

IPR 2023-01422
U.S. Patent No. 11,287,515

Presentation of Petitioner
Hesai Technology Co. Ltd.

'515 Patent

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

(54) **ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY**

(71) Applicant: **Ouster, Inc.**, San Francisco, CA (US)

(72) Inventors: **Angus Pacala**, San Francisco, CA (US); **Mark Frichtl**, San Francisco, CA (US); **Marvin Shu**, Daly City, CA (US); **Eric Younge**, Portola Valley, CA (US)

(73) Assignee: **Ouster, Inc.**, San Francisco, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/323,987**

(22) Filed: **May 18, 2021**

(65) **Prior Publication Data**
US 2021/0278506 A1 Sep. 9, 2021

Related U.S. Application Data
(63) Continuation of application No. 16/209,875, filed on Dec. 4, 2018.

(51) **Int. Cl.**
G01S 17/89 (2020.01)
G01S 7/481 (2006.01)
(Continued)

(52) **U.S. CL**
CPC **G01S 7/4813** (2013.01); **B60L 3/0015** (2013.01); **G01S 7/486** (2013.01); **G01S 7/4814** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC **G01S 17/42**; **G01S 7/4817**; **G01S 17/10**; **G01S 17/89**; **G01S 7/4813**;
(Continued)

(10) **Patent No.:** **US 11,287,515 B2**
(45) **Date of Patent:** **Mar. 29, 2022**

(56) **References Cited**
U.S. PATENT DOCUMENTS
4,358,851 A 11/1982 Scifres et al.
4,634,272 A 1/1987 Endo
(Continued)
FOREIGN PATENT DOCUMENTS
CN 103454625 12/2013
CN 105068085 11/2015
(Continued)
OTHER PUBLICATIONS
US 10,830,892 B2, 11/2020, Pacala et al. (withdrawn)
(Continued)
Primary Examiner — Que Tan Le
(74) **Attorney, Agent, or Firm** — Kilpatrick Townsend & Stockton LLP

(57) **ABSTRACT**
A light ranging system including a shaft; a first circuit board assembly that includes a stator assembly comprising a plurality of stator elements arranged about the shaft on a surface of the first circuit board assembly; a second circuit board assembly rotationally coupled to the shaft, wherein the second circuit board assembly includes a rotor assembly comprising a plurality of rotor elements arranged about the shaft on a surface of the second circuit board assembly such that the plurality of rotor elements are aligned with and spaced apart from the plurality of stator elements; a stator driver circuit disposed on either the second or the first circuit board assemblies and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the plurality of rotor elements to drive a rotation of the second circuit board assembly about the shaft; and a light ranging device mechanically coupled to the second circuit board assembly such that the light ranging device rotates with the second circuit board assembly.

25 Claims, 18 Drawing Sheets

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

(54) **ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY**

(71) Applicant: **Ouster, Inc.**, San Francisco, CA (US)

(72) Inventors: **Angus Pacala**, San Francisco, CA (US); **Mark Frichtl**, San Francisco, CA (US); **Marvin Shu**, Daly City, CA (US); **Eric Younge**, Portola Valley, CA (US)

(73) Assignee: **Ouster, Inc.**, San Francisco, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/323,987**

(22) Filed: **May 18, 2021**

(10) **Patent No.:** **US 11,287,515 B2**
(45) **Date of Patent:** **Mar. 29, 2022**

(56) **References Cited**
U.S. PATENT DOCUMENTS
4,358,851 A 11/1982 Scifres et al.
4,634,272 A 1/1987 Endo
(Continued)
FOREIGN PATENT DOCUMENTS
CN 103454625 12/2013
CN 105068085 11/2015
(Continued)
OTHER PUBLICATIONS
US 10,830,892 B2, 11/2020, Pacala et al. (withdrawn)
(Continued)
Primary Examiner — Que Tan Le
(74) **Attorney, Agent, or Firm** — Kilpatrick Townsend & Stockton LLP

(57) **ABSTRACT**
A light ranging system including a shaft; a first circuit board assembly that includes a stator assembly comprising a plurality of stator elements arranged about the shaft on a surface of the first circuit board assembly; a second circuit board assembly rotationally coupled to the shaft, wherein the second circuit board assembly includes a rotor assembly comprising a plurality of rotor elements arranged about the shaft on a surface of the second circuit board assembly such that the plurality of rotor elements are aligned with and spaced apart from the plurality of stator elements; a stator driver circuit disposed on either the second or the first circuit board assemblies and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the plurality of rotor elements to drive a rotation of the second circuit board assembly about the shaft; and a light ranging device mechanically coupled to the second circuit board assembly such that the light ranging device rotates with the second circuit board assembly.

25 Claims, 18 Drawing Sheets

Demonstrative Exhibit – Not Evidence – Petitioner's Presentation – 3

- Spinning light ranging device
- Rotor circuit board
- Stator circuit board
- Support component

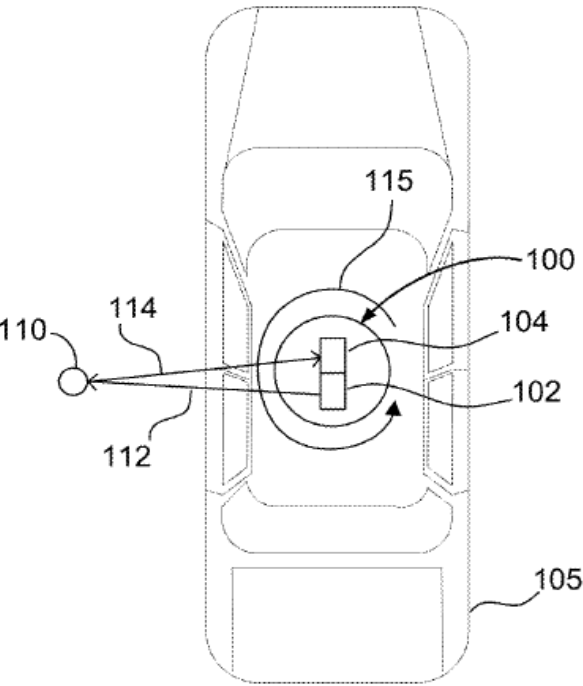


FIG. 1A

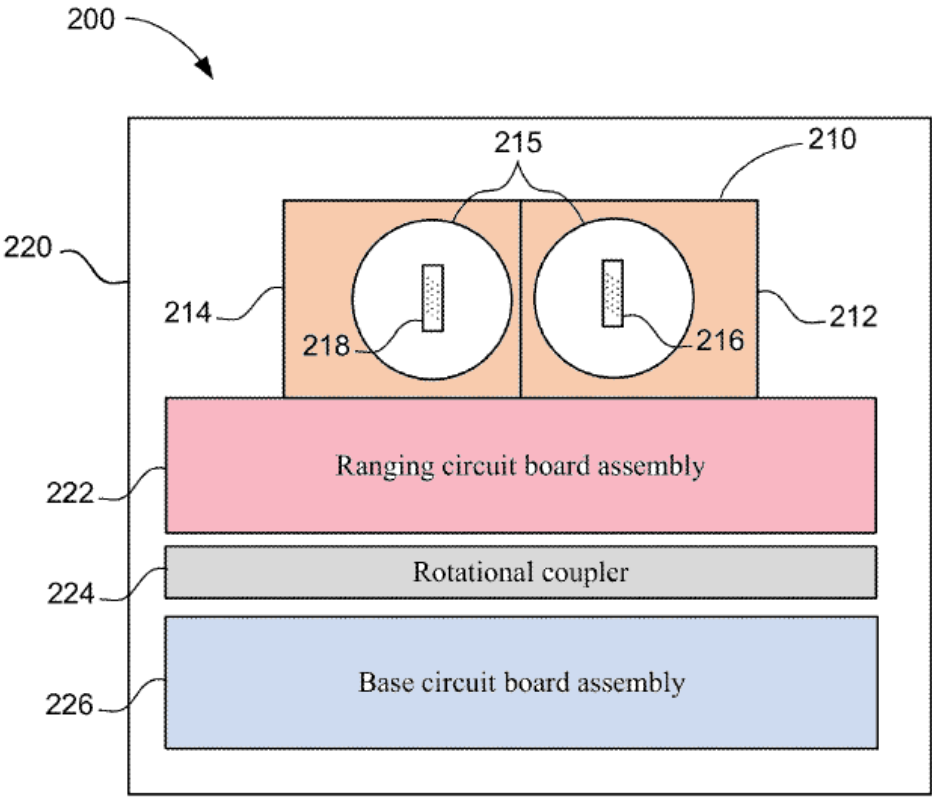


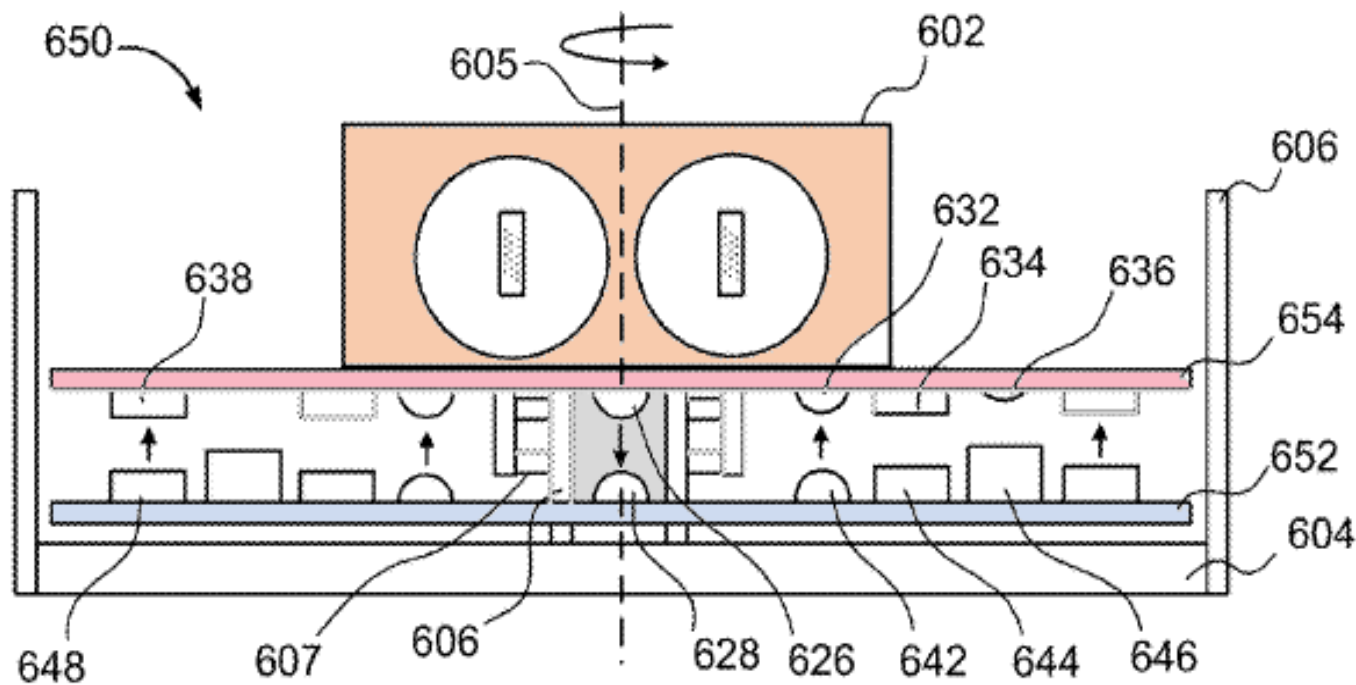
FIG. 2A

Rotational coupler 224 can be implemented in a number of different ways in various embodiments. For example, some embodiments can employ a shaft and bearing structure. In some embodiments, rotational coupler 224 also

'515 patent at 16:12-15

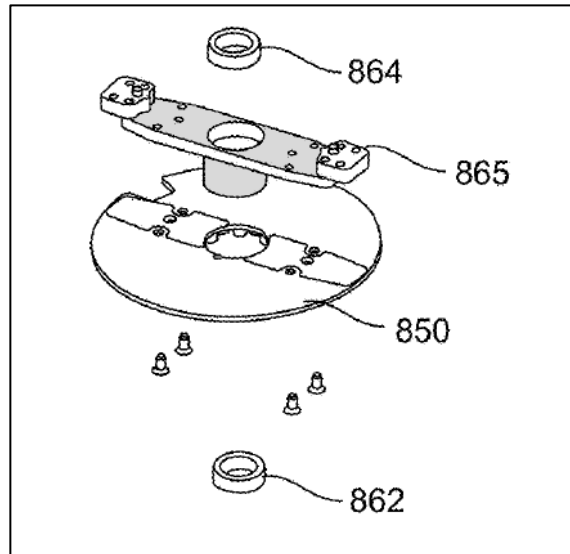
U.S. Pat. No. 11,287,515

- Spinning light ranging device
- Rotor circuit board
- Stator circuit board
- Support component

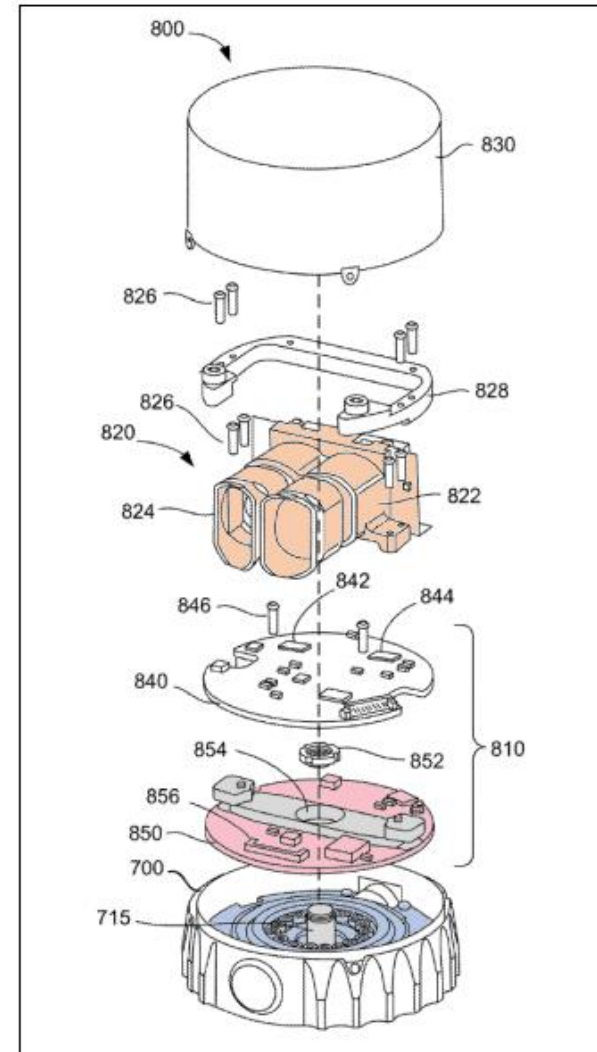


U.S. Pat. No. 11,287,515

- Spinning light ranging device
- Rotor circuit board
- Stator circuit board
- Support component



Rotor board 850 includes a bearing assembly 860, shown in FIG. 8B, which is an exploded view of rotor board 850. Bearing assembly 860 includes bearings 862 and 864, which are inserted into either end of a t-shaped bearing housing 865. T-shaped bearing housing 865 can then be attached to rotor board 850 with screws 866.



