated to implement them to provide analog voltage signals that are “**directly proportional**” to the measured acceleration and rotation. The adverb “**directly**” does not impose a requirement not already disclosed by the “proportional” signals disclosed by the prior art, because “proportional” in the context of Irwin and Smith refers to a linear relationship in which the voltage signal

varies based on a constant ratio to the measured acceleration or angular rate. (EX1002, ¶148 (citing *IEEE Standard Dictionary of Electrical and Electronics Terms* (1996), pp. 830 (“**proportionally** See: linearity.”), 584 (“**linearity** (1) (**analog computer**) A property of a component describing a constant ratio of incremental cause and effect. *Proportionality* is a special case of linearity in which the straight line passes through the origin.”) (bold and italics in original)).) It also would have been obvious to provide analog voltage signals that are directly proportional to the measured acceleration and angular rate, and a skilled artisan would have been motivated to do so in order to provide more accurate (and thus more useful) information. (EX1002, ¶148.)

Finally, claim 4 ends with “**said vehicle**,” which has no antecedent basis in claim 4 or claim 1 from which it depends. Patent Owner has taken the position in the pending litigation that “**said vehicle**” in claim 4 refers to “said carrier,” whereas Petitioner has taken the position that it refers to “a device or structure for transporting persons or things.” Smith discloses either construction because the inertial measurement unit is mounted to the aircraft with which it is used. (Smith, 7:39-41, 22:19-23, 22:35-39; EX1002, ¶149.)

E. Ground 3: Claims 1 and 4 Are Obvious Over Tingleff in View of Chan and Bernstein.

1. Independent Claim 1

The preamble of claim 1 recites “[a] **micro inertial measurement unit**.” As

fully explained in **Part VI.C.1** for **Ground 1**, the preamble is not limiting. But even if it was, it would be obvious over the prior art.

Tingleff discloses an “**inertial measurement unit**,” which includes inertial guidance unit **11** shown in the annotated version of Tingleff’s Figure 1 below.

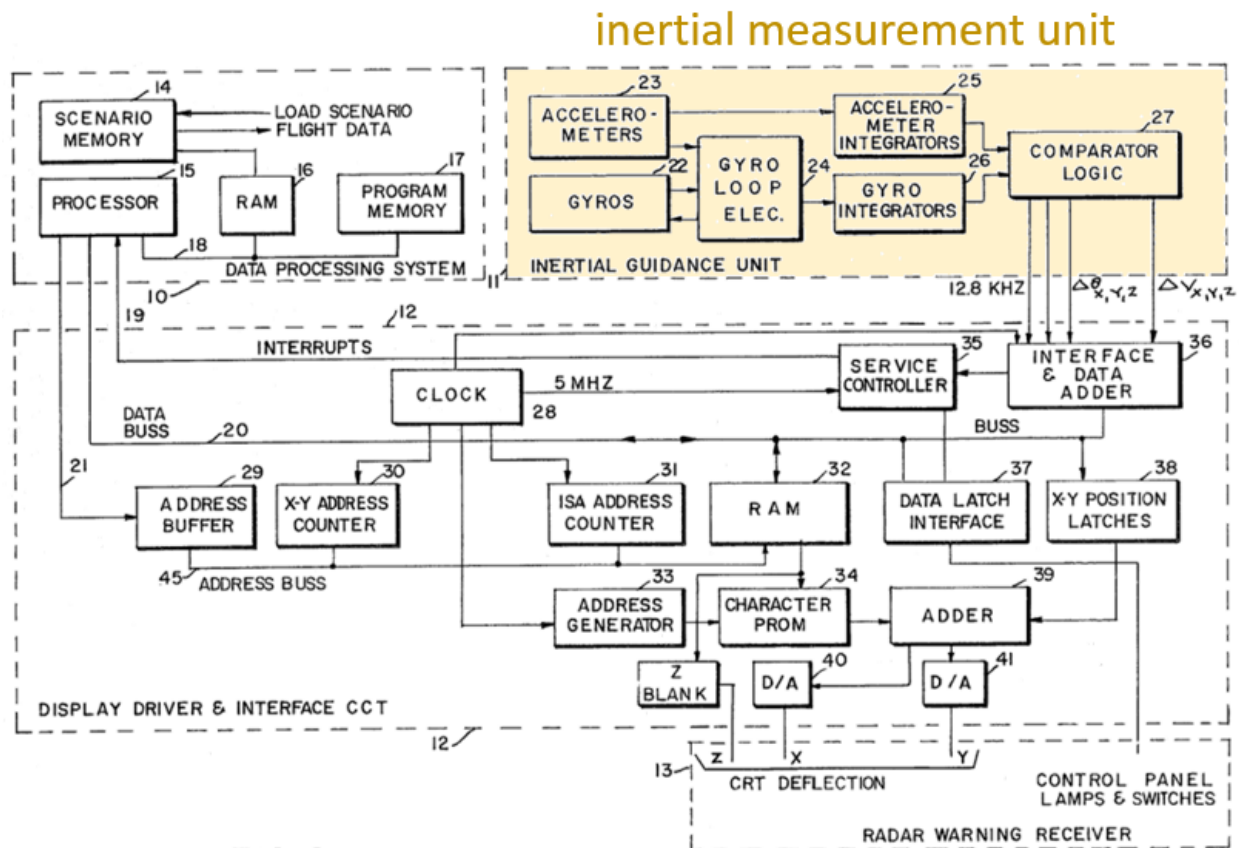


FIG. 1.

(Tingleff, Fig. 1, 6:2-5 (highlighting and annotations added).)

Inertial guidance unit **11** (in yellow) contains “three sets of gyros **22** and accelerometers **23** that sense angular rates and acceleration about the X, Y and Z Cartesian coordinates.” (Tingleff, 6:67-7:2; 4:24-26) (“The inertial navigation system indicates the position of the aircraft with respect to the earth to the processor.”). In other words, Tingleff discloses an inertial unit that “sense[s]” (*i.e.*,

measures) angular rate and acceleration. Accordingly, Tingleff discloses an “**inertial measurement unit.**” (EX1002, ¶155.)

This is also consistent with the description of IMUs in the ’648 patent specification, explained in the discussion of the preamble of **Ground 1** in **Part VI.B.1** above. (EX1002, ¶¶92, 155.) The inertial guidance unit **11** discloses an IMU because it contains three gyros and three accelerometers that determine the motion of a carrier (*e.g.*, an aircraft). A skilled artisan would have understood these sensors to be “orthogonally mounted,” since Tingleff discloses that they measure “angular rates and acceleration about the X, Y and Z Cartesian coordinates.” (Tingleff, 6:67-7:2.) Accordingly, the disclosures of Tingleff are consistent with the disclosure of an IMU provided in the ’648 patent specification. (EX1002, ¶155; ’648, 1:18-28.)

And for substantially the same reasons fully explained for **Ground 1**, it would have been obvious based on Tingleff in light of Chan and Bernstein to use a “**micro**” inertial measurement unit. (EX1002, ¶¶93-105, 156-157.) Under the proposed combination, a skilled artisan would have been motivated to incorporate MEMS gyros and accelerometers into the IMU of Tingleff. (EX1002, ¶156.) Tingleff itself discloses that its simulation system is “relatively small and self-contained.” (Tingleff, 3:11-13.) A skilled artisan would have been motivated to use components, such as MEMS sensors, that are as small as possible. (EX1002, ¶156.) All of the motivations provided for **Ground 1**, including the reduced size, reduced weight,

reduced power consumption, and reduced cost, apply with full force to **Ground 3**. (EX1002, ¶¶156, 101-102.) As also discussed, the use of MEMS sensors in aircraft applications was also known. (EX1002, ¶¶101-102.)

