

American GNC Corp.

May 28, 2025 IPR Hearing

Nintendo v. American GNC, IPR2024-00668

U.S. Patent No. 6,671,648



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

(10) Patent No.: **US 6,508,122 B1**
(45) Date of Patent: ***Jan. 21, 2003**

(54) **MICROELECTROMECHANICAL SYSTEM FOR MEASURING ANGULAR RATE**

(75) Inventors: Hiram McCall, Ching-Fang Lin

(73) Assignee: American Valley, CA

(*) Notice: Subject to patent is e U.S.C. 154

This patent claimer.

(21) Appl. No.: 09/662,438

(22) Filed: Sep. 15, 2000

Related U.S. A

(60) Provisional application 7/1999

(51) Int. Cl. 7

(52) U.S. Cl.

(58) Field of Search

(56) Referen

U.S. PATENT

5,131,789 A * 7/1992

21

Oscillator

Capacitive Pickoff Excitation

22

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

4 Claims, 26 Drawing Sheets

5

6

80

10

Angular Rate Producer

Angular Increment Velocity Increment Producer

Acceleration Producer

Position and Attitude Processor

Position And Attitude Solution

MEMS technology substitution



Claim 1 ('648 Patent)

1. A **micro inertial measurement unit**, comprising:

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;

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

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.

EX1001 at claim 1

Claim 1 ('648 Patent)

1. A micro inertial measurement unit, comprising:

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;

an acceleration producer comprising a X axis acceleration detecting unit which produces a X axis acceleration electrical signal, a Y axis acceleration detecting unit which produces a Y axis acceleration electrical signal, and a Z axis acceleration detecting unit which produces a Z axis acceleration electrical signal;

an angular increment producer comprising a X axis angular increment detecting unit which produces a X axis angular increment electrical signal, a Y axis angular increment detecting unit which produces a Y axis angular increment electrical signal, and a Z axis angular increment detecting unit which produces a Z axis angular increment electrical signal;

In view of the Specification's extensive disclosures underscoring the importance of using MEMS technology in the inventors' IMU, noted above, **we further construe the preamble as requiring the IMU to implement the structures recited in the claims as MEMS—that is, “micromachine” technology.**

Paper 10 at 23

EX1001 at claim 1

references use other sensor technology

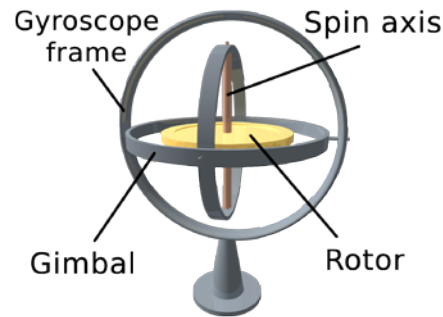
Smith: “a cluster of three **ring laser gyros**” EX1003, Abstract, Fig. 2

Tingleff: “gyro **gimbal**” EX1004, 7:2-7

Yamawaki: “**3D** gyroscope 13” EX1010, Abstract

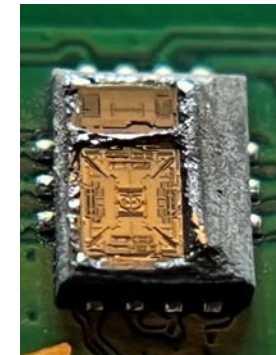


Example Ring Laser Gyro EX2022



Stock Image of Gimbal Gyro

≠



Example MEMS Gyro EX2025

Response at 5, 17, 37-41 (Smith), 45-48 (Tingleff), 48-52 (Yamawaki); Sur-Reply at 1-3

references use other sensor technology

Nintendo cites to *Chan* (accelerometer) and *Bernstein* (gyroscope) only for general proposition of **availability** of MEMS sensor technology:

Petition at 15:

“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.**”

Response at 5, 17, 28-29; Sur-Reply at 1-2

more than “availability” is required

'648 Patent: “MEMS angular rate sensors and MEMS accelerometers are **available commercially**”

EX1001 at 2:46-50; Response at 5-6; Sur-Reply at 1-3.

Petition: “MEMS angular rate sensors and accelerometers were **known and commercially available**”

Petition at 13; *see also id.* at 5 (“well-known”), 7, 8, 13, 14, 15 (“commercially available”), 16, 17, 18, 46, 48, 51, 55 (“which were well-known as discussed”); Reply at 9, 18.

“That is an error as a matter of law. **It does not suffice to simply be known.** A reason for combining must exist.”