Claim 1 – Most Limitations Are Undisputed

1[a]	A light ranging system comprising:	✓
1[b]	an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;	✓
1[c]	a shaft disposed within the enclosure and defining an axis of rotation;	✓
1[d]	a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure;	✓
1[e]	a support component rotationally coupled to the shaft and comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve;	
1[f]	a rotor circuit board coupled to the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover;	
1[g]	a stator assembly disposed between the first and second planes and coupled to the stator circuit board , the stator assembly comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil wound around a magnetic core;	
1[h]	a rotor assembly disposed between the first and second planes and coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles; and	✓
1[i]	a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment; and	✓
1[j]	a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft.	✓

Claims 1/14

- **PO's "a coil wound around a magnetic core" argument applies only to Claim 1**

Claim 1

a stator assembly disposed between the first and second planes and coupled to the stator circuit board, the stator assembly comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil **wound around a magnetic core;**

Claim 14

a stator assembly coupled to the stator circuit board and comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil;

Claim 4 – “Third” and “Fourth” Circuit Boards

4. The light ranging system of claim 1 further comprising:
a third circuit board fixedly coupled to the base and arranged in a plane parallel with the first plane and disposed between the enclosure base and the stator circuit board; and
a fourth circuit board coupled to rotate with the rotor circuit board between the enclosure top and the rotor circuit board and arranged in a plane parallel with the first plane.

Claim 17 – Transformer Coils Outside Motor Perimeter

17. The light ranging system of claim 14 further comprising a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement.

Claims 13/21 – Plurality of SPADs

13. The light ranging system of claim **12** wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs).

21. The light ranging system of claim **20** wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs).

Claim 22 – Adds Dependent Claim Limitations

22. A light ranging system comprising:
an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;
a shaft disposed within the enclosure and defining an axis of rotation, the shaft including a hollow channel axially aligned with the axis of rotation and extending through a length of the shaft;
a stator circuit board assembly disposed within and coupled to the enclosure in a fixed relationship, the stator circuit board assembly comprising:
a first circuit board disposed along a plane perpendicular to the axis of rotation;
a second circuit board disposed parallel to and adjacent to the first circuit board and having a first aperture formed through a central portion of the second circuit board; and
a stator assembly comprising a plurality of stator elements arranged about the axis of rotation;
a rotor circuit board assembly disposed within the enclosure and rotationally coupled to the shaft, the rotor circuit board assembly comprising:
a support component having lower and upper surfaces, a sleeve extending away from the lower surface and fitted over the shaft, a plurality of arms extending away from the sleeve, and a plurality of alignment posts extending away from the upper surface;
a third circuit board coupled to the lower surface of the support component and disposed adjacent to and in an opposing relationship with the second circuit board;
a fourth circuit board coupled to the upper surface of the support component and arranged parallel with the third circuit board between the third circuit board and the top cover, the fourth circuit board having a plurality of alignment cutouts sized and shaped to accept the alignment posts; and

a rotor component coupled to the rotor circuit board assembly and spaced apart from and concentric with the stator assembly, the rotor component comprising an annular arrangement in which a plurality of magnetic segments surround the axis of rotation and are distributed along the annular arrangement in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles;
a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module and a receive module,
the transmit module comprising a bulk transmitting optic and a light source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment,
the receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment, wherein the detector circuitry comprises a plurality of pixels, each pixel comprising a plurality of single photon avalanche detectors (SPADs) and wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the light source and the detection of reflected portions of the electromagnetic radiation pulses by the detector circuitry;
a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the rotor component to drive a rotation of the second circuit board assembly and the light ranging device about the shaft;

a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement; and
a communication channel extending through the hollow channel in the shaft and operatively coupled to allow ranging data from the light ranging device to be transmitted to circuitry disposed within the enclosure in a fixed relationship to the stator circuit board assembly.

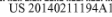
Claim 4

Claim 13/21

Claim 17

Claim 1 (Ground 1)

Pacala (EX1004)



(12) **Patent Application Publication**
PACALA et al.

(10) Pub. No.: US 2014/0211194 A1
(43) Pub. Date: Jul. 31, 2014

Related U.S. Application Data

(60) Provisional application No. 61/757,222, filed on Jan. 27, 2013.

Publication Classification

(51) **Int. Cl.**
G01S 17/06 (2006.01)

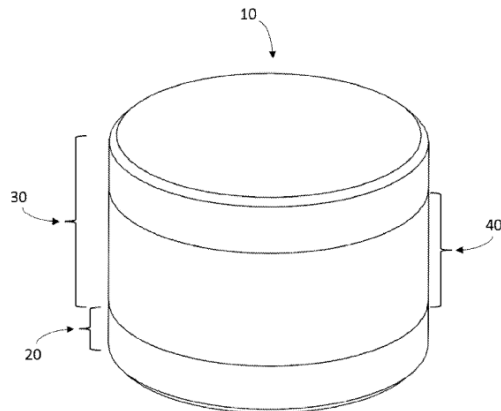
(52) **U.S. CL.**
CPC *G01S 17/06* (2013.01)
USPC **356/5.01**

(57) **ABSTRACT**

A lidar-based apparatus and method are used for multi-signal detection, weak signal detection and signal disambiguation through waveform approximation utilizing a multi-channel time-to-digital converter (TDC) electronic circuit, with each TDC having an individually adjustable voltage threshold. This advanced TDC-based pulse width time-of-flight (ToF) approach achieves the low cost associated with the TDC-based pulse width ToF approach while solving the signal quality issues associated with the standard single-threshold TDC-based approach.

(21) Appl. No.: 14/165,566

(22) Filed: Jan. 27, 2014



(54) **COST-EFFECTIVE LIDAR SENSOR FOR MULTI-SIGNAL DETECTION, WEAK SIGNAL DETECTION AND SIGNAL DISAMBIGUATION AND METHOD OF USING SAME**

(71) Applicants: **ANGUS PACALA**, MENLO PARK, CA (US); **TIANYUE YU**, SUNNYVALE, CA (US); **LOUAY ELDADA**, SUNNYVALE, CA (US)

(72) Inventors: **ANGUS PACALA**, MENLO PARK, CA (US); **TIANYUE YU**, SUNNYVALE, CA (US); **LOUAY ELDADA**, SUNNYVALE, CA (US)

(73) Assignee: **QUANERGY SYSTEMS, INC.**,
SUNNYVALE, CA (US)

(21) Appl. No.: 14/165,566

(22) Filed: **Jan. 27, 2014**

Pacala – Overall LiDAR Structure

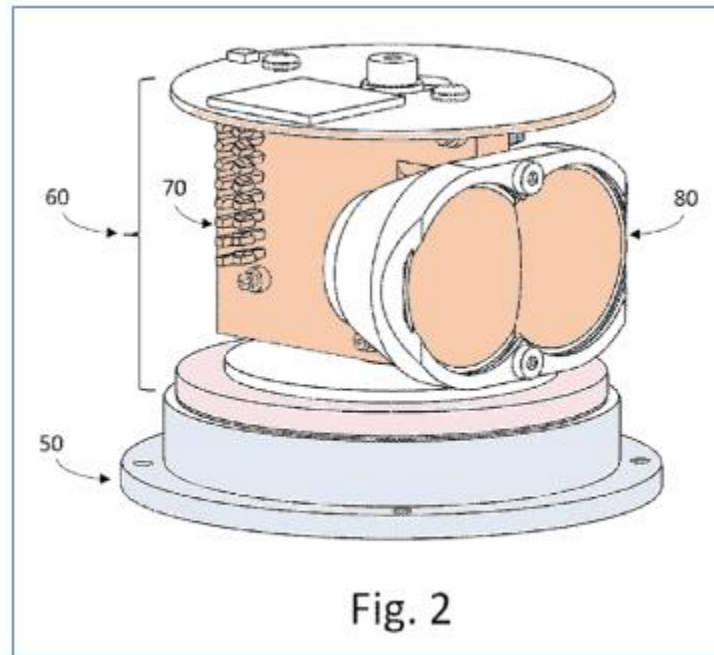


Fig. 2

[0013] The schematic diagram of FIG. 2 provides an internal view of a lidar sensor that can be used in the present invention, depicting a static base 50 that contains a motor and distributed electronics, and a spinning turret 60 that contains optoelectronic components 70 (including optical transmitters and receivers), collimation and focusing lenses 80 and distributed electronics. The multi-channel TDC electronic circuitry of the present invention can be located on said static base and/or on said spinning turret.

Waymo Patents – Johnson (EX1005) & Pardhan (EX1006)

(71) Applicant: **Waymo LLC**, Mountain View, CA (US)

(72) Inventor: **Harry Johnson**, Palo Alto, CA (US)

(73) Assignee: **Waymo LLC**, Mountain View, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 163 days.

(21) Appl. No.: **15/799,432**

(22) Filed: **Oct. 31, 2017**

US 2019/0131042 A1 May 2, 2019

(51) Int. Cl.
H01F 5/00 (2006.01)
H01F 5/02 (2006.01)
H02K 5/28 (2006.01)
H01F 30/16 (2006.01)

(52) U.S. Cl.
CPC H01F 5/003 (2013.01); H01F 5/04 (2013.01); H02K 5/28 (2013.01); H01F 30/16 (2013.01)

(58) Field of Classification Search
CPC H01F 5/003; H01F 30/16; H01F 5/04
USPC 336/200, 232
See application file for complete search history.

References Cited

U.S. PATENT DOCUMENTS

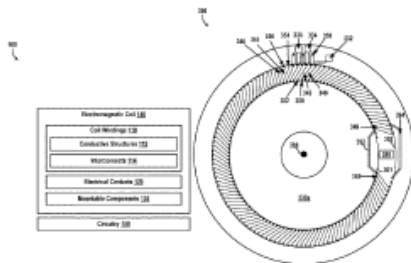
7,106,878 B1 9/2006 Frank et al.
8,825,241 B2 9/2014 Jore et al.
9,946,952 B2 2/2015 Bi et al.

Primary Examiner — Tszfung J Chan
(74) Attorney, Agent, or Firm — McDonnell Boehnen Hulbert & Berghoff LLP

(57) ABSTRACT

Example implementations herein relate to electromagnetic coils. One example device includes a plurality of coil windings. Each coil winding may extend around a shared core region inside the plurality of coil windings between a respective first end and a respective second end. The respective first end is electrically connected to a respective first-end electrical contact. The respective second end is electrically connected to a respective second-end electrical contact. The device also includes a plurality of mountable components. Each mountable component electrically couples a respective first coil winding to a respective second coil winding via the respective first-end electrical contact of the respective first coil winding and the respective second-end electrical contact of the second coil winding.

17 Claims, 9 Drawing Sheets



(71) Applicant: **Waymo LLC**, Mountain View, CA (US)

(72) Inventors: **Rahim Pardhan**, San Francisco, CA (US); **William McCann**, San Francisco, CA (US); **Drew Ulrich**, San Francisco, CA (US); **Pierre-yves Droz**, Los Altos, CA (US)

(73) Assignee: **Waymo LLC**, Mountain View, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 609 days.

