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(54) **CONCRETE MIXTURE MEASUREMENT SENSOR AND METHOD**

BETONMISCHUNGSMESSSENSOR UND -VERFAHREN

CAPTEUR ET PROCÉDÉ DE MESURE DE MÉLANGE DE BÉTON

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(56) References cited:
US-A- 3 147 612 **US-A- 3 631 712**

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Description

FIELD OF THE INVENTION

[0001] The present invention relates, in general, to concrete mixing and, more particularly, this invention relates to a system and a method for measuring of at least one of volume, water cement ratio, consistency, temperature and slump, and also to the control of slump and, yet more particularly, the instant invention relates to improved sensors for measuring at least one of volume, water cement ratio, consistency, temperature and slump.

BACKGROUND OF THE INVENTION

[0002] Concrete production like the production of any other man made material produced in batches requires a consistent repeatability of the properties of the product from batch to batch and even in the same batch. In the concrete manufacturing process it is extremely important to know that the properties haven't changed prior to pouring the concrete mixture.

[0003] It is generally well known that all tests performed on a fresh concrete mixture will indicate the future properties of the hardened concrete.

[0004] The industry testing standard for slump for example is found in ASTM C143 and is based on filling a cone with concrete mixture and measuring the slump of the concrete mixture as the cone is pulled out. Slump generally increases with water content of the concrete mixture or the addition of chemicals. During the concrete manufacturing process, the main problem is a control of the accurate quantity of the water since water can be present in the aggregates and the measurement of the moisture percentage is not accurate. Having a mechanism to determine the water cement ratio before the concrete mixture is poured reduces the uncertainty of the quality and variation of the qualities of the product which is a part of the production process.

[0005] It is known that sensors can be used in the mixing of concrete. For example U.S. Patent No. 6,484,079 issued to Buckelew et al. provides a global positioning satellite receiver to monitor the location of mixers. Similarly, U.S. Patent Number 5,713,663 issued to Zandberg et al. measures the torque applied on the mixer in order to rotate it. U.S. Patent Publication Number 2012/0204625 to Beaupre et al. provides a probe that include a base and a resistance member extending from the base and onto which a resistance pressure is imparted by a rheological substance when the resistance member is submerged and moved therein. The resistance member includes an inner member and an outer member that surrounds the inner member and has a load cell connection therewith. Rheological properties can be obtained using values indicative of the resistance pressure both in a low speed range and in a high speed range. European patents EP1961538A2 and EP0924040 measure the pressure applied on a blade or on a cylinder shaped sensor attached to the wall of the truck mixer as the mixer rotates and the sensor is dragged against the concrete mixture. Zandberg et al. '663 is problematic since there are many factors that influence the torque. Accordingly, the torque measurement is not an adequate measure of the condition of the concrete mixture or slump. Also, due to fact that the stress has to be measured in one rotation speed only, important information is not measured because the concrete mixture moves in two axes, one axis being parallel to the rotation of the mixer's drum and the other axis being disposed at an angle to the first axis, by being vertical to the rotation of the mixer. Movement of the concrete mixture along the second axis is caused by the helix inside the mixer. To the best knowledge of the inventor, the previous inventions do not measure a component of a force along the second axis.

[0006] It has been found that the existing approach does not produce as good an approximation of the desired slump and does not provide the necessary information to estimate the amount of concrete mixture in the mixer or the start and finish times of the pour. Other approaches are based on installing a blade and measure the stress applied on the blade by the moving concrete mixture while the mixer drum is rotating. However, these solutions are problematic due to the concrete buildup behind the blade that, due to deterioration, affects the accuracy of the readings after some time.

[0007] Therefore there is a need to improve measurement of the concrete mixture at variable speeds.

[0008] All existing conventional applications are based on measuring the force and or the pressure applied by the concrete mixture onto the probe/sensor that is attached to the inner wall of the mixer drum while the mixer drum is rotating and the sensor is dragged through the concrete mixture.

[0009] It has been found that existing probes/sensors need to measure the average pressure/force that is applied on the probe/sensor by the movement of the concrete mixture, however, differentiating between a true measurement and the noise has been very challenging. Furthermore, it has been found that existing probes/sensors are also prone to extensive wear due to these reasons: high abrasion created by the aggregates, corrosive materials inside the concrete mixture and alkaline water. Therefore, there is an additional need to protect the sensor body from excessive wear.

