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The Director  
of the United States Patent and  
Trademark Office has received  
an application for a patent for a  
new and useful  
invention, the nature  
and description of the invention  
and the claims  
of law have been complied with,  
and a patent on the same  
is hereby granted.

United States  
of America



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The Director  
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invention, the nature  
and description of the invention  
and the claims  
of law have been complied with,  
and a patent on the same  
is hereby granted.

United States  
of America



To Promote the Progress  
of Science and Useful Arts

The Director  
of the United States Patent and Trademark Office has received  
an application for a new and useful invention. The title  
and description of the invention are enclosed. The requirements  
of law have been complied with, and it has been determined that  
a patent on the invention shall be granted under the law.

Patent

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DIRECTOR OF



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of America

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To Promote the Progress  
of Science and Useful Arts

The Director  
of the United States Patent and  
Trademark Office has received  
an application for a patent for a  
new and useful  
invention, the nature  
and description of the invention  
and the claims  
of law have been complied with,  
and a patent on the same  
is hereby granted.

United States  
of America

# US Patent 11,408,271 B2 Granted Aug 9, 2022



## Brief Description of Claim Granted

### Well pump diagnostics using multi-physics sensor data

A method includes receiving acoustic signals from one or more acoustic sensors that are coupled to a beam pump unit. The method also includes identifying a frequency of the beam pump unit in the acoustic signals. The method also includes detecting an outlier in the acoustic signals based at least partially upon the identified frequency. The outlier represents an operational issue with the beam pump unit.

## Business Relevance

Beam pumps are used to provide artificial lift in wells, allowing producing of hydrocarbons from the wells. The method is popular because of its simplicity, reliability, and applicability to a wide range of operating conditions. However, beam pumps are prone to inefficiency from a variety of issues that can be difficult to diagnose.

Well shutdowns caused by delayed equipment diagnostics may result in lost production and health, safety, and environmental (HSE) issues.

The ability to identify beam pumping operating conditions may thus enhance oil well profitability over the long-term.

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

(10) **Patent No.: US 11,408,271 B2**  
(45) **Date of Patent: Aug. 9, 2022**

(54) **WELL PUMP DIAGNOSTICS USING MULTI-PHYSICS SENSOR DATA**

(58) **Field of Classification Search**  
CPC ..... E21B 47/009; E21B 47/007; E21B 47/06; E21B 47/12; E21B 47/18  
See application file for complete search history.

(71) Applicant: **Noven, Inc.**, Houston, TX (US)

(56) **References Cited**

(72) Inventors: **Mahmut Sengul**, Houston, TX (US);  
**Mario Ruscev**, Houston, TX (US);  
**Karim Boudah**, Houston, TX (US);  
**Juan Felipe Arjona**, Houston, TX (US)

U.S. PATENT DOCUMENTS

(73) Assignee: **NOVEN, INC.**, Houston, TX (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 114 days.

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5,941,305	A	8/1999	Thrasher et al.
6,176,682	B1	1/2001	Mills

(21) Appl. No.: **16/898,639**

(22) Filed: **Jun. 11, 2020**

(65) **Prior Publication Data**  
US 2020/0392834 A1 Dec. 17, 2020

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**Related U.S. Application Data**

AU	2004316883	B2	9/2005
EP	3118409	B1	7/2016
WO	2009/005876	A2	1/2009

(60) Provisional application No. 62/859,979, filed on Jun. 11, 2019, provisional application No. 62/860,038, filed on Jun. 11, 2019.

*Primary Examiner* — Franklin D Balseca  
(74) *Attorney, Agent, or Firm* — MH2 Technology Law Group LLP

(51) **Int. Cl.**  
**E21B 47/009** (2012.01)  
**E21B 47/06** (2012.01)  
**E21B 47/007** (2012.01)  
**E21B 47/18** (2012.01)

(57) **ABSTRACT**  
A method includes receiving acoustic signals from one or more acoustic sensors that are coupled to a beam pump unit. The method also includes identifying a frequency of the beam pump unit in the acoustic signals. The method also includes detecting an outlier in the acoustic signals based at least partially upon the identified frequency. The outlier represents an operational issue with the beam pump unit.

(52) **U.S. Cl.**  
CPC ..... **E21B 47/009** (2020.05); **E21B 47/007** (2020.05); **E21B 47/06** (2013.01); **E21B 47/18** (2013.01)

**15 Claims, 14 Drawing Sheets**

# US Patent 11,560,784 B2 Granted Jan 24, 2023



## Brief Description of Claim Granted

A method for detecting operational issues in a beam pump unit is disclosed. The method includes receiving sensor data representing a position of and a load on the beam pump unit using a sensor coupled to the beam pump unit, generating a surface Dynacard based on the sensor data, predicting a source of inefficiency in the beam pump unit based at least in part on the surface Dynacard using a machine learning algorithm, and identifying one or more corrective actions to take to address the source of inefficiency.