(21) Appl. No.: **15/295,573**

(22) Filed: **Oct. 17, 2016**

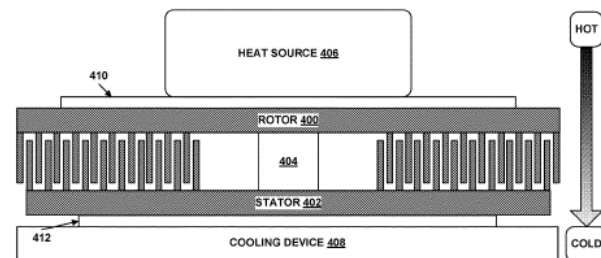
(51) Int. Cl.
H01S 3/04 (2006.01)
H01S 3/067 (2006.01)
(Continued)

(52) U.S. Cl.
CPC H01S 3/0405 (2013.01); G01S 7/4813 (2013.01); G01S 7/4817 (2013.01); G01S 17/931 (2020.01); H01S 3/067 (2013.01)

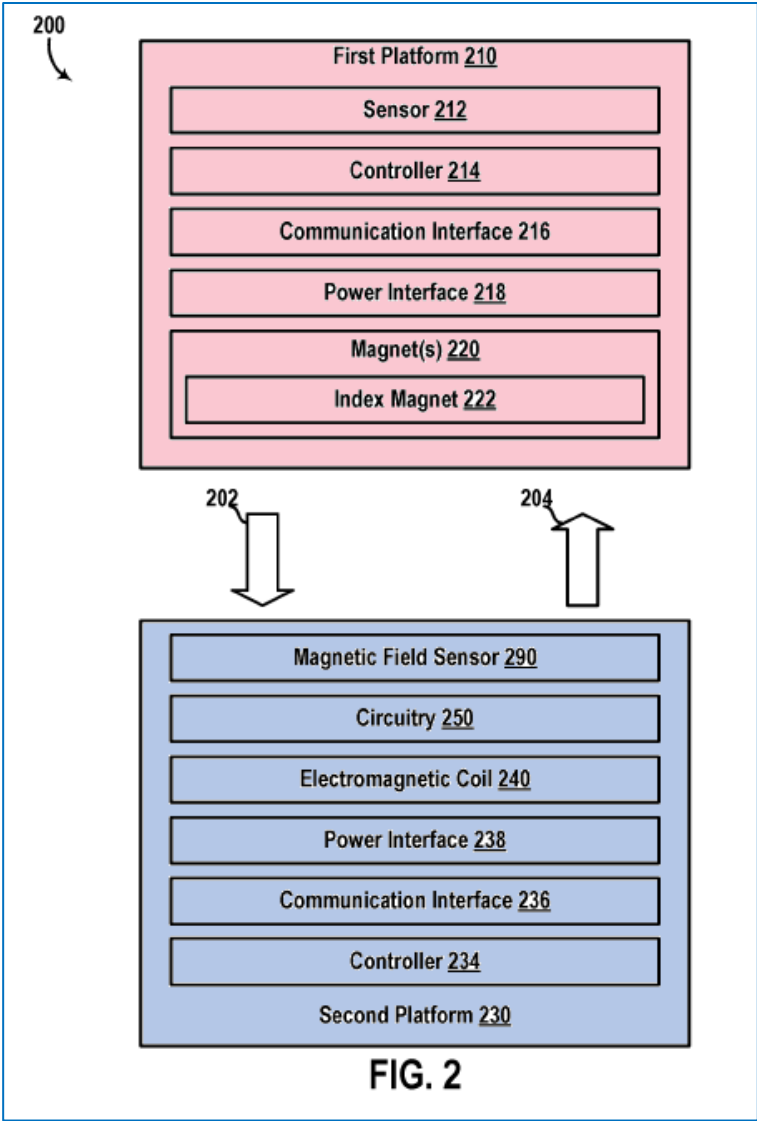
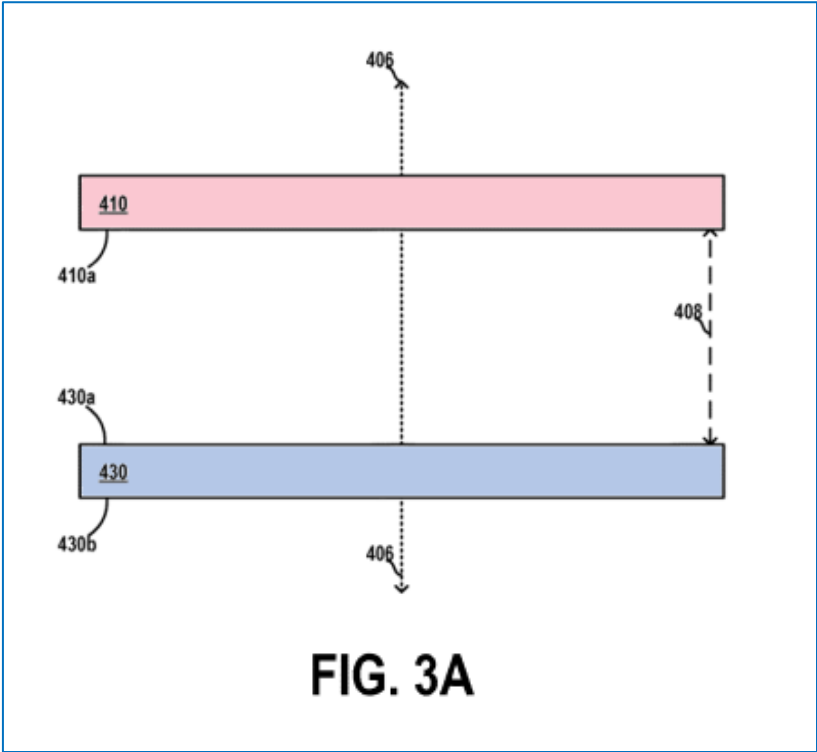
(58) Field of Classification Search
CPC H01S 3/0405; H01S 3/067; G01S 7/4813; F04D 17/127; F28F 5/04; F28F 13/12; F28D 11/00
(Continued)

side. A first plurality of fins may be integral with the first side of the first plate and protruding perpendicularly therefrom. The first plurality of fins may be arranged in first concentric circles separated radially by a first distance. The apparatus may also include a second plate having a first side. The second plate may be rotatably coupled to the first plate. A second plurality of fins may be integral with the first side of the second plate and protruding perpendicularly therefrom. The second plurality of fins may be arranged in second concentric circles separated radially by the first distance. Each fin of the second plurality of fins may interpose between adjacent fins of the first plurality of fins to transfer heat between the second plate and the first plate.

18 Claims, 16 Drawing Sheets



Johnson – Rotor and Stator Circuit Boards



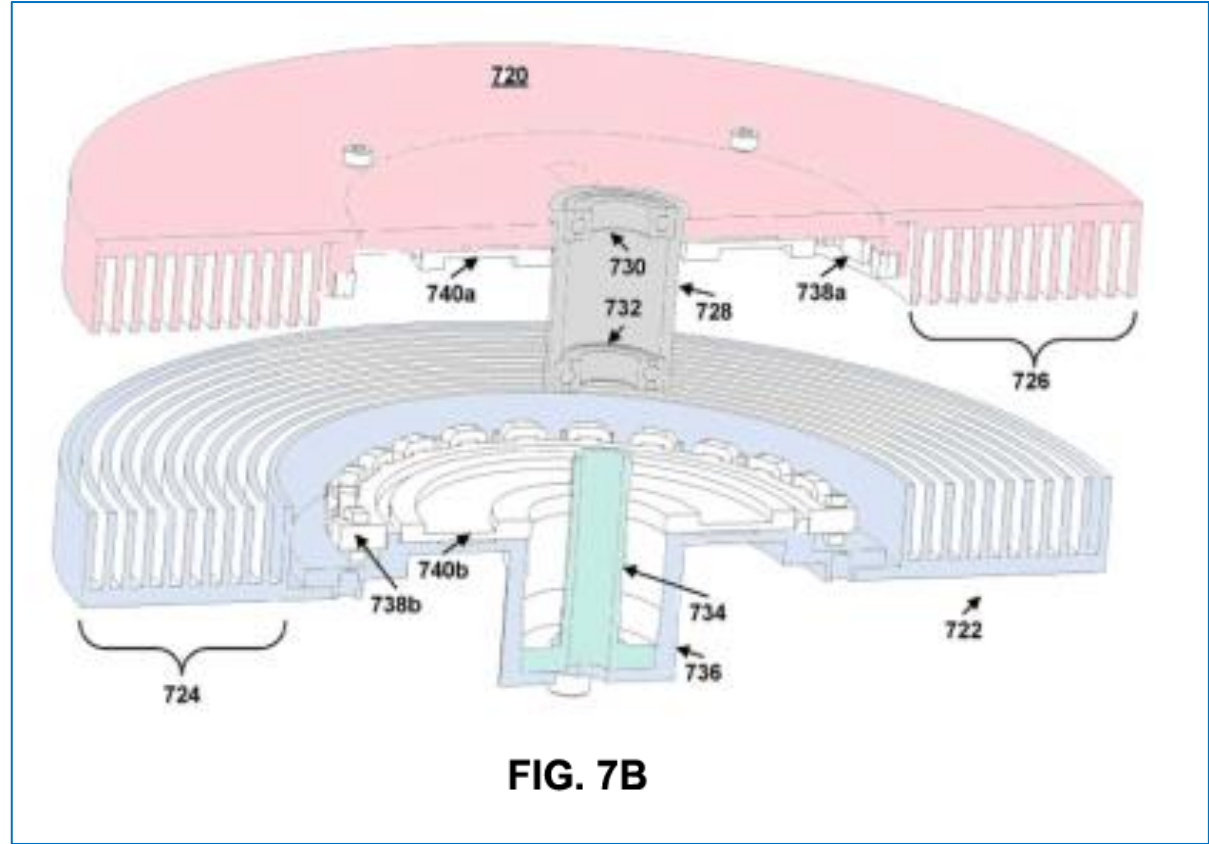
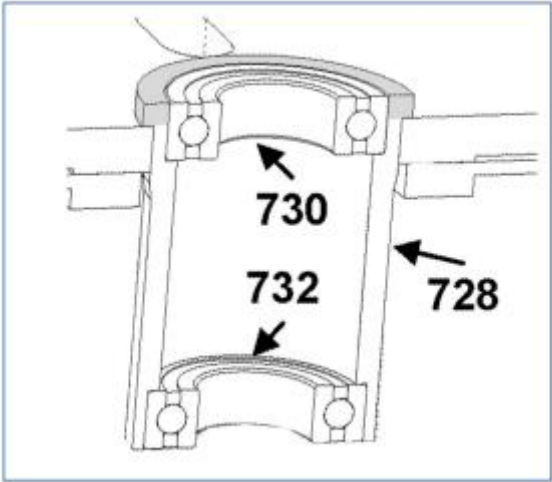


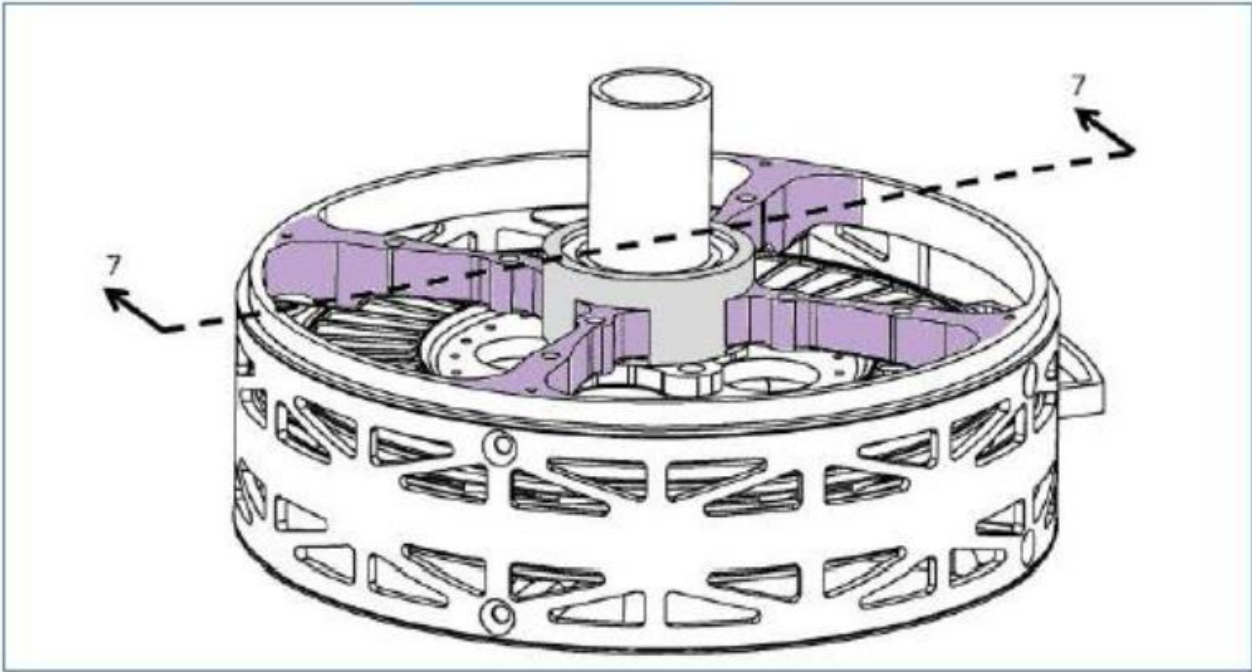
FIG. 7B



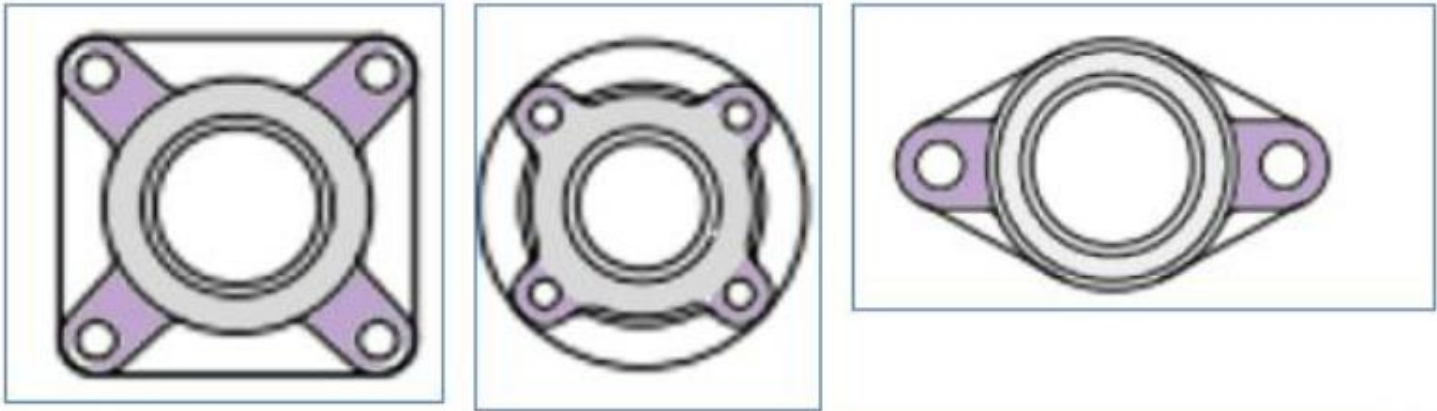
WO 2018/201567 A1 | barcode

Knowledge Of A POSITA – Bearing Housings W/ Arms

EX1042, Fig. 6:



EX1033, 16:



Motivation To Combine Pacala- Johnson-Pardhan

Motivation To Combine Pacala With Johnson's Integrated Motor



Dr. Lebbay Hesai's Expert

“A POSITA would be motivated to utilize Johnson’s teaching of an integrated motor built onto rotor and stator circuit platforms because it provides a more compact design and efficient use of space when compared to using an unintegrated motor”

EX1050, ¶4; see also EX1003, ¶84

(12) United States Patent

Karpus et al.