[0010] Further information pertaining to the prior art can be found in US patent 3 631 712 that discloses a sensor for a concrete mixer in accordance with the preamble of claim 1

SUMMARY OF THE INVENTION

[0011] The present invention provides a sensor to measure the consistency of the aggregate concrete mixture inside the mixer and measure the rheological properties of the aggregate concrete mixture inside the mixer.

[0012] In the conventional mixing process, the mixer is required to idle and count the mixer revolutions to attempt to achieve a consistent mix. The present invention allows the user to charge the mixer and leave the yard, monitoring of the slump
over several revolutions, the deviation from the average will indicate if the material is well mixed, the lower the deviation is the better the mix is mixed.

[0013] The improvement measures the stress in two axes, one parallel to the rotation of the mixer and one vertical to the rotation of the mixer and being generally perpendicular to the first axis. The force on the second axis is caused by the movement of the mixing fin or blade within the rotating mixer drum. A sensor is attached to or through the mixer and the sensor has strain gauges or load cells positioned on the sensor in the two axes. Preferably, two strain gauges are positioned on each axis, although one strain gauge on each axis is also applicable.

[0014] At least one sensor is provided with strain gauges installed on the axis in parallel to the rotation direction and a second set of strain gauges installed on the axis vertical to the rotation direction. Measuring the resistance of the strain gauges will provide a force applied on the sensor by the movement of the concrete in the direction of the strain gauges.

[0015] Rheological characteristics such as viscosity and yield stress can be calculated by using the Bingham model.

[0016] The invention also provides a dual layer cover for the sensor. The outer layer is a hard material, such as metal, that resists the movement of the concrete. A second layer made of a soft material, such as an elastomeric material, between the outer first layer and the sensor body.

[0017] The invention protects the sensor body from the harsh environment of the mixer, the service period of the sensor is increased because the first layer and/or the second layer can be replaced without replacing the sensor.

[0018] The present invention also provides an apparatus and method configured to measure the consistency of the aggregate concrete mixture inside the mixer; measure the consistency of the aggregate concrete mixture between different batches; measure the volume of the aggregate concrete mixture inside the mixer; measure the rheological properties of the aggregate concrete mixture inside the mixer; and measure the water cement ratio of the aggregate concrete mixture inside the mixer.

OBJECTS OF THE INVENTION

[0019] It is, therefore, one of the primary objects of the invention to provide an improved apparatus and method to control and monitor concrete mixing in a rotating mixer.

[0020] Another object of the invention is to provide an improved apparatus to monitor slump and rheological characteristics of concrete in the rotating mixer.

[0021] Still another object is to provide an improved apparatus to record the consistency of the concrete mixed during preparation and pour.

[0022] Another object is to provide a concrete mixing control apparatus according wherein one or more sensors are attached to the interior surface of the rotating mixer.

[0023] Another object is to provide a concrete mixing control apparatus wherein the valve is operatively connected to the computer processing unit and controlled by the computer processing unit.

[0024] Another object is to provide a concrete mixing control apparatus further having an input means operatively connected to the computer processing unit to enter one or more of the requested slump, mix and customer information.

[0025] Another object is to provide a concrete mixing control apparatus wherein the input means is one of a touch screen, voice recognition, keyboard and alphanumeric keypad.

[0026] Another object is to provide a concrete mixing control apparatus wherein the input device permits the user override the data from the sensors and the computer processing unit.

[0027] Another object is to provide a concrete mixing control apparatus wherein the data storage unit is in a remote location from the concrete mixer.

[0028] Another object is to provide a concrete mixing control apparatus further includes an output means.

[0029] Another object is to provide a concrete mixing control apparatus wherein the output means is a printer.

[0030] Another object is to provide a concrete mixing control apparatus wherein the computer processing unit, input means, data storage, second display means and output means separately or in combination are in a remote location from the concrete mixer, wherein the sensors, valve and flow meter are operatively connected by a transmitter and receiver at the mixer and at the remote location.

[0031] Another object is to provide a concrete mixing control apparatus further having a global positioning satellite receiving unit having a digital output operatively connected to the data storage unit.

[0032] Another object is to provide a concrete mixing control apparatus further having a temperature sensor attached to the interior surface of the mixer operatively connected to the data storage unit.

[0033] Another object is to provide a concrete mixing control apparatus further having a moisture sensor attached to the interior surface of the mixer operatively connected to the data storage unit.

[0034] A further object is to provide a concrete mixing control apparatus further having a mixer pour valve operatively connected to the computer processing unit wherein the pour valve.

[0035] Another object is to provide a concrete mixing control apparatus wherein the computer processing unit analyses the input from the sensor to determine the start and end time the pour of concrete.

