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(54) Benævnelse: **ENHED, DER ER INDSKUDT MELLEM ET MOMENTVÆRKTØJ OG ET FASTGØRELSESELEMENT, TIL MÅLING AF MOMENTER OG SPÆNDINGSVINKLER**

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DESCRIPTION

I. BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates in general to sockets for interconnecting torque tools and fastening elements and, more specifically, to an assembly intercalated between a torque tool and a fastening element, for measuring torques and tightening angles.

2. Description of the Prior Art

[0002] In fastening operations, it is often required to tighten a threaded fastener until it is adequately tensioned, thereby insuring that the latter securely holds the work piece. In order to install threaded fasteners, such as screws, bolts, nuts or the like, a tool is used to apply the required torque or tension. In critical applications, the installing tool apparatus does not have the means of measurement, is incapable of accurately measuring the require tension, or it is required that a secondary measurement device be used to verify that the required tension has been achieved.

[0003] There are several accepted methods for measuring the applied tension in threaded fasteners. In one method, the required tension is determined by applied torque, which is previously established by engineering calculus. According to this method, the torque, or torsional load is often measured using strain gauge(s). According to another method, the required tension is measured by an angular displacement of a fastener. Attempts have been made to develop an apparatus, using various ultrasonic techniques, for directly measuring fasteners tension. For example. United States Patent No. 5.058.439 granted on October 22, 1991 to Carpenter for a --UT Socket Assembly" discloses an ultrasonic transducer socket assembly, used with a torque tool, for simultaneously tightening a bolt and measuring bolt load. A pole adaptor rigidly attached to a driving socket for engaging and driving a bolt has a stationary cylinder mounted therein. A second cylinder, rotatable and slidably received in the stationary cylinder, has an ultrasonic transducer pivotally mounted at one end that contacts the bolt to be tightened, when the socket is engaged with the bolt. The rotating cylinder and transducer are rotated approximately 180 degrees during engagement of the socket and bolt to smear an even couplant layer between the bolt and transducer to assure consistent measurements of bolt load during tightening a socket assembly including a ultrasonic transducer capable of measuring the bolt tension.

[0004] Although directly measuring bolt tension is advantageous, the foregoing apparatus has several disadvantages. Among them, the fact that the apparatus incorporates complex

mechanical features which can negatively affect the precision of the measurements, increases the manufacturing cost, reduces the reliability, and greatly increases the length and weight of the socket which in many applications is impractical.

[0005] Patent document published US 2011/0120233 A1 discloses an assembly to be intercalated between a torque tool and a fastening element, for measuring torques and angular displacements of fasteners comprising a socket subassembly having an unitary elongated shaft, including at one extremity a first engaging cavity, at an opposite extremity, a strain transducer subassembly, for measuring torsional strains on said socket subassembly, a circular cover attached to said socket subassembly and an electronic subassembly for converting said torsional strains on said socket subassembly to standard torque values and for determining tightening angular displacements; said electronic subassembly being interconnected to said strain transducer subassembly and mounted on said circular cover to face said strain transducer subassembly; said circular cover subassembly comprising a first and second semicircular segments; said first semi-circular segment incorporating a radial protrusion and diametrically opposed threaded openings; said second semi-circular segment incorporates a pair of fastening openings, corresponding to said diametrically opposed threaded openings; said diametrically opposed threaded openings and said pair of fastening openings being used for attachment of said first and second semi-circular segments by fasteners; said electronic subassembly comprising a processing unit, a user interface unit and a power supply unit; said processing unit including a microcontroller for digital and analog signal processing, mounted on said first semi-circular segment and connected to said strain transducer subassembly for converting the torsional strain into standard engineering units of torque, for measuring angular displacement by means of a sensor and for parameter and configuration memory storage; said user interface unit including a display, mounted on said first semi-circular segment and interconnected to said microcontroller, for showing the selected imposed parameters, and for showing the running and final measured parameters; a keypad, interconnected to said processing unit for selecting the desired parameter for verification, or for selecting the parameter at which to signal said torque tool's own controller to shut- off at the imposed parameter; a pass/fail indicator, interconnected to said processing unit, for showing if the measured parameter, is within the pre-established upper parameter limit and lower parameter limit as defined by the user; and said power supply unit including a power source in the form of a battery and a battery charging and protection circuit.

[0006] Published patent documents US 2010/0299084 A1, US 2003/0065456 A1 and US 2011/0107882 A1 disclose further assemblies to be intercalated between a torque tool and a fastening element, for measuring torques.

II. SUMMARY OF THE INVENTION

[0007] Based on the state of the art. there is a need for an improved apparatus that reliably measures the torque directly applied to a threaded fastener.

[0008] Thus. it is an objective of the present invention to devise an apparatus therefore which is reliable, compact, and provides precise measurements of torsional strain and/or angular displacement.

[0009] It is another objective to provide the applied torque in Engineering Units (for example, lbs-ft, or NM) achieved by storing calibration values relating the torsional strain to torque.

[0010] It is yet another objective of the present invention to provide means to remotely monitor, and record the applied torque and/or angular displacement of a fastener.

[0011] It is yet another objective of the present invention to provide a means to signal to a tool apparatus to shut-off at a pre-established applied torque and/or angular displacement.