(10) Patent No.: US 10,530,299 B2

(45) Date of Patent: Jan. 7, 2020

(54) ROTARY AND METHODS FOR DRIVING A ROTARY PLATFORM

(71) Applicant: Wayne LLC, Mountain View, CA (US)

(72) Inventors: Paul Karpus, Redwood City, CA (US); Seth Michael LaFarge, Mountain View, CA (US)

(73) Assignee: Wayne LLC, Mountain View, CA (US)

(56) References Cited

U.S. PATENT DOCUMENTS

4,390,875 A * 8/1983 Tanaka 1802,2018

4,656,162 A * 4/1987 Koyama 1802,5040

(Continued)

FOREIGN PATENT DOCUMENTS

197452 A2 * 5/1980 1802,5040

2577286 A2 * 8/2001 1802,5040

(Continued)

OTHER PUBLICATIONS

Kanaya Shinkai, "Speed Control Methods of Various Types of Speed Control Motors", Oriental Motor Co., printed on Nov. 27, 2004.

(Continued)

Primary Examiner—John K. Kim

CA, Attorney Agent or Firm—McDonald Boehnen Hubert & Berghoff LLP

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 280 days.

(21) Appl. No.: 15357525

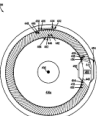
(22) Filed: Oct. 28, 2016

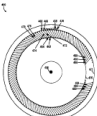
(45) Prior Publication Date: US 2018/0125412 A1 May 3, 2018

(51) Int. Cl. H02K 1/22 (2006.01); H02K 1/27 (2006.01) (Continued)

(52) U.S. Cl. CPC: H02K 1/2791 (2013.01); H02K 1/22 (2013.01); H02K 5/20 (2013.01); H02K 8/28 (2013.01) (Continued)

(53) Field of Classification Search CPC: H02K 1/2791; H02K 5/20; H02K 1/22; H02K 1/225; H02K 1/22; H02K 1/22; H02K 1/22; H02K 1/22; H02K 1/22; H02K 1/22; H02K 1/22 (Continued)





separate actuator is coupled to the first platform, this implementation may be more suitable for small rotary joint configurations by physically implementing the actuator as components included and/or mounted to the rotor and stator platforms for a more compact and/or efficient use of space in the rotary joint device.

EX1045 at 4:64-4:6

Demonstrative Exhibit – Not Evidence –Petitioner's Presentation – 22

Motivation To Further Combine Pardhan Support Component



Dr. Lebby
Hesai's Expert

“Johnson does not expressly disclose the details regarding the shaft and support structure that couples the stator and rotor platforms, but this is ripe for predictable improvement by integrating the known structural elements described in **Pardhan**. Johnson and Pardhan are naturally suited for one another given the **complimentary nature of their rotor-stator structure and that they are both Waymo patents.**”

Motivation To Further Combine Pardhan Support Component



Wavetronix finally contends that the more sophisticated digital signal generator in Farmer is not required for the sensor in Herman to function for its intended purpose, and thus the Board's finding that a person of ordinary skill in the art would have been motivated to combine Herman with Farmer is flawed. SMS responds, and we agree, that the Board properly found that a skilled artisan would have been motivated to combine Herman with Farmer. See Decision, 2017 WL 3034507, at *20. **Herman discusses a sensor that can generate a signal of “any desired type,”** see Herman col. 3 ll. 34–39, and **Farmer discloses the details of a sensor with a digital signal generator, a DDS, as required by the claims,** see Farmer col. 8 ll. 13–16. **Those express disclosures constitute substantial evidence to support the Board's finding of a motivation to combine.**

Wavetronix LLC v. Smart Microwave Sensors GmbH, 746 Fed. Appx 984, 987, 991 (Fed. Cir. 2018)

Motivation To Further Combine Pardhan Support Component



Dr. Lebby
Hesai's Expert

LiDAR device may be mounted on its rotor-stator structure, which, as explained in Pardhan, may “generate excess heat” that made it difficult to operate the device “within a safe operating temperature range” without techniques for “transfer[ing] excess heat away from” the rotating LiDAR device. EX1006,

Motivation To Further Combine Pardhan Support Component



Dr. Lebby
Hesai's Expert

“Implementing the rotor-stator structure taught by Johnson and Pardhan within the enclosure of Pacala would also have involved simple substitution of one known element (the rotation structure of Pacala) for another (the rotation structure of Johnson-Pardhan) to obtain predictable results (a LiDAR device configured to rotate on the rotational structure).”

PO's Motivation To Combine Arguments Lack Merit

Pardhan Does Not Teach Away From Johnson

PO's Expert Provides An Unsupported Claim That Pardhan "Teaches Away" From Johnson:

108. To dissipate the heat generated by running excessive power through its lasers, Pardhan provides an oversized design with vertically oriented fins extending from both the rotor and stator. Ex. 1006 at 18:60-19:6. Pardhan further teaches that a design with a *larger* volume prevents the overheating that can occur by packing electrical components in too small a space. *Id.* at 4:63-67. Thus, in my opinion, Pardhan teaches away from a compact design like the one taught in Johnson.

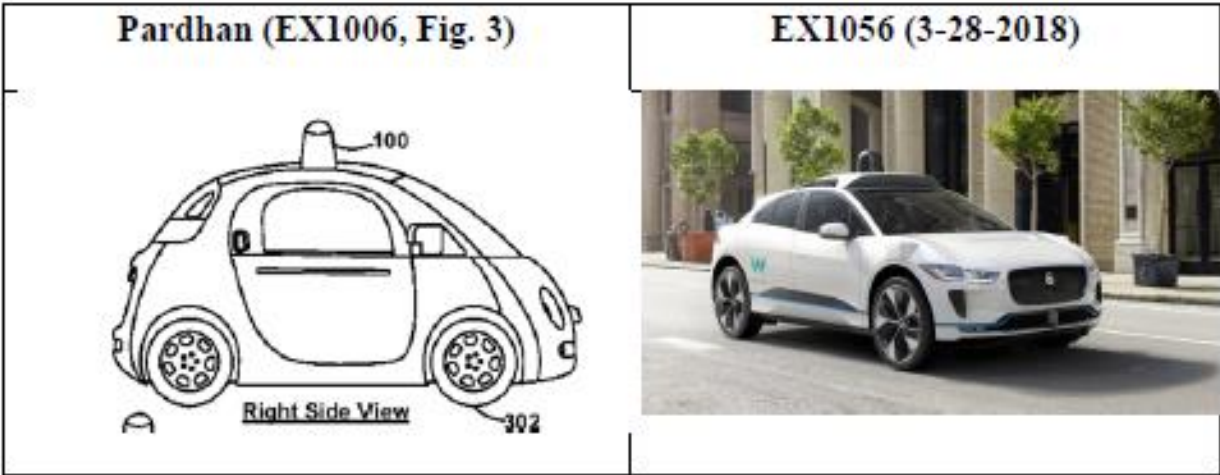
EX2004 ¶108

Pardhan Does Not Teach Away From Johnson or Pacala



Dr. Lebbby
Hesai's Expert

Pardhan and Johnson are both Waymo patents and a POSITA would understand that their **inventions may be applied to LiDAR devices of various sizes**. For instance, Dr. Janet refers to “Figure 3” of Pardhan as ‘illustrating the size of Pardhan’s LiDAR device 100.’ EX.2004, ¶112. Figure 3 illustrates a **LiDAR device mounted on the roof of a self-driving vehicle**, such as a self-driving vehicle from Waymo:



EX1050 ¶5

Pardhan Does Not Teach Away From Johnson or Pacala



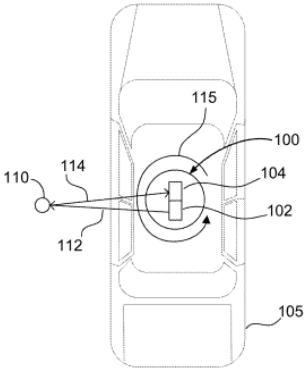
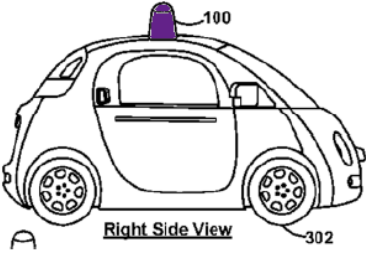
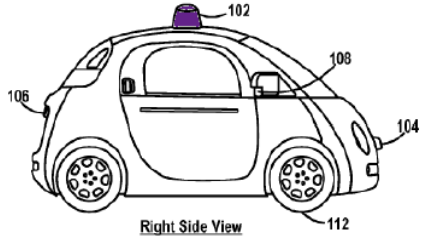
Dr. Lebby
Hesai's Expert

Karplus (EX1045), another Waymo patent, discloses in Figure 1 a LiDAR (102) that is the same (or substantially the same) size as the LiDAR device in Figure 3 of Pardhan, as shown below. Karplus also discloses that the rotor-stator structure disclosed in Johnson may be incorporated into that LiDAR. Compare EX1045 (Karplus), Figs. 4B-4D

Pardhan	Karplus/Johnson
Right Side View 100 302	Right Side View 102 106 108 104 112

EX1050 ¶6

Pardhan Does Not Teach Away From Johnson or Pacala

'515 patent	Pardhan	Karplus/Johnson	Waymo
 A top-down schematic of a vehicle. A central sensor, labeled 100, is shown with a circular field of view, labeled 110. The field of view is divided into segments labeled 112, 114, and 115. Other components are labeled 102, 104, and 105.	 A right side view of a vehicle. A sensor, labeled 100, is mounted on the roof. The sensor's field of view is indicated by a dashed line. The vehicle is labeled with 302 at the rear wheel.	 A right side view of a vehicle. A sensor, labeled 102, is mounted on the roof. The sensor's field of view is indicated by a dashed line. The vehicle is labeled with 106, 108, 104, and 112.	 A photograph of a white Waymo self-driving car (Waymo Freestyle) on a city street. The car is equipped with a sensor on the roof.

Pardhan Does Not Teach Away From Pacala

PO's Expert Provides An Unsupported and Inaccurate Claim That Pacala Does Not Generate Excess Heat

114. In contrast to Pardhan, Pacala teaches a LIDAR system employing a multi-channel TDC (time-to-digital converter) with individually adjustable voltage thresholds, allowing for the detection of weak return signals just above the noise level without necessitating an increase in transmit power. Ex. 1004 at [0014], claims 12, 19, 27. A POSITA would recognize that use of Pacala's sensitive multi-channel TDC receiver would avoid the need to operate the LIDAR device at the high power levels described in Pardhan in the first place. As a result, heat generation would be minimized such that no excess heat would be generated by Pacala's design. As explained above, a POSITA would have been aware of the

EX2004 ¶114

Pardhan Does Not Teach Away From Pacala



Dr. Lebbby
Hesai's Expert

While the power level that a LiDAR device is operated at can contribute to the need for heat dissipation, operating below a threshold power does not eliminate the need for heat dissipation. **Other sources of heat exist.** For instance, the circuit boards of a LiDAR device and their electrical components generate heat that can lead to overheating. In fact, **Pardhan states that electrical and optical components in a LiDAR devices may be densely packaged, thereby generating heat that needs to be dissipated.** EX1006, 4:63-67. **This teaching regarding overheating relates to the packaging of the components, not the power levels of the device.**

EX1050 ¶9

The Evidence Contradicts The Unsupported Assertions Of PO's Expert



(72) Inventors: **ANGUS PACALA**, MENLO PARK, CA (US); **TIANYUE YU**, SUNNYVALE, CA (US); **LOUAY ELDADA**, SUNNYVALE, CA (US)

(73) Assignee: **QUANERGY SYSTEMS, INC.**, SUNNYVALE, CA (US)



Customers who remove the detachable base plate (400g aluminum) must substitute a heat sink of similar or greater thermal mass to prevent the sensor from overheating and to enhance its longevity.

EX1054, 22

Most issues that might be encountered with the M8 sensor can be resolved by using one or more of these strategies:

- Make sure the sensor has an adequate heat sink, as explained on page 22.

EX1054, 64



WARNING: The sensor's detachable, rectangular base plate (400g aluminum) provides a platform for the sensor and dissipates heat produced by the sensor's electronics and motor, keeping the sensor's operating temperature range within -20°C to +60°C (-4°F to +140°F). If removed, substitute a heat sink of similar or greater thermal mass to prevent the sensor from overheating and enhance its longevity.