[0036] An additional object is to provide a method to control the slump of concrete comprising the following steps: charging a mixer having a drum and interior surface with particulate material; rotating the mixer drum; receiving data in a data storage unit of slump measured by the sensor; inputting at least the desired slump with an input device operatively connected to a computer processing unit further operatively connected to the data storage unit; determining the amount of liquid needed for the desired slump by the computer processing unit; and controlling the addition of liquid to the mixer through a fluid supply line in fluid communication with the mixing drum wherein the fluid supply line has a valve operatively connected to the computer processing unit and a flow meter operatively connected to the data storage unit.

[0037] Another object is to provide a method to determining the quantity of concrete mixture within the mixing drum comprising: monitoring if a sensor is submerged into the concrete within a mixing drum; rotating such mixing drum; recording the time difference between the point where the sensor is at the top and the time it is submerged within such concrete; recording the total revolution time, recording the time difference between that such sensor submerged and emerges from such concrete mixture; and calculating the volume of concrete within such mixing drum analyzing the measured periods.

[0038] Yet another object is to provide a method to determine if the concrete mix within a mixing drum is consistent comprising: monitoring the rheological characteristics of the concrete by the sensor in the concrete per each revolution and calculating the variance between following revolutions, the lower the variance is, the better the concrete is mixed.

[0039] An object of the invention is to provide a sensor that includes a plurality of strain gauges or electrodes.

[0040] Another object of the invention is to provide a sensor that includes a protection from the harsh environment in the mixer.

[0041] Yet another object of the invention is to reduce the signal to noise ratio of the sensor.

[0042] Still another object of the invention is to increase the service life of the sensor by providing a less costly replacement of the outer layers to prolong the sensor life.

[0043] A further object of the invention is to provide an improved apparatus to monitor water/cement ratio of concrete in the mixer.

[0044] Yet a further object is to provide an improved apparatus to monitor amount of concrete poured.

[0045] Still a further object is to provide an improved apparatus to measure the long term permeability of the concrete to chloride; this also will allow the prediction of the service time of the concrete.

[0046] Still a further object is to provide an improved apparatus to record the consistency of the concrete mixed during preparation and pour.

[0047] Yet a further object is to provide an apparatus and method to record the time of beginning the pour of mixed concrete and its conclusion.

[0048] Another object is to provide a concrete mixing control apparatus comprising a concrete mixer with an interior surface and at least one sensor with electrodes to measure the electrical characteristics (resistance and impedance in various frequencies) of the concrete. Monitor the angle or the time tick in which the sensor is submerged into the concrete and the angle or the time tick in which it is emerged out of the concrete by measuring the conductivity/resistance of the concrete.

[0049] Another object is to provide a concrete mixing control apparatus having a mixer pour valve operatively connected to the computer processing unit.

[0050] Another object is to provide a concrete mixing control apparatus wherein the computer processing unit analyses the input from the sensor to determine the start and end time the pour of concrete.

[0051] Yet another object is to provide a method for determining the slump of concrete mixture within the mixing drum comprising: rotating such mixing drum; recording the angle that the sensor is submerged within such concrete; recording the angle that such sensor emerges from such concrete mixture; and calculating the slump of concrete within such mixing drum analyzing the submerge angle and emerge angle, using a conversion table or a mathematical function.

[0052] Still another object is to provide a method for determining the water/cement ratio of concrete mixture within the mixing drum comprising: monitoring if a sensor is submerged into the concrete within a mixing drum; rotating such mixing drum; recording the electrical resistance of the concrete; and calculating the water/cement ratio of concrete within such mixing drum analyzing the electrical resistance.

[0053] Another object is to provide a method for determining the slump of concrete mixture within the mixing drum comprising: rotating such mixing drum; recording the time difference between the point where the sensor is at the top and the time it is submerged within such concrete; recording the total revolution time, recording the time difference between the times such sensor submerged and emerges from such concrete mixture; recording the time difference between the time the sensor emerged out of the concrete and the time it arrived to the top of the mixer; and calculating the slump of the concrete within such mixing drum analyzing the times.

[0054] Yet another object is to provide a method for determining the quantity of concrete mixture within the mixing drum comprising: monitoring if a sensor is submerged into the concrete within a mixing drum; rotating such mixing drum; recording the angle that the sensor is submerged within such concrete; recording the angle that such sensor emerges from such concrete mixture; and calculating the volume of concrete within such mixing drum analyzing the submerge angle and emerge angle.