## Business Relevance

Dynamometer Cards considered as gold standard in determining the operating health condition of the Surface and subsurface pump.

Dynamometer measurements are manual operation, and it requires a technician visit to wellsite, stopping the pump and acquire test. Test data is not interpreted automatically. Often lacking vital inputs related to the well completion, fluid composition and production rate. Not reliable

Achieving this measurements and diagnosing on the well site automatically eliminates human error, reduce windshield time for driving to location. It is available any time anywhere, with the fraction of the cost of conventional Echometer surveys

### (12) United States Patent Sengul et al.

(10) Patent No.: US 11,560,784 B2  
(45) Date of Patent: Jan. 24, 2023

#### (54) AUTOMATED BEAM PUMP DIAGNOSTICS USING SURFACE DYNACARD

#### (56) References Cited

- (71) Applicant: **Noven, Inc.**, Houston, TX (US)
- (72) Inventors: **Mahmut Sengul**, Houston, TX (US); **Mario Ruseev**, Houston, TX (US); **Juan Felipe Arjona**, Houston, TX (US); **Vyacheslav Nadovoretskiy**, Houston, TX (US); **Hanna Broadus**, Houston, TX (US)
- (73) Assignee: **NOVEN, INC.**, Houston, TX (US)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 231 days.

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Primary Examiner — Charles G Freay  
(74) Attorney, Agent, or Firm — MH2 Technology Law Group LLP

- (21) Appl. No.: **16/898,019**
- (22) Filed: **Jun. 10, 2020**
- (65) **Prior Publication Data**  
US 2020/0392833 A1 Dec. 17, 2020

- Related U.S. Application Data**
- (60) Provisional application No. 62/859,997, filed on Jun. 11, 2019, provisional application No. 62/860,012, filed on Jun. 11, 2019.
- (51) **Int. Cl.**  
**E21B 47/009** (2012.01)  
**G06N 20/00** (2019.01)  
**F04B 51/00** (2006.01)
- (52) **U.S. Cl.**  
CPC ..... **E21B 47/009** (2020.05); **G06N 20/00** (2019.01); **F04B 51/00** (2013.01)
- (58) **Field of Classification Search**  
CPC ..... E21B 47/009; G06N 20/00; F04B 51/00

(57) **ABSTRACT**

A method for detecting operational issues in a beam pump unit includes receiving sensor data representing a position of and a load on the beam pump unit, using a sensor coupled to the beam pump unit, generating a surface dynacard based on the sensor data, predicting a source of inefficiency in the beam pump unit based at least in part on the surface dynacard using a machine learning algorithm, and identifying one or more corrective actions to take to address the source of inefficiency.

# US Patent 11,542,809 B2 Granted Jan 3, 2023



US011542809B2

## Brief Description of Claim Granted

### POISHED ROD LOAD CELL

An apparatus for measuring strain in a polished rod of a beam pump unit includes a body having an upper wide section, a lower wide section, and a narrow section having a reduced width in comparison to each of the upper and lower wide sections. A bore is formed in the narrow section. The apparatus also includes at least two connectors configured to connect the body to the rod. The bore is positioned between the two connectors in a direction that is parallel to an axis of the rod. The apparatus further includes a strain gauge positioned in the bore, to measure strain in the rod between the two points of connection.

## Business Relevance

Polished Rod Load Cell is the vital component of the beam pumping condition monitoring, well production performance monitoring and diagnostics. Conventional technology is using either a wired horseshoe type or canister type load cells. Installation require oilfield crane, and removal of horse head, labor intensive costly operation. Run life, reliability is low due to susceptibility of cable damage, cut.

Noven wireless load cell does not require well intervention. It is easily installed using proprietary clamp elements designed for each rod size. Extreme load bearing capability acts as secondary safety barrier to prevent rod string to slipped. Low power battery operation makes its applicable even in gas powered pump units.