[0012] Broadly stating, the assembly, intercalated between a torque tool and a fastening element, for measuring torques and tightening angles comprises, in combination:

- a socket subassembly having an unitary elongated body, including at one extremity a first engaging cavity, at an opposite extremity, a second engaging cavity; and incorporating an externally open, annular channel provided between the extremities of the socket subassembly;
- a strain transducer subassembly, for measuring torsional strains on the socket subassembly, mounted in the externally open, annular channel;
- a circular cover attached to the socket subassembly for enclosing the externally open, annular channel; and
- an electronic subassembly for converting the measured torsional strains on the socket subassembly to standard torque values and for measuring angular displacement of the fastener; the electronic subassembly being interconnected to the strain transducer subassembly and mounted on the circular cover to face the strain transducer subassembly.

[0013] In one aspect, the assembly, intercalated between a torque tool and a fastening element, for measuring torques and tightening angles comprises, in combination:

a socket subassembly including a first engaging cavity, shaped to conform to and engage with the torque tool exit shaft, usually of square drive type; a second engaging cavity being shaped to conform to and engage with the fastening element, of a specific size; the externally open, annular channel being provided with a circular bottom surface for mounting a strain transducer subassembly;

the strain transducer subassembly comprising four strain gages, equally spaced from each other on the circular bottom surface, intended for measuring torsional strains; each of the four strain gages being of the 45 degree dual grid shear pattern and being made of constantan comprising a pair of parallel, juxtaposed strain elements, so arranged that a convergence line

of the parallel, juxtaposed strain elements is parallel to the longitudinal axis of symmetry of the socket subassembly, for measuring torsional strains, only; the strain transducer subassembly being wired in a Wheatstone bridge to produce analog voltage signals, proportional to only torsional strains in the socket assembly, and therefor in the fastening element;

said circular cover subassembly comprising a first and second semicircular segments; the first semi-circular segment incorporating an axial and radial protrusion and diametrically opposed threaded openings: the second semi-circular segment incorporates a pair of fastening openings, corresponding to the diametrically opposed threaded openings; the diametrically opposed threaded openings and the pair of fastening openings being used for attachment of the first and second semi-circular segments by fasteners;

an electronic subassembly comprising a processing unit, a user interface unit and a power supply unit;

the processing unit including a microcontroller for digital and analog signal processing, mounted on the first semi-circular segment and connected to the strain transducer subassembly for converting the torsional strain into standard engineering units of torque, for measuring angular displacement by means of a sensor for providing date/time function to time stamp tightening cycles and measured parameters, and for parameter and configuration memory storage;

the user interface unit including
a display, mounted on the first semi-circular segment and interconnected to the microcontroller, for showing the selected imposed parameters (applied torque and/or angular displacement), and for showing the running and final measured parameters (applied torque and/or angular displacement);

a connection port, mounted to the first semi-circular segment and interconnected to the processing unit for communication to an external device or for the purpose of controlling the torque tool shut-off at the imposed parameter (applied torque and/or angular displacement);

a keypad, interconnected to the processing unit for selecting the desired parameter for verification (applied torque and/or angular displacement), or for selecting the parameter (applied torque and/or angular displacement) at which to signal the torque tool's own controller to shut-off at the imposed parameter (applied torque and/or angular displacement);

a pass/fail indicator, interconnected to the processing unit, for showing if the measured parameter (applied torque and/or angular displacement), is within the pre-established upper parameter limit and lower parameter limit as defined by the user; and

the power supply unit including
a power source in the form of a battery and a battery charging and protection circuit.

II. BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG. 1 is a prospective, exploded view of the assembly, intercalated between a torque tool and a fastening element, for measuring torques and tightening angles;

FIGS. 1A, 1B and 1C are prospective views of a processing unit **A**, a user interface unit **B** and a power supply unit C, which units compose an electronic subassembly of the assembly of Fig. 1;

FIG. 2 is a vertical cross-section of the socket subassembly, along its longitudinal axis of symmetry (see also line **Y-Y** of FIG. 3);

FIG. 3 is a elevation view of the socket subassembly with strain gages of the strain transducer subassembly mounted in externally open. annular channel and indicating vertical cross-section line **Y-Y,** horizontal cross-section line **X-X** and a zone **Z;**

FIG. 4 is a horizontal cross-section along line **X-X** of FIG, 3 showing the circumferential disposal of four strain gages of the strain transducer subassembly;

FIG. 5 depicts an enlarged view of zone **Z** shown in FIG. 3;

FIG. 6 is a prospective, exploded view of the circular cover subassembly; and

FIG. 7 is a diagrammatic view of the electronic subassembly.