EX1054, 22

The Evidence Contradicts The Unsupported Assertions Of PO's Expert

(54) LIGHT RANGING DEVICE HAVING AN ELECTRONICALLY SCANNED EMITTER ARRAY

(71) Applicant: **Ouster, Inc.**, San Francisco, CA (US)

(72) Inventors: **Angus Pacala**, San Francisco, CA (US);
Mark Frichtl, San Francisco, CA (US)

(71) Applicant: **Ouster, Inc.**, San Francisco, CA (US)
6,133,989 A 12/19/21 Stettin et al.
10/2000 Stettin et al.
(Continued)

(72) Inventors: **Angus Pacala**, San Francisco, CA (US);
Mark Frichtl, San Francisco, CA (US)

(73) Assignee: **Ouster, Inc.**, San Francisco, CA (US)
CN 104899125 9/2015
CN 106443634 2/2017
(Continued)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 275 days.

(21) Appl. No.: **17/239,410**
Application No. JP2020-500210, Office Action, dated Feb. 21, 2022, 13 pages.
(Continued)

(22) Filed: **Apr. 23, 2021**

(65) **Prior Publication Data**
US 2021/0318434 A1 Oct. 14, 2021

Related U.S. Application Data
(63) Continuation of application No. 16/028,178, filed on Jul. 5, 2018, now Pat. No. 11,016,193.
(Continued)

(51) **Int. Cl.**
G01S 17/00 (2020.01)
G01S 17/08 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **G01S 17/08** (2013.01); **B61D 5/00** (2013.01); **G01S 7/4815** (2013.01);
(Continued)

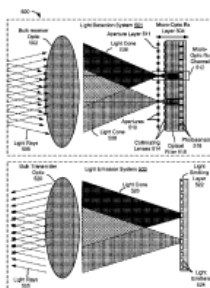
(58) **Field of Classification Search**
USPC 356/5.01
See application file for complete search history.

OTHER PUBLICATIONS
Application No. JP2020-500210, Office Action, dated Feb. 21, 2022, 13 pages.
(Continued)

Primary Examiner — James R Halka
(74) **Attorney, Agent, or Firm** — Kilpatrick Townsend & Stockton LLP

ABSTRACT
(57) Embodiments describe a solid state electronic scanning LIDAR system that includes a scanning focal plane transmitting element and a scanning focal plane receiving element whose operations are synchronized so that the firing sequence of an emitter array in the transmitting element corresponds to a capturing sequence of a photosensor array in the receiving element. During operation, the emitter array can sequentially fire one or more light emitters into a scene and the reflected light can be received by a corresponding set of one or more photosensors through an aperture layer positioned in front of the photosensors. Each light emitter can correspond with an aperture in the aperture layer, and each aperture can correspond to a photosensor in the receiving element such that each light emitter corresponds with a specific photosensor in the receiving element.

20 Claims, 23 Drawing Sheets



Hesai Exhibit 1052 Page 1

In some embodiments, light transmission module 1700 can include a heat sink 1716 that is coupled to interconnection structure 1708 on a side opposite from the side on which emitter array 1702 is coupled. That way, heat sink 1710 can draw heat away from emitter array 1702 during operation to prevent overheating. To provide this capability, various

vias, as shown in FIG. 17. Heat sink 1710 can be any suitable heat sink that can dissipate heat into the ambient environment, such as a metal structure with fins. In some

See EX1052, 44:46-45:3

Pardhan Does Not Teach Away From Pacala

Ouster's Website Contradicts PO's Expert:

Where does the heat come from?

There are two primary heat-dissipating assemblies in the sensor.

- The **Optical Turret** - containing the lasers and receivers.
- The **Base Assembly** - containing the computing, communication, and power.

The **Optical Turret** dissipates heat to both the **TOP CAP** and the **SENSOR BASE**. While, the **BASE ASSEMBLY** conducts most of its heat to the **SENSOR BASE**.

Where does the heat go?

Standard Heatsinks

The sensor comes with two standard heatsinks attached to it.

- The base heatsink and mounting plate. (referred to as **HEATSINK-BASE**)
- The radial finned or halo heatsink modular caps. (referred to as **HEATSINK-RADIAL**, **HEATSINK-HALO**)

Note

Both have the same thermal performance.

It is also possible to **create** your own custom heatsinks for your specific integration, given that it adequately dissipates the heat from the sensor. For more information contact our [Support team](#).

EX1057

PO's Bodily Incorporation Arguments Are Legally Irrelevant

Bodily Incorporation Is Legally Irrelevant



Contrary to Allied's position, “it is not necessary that [Caterpillar and Ogawa] be physically combinable to render obvious the ['489 patent].” ... **“The test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference,”** ... but rather whether “a skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention.”

Allied Erecting & Dismantling Co. v. Genesis Attachments,
825 F.3d 1373, 1381 (Fed. Cir. 2016)

Bodily Incorporation Is Legally Irrelevant



Elbrus argues that combining Lu with Sukegawa would lead to an inoperable circuit absent significant additional design work. However, “it is not necessary that [Sukegawa and Lu] be physically combinable to render [a claim] obvious.” *Allied Erecting & Dismantling Co. v. Genesis Attachments, LLC*, 825 F.3d 1373, 1381 (Fed. Cir. 2016) (quoting *In re Sneed*, 710 F.2d 1544, 1550 (Fed. Cir. 1983)). That is so because **“[t]he test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference... Therefore, Elbrus's argument that combining Sukegawa and Lu could lead to an unworkable circuit is “basically irrelevant.”** *In re Etter*, 756 F.2d 852, 859 (Fed. Cir. 1985) (en banc).

Elbrus International Limited v. Samsung Electronics Co., Ltd.,
738 Fed. Appx. 694, 698-699 (Fed. Cir. 2018).

Bodily Incorporation Is Legally Irrelevant



[W]hether one reference can be incorporated in another is 'basically irrelevant' since the test for obviousness is 'not whether the references could be physically combined' but whether the claimed inventions are rendered obvious by the teaching of the prior art as a whole.

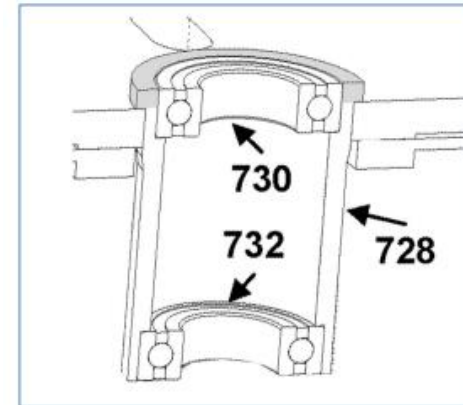
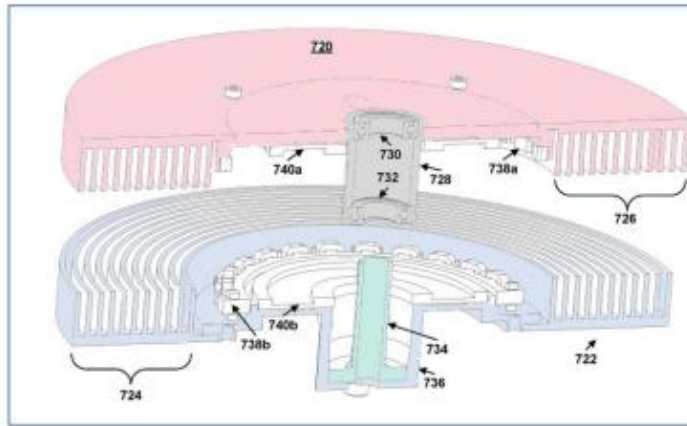
Intel Corporation v. PACT XPP Schweiz AG, 2023 WL 2198649, *2–*4 (Fed. Cir. 2023)



A person of ordinary skill is also a person of ordinary creativity, not an automaton.

KSR Int'l Co. v. Teleflex Inc., 127 S. Ct. 1727, 1742 (2007)

Pardhan – Bearing Housing For Assembling Rotor-Stator Circuit Boards



Q. And that bearing housing is used to -- sorry. **That bearing housing is coupled to Pardhan's rotor platform 720, right?**

A. **Yes.**

Q. And **it's used to assemble the rotor and stator structure** of Pardhan, right?

A. **Yes**, sir.

Q. And, in fact, **those bearings are rotationally coupled to offer rotation about the shaft** of Pardhan's, and that shaft is labeled 734; is that right?

A. **Yes**, I believe so.

PO's Bodily Incorporation Arguments Lack Evidentiary Support

PO Does Not Raise Any Challenges With Respect To Pardhan's Bearing Housing



Dr. Lebby
Hesai's Expert

I further note that all of the "complications" that Dr. Janet raises assume that a POSITA would implement Pardhan's thermal rotary link in full, including its heat sink. However, a POSTIA would use their engineering judgment to identify those aspects and structures in prior art that are desired. For example, **a POSITA can adjust the number, size, position, and material of fins when designing the combined system** based on the level of heat generated by the LiDAR. Moreover, I understand that Dr. Janet has acknowledged that **Pardhan's bearing housing is a "support component," and Dr. Janet does not challenge my opinion that a POSITA would have been motivate to use the bearing housing of Pardhan when assembling the rotor-stator structure of Johnson.**

PO Ignores The Engineering Judgment Of A POSITA



Dr. Lebby
Hesai's Expert

The smattering of other issues Dr. Janet identifies in paragraphs 118 through 122 are also within the expertise of a POSITA and would be overcome as part of the standard design process. For instance, Dr. Janet asserts that "Pardhan's fins limit the placement of the rotor magnets and stator coils to a small radius which reduces torque capacity." EX2004, ¶118. This conclusory assertion is confusing in view of Dr. Janet's assertion elsewhere that Pardhan provides a cavity with a "large volume." EX2004, ¶109. In any event, Dr. Janet does not provide any reason why a POSITA would not have used their **engineering judgment** to design the finned heat sink so that its cavity could accommodate a motor of appropriate size for the application.

EX1050 ¶ 17

PO Ignores The Engineering Judgment Of A POSITA



Dr. Lebbby
Hesai's Expert

Dr. Janet states that combining Pardhan would "increas[e] the total mass of the [Pacala] system by 50%" and thus increase "the moment of inertia." EX2004, ¶117. ...

But, as I showed above, the LiDAR device illustrated in the embodiment of Figure 3 of Pardhan has a size and mass that is roughly the same as that of Waymo's commercial LiDAR. These Waymo LiDAR devices drive around various cities (e.g. Los Angeles and San Francisco) without catastrophic failures, thereby

demonstrating that a POSITA would have been more than capable of addressing motor and stability issues for a device of this size.

EX1050 ¶¶ 14-15

PO Ignores The Engineering Judgment Of A POSITA



Dr. Lebby
Hesai's Expert

A POSITA would have known that structures within these devices can be physically scaled depending on the needs of the application at hand.

Examples of such scaling were ubiquitous by the time of the alleged invention of the '515 patent. To cite two simple examples, not all automotive tires are the same size and not all hard disk drives have the same size internal mechanisms. Despite differences in size, similarities with regard to materials, construction, features, and appearance are recognized by a POSITA.

PO Ignores The Engineering Judgment Of A POSITA



Dr. Lebbby
Hesai's Expert

[G]yroscopic forces are directly proportional to rotational speed. Here, Dr. Janet states that the system spins at "10 Hz" (EX2004, ¶117), which is a speed of 10 revolutions per second... Compared to many common applications, this is slow. A POSITA would know, for example, that many fans found in household items such as window fans, forced hot air furnaces, heat pumps, and air conditioners turn at higher speeds. It is also slow compared to common hard disk drives that typically spin at speeds between 5,400 RPM and 7,200 RPM.... **the magnitude of these forces is insignificant and can be addressed as part of the design process.**

EX1050 ¶ 16

PO's Bodily Incorporation Lack Evidentiary Support



Dr. Lebbby
Hesai's Expert

Dr. Janet claims that utilizing Johnson's motor with Pardhan is not simple substitution because Pardhan discloses a radial flux motor and Johnson discloses an axial flux motor. EX2004, ¶¶128-129. **But a POSITA would recognize the functional equivalence of Pardhan's radial flux motor and Johnson's axial flux motor.** They are both spindle motors that produce the torque needed for their applications. A POSITA would recognize that **radial and axial flux configurations, including those constructed on a printed circuit boards, were well known and could be designed to deliver the torque needed for a given application.**

EX1050 ¶ 21

PO's Bodily Incorporation Lack Evidentiary Support



Dr. Lebbby
Hesai's Expert

Dr. Janet also identifies **magnetic field issues (e.g., eddy currents)** that would only be a concern if one blindly attempted to physically jam Johnson's rotor stator structure into Pardhan's **thermal rotary link**, without using any engineering judgment. EX2004, ¶130.... In other words, eddy currents and their impact on designs would be understood by a POSITA. **A POSITA would have designed a motor to address eddy currents, if necessary. This includes designing the motor structures so that magnetic fields are shielded from surrounding areas to minimize negative consequences.**

EX1050 ¶ 22

A POSITA Would Use Commercially Available Tools To Address And Overcome Any Design Issues



Dr. Lebby
Hesai's Expert

Dr. Janet goes on to state that a POSITA would have needed to determine “mechanical, electric, and electromagnetic power losses (e.g., due to eddy currents), performing a thermal analysis (e.g., with a computational fluid dynamics (CFD) analysis), conducting a new torsional analysis, and so on” and would have needed to consider “fluid dynamics, gyroscopic forces, etc.” EX2004, ¶¶131-134. **These considerations are part of the normal design process and a POSITA would have used their engineering knowledge and software tools (e.g., MATLAB, CAD, ANSYS, etc.) to design a suitable LiDAR device that accounts for them.**

A POSITA Would Use Commercially Available Tools To Address And Overcome Any Design Issues

- **PO's Expert Admitted A POSITA Would Use Industry Tool:**

Q. Have you performed thermal analysis before as part of design process?

A. Yes, I have.

Q. Have you performed torsional analysis before as part of the design process?

A.... yes.