- (a) **“an angular rate producer comprising a X axis angular rate detecting unit which produces a X axis angular rate electrical signal, a Y axis angular rate detecting unit which produces a Y axis angular rate electrical signal, and a Z axis angular rate detecting unit which produces a Z axis angular rate electrical signal;” (1[a])**

Tingleff discloses an **“angular rate producer”** comprising three **“angular rate detecting unit[s],”** which each produces an **“angular rate electrical signal”** for the **“X axis,” “Y axis,”** and **“Z axis,”** respectively. The **“gyros 22”** block in Tingleff’s Figure 1 contains **“three sets of gyros... that sense angular rates... about the X, Y and Z Cartesian coordinates.”** (Tingleff, 6:67-7:2.) These three sets of gyros—corresponding to the X, Y, and Z axis—are shown in the below annotated version of Tingleff’s Figure 1:

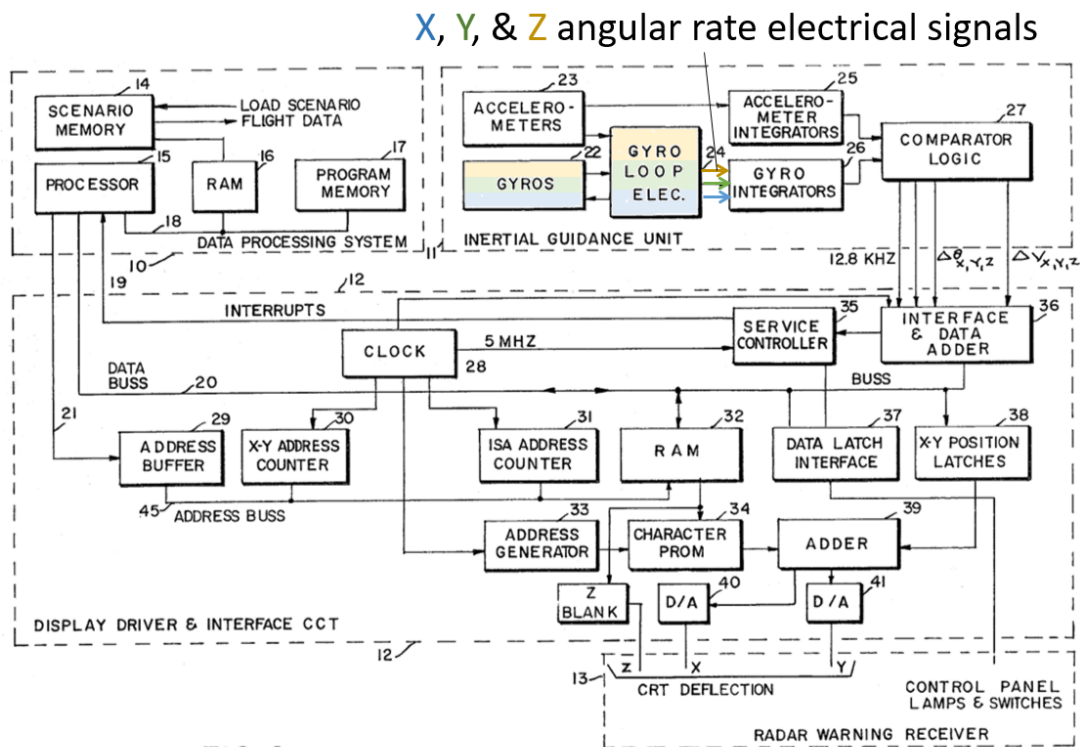


FIG. 1.

(Tingleff, Fig. 1 (annotations and highlighting added). “As motion of the aircraft is sensed by the inertial guidance unit 11, the error signal from gyros 22 and accelerometers 23” are output to gyro loop electronics 24. (*Id.*, 7:2-5 (emphasis added).) Using these error signals, the gyro-loop electronics 24 “attempts to hold the accelerometer pendulum and gyro gimbal nulled.” (*Id.*, 7:5-7 (emphasis added).) “[T]hese signals are also used as the analog rate signals within unit 11.” (*Id.*, 7:3-8.) Gyro loop electronics 24 then outputs the analog signals to the gyro integrators 26 that converts the angular rate electrical signal to digital pulse trains. (*Id.*, 7:8-11.) Each of the three sets of gyros and associated circuitry in the gyro loop electronics 24 constitutes an “**angular rate detecting unit**” that produces an analog electrical signal indicating X, Y, and Z-axis angular rate, respectively.

A skilled artisan would have understood that the angular rate “error signal” from the gyros in Tingleff is a signal output due to angular rotation. (EX1002, ¶159.) The term “error signal” in this context refers to a signal that represents the difference between a sensing signal and a constant or reference. (*Id.* (citing *IEEE Standard Dictionary of Electrical and Electronics Terms* (1996), p.371 (“**error signal (1)**... In a control system the error signal is the difference between a sensing signal and a constant reference signal.”) (bold in original)).) The angular rate “error signal” here thus represents the difference between the current position of a gyro gimbal and its original (null) position. (EX1002, ¶159.) A skilled artisan would therefore have understood that Tingleff’s angular rate “error signal” as a signal resulting from rotation that causes a displacement in a gyro gimbal, which is fed back to gyro **22** to hold the gimbal at its original (null) position. (*Id.*) Tingleff accordingly discloses that the error signals entering the gyro-loop electronic **24** “are also used as the analog rate signals within unit **11**.” (Tingleff, 7:3-8.)

Moreover, to the extent the word “**micro**” in the preamble is limiting, as fully explained in connection with **Ground 1**, it would have been obvious for the gyros in Tingleff to have been replaced with micromechanical gyroscopes which were well-known, each of which would have produced an angular rate electrical signal. Petitioner provided a full explanation of the rationale and motivation to provide

MEMS-based gyroscopes above and in the discussion of the preamble above and for

Ground 1. (EX1002, ¶¶161, 109.)

- (b) **“an acceleration producer comprising a X axis accelerometer which produces a X axis acceleration electrical signal, a Y axis accelerometer which produces a Y axis acceleration electrical signal, and a Z axis accelerometer which produces a Z axis acceleration electrical signal; and;” (1[b])**

Tingleff discloses an **“acceleration producer”** comprising three **“accelerometer[s],”** which each produces an **“acceleration electrical signal”** for the **“X axis,” “Y axis,”** and **“Z axis,”** respectively. The **“accelerometers 23”** block in Tingleff’s Figure 1 contains **“three sets of... accelerometers... that sense... acceleration about the X, Y and Z Cartesian coordinates.”** (Tingleff, 6:67-7:2.) These three sets of accelerometers—corresponding to the X, Y, and Z axis—are shown in the below annotated version of Tingleff’s Figure 1:

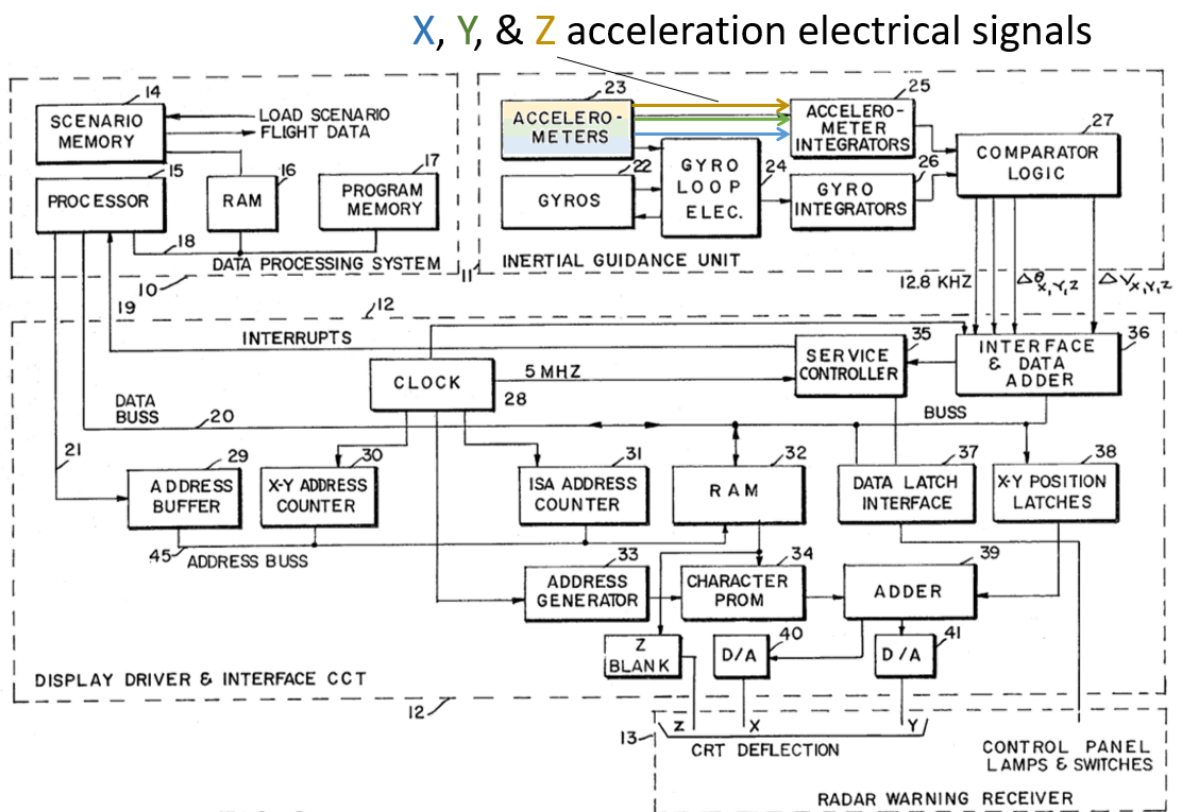


FIG. 1.

(Tingleff, Fig. 1 (annotations and highlighting added).) “As motion of the aircraft is sensed by the inertial guidance unit 11, the error signal from gyros 22 and accelerometers 23” are output to gyro loop electronics 24. (*Id.*, 7:2-5 (emphasis added).) Using these error signals, the gyro-loop electronics 24 “attempts to hold the accelerometer pendulum and gyro gimbal nulled.” (*Id.*, 7:5-7 (emphasis added).) “[T]hese signals are also used as the analog rate signals within unit 11.” (*Id.*, 7:3-8.) Accelerometers 23 as shown in Figure 1 then output the analog signals to the accelerometer integrator 25 that converts the acceleration electrical signal to digital pulse trains. (*Id.*, 7:8-11.)

As explained in the discussion of limitation 1 [a] above, the term “error signal”

in this context refers to a signal that represents the difference between a sensing signal and a constant or reference. (EX1002, ¶¶163, 158-159.) A skilled artisan would thus have understood that the acceleration “error signal” in Tingleff is caused by the acceleration of the moving object and represents the difference between the current position of the accelerometer pendulum and its original (null) position. (EX1002, ¶163.) A skilled artisan would therefore have understood that Tingleff’s acceleration “error signal” as a signal resulting from an acceleration that causes a displacement in the accelerometer pendulum, which is processed by the gyro loop electronics **24** to hold the pendulum to its original (null) position. A skilled artisan would have understood that each accelerometer produces an analog electrical signal indicating X, Y, and Z-axis acceleration, respectively. (*Id.*)

Moreover, to the extent the word “**micro**” in the preamble is limiting, as fully explained for the preamble and in connection with **Ground 1**, it would also have been obvious for the accelerometers in Tingleff to have been replaced with micromechanical accelerometers which were well-known, each of which would have produced an acceleration electrical signal. (EX1002, ¶¶164, 113.)

- (c) **“an angular increment and velocity increment producer, which is electrically connected with said X axis, Y axis and Z axis angular rate detecting units and said X axis, Y axis and Z axis accelerometers, receiving said X axis, Y axis and Z axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals from said angular rate producer and said acceleration producer respectively, wherein said X axis, Y axis and Z**

axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals are converted into are digital angular increments and digital velocity increments respectively.” (1[c])

Tingleff discloses an “angular increment and velocity increment producer,” as shown in the annotated version Figure 1 circuit below:

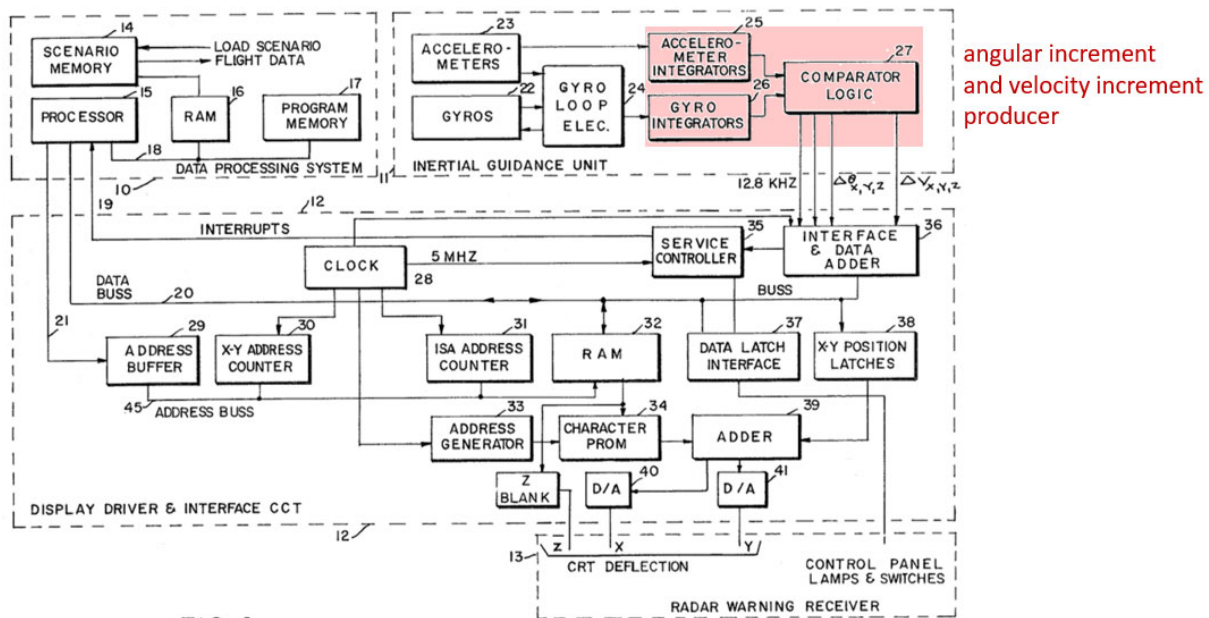


FIG. 1.

(Tingleff, Fig. 1 (highlighting and annotations added).)

The identified angular increment and velocity increment producer circuitry in Tingleff is “electrically connected with said X axis, Y axis and Z axis angular rate detecting units and said X axis, Y axis and Z axis accelerometers.” As discussed for limitations 1[a] and 1[b], blocks 22-24 in Figure 1 comprise said X axis, Y axis and Z axis angular rate detecting units and said X axis, Y axis and Z axis accelerometers. The block diagram in Figure 1 shows that blocks 22-24 are electrically connected to blocks 25-27—i.e., the angular increment and velocity