[0055] A further object is to provide a concrete mixing control apparatus having an input from a pressure sensor mounted on the hydraulic system, analyzing the changes of the pressure with the measurement of the slump and the quantity indicates the mechanical condition of the hydraulic system, thus improving the maintenance of the hydraulic system.

[0056] In addition to the various objects and advantages of the present invention described with some degree of specificity above it should be obvious that additional objects and advantages of the present invention will become more readily apparent to those persons who are skilled in the relevant art from the following more detailed description of the invention, particularly, when such description is taken in conjunction with the attached drawing figures and with the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0057]

FIG. 1 is an environmental elevation view of a mixer employing a sensor of the instant invention for sensing aggregate concrete mixture;
FIG. 2 is a diagrammatic view of the sensor for sensing concrete mixture within a rotating mixer of FIG. 1;
FIG. 3 is a diagrammatic view of forces acting onto the sensor of FIG. 2;
FIG. 4 is a perspective view of one embodiment of the sensor employed in FIG. 2;
FIG. 5 is a block diagram of a control circuit employed with the sensor of FIG. 4;
FIG. 6 is illustrates an alternative form of the sensor of FIG. 4;
FIG. 7 is an elevation view of another form of the sensor of FIG. 4, adapted with a protective sleeve;
FIG. 8 is a planar end view of the apparatus of FIG. 7;
FIG. 9 is a graph of sensor output with the protecting sleeve of FIGS. 7-8;
FIG. 10 is a graph of sensor output without the protecting sleeve of FIGS. 7-8;
FIG. 11 is an elevation view of another embodiment of a sensor for sensing concrete mixture within a rotating mixer of FIG. 1;
FIG. 12 is a planar end view of the apparatus of FIG. 11;
FIG. 13 is an elevation view of an alternative form of the sensor of FIG. 11;
FIG. 14 is a planar end view of the apparatus of FIG. 13;
FIG. 15 is a block diagram showing connection of the sensor of FIGS 13-14 to a control circuit;
FIG. 16 is an elevation view of another alternative form of the sensor of FIG. 11;
FIG. 17 is a planar end view of the sensor of FIG. 16;
FIG. 18 is a diagrammatic elevation view of one form of a further embodiment of a sensor for sensing concrete mixture within a rotating mixer of FIG. 1; and
FIG. 19 is a diagrammatic planar view of another form of the further embodiment of a sensor for sensing concrete mixture within a rotating mixer of FIG. 1.

BRIEF DESCRIPTION OF THE EMBODIMENTS

[0058] Prior to proceeding to the more detailed description of the present invention it should be noted that, for the sake of clarity and understanding, identical components which have identical functions have been identified with identical reference numerals throughout the several views illustrated in the drawing figures.

[0059] Instant invention, in accordance with one embodiment, provides an improved sensor, generally designated as 100, for a concrete mixer 10. The sensor 100 comprises a sensor body 110 and sensing elements mounted on a surface of or within the sensor body 110 and connectable to a control circuit 140.

[0060] Reference is now made, more particularly, to FIGS. 1-6, wherein a concrete mixer 10, illustrated in FIG. 1 as a conventional rotating drum, has a sensor 100 being attached to the wall of the mixer 10 so that a body 110 of the sensor 100 extends, generally radially, into the hollow interior 11 of the mixer 10. The presently preferred cross-sectional shape of the sensor body 110 is an annular ring.

[0061] Although conventionally it has been considered that the concrete mixture applies a force onto the body 110 only in one direction being parallel to the rotational axis of the concrete mixer 10, the inventor found that the mixing drum 10 and, more particularly, the fins or blades 10a of the helix inside the mixer 10 apply a force onto the sensor body 110 along a second axis being disposed at an angle to the rotational axis of the mixer 10, as is best shown in FIG. 3.