IV. DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] Broadly describing, with reference to FIGS.1 to 4, an assembly, intercalated between a torque tool and a fastening element, for measuring torques and tightening angles, generally referenced as **10,** comprises in combination;

- a socket subassembly **100** having an unitary elongated body, including at one extremity a first engaging cavity **110,** at an opposite extremity, a second engaging cavity **120**; and incorporating an externally open, annular channel **130** provided between the extremities of socket subassembly **100**;
- a strain transducer subassembly **200,** for measuring an torsional strain on the socket subassembly **100,** mounted in externally open, annular channel **130**;
- a circular cover **300** attached to socket subassembly **100** for enclosing externally open, annular channel **130; and**
- a electronics subassembly **400** for converting the torsional strains on the socket subassembly **100** to standard torque values and for determining tightening angular displacement; electronic subassembly **400** is interconnected to strain transducer

subassembly **200** and mounted on circular cover **300** to face strain transducer subassembly **200**;

[0016] Describing now in detail,

- socket subassembly **100** includes first engaging cavity **110**, shaped to conform to and engage with a torque tool exit shaft (not shown), usually of a square drive type; second engaging cavity **120** is shaped to conform to and engage with a fastening element, such as a bolt or nut of a specific size (also not shown); externally open, annular channel **130** is provided with a circular bottom surface **140**, precision machined for mounting strain transducer subassembly **200**;
- strain transducer subassembly **200** comprises four strain gages **210,** equally spaced from each other on circular bottom surface **140**, intended for measuring torsional strains; each of the four strain gages **210**, is of the 45 degree dual grid shear pattern and is made of constantan which is a copper/nickel alloy characterized by constant resistance under variations of temperature, reliability, and extensive service life; each of the four strain gages **210** comprises a pair of parallel strain elements **220**, so arranged that a convergence line of parallel strain elements **220** is parallel to the longitudinal axis of symmetry of socket subassembly **100**, for measuring torsional strains, only; strain transducer subassembly **200** is wired in a Wheatstone bridge to produce analog voltage signals, proportional to only torsional strains in socket assembly **100,** and therefrom in the fastening element;
- circular cover subassembly **300** comprises a first and second semicircular segments **305** and **310**;
  first semi-circular segment **305** incorporates an axial protrusion **315** provided with a indented zone 320 including an opening **325,** a window **330** located above axial and radial protrusion **315,** a first and a second transversal openings **340, 345,** located on either side of window **330;** axial and radial protrusion **315** includes a pair of fastening openings **350** for attachment to socket sub-assembly **100;** first semi-circular segment **305** includes diametrically opposed threaded openings **355;**
  second semi-circular segment **310** incorporates a pair of fastening openings **360,** corresponding to diametrically opposed threaded openings **355**; the former and the latter are used for attachment of first and second semi-circular segments **305** and **310** by fasteners (not shown).
- electronic subassembly **400** comprises a processing unit **A**, a user interface unit **B** and a power supply unit **C**;

[0017] Processing unit **A** includes:

- a microcontroller **405** for digital and analog signal processing, such as an 8-bit microcomputer of the type made by Silicon Industries, under the name of C8051,

mounted on first semi-circular segment **305** and connected to strain transducer subassembly **200**, for converting the torsional strain into standard engineering units of torque, for measuring angular displacement by means of a sensor (not shown), for providing date/time function to time stamp tightening cycles and measured parameters, and for parameter and configuration memory storage.

- user interface unit **B** includes;
- a display **410**, such as EINK display, manufactured by Kent Displays, mounted on first semi-circular segment **305** and viewed through window **330**, interconnected to microcontroller **405** providing a feature for displaying the selected imposed parameters (applied torque and/or angular displacement), and for displaying the running and final measured parameters (applied torque and/or angular displacement);
- a connection port **420**, mounted to first semi-circular segment **305** and accessed through first transversal opening **340**, is interconnected to processing unit **A** for communication to an external device, such as a personal computer or tool's own controller for the purpose of verification of applied torque or angular displacement, or for the purpose of controlling the tool shut-off at the imposed parameter (applied torque and/or angular displacement;
- a keypad **415**, in the form of multiple discrete push-buttons, of membrane type, as the one made by Padtech Industries, mounted in indented zone **320**, is interconnected to processing unit A via opening **325**, for selecting the desired parameter for verification (applied torque and/or angular displacement), or for selecting the parameter (applied torque and/or angular displacement) at which to signal the tool's own controller to shut-off at the imposed parameter (applied torque and/or angular displacement;
- a pass/fail indicator **418**, in the form of a multi color LED, located in second transversal opening **345,** and is interconnected to processing unit A for indicating if the measured parameter (applied torque and/or angular displacement), is within the pre-established upper parameter limit and lower parameter limit as defined by the user.
- power supply unit C includes;
- a power source in the form of a battery **430**, such as a compact, rechargeable single cell Lipo, for powering electronic subassembly **400** and ;
- a battery charging and protection circuit **(not shown)** for charging battery **430** which is connected to a DC power source (not shown) and protects the battery **430** from over-voltage, under voltage, short circuit and over-temperature.

Operation of the tool

[0018] The user will mount assembly **10,** intercalated between a torque tool **(not shown)** and a fastening element (also not shown), for measuring torques and tightening angles, onto torque tool, such as a powered torque tool (not shown), by inserting the driving tool shaft of the latter into first engaging cavity **110,** wherein may be retained by a locking pin. The user will then engage the fastener assembly 19 **(not shown)** with assembly **10,** respectively its second

engaging cavity **120.**

[0019] The user, by using display **410** and keypad **415**, can select and modify the ultimate torque and angular displacement values, which are displayed in standard engineering units, by incrementing or decrementing the values via the keypad pushbuttons, or select from a pre-established list of values. By the same means the user may also change the desired standard engineering units for torque, for example NM, ft lbs, etc. Display **410** also indicates the operational readiness of assembly **10.**

[0020] Under normal operation, microcontroller **405**, by means of display **410**, will indicate "Ready" when the device has sufficient battery power, and is ready for measurements.