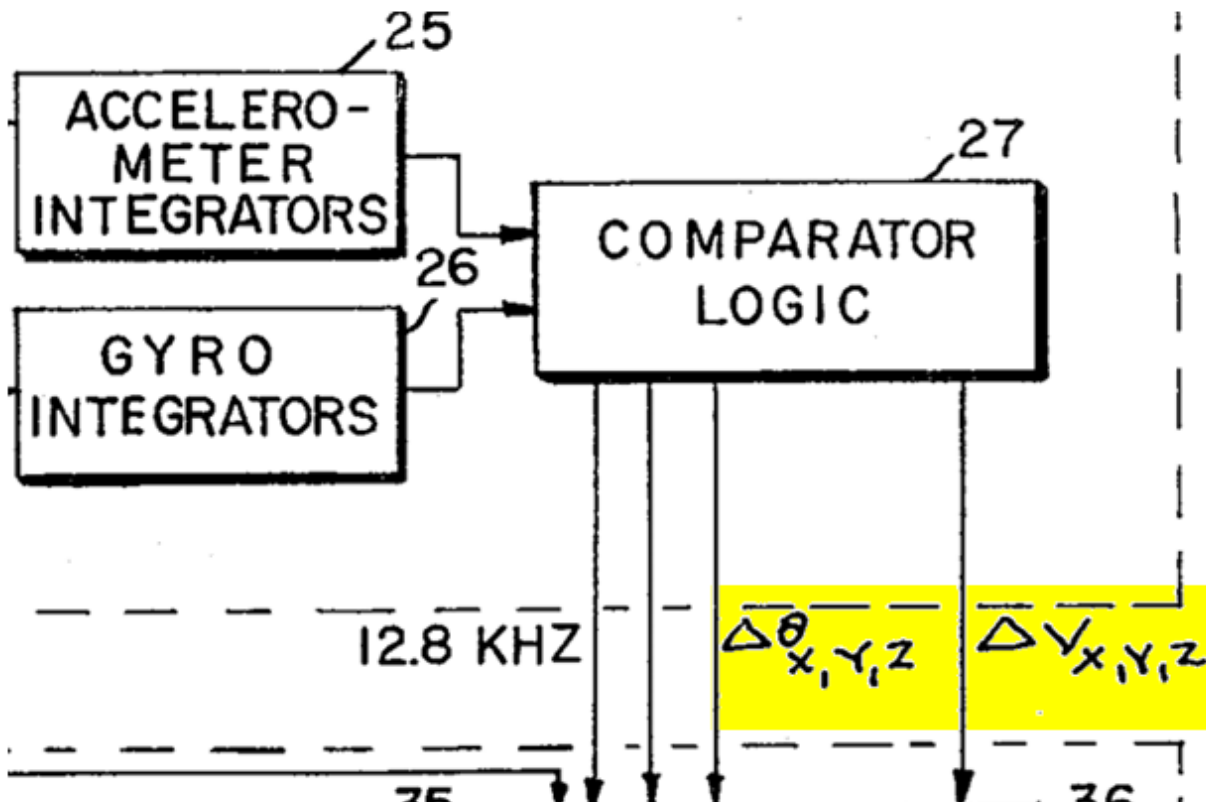
increment producer. (*See also* Tingleff, 7:8-11; EX1002, ¶167.)

Tingleff also discloses that the identified angular increment and velocity increment producer circuitry “receiv[es] **said X axis, Y axis and Z axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals from said angular rate producer and said acceleration producer respectively.**” Tingleff discloses that analog signals are “input” to “[a]ccelerometer integrator **25** and gyro integrator **26**” from “units **23** and **24**.” (Tingleff, 7:8-11.)

Tingleff further teaches that “**said X axis, Y axis and Z axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals are converted into digital angular increments and digital velocity increments respectively.**” Tingleff discloses that “[a]ccelerometer integrator **25** and gyro integrator **26** convert the respective analog signals input thereto from units **23** and **24** into digital pulse trains that are input to comparator logic **27**.” (Tingleff, 7:8-11.) Tingleff further discloses that following the addition of a reference signal by comparator logic circuit **27**, the outputted pulse trains “represent the **incremental changes in attitude** $\delta\theta_{X, Y, Z}$ and **incremental changes in velocity** $\delta V_{X, Y, Z}$ experienced by the inertial guidance platform.”¹ (*Id.*, 7:15-18 (emphasis added).)

¹ A skilled artisan would have understood “angular increments,” “incremental changes in attitude,” “ $\delta\theta_{X, Y, Z}$,” and “ $\Delta\theta_{X, Y, Z}$ ” as used in Tingleff to be synonymous—in each case, referring to increments to three-dimensional orientation (pitch, yaw, and/or roll). (EX1002, ¶169 n.3.)

Figure 1 of Tingleff confirms that the digital outputs of comparator logic circuit 27 are digital angular increments and digital velocity increments, labeling the signals as shown in the zoomed-in subpart of Figure 1 below:



(Tingleff, Fig. 1 (subpart; highlighting added).)

The pulse trains output by comparator logic circuit 27 qualify as “**digital angular increments and digital velocity increments**,” as claimed. (EX1002, ¶¶169-171.) This is because Tingleff discloses “incremental changes in attitude $\delta\theta_{x,y,z}$ and incremental changes in velocity $\delta V_{x,y,z}$ experienced by the inertial guidance platform.” (Tingleff, 7:15-18 (emphasis added).) These changes, as noted, are

expressed digitally. It would also have been obvious that these changes represent accumulated changes in angle over a predetermined time interval expressed in digital form, because determining the incremental change in rotation and velocity would have required a sampling of signals from the accelerometers and gyroscopes over a period of time. (EX1002, ¶171.) Indeed, Tingleff states that comparator logic 27 relies on a 12.8 KHz signal, among other things, “to provide an accurate time base for the data sampling interval.” (Tingleff, 7:13-15.)

Additionally, to the extent the word “**micro**” in the preamble is limiting, as discussed above, it would also have been obvious for the gyroscopes and accelerometers in Tingleff to have been substituted with micromechanical gyroscopes and accelerometers as explained for limitation 1[a]-[b], which were well-known as discussed. Under the proposed combination, therefore, the IMU in Tingleff would have been adapted to receive and process signals from MEMS gyroscopes and accelerometers to produce the claimed digital angular and velocity increments. (EX1002, ¶172.)

2. Dependent Claim 4

Tingleff discloses that the “**angular rate electrical signals**” and “**acceleration electrical signals**,” discussed for claim limitations 1[a] and 1[b] above, are analog signals. (See Tingleff, 7:7-11.) Tingleff does not state that these signals are “**voltage signals**,” that are “**directly proportional**” to the angular rate or

acceleration they measure. But as explained extensively in **Part VI.D** for **Ground 2**, these limitations are basic concepts of analog signals that would have been well-known and basic knowledge to skilled artisans. (EX1002, ¶¶176, 140-141.)

It therefore would have been obvious that the “**electrical signals**” produced from the angular rate producer and the acceleration producer in Tingleff would have been “**analog voltage signals directly proportional to,**” respectively, the angular rotation and acceleration of the IMU or aircraft carrying the gyroscopes and accelerometers in Tingleff. (EX1002, ¶¶141, 148, 177-178.) As noted for **Ground 2**, Irwin confirms the basic knowledge of a skilled artisan that an electric signal generated by a sensor “provides an analog signal proportional to the parameter” (Irwin, §7.3, p.242), such as “[a]cceleration” or “[r]otation” (*id.*, Table 7.1, p.241); EX1002, ¶¶140, 176.) And as fully explained for **Ground 2**, a skilled artisan would have been motivated to provide directly proportional analog voltage signals to obtain more accurate and thus more useful measurements. (EX1002, ¶¶148, 177-178.)

Claim 4 ends with “**said vehicle,**” which has no antecedent basis in claim 4 or claim 1 from which it depends. Patent Owner has stated in the pending litigation that “said vehicle” refers to “said carrier,” whereas Petitioner says that it refers to “a device or structure for transporting persons or things.” Tingleff discloses either construction because the IMU is mounted to the device, vehicle or carrier (*e.g.* aircraft) with which it is used. (Tingleff, 7:2-5; EX1002, ¶¶179-180.)