Virtek Vision Int'l ULC v. Assembly Guidance Systems, Inc., 97 F. 4th 882, 887-88 (Fed. Cir. 2024).

Response at 5-6, 29-30, 40-41; Sur-Reply at 2

more than “availability” is required

Technology can be “available” and yet beyond ordinary skill.

'648 Patent:

“difficulties” of “building a micro IMU” with MEMS sensors

EX1001, 6:6-43

“insufficient accuracy, sensitivity, and stability”

Id., 17:19-36

Response at 5, 10-11, 31, 47; Sur-Reply at 3-4, 8-14

more than “availability” is required

Technology can be “available” and yet beyond ordinary skill.

“So I believe that the inertial navigation [MEMS] people were still maybe struggling more in the research phase at this time”

Professor Larson, EX1046, 27:3-15; EX2019, ¶¶52-54, 76-80

“it required substantial expertise, design, and experimentation”

Hiram McCall, EX2023, ¶¶3, 5- 14, 24-25

“I worked on it for about ten years”

Professor Young, EX2020 at 31:24-36:2

Response at 5, 10-11, 31, 47; Sur-Reply at 3-4, 8-14

MEMS substitution was not obvious

77. ... In my opinion, Professor Young severely underestimates the knowledge, skill, and level of re-design that would be required to make this substitution of sensor technology type. **Changing one type of sensor for another would require non-trivial re-design of the manufacturing process and associated control circuits**, as Professor Young appears to acknowledge. EX1002 ('648 Petition), ¶99. And in particular, **MEMS sensors at the time required complicated electronic circuitry to reliably control**, as the '648 Patent described and taught.



Professor Larson

Response at 7-8, 29-41; Sur-Reply at 2-4, 10-14; EX2019 at ¶¶76-80

MEMS substitution was not obvious

78. I do not agree with Professor Young's suggestion that this substitution would be "straightforward" or implemented with "conventional techniques without undue experimentation." EX1002 ('648 Petition), ¶¶99, 104. While MEMS sensors existed at the time, **the field of applying them in practice was nascent, without many successful examples to guide persons of ordinary skill.**

... integration of MEMS rate and acceleration sensors into an IMU at the time of the American GNC Patents was **a difficult challenge beyond the capabilities of one of only ordinary skill**, in what was a rapidly developing art.



Professor Larson

Response at 7-8, 29-41; Sur-Reply at 2-4, 10-14; EX2019 at ¶¶76-80

MEMS substitution was not obvious

25. ... In 1999 and since then, the specifics of the required control system electronics for a gyroscope or an IMU design are dependent on the sensor technology type. **Changing one sensor technology for another is not less work than designing from scratch with a MEMS sensor.** As my own work discussed above showed, it **required substantial expertise, design, and experimentation** to produce the American GNC coremicro IMU product.



Hiram McCall

Response at 7-8, 29-41; Sur-Reply at 2-4, 10-14; EX2023 at ¶¶13, 5-20, 24-25

MEMS substitution was not obvious

11. **In the capacitive MEMS gyroscopes available at the time of the invention, there were significant unaddressed problems.** For example, mechanical crosstalk was a major issue. Also, low materials quality caused differences from one device to another even in the same design, often requiring individual tuning and calibration to counteract. And of course, the small signal size relative to the many sources of noise made it **nearly impossible to obtain a suitably accurate measurement of angular rate with the analog loop control systems that were being used.** *See, e.g., '648 Patent, at 17:19-28; '122 Patent at 2:1-4.*



Hiram McCall

Response at 7-8, 29-41; Sur-Reply at 2-4, 10-14; EX2023 at ¶¶13, 5-20, 24-25

MEMS substitution was not obvious

“... I worked on it for about ten years”

...

“I started that project around 2007/2008”

...

“there was a team of people working on it”

...

“those were commercially-available MEMS sensors, accelerometers, gyroscopes”



Dr. Young

EX2020 at 31:24-36:2; *see also id.* at 66:22-70:3, 77:7-81:13

MEMS substitution was not obvious

“I don’t think I said that person could have easy time with it; right?”