[0021] The user will then proceed tightening the fastener by operating the torque tool. On cessation of tool operation, microcontroller **405** will indicate the final measured parameter(s) (applied torque and/or angular displacement) via display **410** and via pass/fail indicator **418**, During the tightening process, microcontroller **405** monitors and stores the running measured parameter(s) (applied torque and/or angular displacement) for analysis by the user.

[0022] In another operational variant, the user selects an ultimate torque value, and a desired ultimate angular displacement value, therefore providing a means for after the ultimate torque value is achieved microcontroller **405** will zero the position count, and at a pre-established threshold prior to the desired ultimate angular position, the microcontroller **405** sends a signal, or plurality of signals via connection port **420** to the tool's own controller (not shown) to control the approach of, and the shutoff of, the tool to achieve the imposed parameter (applied torque and/or angular displacement) within the desired upper and lower parameter limits.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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- US20110120233A1 **[0005]**
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- US20110107882A1 **[0006]**

Patentkrav

1. Enhed (10), der er indskudt mellem et momentværktøj og et fastgørelseselement, til at måle momenter og forskydningsvinkler på fastgørelseselementer, der i kombination omfatter:
- en holder (100), der har et aflangt enhedshus, herunder et første indgrebshul (110) ved det ene yderpunkt, et andet indgrebshul (120) ved det andet yderpunkt samt sammenbygningen af en ringformet kanal, der er åbent udadtil, (130) og som er tilvejebragt mellem yderpunkterne i holderen;
- en belastningstransducer (200) til at måle vridningskraften på holderen (100), der er monteret i den ringformede kanal, der er åben udadtil (130);
- en rund overdækning (300), der er monteret på holderen (100) for at indeslutte den ringformede kanal, der er åben udadtil (130); og
- en elektronisk underenhed (400) til at konvertere vridningskræfterne på holderen (100) til normale momentværdier og til at fastlægge forskydningsvinklerne for spænding; idet den elektroniske underenhed er indbyrdes forbundet til belastningstransduceren (200) og er monteret på den runde overdækning (300), så den vender mod belastningstransduceren (200);
holderen (100), herunder det første indgrebshul (110), der er formet til at tilpasse sig til og gå i indgreb med momentværktøjets udgangsaksel, der som regel er med indvendig firkant; idet det andet indgrebshul (120) er formet til at tilpasse sig til og gå i indgreb med fastgørelseselementet, af en bestemt størrelse; idet den ringformede kanal, der er åben udadtil, (130) er tilvejebragt med en rund bund (140) til at montere belastningstransduceren (200);
belastningstransduceren (200) omfatter fire strækfølere (210), der er monteret med ensartet afstand til hinanden på den runde bund (140), som er beregnet til at måle vridningskræfter; idet hver af de fire strækfølere (210) har et forskydningsmønster med et dobbeltgitter med en vinkel på 45 grader og er lavet af konstantan, der omfatter et par parallelle, sidestående

belastningselementer (220), der er placeret, så en konvergenslinje for de parallelle, sidestående belastningselementer (220) er parallel med den symmetriske længdeakse af holderen (100), til kun at måle vridningskræfter; idet belastningstransduceren (200) er forbundet i en Wheatstone-bro til at generere analoge spændingssignaler, som er proportionale med kun vridningskræfter i holderenheden (100), og derfra i fastgørelseselementet;

den runde overdækning (300), der omfatter et første og et andet halvcirkelformet segment (305, 310); idet det første halvcirkelformede segment (305) omfatter et aksialt fremspring og diametralt modstående gevindåbninger (355); idet det andet halvcirkelformede segment (310) omfatter et par fastgørelsesåbninger (360), der svarer til de diametralt modstående gevindåbninger (355); idet de diametralt modstående gevindåbninger (355) og fastgørelsesåbninger (360) bruges til at montere det første og andet halvcirkelformede segment (305, 310) med fastgørelseselementer;

den elektroniske underenhed (400), der omfatter en procesenhed, en brugergrænsefladeenhed og en strømforsyningsenhed; idet procesenheden omfatter en mikrokontroller (405) til digital og analog signalbehandling, der er monteret på det første halvcirkelformede segment (305) og er forbundet til belastningstransduceren (200) til konvertering af vridningskraften til normale ingeniørmæssige enheder for moment, til måling af forskydningsvinkler ved hjælp af en sensor for tilvejebringelse af dato-/tidsfunktion for at tidsstemple spændingscyklusser og målte parametre og til lagring af parametre og konfigurationer;

brugergrænsefladeenheden, herunder

et display (410), der er monteret på det første halvcirkelformede segment (305) og er indbyrdes forbundet til mikrokontrolleren (405), til at vise de valgte, fastlagte parametre og til at vise løbende og endelige målte parametre;

en tilslutningsport (420), der er monteret på det første halvcirkelformede segment (305) og er indbyrdes forbundet til procesenheden til kommunikation til en ekstern enhed eller med

det formål at kontrollere standsning af momentværktøjet ved den fastlagte parameter;

et tastatur (415), der er indbyrdes forbundet til procesenheden til at vælge den ønskede parameter til bekræftelse eller til at vælge den parameter, hvor der skal signaleres til momentværktøjets egen kontrolenhed om at standse ved den fastlagte parameter;

en indikator for bestået/ikke-bestået (418), der er indbyrdes forbundet til procesenheden, til at angive, om den målte parameter er inden for den på forhånd fastlagte øvre parametergrænse og nedre parametergrænse, som defineret af brugeren; og

strømforsyningsenheden, der indbefatter en strømkilde i form af et batteri (430) og et batterioplader- og beskyttelseskredsløb.