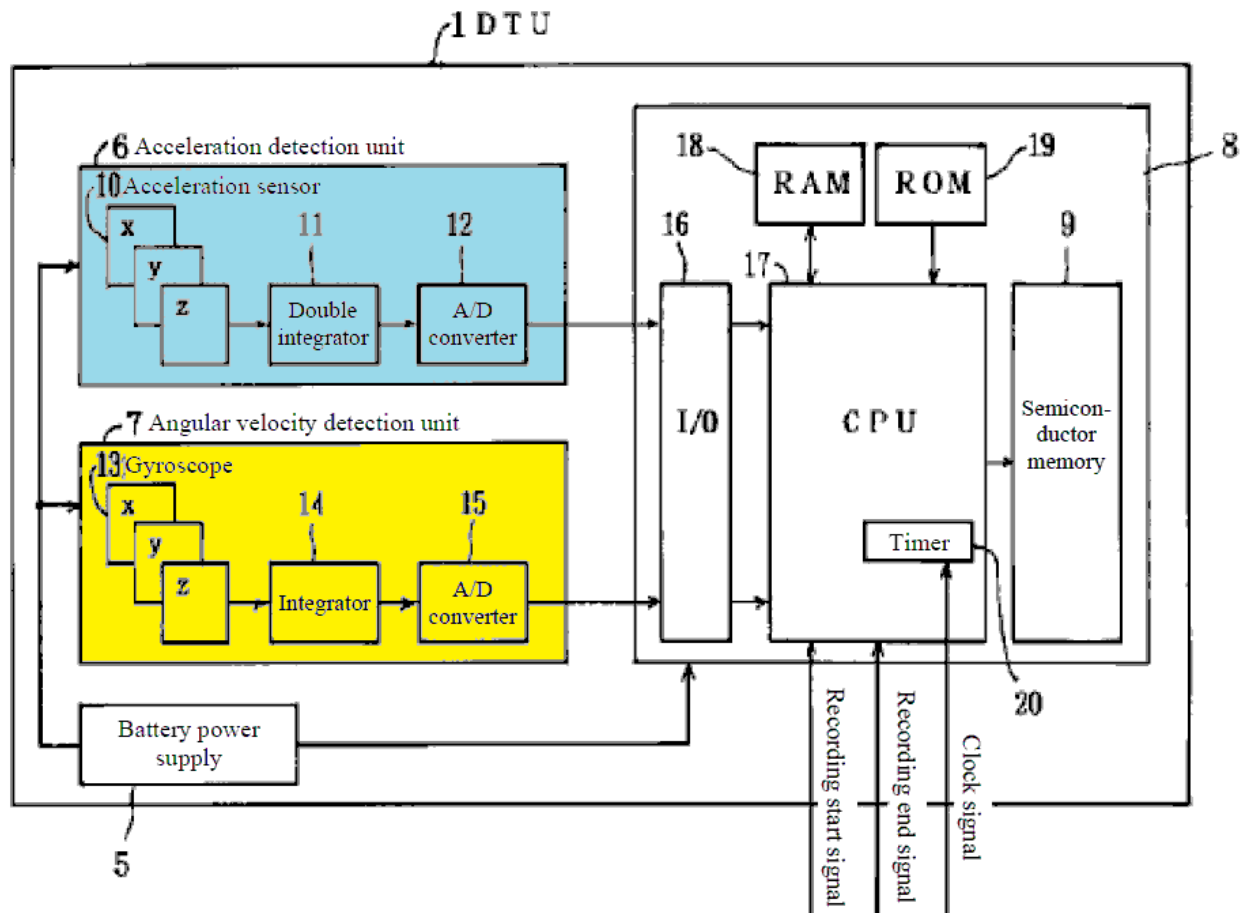
F. Ground 4: Claims 1 and 4 Are Obvious Over Yamawaki in View of Chan, Bernstein and Saubolle.

1. Independent Claim 1

The preamble of claim 1 recites “[a] **micro inertial measurement unit.**” As fully explained in **Part VI.C.1 for Ground 1**, the preamble is not limiting. But even if the preamble was limiting, it would be obvious over the prior art.

Yamawaki discloses an “**inertial measurement unit,**” which is shown in highlighted Figure 1 below:

[FIGURE 1]



(Yamawaki, Fig. 1 (partial figure; highlighting added).) The claimed “**inertial measurement unit**” in Yamawaki includes the **acceleration detection unit** 6 and **angular velocity detection unit** 7.

Angular velocity detection unit 7 includes 3D gyroscope 13 that “comprises a gyro sensor and detects the rotational velocity of the diver during underwater movement.” (Yamawaki, ¶[0016].) Angular velocity detection unit 7 also includes integrator 14 and analog-to-digital (A/D) converter 15. (*Id.*) “Output from the gyroscope 13 is obtained for rotation relative to the previous position, subjected to A/D conversion at a fixed sampling period, and imported into the CPU as a digital value to calculate the change in the diver’s movement direction.” (*Id.*, ¶[0029].)

Acceleration detection unit 6 includes “3D acceleration sensor 10 which... detects acceleration during underwater movement of the diver as a moving body.” (Yamawaki, ¶[0016].) Acceleration detection unit 6 also includes double integrator 11 and analog-to-digital (A/D) converter 12. (*Id.*) “Output from the acceleration sensor 10 is obtained of changes in movement speed or acceleration in the movement direction relative to the immediately preceding position and is then passed through the double integrator 11, subjected to A/D conversion by the A/D converter 12, acquired at a fixed sampling period, and recorded in the memory with the relative time from the starting point added.” (*Id.*, ¶[0023].)

Yamawaki therefore discloses an inertial unit that measures angular rate and

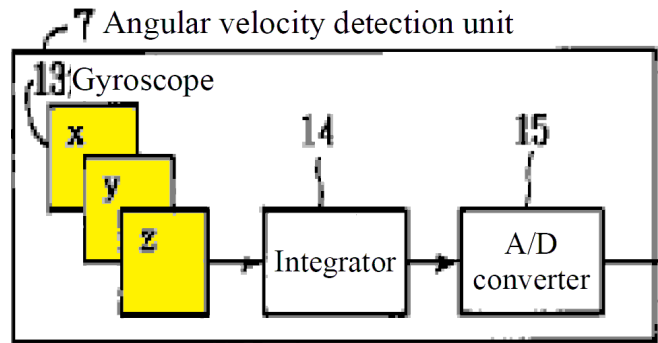
acceleration, and thus, discloses an “**inertial measurement unit**” that contains three gyros and three acceleration detectors that determine the motion of a carrier (*e.g.*, an underwater body). A skilled artisan would have understood these sensors to be “orthogonally mounted,” as Yamawaki discloses that they measure angular rates and acceleration about the X, Y and Z axes. (EX1002, ¶186; Yamawaki, Fig. 4.)

For substantially the same reasons as **Ground 1**, it would have been obvious in light of Chan and Bernstein to use a “**micro**” inertial measurement unit. (EX1002, ¶¶93-105.) A skilled artisan would have been motivated to incorporate MEMS accelerometers and gyros into Yamawaki’s data collection device because it is “portable” and “inexpensive,” with components “compactly accommodated in the device body,” and relies on battery power. (Yamawaki, ¶¶[0005]-[0006], [0014]-[0015].) In light of Yamawaki’s need for a small, compact and energy-efficient device, the motivations provided for **Ground 1**, including the reduced size, reduced weight, power consumption, and cost of MEMS sensors, would have applied here and amply motivated a skilled artisan to implement the collection device using MEMS acceleration detectors and gyroscopes. (EX1002, ¶¶187, 101, 103.)

- (a) “**an angular rate producer comprising a X axis angular rate detecting unit which produces a X axis angular rate electrical signal, a Y axis angular rate detecting unit which produces a Y axis angular rate electrical signal, and a Z axis angular rate detecting unit which produces a Z axis angular rate electrical signal;**” (1[a])

The claimed “**angular rate producer**” in Yamawaki comprises **3D gyroscope**

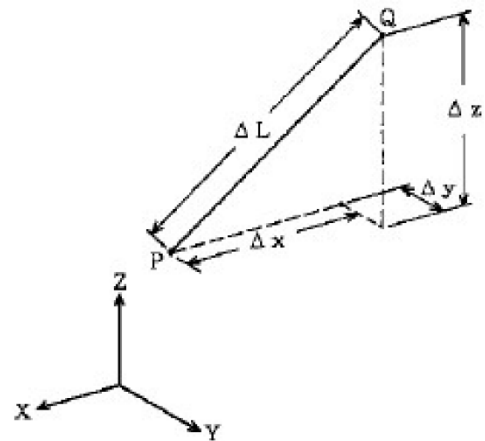
13 of the angular velocity detection unit 7 of Figure 1 (shown at right, partial figure). 3D gyroscope 13, according to Yamawaki, “detects the rotational velocity of the diver during underwater movement.” (Yamawaki, ¶[0016].)