Q. How did you go about performing those analysis? Were there any tools that are used in the industry?

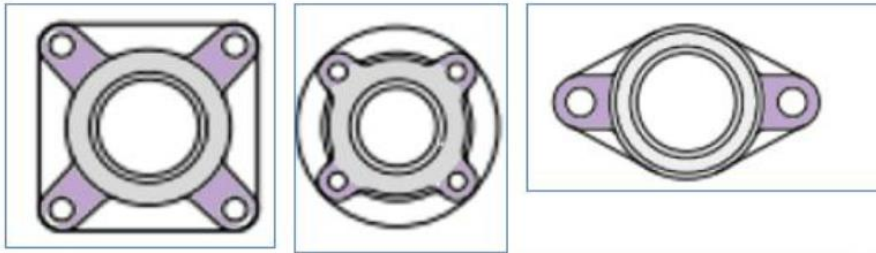
A. There are tools used in industry, and there are calculations that one would use. A person of ordinary skill in the art could employ basic force torque kinematics and dynamics equations in a home brew type of analysis; for example, MATLAB or even Excel; or if they were to code something, write some software from scratch.

Support Component With Arms

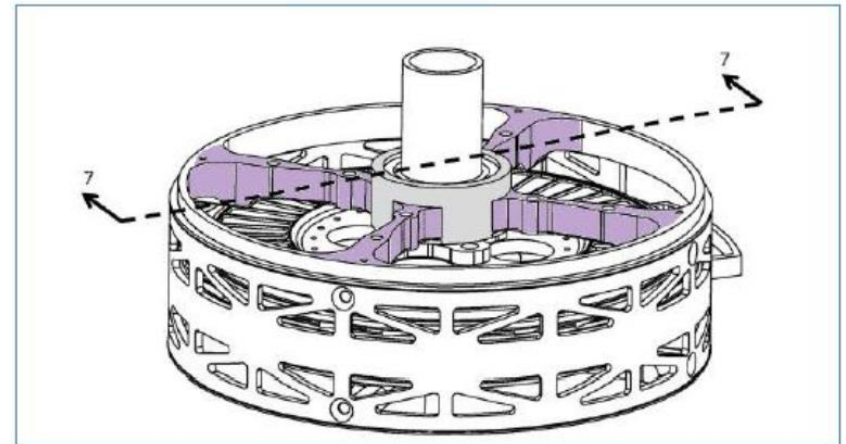
Knowledge Of A POSITA – Bearing Housing With Arms

Pet. at 25:

“**Numerous bearing housing designs were known** by the priority date, including the designs below with arms (purple) **for strengthening the attachment of the sleeve to the rotor plate.**”



EX1033, 16:



EX1042, Fig. 6:

Motivation To Combine A Bearing Housing With Arms

Pet. at 53:

A POSITA would have also been motivated to modify Pardhan's support structure to use a bearing housing with arms. *Id.*, ¶253. **Pardhan employs one exemplary type of bearing housing, but by the time of the '515 Patent, bearing housings were well known and POSITAs understood different designs could be used in a rotor-stator structure interchangeably.** *Id.*, ¶¶253, 60-62; *Almirall, LLC v. Amneal Pharmaceuticals LLC*, 28 F.4th 265, 272–75 (Fed. Cir. 2022) (affirming finding of motivation to combine where expert explained that alternative designs performed “the same function” and were “interchangeable,” and that substitution “was routine and predictable” because designs were known).

Motivation To Combine A Bearing Housing With Arms

Pet. at 53:

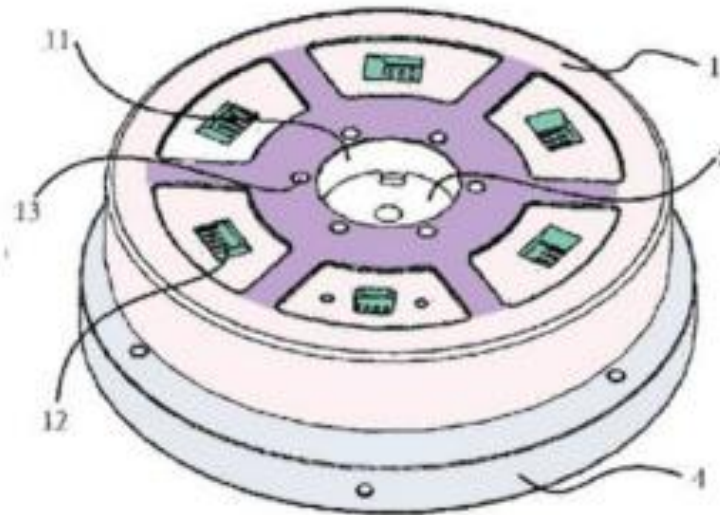
A POSITA would have also understood that **when mounting a LiDAR device to a rotor platform, it is desirable to minimize vibration, and employing a bearing housing with arms furthers this goal by strengthening the attachment of the shaft to the rotor**. EX1031, 329-331 (“Section 6.2.5 Prevention of Bearing Axial Movement”).

Employing a bearing housing with arms is thus a **simple substitution of one known bearing housing (from Pardhan) for another (bearing housings with arms)** and would have resulted in an improved structure that benefits from additional support provided by the arms.

Zhang Also Discloses A Support Structure With Arms

Pet. at 26:

“Additionally, Zhang also discloses a support component with a plurality of arms that prevents a LiDAR device from overheating. *Id.*, ¶165. The support component is shown below with arms (purple) extending outwards from a “hollow shaft” and heat dissipation passages (green) positioned between the arms:



EX1007 [Zang], Fig. 1

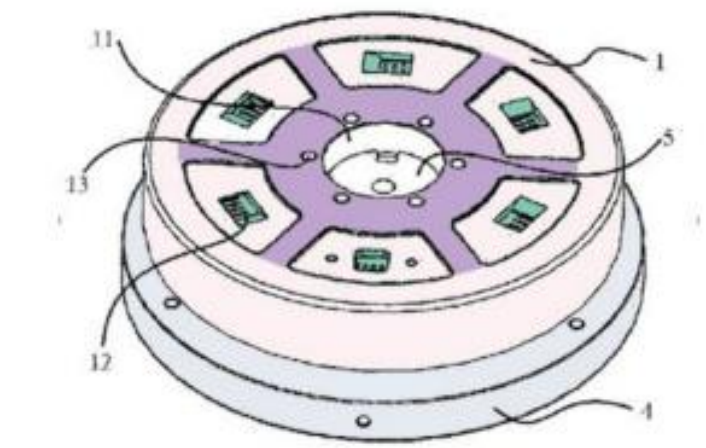
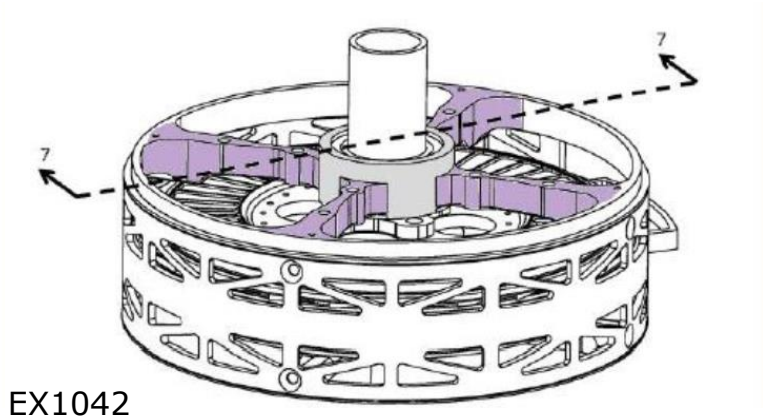
Motivation To Combine Zhang

Zhang's support structure includes heat dissipation passages between a plurality of arms to further "dissipate heat generated during the operation of the internal rotating structure, thereby increasing the operating life of the rotating structure." EX1007, pg. 6, Fig. 1. Thus, **a POSITA would be motivated to use the support structure disclosed in Pardhan alone and in combination with Zhang to support the LiDAR device in a manner that provides for efficient heat dissipation, ventilation, and increased operating life.**

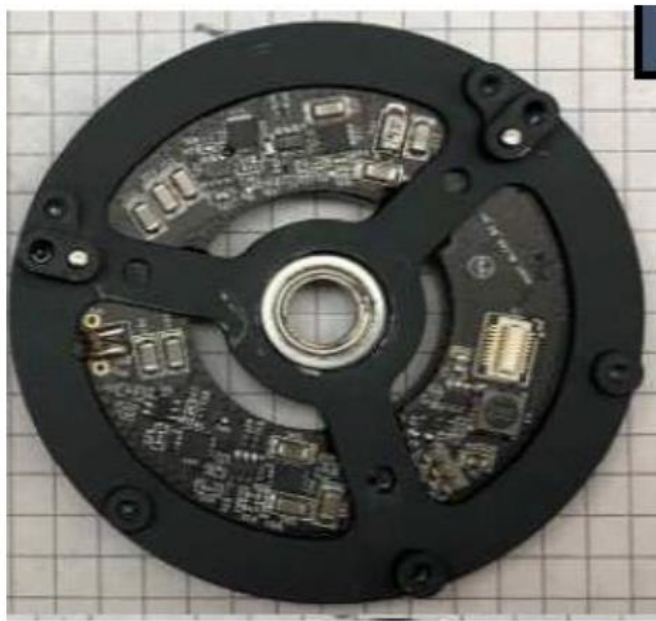
A POSITA would be motivated to combine the teachings of Zhang and Pardhan which disclose similar structures and subject matter. In fact, Dr. Janet emphasizes the importance of reducing weight throughout his declaration. **A POSITA would understand that compared to a solid or fully enclosed rotor plate, a rotor plate with arms that are realized by featuring spaces or gaps between arms such as in Zhang can reduce the volume of the material used thus reduce the weight.**

Petitioner's Infringement Allegations

Prior Art



Infringement



“Each Of The Plurality Of Stator
Elements Including A Coil Wound
Around A Magnetic Core”

Undisputed: Johnsons Discloses Each Stator Element Is Wound Around A Shared Core

PO's Expert:

Q. Yeah. **There's no dispute that Johnson discloses a plurality of coil windings wound around a single ring-shaped core?**

A. **I think that's fair**, you know, unless there's another aspect of my declaration that might dispute that. But I'm -- I see where you could interpret it that way right now.

However, in other examples, device 300 may include a magnetically permeable core (not shown) between the two layers of FIGS. 3C and 3D to direct or focus the generated stator-platform magnetic field. For instance, a middle layer

Johnson at 14:1-10

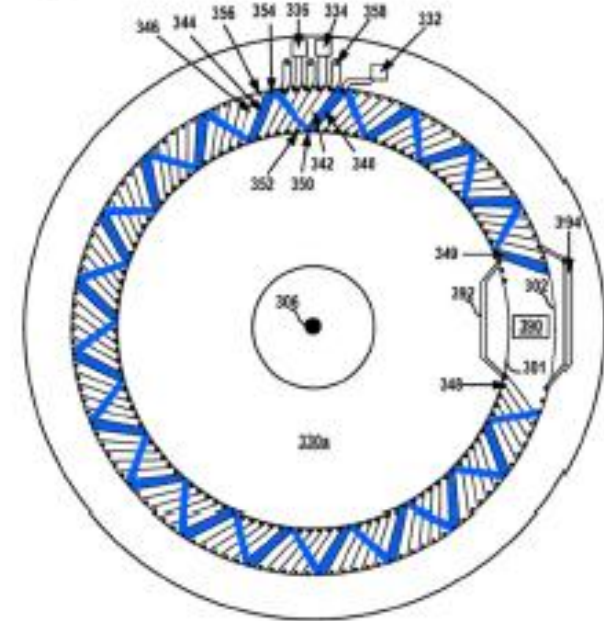


FIG. 3C

PO Seeks To Rewrite The Claim Language

- The plain meaning of the claim language does not exclude a coil wound around a shared core
- PO improperly seeks to rewrite the claim language to add in a new requirement:

a stator assembly disposed between the first and second planes and coupled to the stator circuit board, the stator assembly comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil wound around a magnetic core; **that is not a shared magnetic core**

Improper To Import Limitations From The Preferred Embodiment Absent Disclaimer Or Lexicography



“Even when the specification describes only a single embodiment, the claims of the patent will not be read restrictively unless the patentee has demonstrated a clear intention to limit the claim scope using ‘words or expressions of manifest exclusion or restriction.’ ”

Hill-Rom Services, Inc. v. Stryker Corp., 755 F.3d 1367, 1372 (Fed. Cir. 2014)

“Stator Assembly ... Coupled To The
Stator Circuit Board”

“Coupled To” – Plain Meaning

- “coupling” means “joining together, pairing...” (EX1049, Webster Dictionary)
- ‘515 Patent teaches stator assembly can be “built onto” or “integrated” on the circuit board:

According to some embodiments, a rotation of an upper circuit board assembly can be driven by stator and rotor elements integrated on upper and lower circuit boards, thereby making the light ranging system compact. For example, the upper circuit board assembly can include a plurality of rotor elements symmetrically arranged about a rotation shaft, and a lower circuit board assembly can include a plurality of stator elements symmetrically arranged about the shaft. A driver circuit can drive the stator elements. Having such rotor and stator elements built onto the circuit boards themselves provides various advantages over products that use bulkier motors (e.g., stepper motors, brushed motors or unintegrated brushless motors).