DRAWINGS

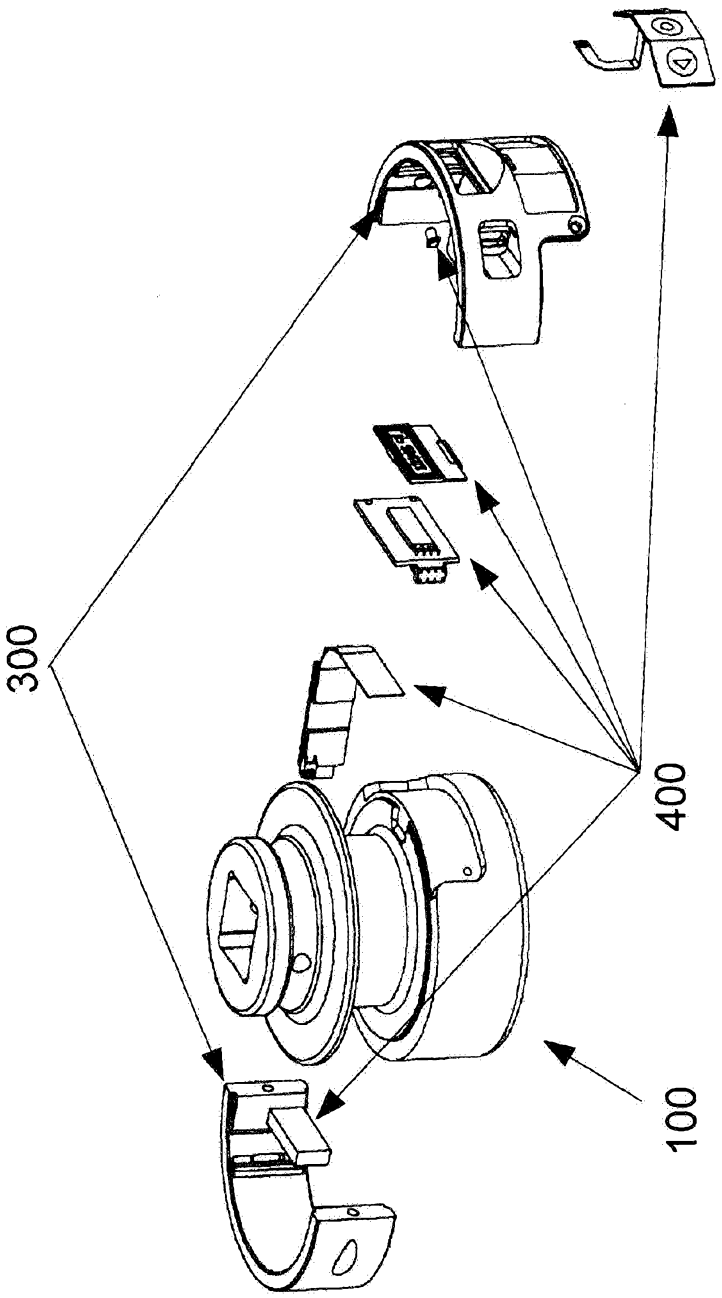

FIG. 1

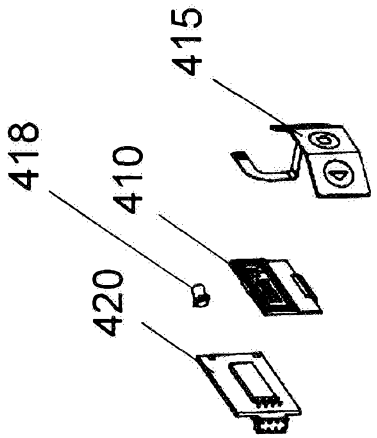

FIG. 1B

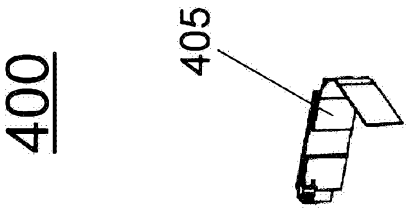