It would have been obvious that 3D gyroscope 13 in Yamawaki comprises “**X axis**,” “**Y axis**,” and “**Z axis**,” angular rate detecting units producing, respectively, an X, Y, and Z axis “**angular rate electrical signals**.” (EX1002, ¶189.) As shown in Figure 1, 3D gyroscope 13 is expressly shown with boxes for providing rotational velocity information for X, Y, and Z axes – consistent with Yamawaki’s repeated reference to gyroscope 13 as “**3D** gyroscope.” (Yamawaki, *e.g.*, ¶¶[0006], [0016], [0037].) The claimed angular rate electrical signals are also shown in Figure 1, being output from 3D gyroscope 13 to integrator 14. (Yamawaki, ¶[0029].)

This is also consistent with Figure 4 (shown at right), which shows a diver moving from point P to point Q, potentially resulting in movement changes in the X, Y, and Z axes. It therefore would have been obvious that 3D gyroscope 13 in Yamawaki would have included angular rate detecting units and would have produced angular rate electrical signals to respond to rotation across the X, Y, and Z axes. (EX1002, ¶189.)

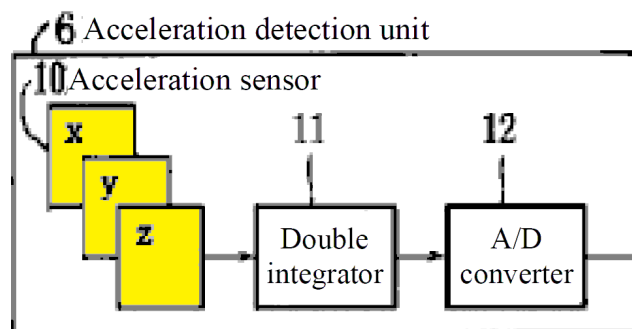
[FIGURE 4]



Moreover, to the extent “**micro**” in the preamble is limiting, as fully explained for the preamble and in connection with **Ground 1**, it would also have been obvious for the gyros in Yamawaki to have been MEMS gyroscopes, which would have produced the claimed angular rate electrical signals. (EX1002, ¶190.)

- (b) “an acceleration producer comprising a X axis accelerometer which produces a X axis acceleration electrical signal, a Y axis accelerometer which produces a Y axis acceleration electrical signal, and a Z axis accelerometer which produces a Z axis acceleration electrical signal; and;” (1[b])

The claimed “**acceleration producer**” in Yamawaki comprises **3D acceleration sensor** 10 within acceleration detection unit 6 (shown at right, partial figure). Yamawaki explains that “3D acceleration sensor

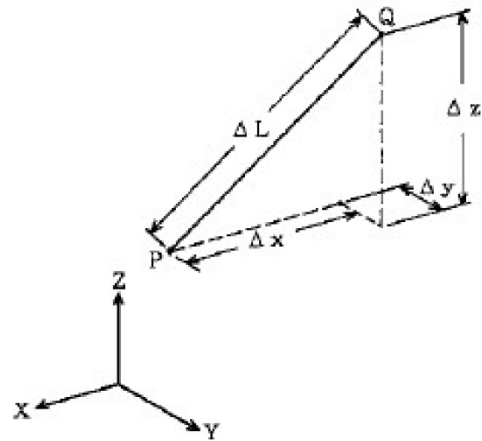


10... detects acceleration during underwater movement of the diver as a moving body.” (Yamawaki, ¶[0016].) Acceleration detection unit 6 also includes a double integrator 11 and an analog-to-digital (A/D) converter 12. (*Id.*) “Output from the acceleration sensor 10 is obtained of changes in movement speed or acceleration in the movement direction relative to the immediately preceding position and is then passed through the double integrator 11, subjected to A/D conversion by the A/D converter 12, acquired at a fixed sampling period, and recorded in the memory with the relative time from the starting point added.” (*Id.*, ¶[0023].)

It would have been obvious that acceleration sensor 10 in Yamawaki comprises “**X axis**,” “**Y axis**,” and “**Z axis**,” accelerometers producing, respectively, an X, Y, and Z axis “**acceleration electrical signals**.” (EX1002, ¶192.) As shown in Figure 1, acceleration sensor 10 is expressly shown with boxes providing acceleration information for X, Y, and Z axes – consistent with Yamawaki’s repeated reference to acceleration sensor 10 as “**3D** acceleration sensor.” (Yamawaki, *e.g.*, ¶¶[0006], [0016], [0037].) The claimed signals are shown in Figure 1, above showing output from acceleration sensor 10 to double integrator 11. (Yamawaki, ¶[0023].)

This is also consistent with Figure 4 discussed above (again shown at right), which as explained, shows the possibility of movement along the X, Y, and Z axes. It therefore would have been obvious that the acceleration sensor in Yamawaki provides accelerometers and acceleration electrical signals across the X, Y, and Z axes. (Yamawaki, ¶[0028] (showing processing of acceleration sensors for X-direction by explaining that “the same process can be used to calculate the components in Y- and Z-directions as well.”).) It would also have been obvious that each of the X, Y, and Z acceleration sensors in Yamawaki is an “**accelerometer**,” as each device is designed to detect acceleration in a particular direction. (EX1002, ¶192.) Yamawaki expressly uses the word “accelerometer” in describing an example of the processing of output from one of these devices. (*Id.*, ¶[0027], Table 1.)

[FIGURE 4]

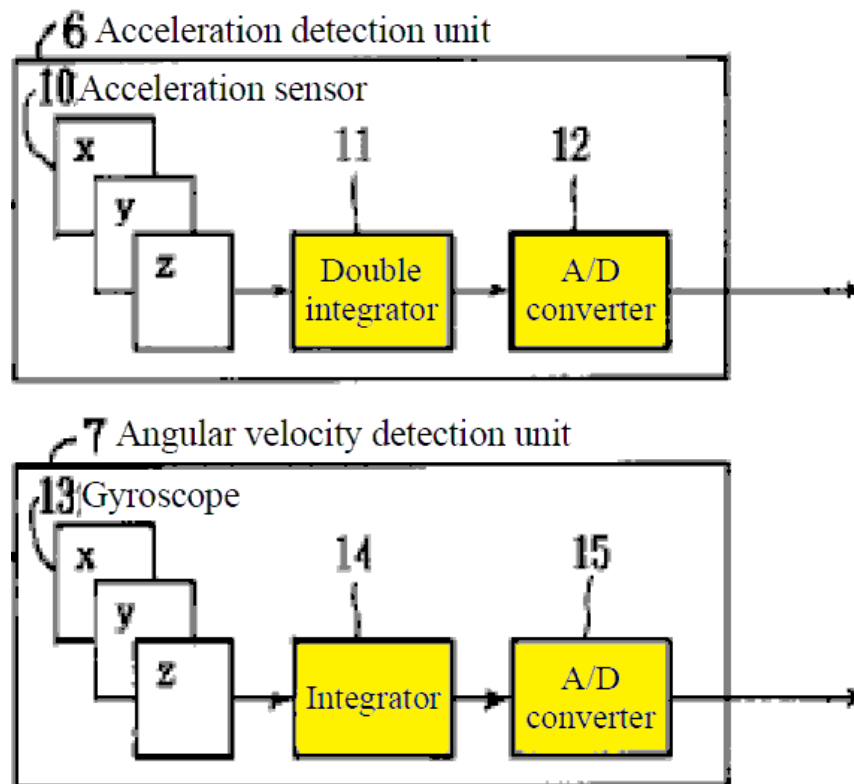


Moreover, to the extent “**micro**” in the preamble is limiting, as fully explained above, it would also have been obvious for the acceleration sensors in Yamawaki to have been MEMS accelerometers, which would have produced the claimed acceleration electrical signals. (EX1002, ¶190.)