“**would have required a change in the manufacturing processes**”
and “**a change to the signal conditioning electronics**”



Dr. Young

EX2020 at 76:25-80:3; EX1002 at ¶99

considerations of non-obviousness



American GNC's coremicro IMU product

“My circuit designs that led to the '122 and '648 Patents, including the digital signal processing elements of those designs, were **successfully implemented in American GNC's coremicro IMU product**”

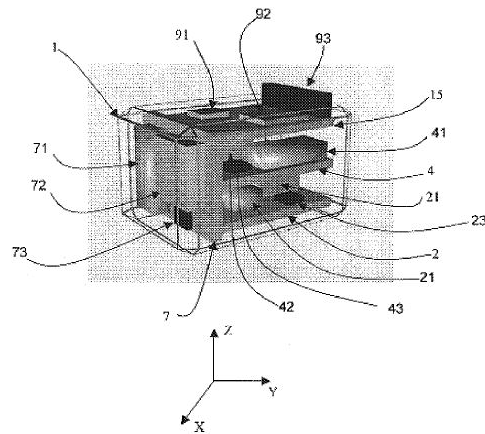


Figure 17

EX1001, Fig. 17



Image of coremicro IMU. See, e.g., EX2002 at 2

EX2023, ¶¶15-20

Response at 1-2, 21-22; Sur-Reply at 4-6, 14-18

American GNC's coremicro IMU product

Inventor McCall worked on the patents and the coremicro IMU together.

EX2024, 16 (“MEMS Provisional patent” and “MEMS Micro IMU Development”)

The coremicro IMU is the preferred embodiment of the '648 Patent.

EX1001 at 17:37-42 (“the micro IMU of the present invention”), 23:42-24:21 (claim 1), Fig 17

American GNC is entitled to a presumption of nexus, because the coremicro IMU product **“is** the invention disclosed and claimed.”

Demaco Corp. v. F. Von Langsdorff Licensing Ltd., 851 F.2d 1387, 1392 (Fed. Cir. 1988);
Polaris Indus., Inc. v. Arctic Cat, Inc., 882 F.3d 1056, 1072 (Fed. Cir. 2018)

Response at 1-2, 21-22; Sur-Reply at 4-6, 14-18

the inventions were successful

20. My circuit designs that led to the '122 and '648 Patents, including the digital signal processing elements of those designs, were successfully implemented in American GNC's coremicro IMU product. I understand that **this product was commercially successful for American GNC** as well.



Hiram McCall

Response at 2-4, 39; Sur-Reply at 4-6, 10-14; EX2023 at ¶¶19-20; EX2019 at ¶55

the inventions were successful

American GNC succeeded before NASA JPL and Draper Labs.

22. For example, **NASA Jet Propulsion Laboratories** attempted to develop a navigation-grade silicon MEMS device, but I understand that it was not robust enough to survive the required environmental testing. Similarly, **Draper Labs** had funding from DARPA to develop such a sensor, but I understand that it did not achieve navigation-grade performance.

JPL - PH II Fengs proposal
substituted with figure on page 14

4. Business related contacts.

Neil Barber of Draper Labs for MEMS data.

- b) Preparation for a trip to camp Pendleton CDNU on 3/17.
- c) Discussion for tracker Ball Kalman Filter for JPL trip on 4/2
- d) Discussion for Army [REDACTED] demonstration on PC 104



Hiram McCall

EX2005 at 3; EX2024 at 1, 4

Response at 2-4, 39; Sur-Reply at 4, 11, 16-17; EX2023, ¶¶5-23; EX1048, 18:8-15, 18:23-19:11

the inventions were successful

55. ... American GNC was **successful at developing and commercializing** a MEMS Inertial Measurement Unit based on the techniques claimed and patented in the '648 Patent.

78. ... **I understand that American GNC also received patents, recognition, and citations for its work in MEMS motion sensors.** *E.g.*, EX2007 at ¶¶16-37. Based on this, and on my understanding as detailed here, integration of MEMS rate and acceleration sensors into an IMU at the time of the American GNC Patents was a difficult challenge beyond the capabilities of one of only ordinary skill, in what was a rapidly developing art.



Professor Larson

Response at 4, 38-39; Sur-Reply at 4, 14-17; EX2019 at ¶¶52-55, 77-80; EX1046, 27:3-15; EX1048, 37:18-38:16

the inventions were cited and licensed

Q. Okay. "From 2015 to the present **Hiram has supported the successful licensing of AGNC patents** (including but not limited to those patents with him as the inventor) **in the areas of silicon MEMS inertial rate sensors and critical interfacing circuits.**" Do you see that?

A. Yes. This is an accurate statement.

EX1048 at 37:18-38:16



Hiram McCall

Response at 4, 33, 39; Sur-Reply at 1, 4, 16-17; EX2023 at ¶¶19-20; EX2019 at ¶¶55, 78

other missing elements



Claim 1 ('648 Patent)

1. A micro inertial measurement unit, comprising:

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;

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

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.