FIG. 1A

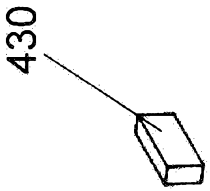

FIG. 1C

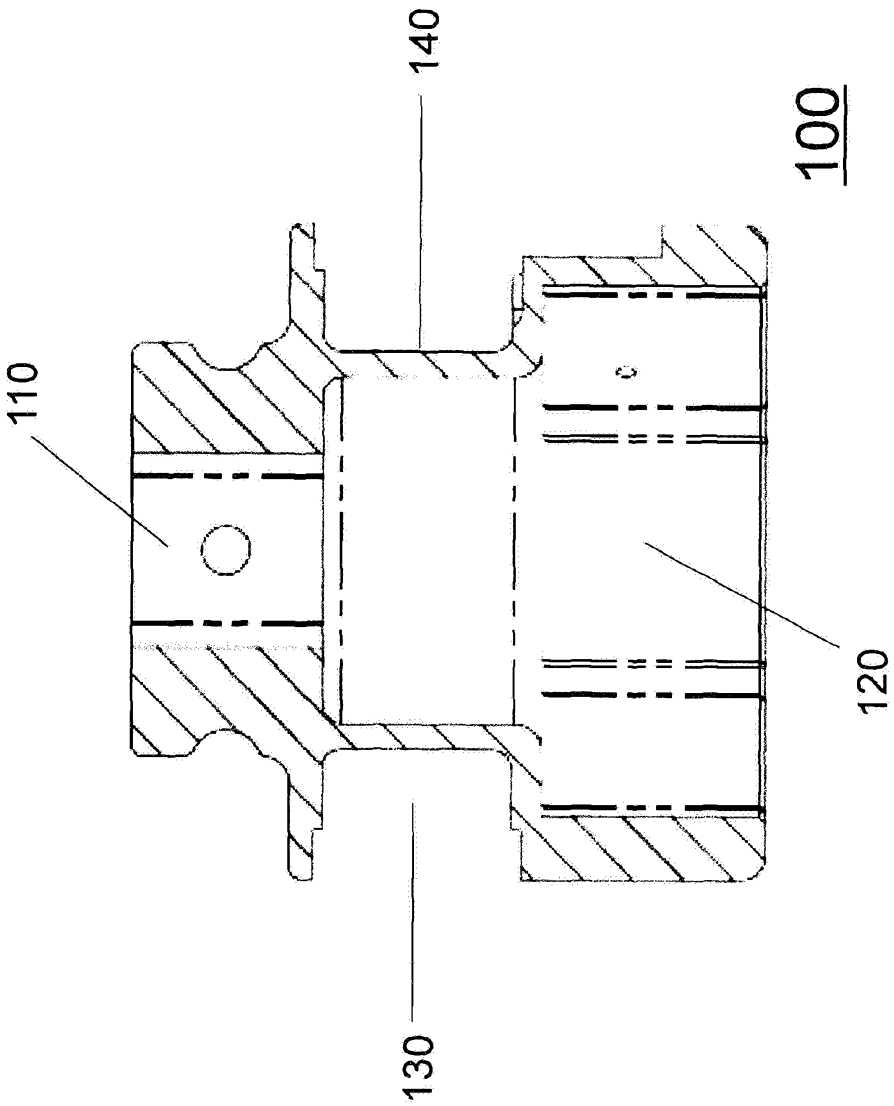

FIG. 2

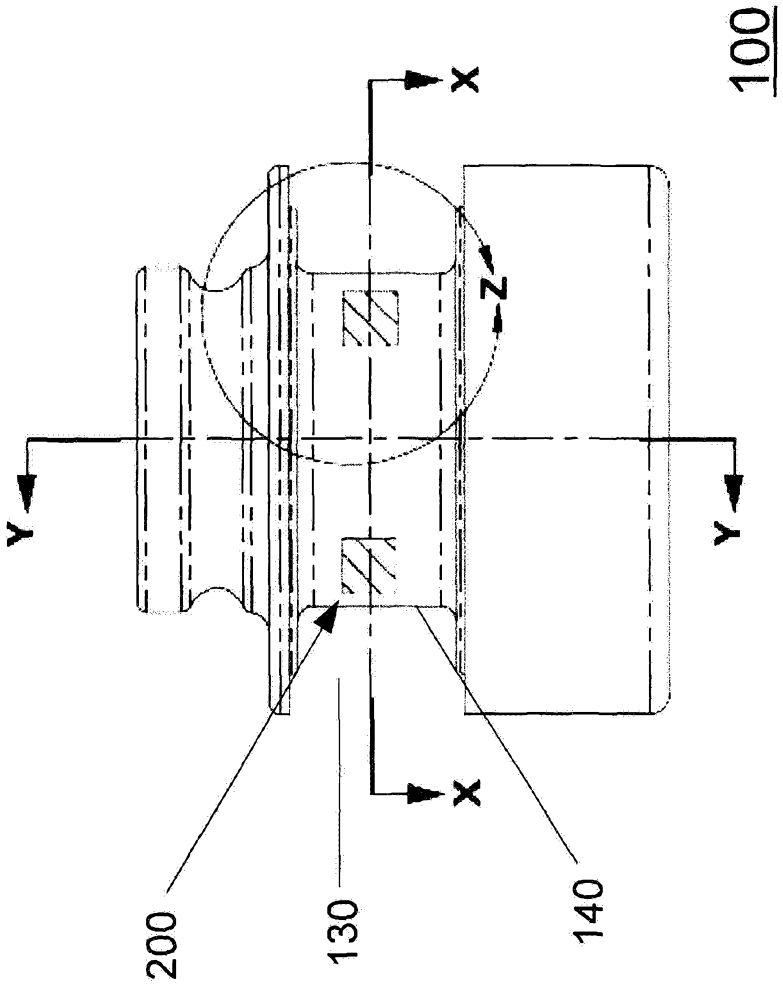

FIG. 3