Noven Load Cell is a combo device including force and position measurements in one sensor. Easy to deploy, unlimited Dynacard measurements available remotely. Cost effective and smart sensor designed for future proof IIoT technology platform

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

(10) **Patent No.:** **US 11,542,809 B2**  
(45) **Date of Patent:** **Jan. 3, 2023**

(54) **POLISHED ROD LOAD CELL**

(56) **References Cited**

(71) Applicant: **Noven, Inc.**, Houston, TX (US)

U.S. PATENT DOCUMENTS

(72) Inventors: **Mahmut Sengul**, Houston, TX (US);  
**Mario Ruscev**, Houston, TX (US)

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73/152.61  
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73/152.61  
4,490,094 A \* 12/1984 Gibbs ..... E21B 47/009  
417/42  
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73/765  
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166/250.01  
9,080,438 B1 \* 7/2015 McCoy ..... E21B 47/009

(73) Assignee: **NOVEN, INC.**, Houston, TX (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 135 days.

(21) Appl. No.: **16/897,566**

(22) Filed: **Jun. 10, 2020**

(65) **Prior Publication Data**

US 2020/0393309 A1 Dec. 17, 2020

**Related U.S. Application Data**

(60) Provisional application No. 62/859,912, filed on Jun. 11, 2019.

(51) **Int. Cl.**  
**E21B 47/009** (2012.01)  
**G01L 1/22** (2006.01)  
**E21B 43/12** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **E21B 47/009** (2020.05); **G01L 1/22** (2013.01); **E21B 43/127** (2013.01)

(58) **Field of Classification Search**  
CPC ..... E21B 47/007; E21B 47/009  
See application file for complete search history.

(Continued)  
*Primary Examiner* — Kristyn A Hall  
*Assistant Examiner* — Nicholas D Wlodarski  
(74) *Attorney, Agent, or Firm* — MH2 Technology Law Group LLP

(57) **ABSTRACT**

An apparatus for measuring strain in a polished rod of a beam pump unit includes a body having an upper wide section, a lower wide section, and a narrow section having a reduced width in comparison to each of the upper and lower wide sections. A bore is formed in the narrow section. The apparatus also includes at least two connectors configured to connect the body to the rod. The bore is positioned between the two connectors in a direction that is parallel to an axis of the rod. The apparatus further includes a strain gauge positioned in the bore, so as to measure strain in the rod between the two points of connection.

**25 Claims, 6 Drawing Sheets**

# US Patent 11,572,770 B2

## Granted Feb 7, 2023



US011572770B2

### Brief Description of Claim Granted

An apparatus includes a body first and second clamping mechanisms that are configured to grip a tubular member of a beam pump unit at first and second axially-offset locations along the tubular member, respectively. The body also includes a base positioned at least partially between the first and second clamping mechanisms. The apparatus also includes a strain gauge coupled to the base and configured to measure a strain on the tubular member as the tubular member moves. The apparatus also includes an accelerometer configured to measure an acceleration of the beam pump unit as the beam pump unit operates.

### Business Relevance

Beam pumping is the most widely used type of artificial lift method for oil and gas wells. Typical methods for analyzing the performance of the beam pump unit are based on Gilbert's development of the beam pump dynamometer. Using those methods, the load on the polished rod is recorded graphically as a function of its travel to generate a chart that shows the work undertaken at the surface unit for each pump stroke. Old technology

With the advent of high-performance digital data acquisition systems, attention has been directed to a more complete analysis of the performance of the beam pump unit. However, traditional Supervisory Control And Data Acquisition (SCADA) systems generally have a large footprint at the wellsite, and rely on a costly field-level, local telecommunication infrastructure. In addition, such SCADA systems are oftentimes not compatible with computing systems used at the wellsite. Therefore, it would be **beneficial to have an improved system and method for analyzing the performance of a beam pump unit.**

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

(10) **Patent No.:** US 11,572,770 B2  
(45) **Date of Patent:** Feb. 7, 2023

(54) **SYSTEM AND METHOD FOR DETERMINING LOAD AND DISPLACEMENT OF A POLISHED ROD**

(71) Applicant: **Noven, Inc.**, Houston, TX (US)

(72) Inventors: **Mahmut Sengul**, Houston, TX (US);  
**Mario Ruscev**, Houston, TX (US)

(73) Assignee: **NOVEN, INC.**, Houston, TX (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 206 days.

(21) Appl. No.: **16/898,050**

(22) Filed: **Jun. 10, 2020**

(65) **Prior Publication Data**  
US 2020/0392822 A1 Dec. 17, 2020

**Related U.S. Application Data**

(60) Provisional application No. 62/859,958, filed on Jun. 11, 2019.