EX1001 at claim 1

Claim 4 ('648 Patent)

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.

For both claims, angular rate electrical signals must be directly proportional to the angular rate, i.e., **directly reflect the angular rate**

For claim 4, must also be “analog” and “voltage”-varying, and relate to a “carrier”

EX1001 at claim 4, 16:54-59; Response at 24-26; Sur-Reply at 7-8

no angular rate electrical signals

Smith's ring laser gyros work differently than vibrating type.

Do not produce angular rate signal, but rather “a train of pulses whose **frequency** is directly proportional to Ω .”

EX1008, 21-23, Figure 8.2:

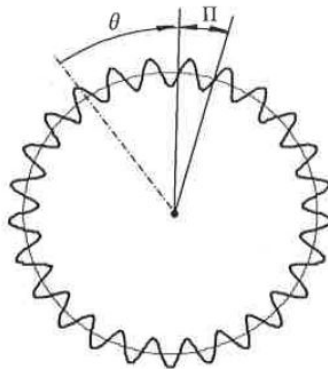


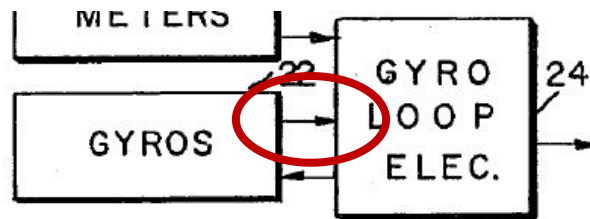
Figure 8.2. Annular standing wave interpretation of the RLG.

Requires additional step (pulse counting) to infer an angular rate, and so is not an angular rate electrical signal properly understood

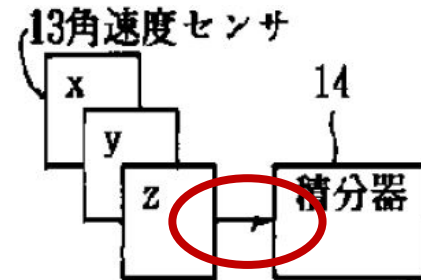
Response at 17, 24-26, 42-44; Sur-Reply at 18-20

no angular rate electrical signals

Tingleff and Yamawaki provide no details about their gyroscope outputs.



EX1004, Fig. 1 (detail)



EX1009, Fig. 1 (detail)

Arrows from a box do not disclose or suggest the particular signal requirements of claims 1 and 4.

Response at 48, 55; Sur-Reply at 18-20

no angular rate electrical signals

Nintendo did not cite or rely on *Bernstein* for these elements.

Petition at 18-20, 47-48, 53, 60-61; *see also id.* at 15:

“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.”

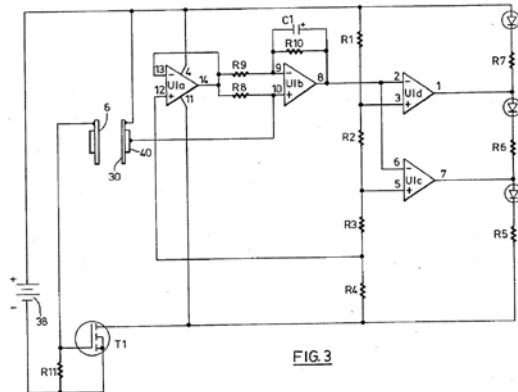
Sur-Reply at 18-20

digital velocity increments

Yamawaki admittedly doesn't have this element.

Saubolle doesn't either, disclosing an **analog threshold detector**.

EX1011, Abstract, Figure 3:



Combination of two references that don't output a digital velocity increment cannot render that element obvious. And it is improper to apply hindsight masquerading as alleged "background" knowledge.

Response at 52-54; Sur-Reply at 21

RPI and Motion for Discovery



RPI and Motion for Discovery

Issue needn't be reached if claims upheld.

Recent Director guidance supports discovery in this proceeding.

Semiconductor Components Industries, LLC v. Greenthread, LLC, IPR2023-01242, Decision on Director Review, Paper 94 (P.T.A.B. April 24, 2025).

Requested discovery is narrowly tailored and appropriate.

Samsung Electronics Co., Ltd. v. Netlist, Inc., IPR2022-00615, 2023 WL 9787488 at *4 (P.T.A.B. Feb. 3, 2023).

The RPI statute applies to STMicro entities, who were “served with a complaint alleging infringement of the patent” here.

35 U.S.C § 315(b).

Response at 63-66; Sur-Reply at 21-24; Paper 41

Thank You