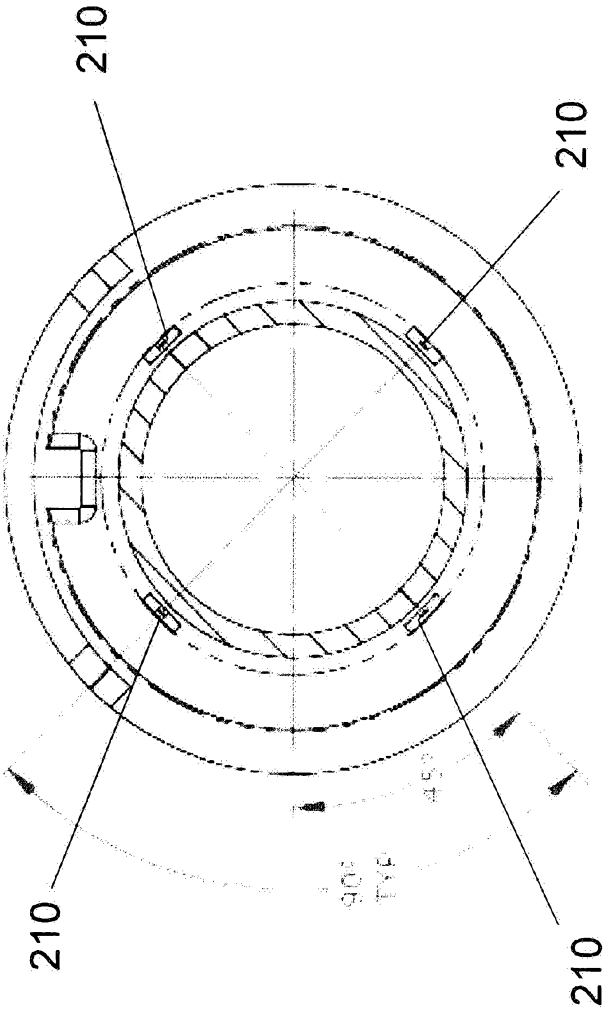

FIG. 4

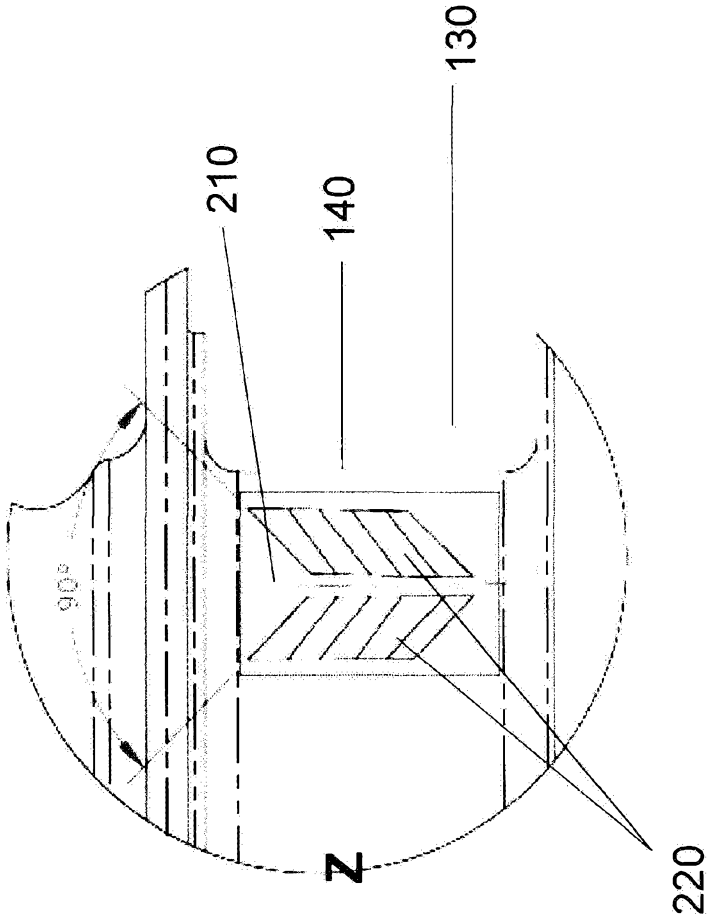

FIG. 5

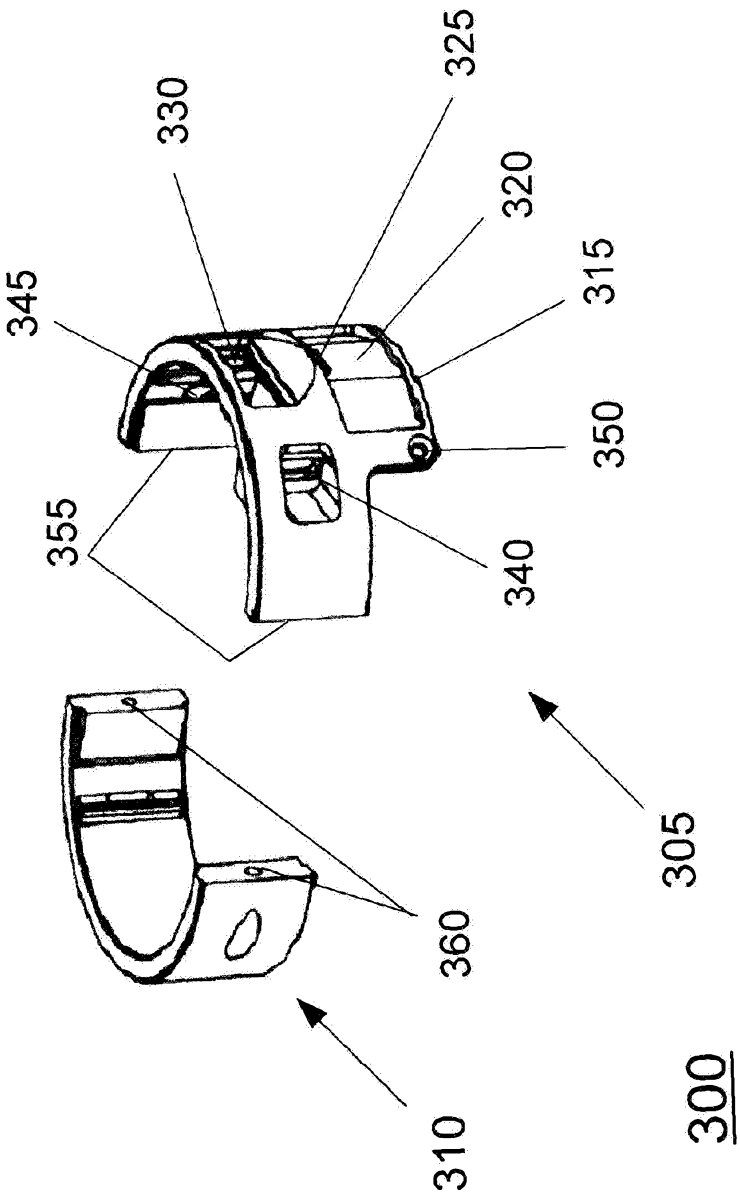

FIG. 6