- (c) “an angular increment and velocity increment producer, which is electrically connected with said X axis, Y axis and Z axis angular rate detecting units and said X axis, Y axis and Z axis accelerometers, receiving said X axis,

Y axis and Z axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals from said angular rate producer and said acceleration producer respectively, wherein said X axis, Y axis and Z axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals are converted into are digital angular increments and digital velocity increments respectively.” (1[c])

The claimed “**angular increment and velocity increment producer**” in Yamawaki is shown in Figure 1 as including the components shown in yellow:



(Yamawaki, Fig. 1 (partial figure; highlighting added).)

The claimed “**angular increment and velocity increment producer**” in Yamawaki therefore comprises the integrator 14 and A/D converter 15 (of the angular velocity detection unit 7), and the double integrator 11 and A/D converter

12 (of the acceleration detection unit 6). (EX1002, ¶194.) This mapping is consistent with the '648 patent, which discloses an angular increment and velocity increment producer that includes (among other components) angular integrating means **620** and a separate acceleration integrating means **630**. ('648, 8:29-33.)

These components are also “**electrically connected with said X axis, Y axis and Z axis angular rate detecting units and said X axis, Y axis and Z axis accelerometers,**” as shown by the arrows in Figure 1 and the fact that, as discussed, these components receive signals from 3D gyroscope 13 and 3D acceleration sensor 10. (Yamawaki, ¶[0023], [0029]; EX1002, ¶194.)

Yamawaki further discloses that the identified angular increment and velocity increment producer circuitry “**receiv[es] said X axis, Y axis and Z axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals from said angular rate producer and said acceleration producer respectively.**” As noted, Yamawaki discloses that these signals are output from 3D gyroscope 13 and 3D acceleration sensor 10. (Yamawaki, ¶[0023], [0029].)

Yamawaki further teaches and renders obvious that “**said X axis, Y axis and Z axis angular rate electrical signals and said X axis, Y axis and Z axis acceleration electrical signals are converted into digital angular increments and digital velocity increments respectively.**”

Starting with “**digital angular increments,**” these are produced by integrator

14 and A/D converter 15. Yamawaki explains that “the angle of rotation (change in movement direction) can be calculated by using with the integrator 14 to integrate the data obtained chronologically from the gyroscope over time.” (Yamawaki, ¶[0030] (emphasis added).) As Yamawaki further explains:

Assuming that the diver rotates underwater $\Delta\theta_{xy}$ in the X-Y plane during the time Δt , the angular rate $\Delta\omega_{xy}$ in the X-Y plane is expressed as

$$\Delta\omega_{xy} = \Delta\theta/\Delta t.$$

Therefore, the angle of rotation (change in movement direction) can be calculated by using with the integrator 14 to integrate the data obtained chronologically from the gyroscope over time.

(Yamawaki, ¶[0030].) The output is also “subjected to A/D conversion at a fixed sampling period, and imported into the CPU as a digital value to calculate the change in the diver’s movement direction.” (*Id.*, ¶[0029].) Although the particular example above shows movement across the X and Y axes, as explained, 3D gyroscope 13 can generate angular rate information across all three axes. It thus would have been obvious that the angular velocity detection unit would have been capable of measuring change of angular rate across all three axes. (EX1002, ¶197.)

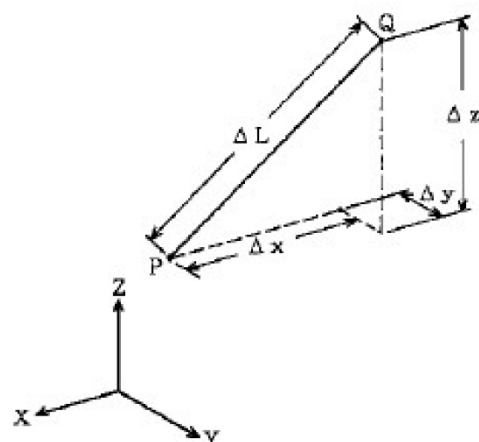
Yamawaki thus discloses “**an angular increment ... producer, which is electrically connected with said X axis, Y axis and Z axis angular rate detecting units... receiving said X axis, Y axis and Z axis angular rate electrical signals... from said angular rate producer,**” *i.e.*, the signals received from 3D gyroscope 13

for the X, Y, and Z axes as discussed above, which are “**converted into... digital angular increments,**” *i.e.*, the change in the angular rate for each of the X, Y, and Z axes produced by the process as discussed above, that uses integrator 14 and analog-to-digital converter 15. (EX1002, ¶198.)

Moving next to “**digital velocity increments,**” it would have been obvious that velocity increments would have been produced within double integrator 11. (EX1002, ¶199.) Yamawaki explains that “[o]utput from the acceleration sensor 10 is obtained of changes in movement speed or acceleration in the movement direction relative to the immediately preceding position and is then passed through the double integrator 11, subjected to A/D conversion by the A/D converter 12, acquired at a fixed sampling period, and recorded in the memory with the relative time from the starting point added.” (Yamawaki, ¶[0023]) (emphasis added).) “This data indicates the distance moved from the position at the previous unit of time.” (*Id.*) Using Figure 4 as an example (shown at right), Yamawaki explains:

[W]hen the diver is at point P in an underwater 3D coordinate system at time t_0 and moves a very small distance ΔL to reach point Q at time t_1 after a minute of time Δt has elapsed, looking at the X-direction component Δx of the movement distance ΔL , the elapsed time Δt is defined as

[FIGURE 4]



$$\Delta t = t_1 - t_0$$

the amount of change in speed in X direction ΔV_x is expressed as

$$\Delta V_x = \Delta x / \Delta t$$

and the acceleration α_x in the X direction is expressed as

$$\alpha_x = \Delta V_x / \Delta t$$

(Yamawaki, ¶[0026] (emphasis added).) “Therefore, by integrating the data obtained chronologically from the acceleration sensor, the change in speed can be calculated, and by integrating this over time, the movement distance can be calculated.” (*Id.*, ¶[0028] (emphasis added).) Although this example only shows “movement components in the X-direction,” the “same process can be used to calculate the components in Y- and Z-directions as well.” (*Id.*)

Yamawaki thus discloses “**a velocity increment producer, which is electrically connected to ... said X axis, Y axis and Z axis accelerometers, receiving... said X axis, Y axis and Z axis acceleration electrical signals from... said acceleration producer,**” *i.e.*, the signals received from 3D acceleration sensor 10 with respect to the X, Y, and Z axes discussed above, which are “**converted into... velocity increments,**” *i.e.*, the amount of the change in speed as discussed above. (EX1002, ¶¶199-200.)

The claim requires production of “**digital velocity increments,**” but Yamawaki does not expressly state that the computed change of speed is passed to an A/D converter after integration of data obtained from acceleration sensor 10. But

this would have been obvious in view of Saubolle. (EX1002, ¶¶201-208.)

Saubolle “relates to a device for monitoring the rate of ascent of divers or similar applications.” (Saubolle, 1:5-6.) Saubolle explains that “[d]ivers using underwater breathing apparatus for diving must control their rate of ascent towards the water surface,” because if they fail to do so, they may suffer “dangerous, unpleasant and possibly fatal decompression effects, commonly referred to as the ‘bends’.” (Saubolle, 1:7-11.) Saubolle goes on to describe a device for monitoring a rate of ascent for use by recreational divers. (Saubolle, 1:66-2:3.)