‘515 patent at 4:19-31

Johnson Discloses This Limitation Even Under PO's Interpretation

- Stator assembly can be implemented with coil windings separate from the PCB **or** interconnected conductive structures built onto the PCB

In one implementation, the coil windings may comprise a plurality of coil-shaped wires that are wound around the shared core region. In some instances, two or more of the coil-shaped wires may be connected in series to form an electrically conductive path that extends along a length of the core region two or more times. In other instances, two or more of the coil-shaped wires may be connected in parallel to form two separate electrically conductive paths that each extend along a length of the core region.

In another implementation, the coil windings can be formed in a multi-layer circuit board (e.g., printed circuit board (PCB)). For example, the coil windings may comprise a first plurality of conductive structures (e.g., copper traces, etc.) in a first layer of the PCB, and a second plurality of conductive structures in a second layer of the PCB. In one

Johnson 3:30-56

Coil windings 110 can be implemented in various ways. In some examples, a coil winding can be formed from a wire or other electrical conductor that is wound around a core region to define a magnetic axis of coil 140. In other examples, a coil winding can be formed from multiple conductive structures that are connected to one another to form an electrically conductive path in the shape of a coil, helix, spiral, etc. To that end, the core region of coil 140 can have various shapes such as a cylindrical shape or a toroidal shape, among others.

Johnson 5:8-16

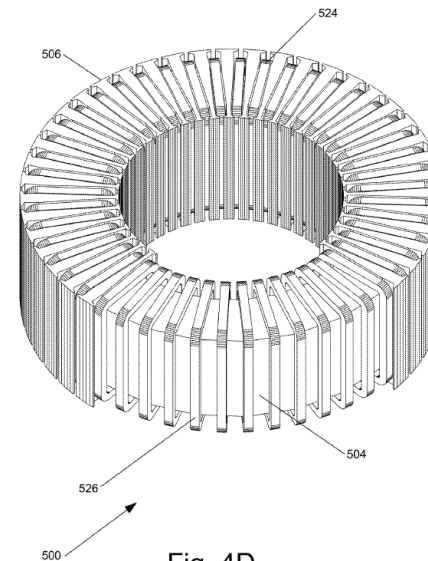


Fig. 4D

EX1058, Fig. 4D; EX1050 ¶30

Claim 1 Is Obvious

1[a]	A light ranging system comprising:	✓
1[b]	an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;	✓
1[c]	a shaft disposed within the enclosure and defining an axis of rotation;	✓
1[d]	a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure;	✓
1[e]	a support component rotationally coupled to the shaft and comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve;	✓
1[f]	a rotor circuit board coupled to the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover;	✓
1[g]	a stator assembly disposed between the first and second planes and coupled to the stator circuit board , the stator assembly comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil wound around a magnetic core;	✓
1[h]	a rotor assembly disposed between the first and second planes and coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles; and	✓
1[i]	a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment; and	✓
1[j]	a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft.	✓

Claim 4

Claim 4 – “Third” and “Fourth” Circuit Boards

4. The light ranging system of claim 1 further comprising:
a third circuit board fixedly coupled to the base and arranged in a plane parallel with the first plane and disposed between the enclosure base and the stator circuit board; and
a fourth circuit board coupled to rotate with the rotor circuit board between the enclosure top and the rotor circuit board and arranged in a plane parallel with the first plane.

Obvious In View Of Knowledge Of A POSITA

- Number of circuit boards is a design choice



Dr. Lebby
Hesai's Expert

Additionally, a POSITA would also recognize that **LiDAR electronics may not fit within the space provided by a single stator and rotor circuit board, such that additional circuit boards are needed.**

EX1050 ¶ 222

Petitioner's Expert Provides Corroborating Evidence

A further circuit board 52 which is electrically connected to the second circuit board 42 is likewise located in the base unit 14. This circuit board 52 functionally serves as an extension of the second circuit board 42, provided that the latter does not provided sufficient space and capacity. Depending on the embodiment, the further circuit board 52 can be dispensed with or, conversely, even more circuit boards can be provided.

EX1043 [Nubling], 6:1-8

base unit. In general, the electronic functions, in particular the control and evaluation unit, but also almost any desired functions, can be distributed over the first circuit board, the second circuit board and further circuit boards in the sampling unit and/or base unit.

EX1043 [Nubling], 3:36-40

ation elements. It is additionally conceivable to provide at least one further circuit board in the sampling unit, with the named elements then being distributed over the circuit boards.

EX1043 [Nubling], 2:63-3:3

Figure 3

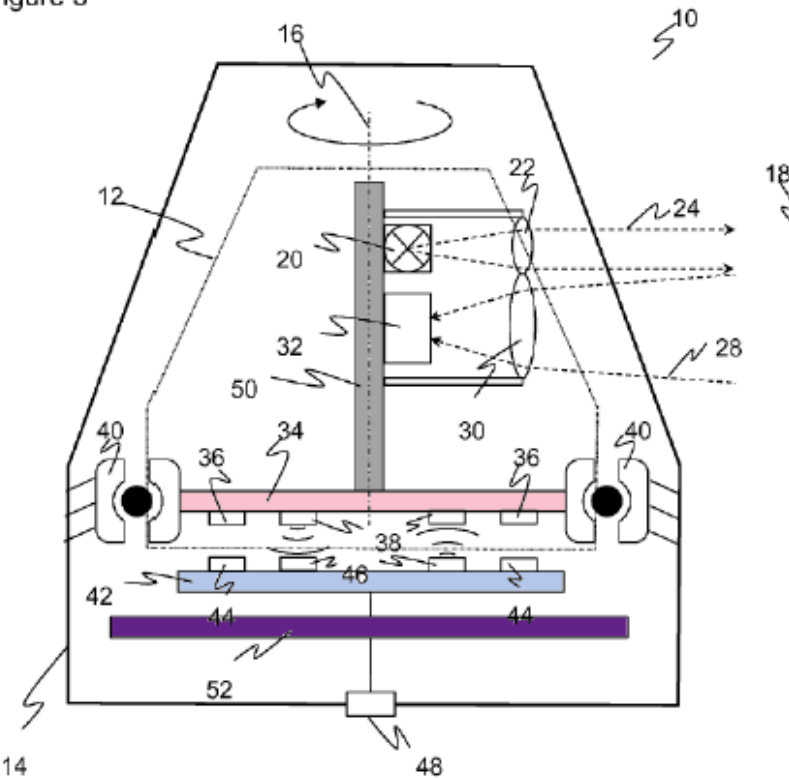
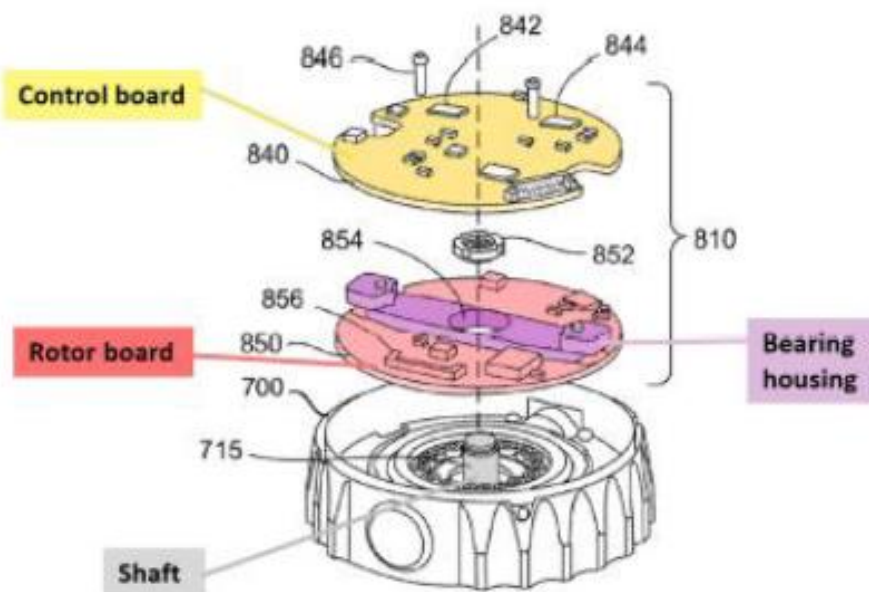


FIG. 3 shows a schematic sectional representation through a further embodiment of an optoelectronic sensor 10. In this, the same reference numerals designate the same features as in FIG. 1. The sensor 10 differs from that in accordance with FIG. 1 by the optical design in the sampling unit 12 and by additional circuit boards 50, 52. The latter should only serve as an example for the additional circuit boards which have been mentioned several times and which complement the first circuit board 34 or the second circuit board 42.

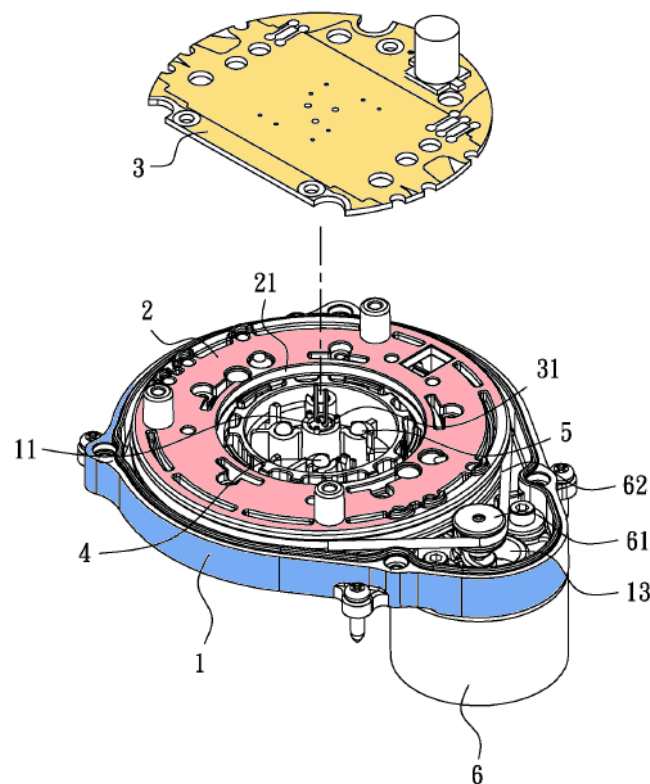
EX1043 [Nubling], 5:47-56

Petitioner's Expert Provides Corroborating Evidence

- For instance, Yan (EX1012) discloses implementing the control circuit board on the surface of the rotor board:



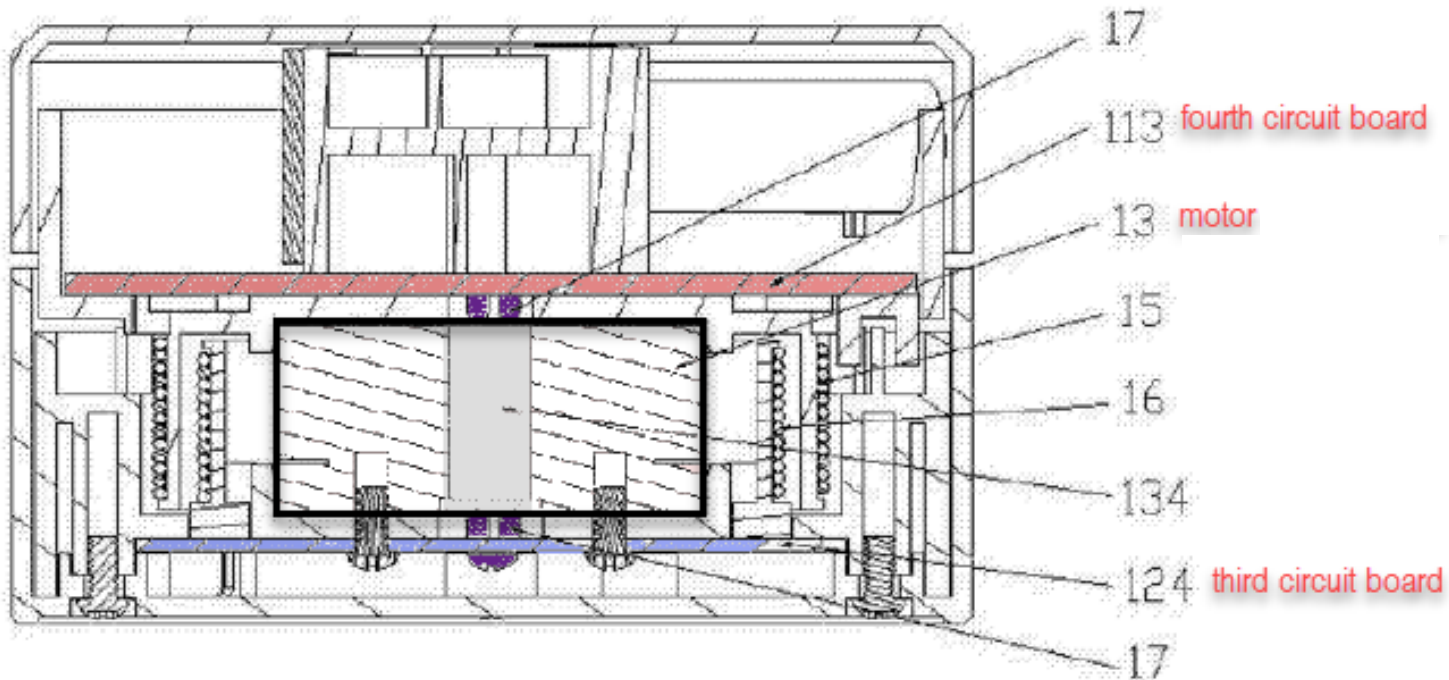
'515 Patent, Fig. 8A



EX1012 [Yan], Fig. 4

Third And Fourth Circuit Boards Are Also Obvious In View Of Cai (Ground 2)

- Cai discloses implementing transceiver boards above and below motor containing rotor-stator boards



Cai Provides An Express Motivation To Combine



Dr. Lebby
Hesai's Expert

Cai teaches that implementing these communication means as signal transceivers 17 mounted in the center region of circuit boards that are located above and below a hollow shaft in a motor allows for data to be exchanged through the hollow shaft.... **because the transceiver is mounted in the middle of the circuit board, its position is "guaranteed to be relatively unchanged" when the rotor rotates, "thereby providing reliable signal transmission."** EX1008, [0002], [0030]. A POSITA would also understand that **forming the communication channel within a hollow shaft helps avoid interference.** EX1007, pg. 1 (having space in the hollow shaft "to accommodate a signal transmission structure... prevents mutual interference of signal transmissions systems.").