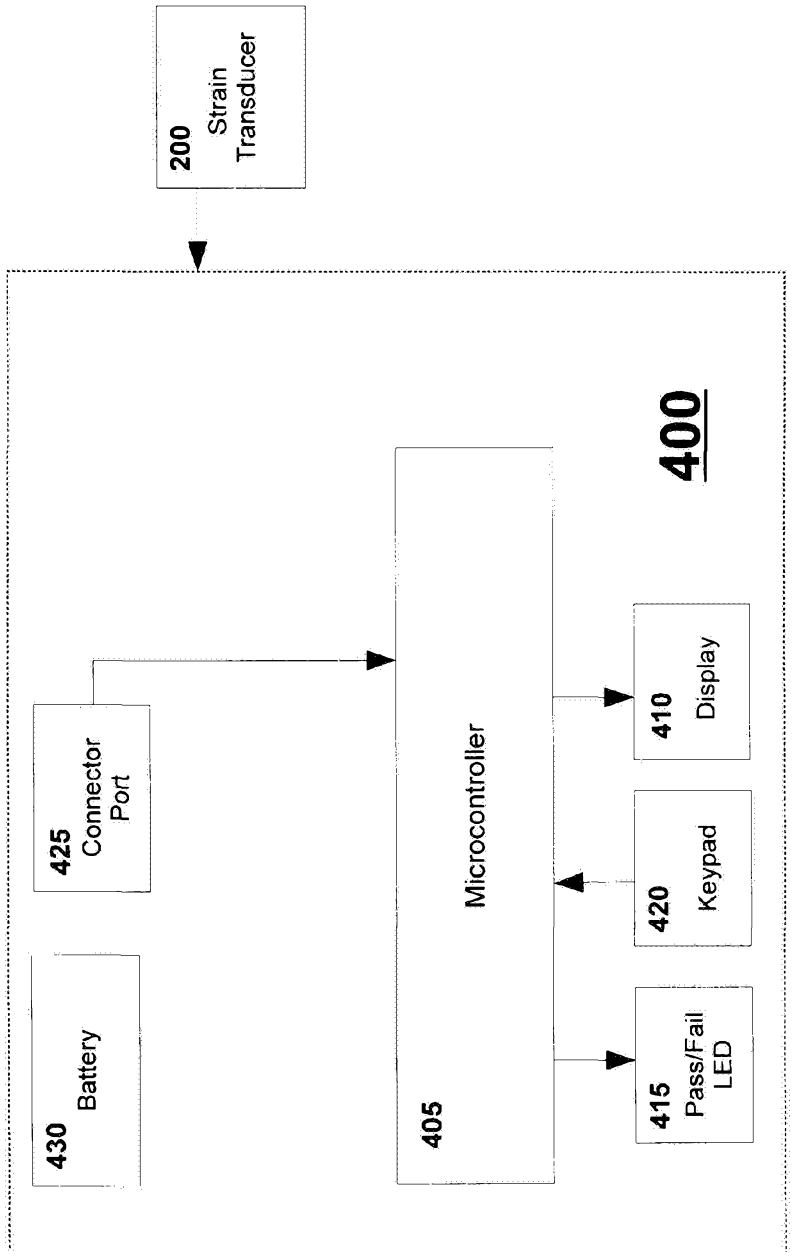
200
Strain Transducer
400
425
Connector Port
430
Battery
405
Microcontroller
410
Display
420
Keypad
415
Pass/Fail LED

FIG. 7