(51) **Int. Cl.**  
*F04B 47/02* (2006.01)  
*E21B 43/12* (2006.01)  
*F04B 49/06* (2006.01)

(52) **U.S. Cl.**  
CPC ..... *E21B 43/12* (2013.01); *F04B 47/026* (2013.01); *F04B 49/06* (2013.01); *F04B 2201/121* (2013.01)

(58) **Field of Classification Search**  
CPC ..... *E21B 43/12*; *F04B 47/026*; *F04B 49/06*; *F04B 2201/121*  
See application file for complete search history.

(56) **References Cited**

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*Primary Examiner* — Taras P Bemko  
(74) *Attorney, Agent, or Firm* — MH2 Technology Law Group LLP

(57) **ABSTRACT**

An apparatus includes a body. The body includes first and second clamping mechanisms that are configured to grip a tubular member of a beam pump unit at first and second axially-offset locations along the tubular member, respectively. The body also includes a base positioned at least partially between the first and second clamping mechanisms. The apparatus also includes a strain gauge coupled to the base and configured to measure a strain on the tubular member as the tubular member moves. The apparatus also includes a gyroscope configured to measure an orientation, an angular velocity, or both of the beam pump unit as the beam pump unit operates. The apparatus also includes an accelerometer configured to measure an acceleration of the beam pump unit as the beam pump unit operates.

20 Claims, 5 Drawing Sheets

# US Patent 11,560,045 B2 Granted Nov. 22, 2022



## Brief Description of Claim Granted

### Two Point Polished Road Load Sensing System

An apparatus includes a first clamping mechanism configured to grip a tubular member at a first location along the tubular member. The apparatus also includes a second clamping mechanism configured to grip the tubular member at a second location along the tubular member that is axially-offset from the first location. The apparatus also includes a base positioned between the first and second clamping mechanisms. The apparatus also includes a strain gauge coupled to the base

## Business Relevance

Beam pumping is the most widely used type of artificial lift method for oil and gas wells. A beam pump unit typically includes three segments: a surface unit, a rod string, and a subsurface pump. Dynamometer surveys are performed to capture load measurements on the beam pump unit.

The load measurements may provide insight into the volumetric efficiency, mechanical integrity, and operating efficiency of the beam pump unit. Dynamometer surveys are typically performed using either a transducer placed on the rod string, or a horseshoe load cell placed between the carrier bar and the polished rod clamp. However, installation of such transducers may be expensive and labor-intensive, and may involve shutting down the beam pump unit for hours or days. Therefore, it would be beneficial to have an improved system and method for capturing relative load measurements on a beam pump unit.

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

(10) **Patent No.:** **US 11,506,045 B2**

(45) **Date of Patent:** **Nov. 22, 2022**

(54) **TWO-POINT POLISHED ROD  
LOAD-SENSING SYSTEM**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **Noven, Inc.**, Houston, TX (US)

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(72) Inventors: **Mahmut Sengul**, Houston, TX (US);  
**Mario Ruscev**, Houston, TX (US)

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(73) Assignee: **NOVEN, INC.**, Houston, TX (US)

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4,644,785 A \* 2/1987 Doyle ..... F04B 47/026  
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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 259 days.

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(21) Appl. No.: **16/897,639**

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73/831

(22) Filed: **Jun. 10, 2020**

(65) **Prior Publication Data**  
US 2020/0392832 A1 Dec. 17, 2020

7,634,328 B2 12/2009 Medzade et al.  
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(Continued)

**Related U.S. Application Data**

FOREIGN PATENT DOCUMENTS

(60) Provisional application No. 62/859,938, filed on Jun. 11, 2019.

WO 2009/005876 A2 1/2009  
*Primary Examiner* — Kipp C Wallace  
(74) *Attorney, Agent, or Firm* — MH2 Technology Law Group LLP

(51) **Int. Cl.**  
**E21B 47/009** (2012.01)  
**G01L 1/22** (2006.01)  
**E21B 43/12** (2006.01)

(57) **ABSTRACT**

(52) **U.S. Cl.**  
CPC ..... **E21B 47/009** (2020.05); **G01L 1/225**  
(2013.01); **E21B 43/127** (2013.01)

An apparatus includes a first clamping mechanism configured to grip a tubular member at a first location along the tubular member. The apparatus also includes a second clamping mechanism configured to grip the tubular member at a second location along the tubular member that is axially-offset from the first location. The apparatus also includes a base positioned between the first and second clamping mechanisms. The apparatus also includes a strain gauge coupled to the base.

(58) **Field of Classification Search**  
CPC ..... E21B 43/127; E21B 47/009; G01L 1/22;  
F04B 2201/121

See application file for complete search history.

**22 Claims, 7 Drawing Sheets**