Rationale and Motivation to Combine (Yamawaki with Saubolle): It would have been obvious to combine Yamawaki with Saubolle, predictably resulting in the mobile data collection device of Yamawaki, adapted such that the acceleration detection unit 6 outputs not just distance the diver has moved, but *also* the change in speed of the diver. (EX1002, ¶203.) In one exemplary implementation of the proposed combination, an additional A/D converter could have been readily provided to convert the change of speed information into digital form, thus resulting in production of “**digital velocity increments**,” as claimed. (*Id.*)

Under the proposed combination, therefore, the mobile collection device would have made available, for recording and later analysis, both of these pieces of information. Petitioner does not rely on the particular details of the allegedly inventive ascent/descent rate monitoring system in Saubolle, but on his general

disclosure of the need to carefully monitor the rate of ascent or descent in a diving scenario, which as explained below, would have provided a clear motivation to adapt Yamawaki to obtain and record change of speed information. (EX1002, ¶203.) This combination is particularly straightforward because, as noted, above, the data collection device in Yamawaki *already* determines the change in velocity of the diver across all three axes. (Yamawaki, ¶¶[0028]; EX1002, ¶207.) Yamawaki and Saubolle are analogous references in the same field of systems for monitoring movement, such as velocity and/or angular position, and would have been reasonably pertinent to problems facing the inventors. (EX1002, ¶204.)

A skilled artisan would have been motivated to adapt Yamawaki to record velocity information. The purpose of Yamawaki, after all, is to record information about the swimmer's path to allow training of beginning and even more experienced divers. (Yamawaki, *e.g.*, ¶¶[0002]-[0003], [0008], [0010].) Yamawaki confirms that diving entails certain dangers, including the effects of "water depth," thus "making it essential for beginners to receive training." (Yamawaki, ¶[0002] (emphasis added).) And as Saubolle explains, it is important for divers to "control their rate of ascent towards the water surface, if they are not to suffer dangerous, unpleasant and possibly fatal decompression effects, commonly referred to as the 'bends'." (Saubolle, 1:7-11.) It therefore would have been obvious that information about the diver's velocity – such as the rate of ascent towards the surface – would

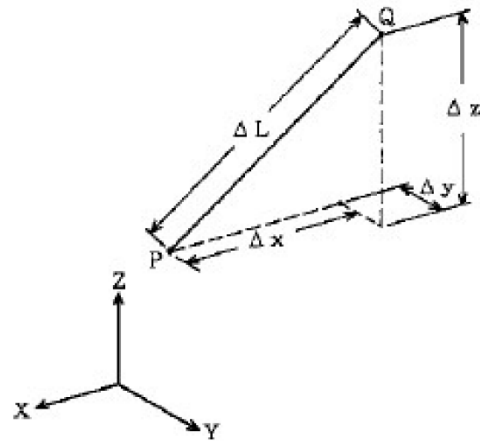
have been valuable for training purposes. (EX1002, ¶205.) By recording velocity, for example, a diver could have been informed during training if their rate of ascent during previous dives created risks of decompression effects. (*Id.*)

Although the need to prevent decompression effects is primarily concerned with the diver's velocity in the vertical (Z axis)

[FIGURE 4]

direction towards the surface, it would also have been obvious and beneficial to record velocity increments across all three (X, Y, and Z) axes.

(EX1002, ¶206.) This is because, as Saubolle explains, “[d]ivers may also become disoriented, and become unaware of whether they are



ascending or descending[.]” (Saubolle, 1:21-22.) In the example shown in Figure 4 (at right), a diver moving from point P to point Q may have moved a distance across all three axes (Δx , Δy , Δz). The diver in this case may have deliberately increased their speed across the X and Y axes in order to reach an object of interest, not realizing that they also increased their rate of ascent across the Z axis. It therefore would have been obvious to capture and record velocity information across all three axes in order to facilitate training, so the diver can better understand how an increase in their swimming velocity could inadvertently result in a potentially dangerous increase in velocity across the Z axis towards the surface. (EX1002, ¶206.)

A skilled artisan would have had more than a reasonable expectation of success and could have implemented the proposed combination using conventional techniques without undue experimentation. Yamawaki explains that memory is finite such that “in order to effectively utilize this limited memory capacity, it is necessary to record the maximum amount of significant data.” (Yamawaki, ¶[0024].) Nevertheless, as explained, the diver’s change of velocity is significant data worthy of collection for training. (EX1002, ¶207.)

Finally, to the extent the word “**micro**” in the preamble is limiting, as discussed extensively above, it would also have been obvious for the gyroscopes and accelerometers in Yamawaki to have been substituted with micromechanical gyroscopes and accelerometers. Under the proposed combination, therefore, the data collection device in Yamawaki would have been adapted to receive and process signals from MEMS gyroscopes and accelerometers to produce the claimed digital angular and velocity increments. (EX1002, ¶208.)

2. Dependent Claim 4

It would have been obvious that the “**angular rate electrical signals**” and “**acceleration electrical signals**,” discussed for claim limitations 1[a] and 1[b] above, are analog signals. This is evident by the fact that, as shown in Figure 1 of Yamawaki, these signals (after integration and double-integration) undergo analog-to-digital conversion through A/D converters 15 and 12. (EX1002, ¶211.)

Yamawaki does not state that the angular rate electrical signals and acceleration electrical signals are “**voltage signals**,” that are “**directly proportional**” to the angular rate or acceleration. As fully explained in **Ground 2**, these are basic concepts that were well-known and basic knowledge. (EX1002, ¶¶212, 140-141.) It therefore would have been obvious that the “**electrical signals**” produced from the angular producer and the acceleration producer in Yamawaki would have been “**analog voltage signals directly proportional to**,” respectively, the angular rotation and acceleration of the data collection unit carrying the gyroscopes and accelerometers. (EX1002, ¶¶141, 148, 213-214.) As noted for **Ground 2**, Irwin confirms the basic knowledge of a skilled artisan that an electric signal generated by a sensor “provides an analog signal proportional to the parameter” (Irwin, §7.3, p.242), such as “[a]cceleration” or “[r]otation” (*id.*, Table 7.1, p.241); EX1002, ¶¶140, 213.) And as fully explained for **Ground 2**, a skilled artisan would have been motivated to provide directly proportional analog voltage signals to obtain more accurate and thus more useful movement-related information. (EX1002, ¶¶148, 177-178; 213-214.)

Claim 4 ends with “**said vehicle**,” which has no antecedent basis in claim 4 or claim 1 from which it depends. Patent Owner has taken the position in the pending litigation that “said vehicle” in claim 4 refers to “said carrier,” whereas Petitioner says that it refers to “a device or structure for transporting persons or things.”

Yamawaki discloses either construction because the accelerometers and gyros are mounted to the data collection device, in turn mounted to an underwater moving body, *e.g.*, worn by a diver. (Yamawaki, ¶[0008]; EX1002, ¶¶215-216.)

VII. CONCLUSION

Petitioner respectfully requests institution of IPR.

Dated: March 7, 2024

Respectfully submitted,

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CERTIFICATE OF COMPLIANCE WITH WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), I certify that this petition complies with the type-volume limits of 37 C.F.R. § 42.24(a)(1)(i) because it contains 13,910 words, according to the word-processing system used to prepare this petition, excluding the parts of this petition that are exempted by 37 C.F.R. § 42.24(a) (including the table of contents, a table of authorities, mandatory notices, a certificate of service or this certificate word count, appendix of exhibits, and claim listings).

DATED: March 7, 2024

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/s/ Matthew J. Brigham
Matthew J. Brigham

CERTIFICATE OF SERVICE

I hereby certify, pursuant to 37 C.F.R. Sections 42.6 and 42.105, that a complete copy of the attached **PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 6,671,648 B2**, including all exhibits (**EXS1001-1023**) and related documents, are being served via Federal Express on the 7th day of March, 2024, the same day as the filing of the above-identified document in the United States Patent and Trademark Office/Patent Trial and Appeal Board, upon Patent Owner by serving the correspondence address of record with the USPTO as follows:

David and Raymond Patent Firm
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Monterey Park, CA 91754
United States

And, via Federal Express upon the following counsel for Patent Owner in *American GNC Corp. v. Nintendo Co., Ltd., et al.*, in the United States District Court, Western District of Washington, Case No. 2:23-cv-00302-TL as follows:

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