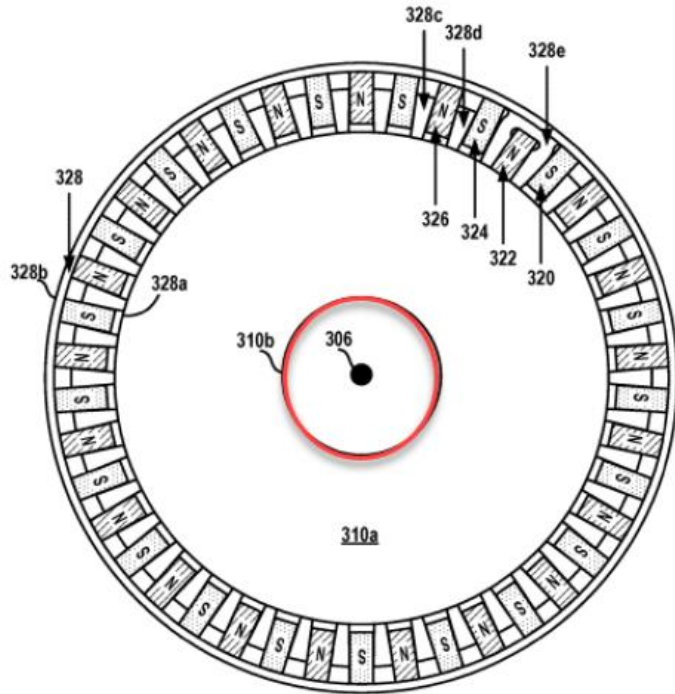
Claim 17

Claim 17 – Transformer Coils Outside Motor Perimeter

17. The light ranging system of claim 14 further comprising a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement.

Johnson Discloses A Wireless Power Transformer

- Johnson positions transformer coils on the inside of the motor in the preferred embodiment, but says other configurations can be used:

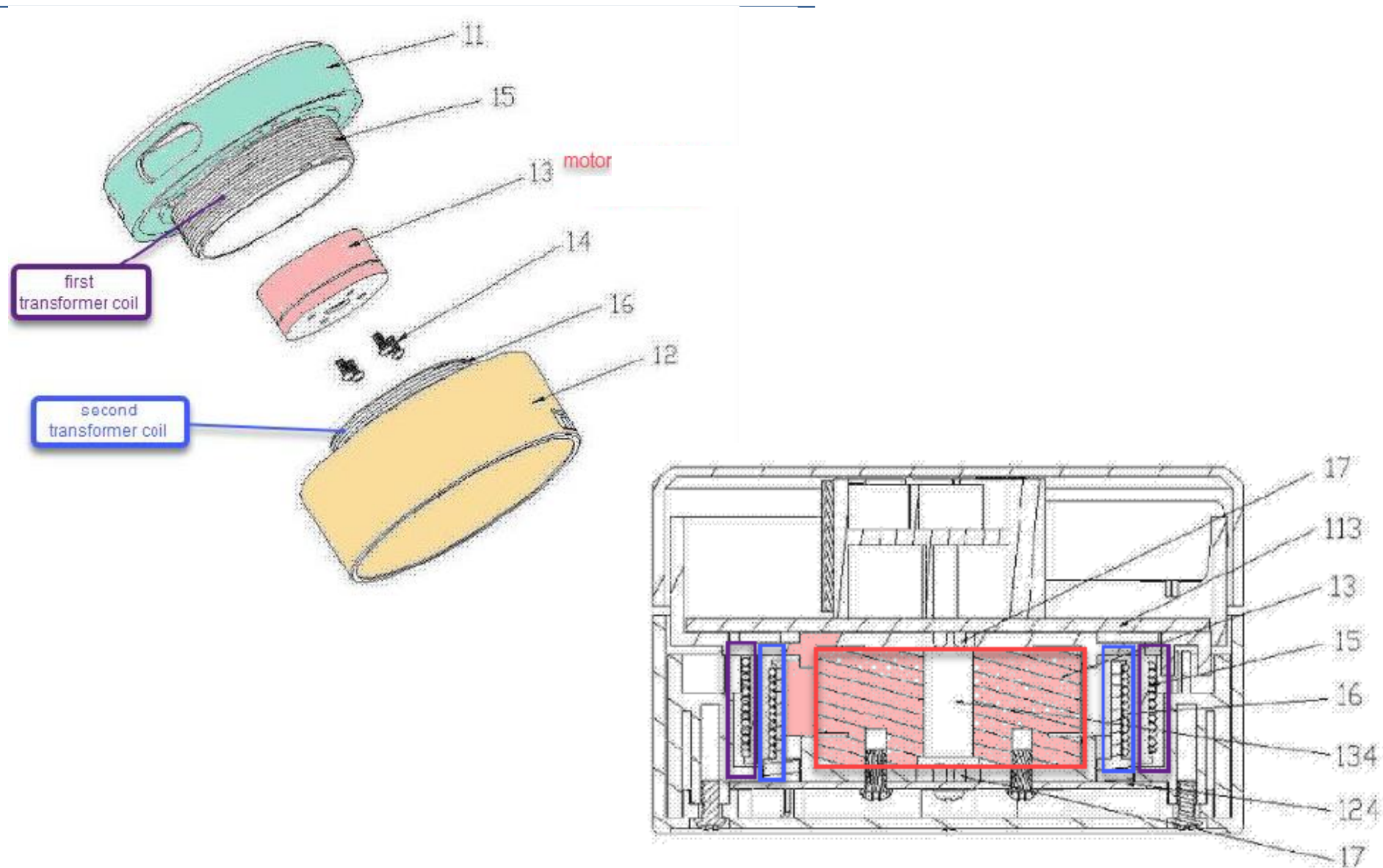


communication interface 216, etc.) of platform 210. For instance, the transformer coils can be arranged around a center region of platform 210 opposite to corresponding transformer coils included in platform 230. Further, for instance, device 200 may also include a magnetic core (not shown) extending through the transformer coils in interface 218 (and/or transformer coils included in platform 230) to guide the magnetic flux through the respective transformer coils thereby improving efficiency of power transmission between the two platforms. Other configurations are possible as well.

Johnson, 8:14-15

Johnson, Fig. 3

Cai - Transformer Coils Outside Motor Perimeter



EX1008, [0025], Fig. 2, 8.

Cai Provides An Express Motivation To Combine



Dr. Lebby
Hesai's Expert

The location of the transformer coils in this respect is a straightforward design choice that relates to considerations such as the amount of torque and power needed for the device and the space available in the center region of the circuit board. For instance, for an axial-flux motor, like that disclosed in Johnson, the amount of torque provided by the motor generally depends on how close or far away the magnets are from the central rotating axis. **A larger motor with a larger radius will create more torque, while one with a smaller radius will generate less torque.** A POSITA would have understood that in certain LiDAR systems the **size of the motor and torque output that is needed will result in a smaller motor radius such that the space in the center region would be insufficient to fit the transformer coils** along with the other electronics of the system.

Cai Provides An Express Motivation To Combine



Dr. Lebby
Hesai's Expert

Further, certain LiDAR applications may need to use larger transformer coils that have a larger radius to increase the power and transfer distance, such that the transformer coils would not fit within the perimeter of the motor and stator coils. In short, the location of the motor magnets and coils is a design choice with no novel or unpredictable results.

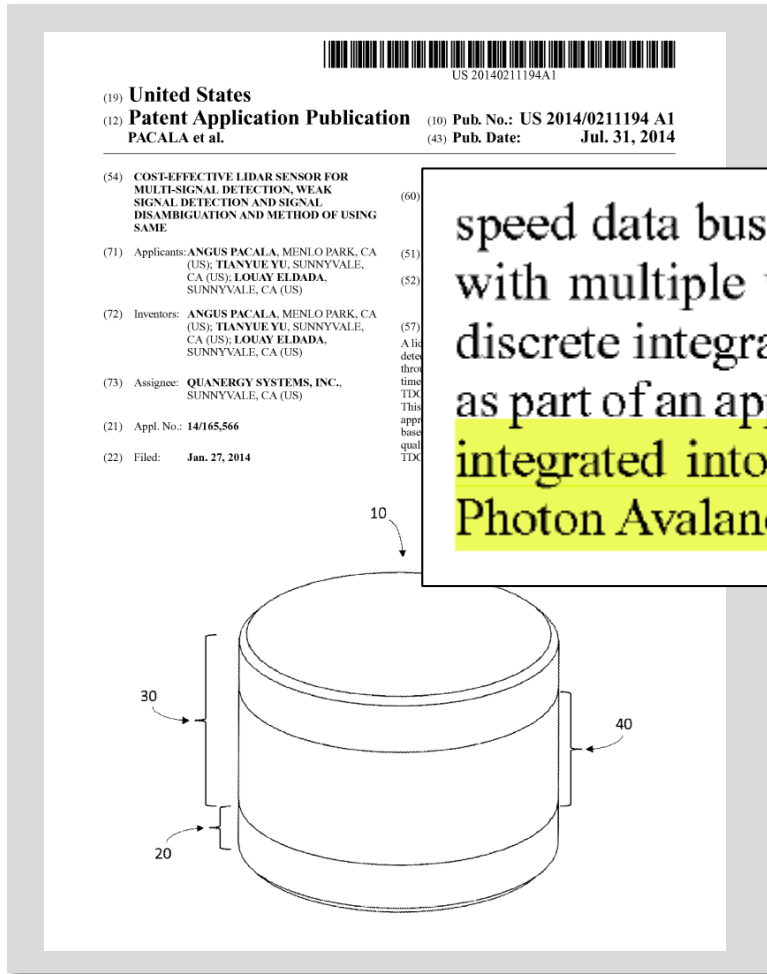
Claim 13

Claims 13/21 – Plurality of SPADs

13. The light ranging system of claim **12** wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs).

21. The light ranging system of claim **20** wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs).

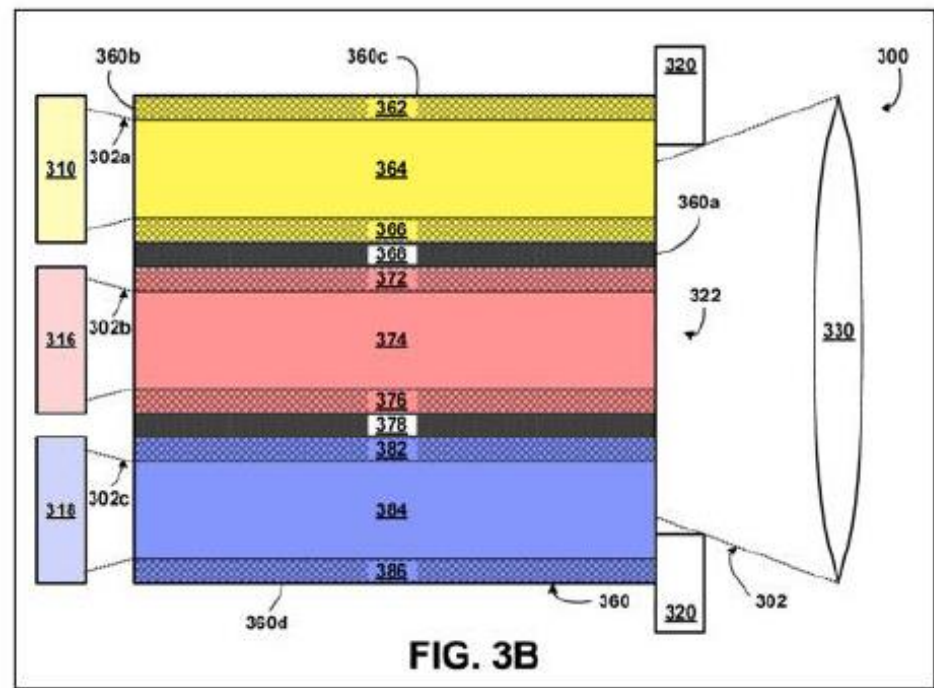
Pacala (EX1004) – Discloses SPADs



speed data bus. The multi-channel TDC electronic circuitry with multiple voltage thresholds can be implemented with discrete integrated circuits (ICs), in the form of FPGA logic, as part of an application-specific integrated circuit (ASIC), or integrated into the pixels of a detector array (e.g., Single-Photon Avalanche Diode [SPAD] array).

EX1004, ¶ 14

Droz– Plurality of SPADs



rately and simultaneously. As shown, for instance, each output from a light detector array (310, 316, or 318) may correspond to an image pixel of a vertical arrangement of pixels representing the scene. Further, the image pixel is

EX1011, 13:1-3

5. The system of claim 1, wherein the array of light detectors comprises a plurality of single photon avalanche diodes (SPADs).

EX1011, 18:55-57

No Copying

There Is No Evidence Of Copying

Ouster OS1-64 (EX2024)	Hesai's Pandar QT (EX2025)
	

Ouster OS1-64 (EX2024)	Hesai's Pandar QT (EX2025)
	