[0062] Accordingly, as is best shown in FIG. 4, the body 110 is hollow, and the sensing elements includes at least two and preferably four strain gauges 120 mounted on an interior round surface 112 of the hollow sensor body 110. Two of the four strain gauges 120, referenced for the sake of clarity with numeral 120a, are mounted, mediate ends of the hollow sensor body 110, along a first axis 122 being parallel to an axis of rotation of the concrete mixer 10 and the remaining two strain gauges 120, referenced for the sake of clarity with numeral 120b, are mounted along a second axis 124 being disposed at an angle to the first axis 122 when the sensor 100 is attached to the wall of the concrete mixer 10. The second axis 124 is defined by a rotation of the helix fin or blade 10a within the mixer 10. Preferably, strain gauges 120a and 120b are identical to each other and could be of any conventional strain gauge type. The sensor body 110 may be attached to the wall of the mixer 10 by any conventional means and, preferably, the sensor 100 further comprises a base 130 attached, either permanently or removably, to one end of the hollow sensor body 110. The base 130 may be adapted with mounting apertures 131, so as to conventionally fasten the sensor 100 to the wall of the mixer 10, either directly or through intermediate member(s). It is to be understood, that use of the strain gauges 120a and 120b does not require a flexible connection between the sensor body 110 and the base 130 and, thus such connection is preferably a rigid connection, for example such as by welding, threaded arrangement (not shown), friction fit or by a unitary one-piece construction of the sensor body 110 and base 130, for example by a casting or a molding process.

[0063] Preferably, the base 130 has a hollow interior 132, best shown in FIG 7, wherein the control circuit 140 is disposed within such hollow interior 132 of the base 130 and includes a controller, preferably such as a microprocessor 142, wherein the four strain gauges 120a, 120b are connected with wires to the central processing unit (CPU) or processor 142 in a Wheatstone bridge arrangement. The control circuit 140 further includes conventional A/D converter(s) 144 and signal amplifier(s) 146, as is bet shown in FIG. 5.

[0064] In operation, measurement of the resistance of the strain gauges 120a, 120b provides forces applied onto the sensor 100 by the movement of the concrete mixture in the direction of the strain gauges 120a and in the direction of the strain gauges 120b.

[0065] Preferably, the strain gauges 120a, 120b are mounted in a close proximity to the base 130 and to the inner surface of the rotating drum 10 to take advantage of a condition wherein the sensor 100 rotates with the mixing drum 10 and wherein the concrete mixture is pushed to the bottom of the concrete mixer (mixing drum 10). Thus, positioning the strain gauges 120a, 120b in the close proximity to the base 130 improves sampling of the concrete mixture by comparing results collected from each revolution of the mixing drum 10.

[0066] Furthermore, the strain gauges 120a, 120b are only mounted on the inner surface 112 of the hollow sensor body 110 and do not require any connection with the base 130 besides the electrical connections.

[0067] By way of one example only, the total force applied onto the sensor 100 is calculated as the vector sum of both forces:

F - The total force applied onto the sensor body 100 of the sensor 100.

Fp - The force applied on along first axis 122 as measured by strain gauges 120a.

Fv - The force applied along the second axis 124 as measured by strain gauges 120b.

$$F = \sqrt{Fp^2 + Fv^2}$$

[0068] The slump of the concrete mixture is directly related to the force F and can be calculated from the measured force F by several ways, including a conversion table and a mathematical equation based on the Bingham model of non-Newtonian fluids.

[0069] Rheological characteristics, such as viscosity and yield stress, can be also calculated by using the Bingham model. Additionally, calculating the variance between subsequent revolutions provides a mixing quality of the concrete mixture, wherein the lower the variance is, the better the concrete mixture is mixed.

[0070] Now in a particular reference to FIG. 6, the instant invention also contemplates that strain gauges 120a and 120b may be carried by separate sensors 100. More specifically, the instant invention provides two sensors 100, each containing one and preferably two strain gauges 120, wherein these two sensors 100 are oriented, at installation, such that the strain gauge(s) 120 is(are) disposed along the first axis 122 and the strain gauge (s) 120 is (are) disposed along the second axis 124.

[0071] The sensor 100, and more particularly, the control circuit 140, is operatively connected to a computer processing unit 12 via wired or wireless connection. In operation, a particulate matter as an ingredient of concrete is added to the mixer 10. The mixer 10 rotates and, as is conventional, the sensor body 110 and the sensing elements 120a, 120b are being cyclically submerged in the concrete mixer and emerge from the concrete mixture.

[0072] Now in a further reference to FIG. 1, the computer processing unit 12 is operably connected to an input means 13, preferably one of a touch screen, voice recognition, keyboard and alphanumeric keypad (not shown). The input means 13 permits the user to enter one or more of the requested slump, mix and customer information. The instant invention contemplates that the computer processing unit 12 may integrate therewithin the above described control 140.

[0073] The desired slump, mix and the customer information is entered by the user. The computer processing unit 12 determines the quantity of liquid to be added to the mixer 10 to obtain the required slump based on the measured slump and water/cement ratio, the system will assure that the water/cement ratio will not be out of the required range.

[0074] The concrete mixer 10 also has a conventional liquid supply line 14 that is attached to and in fluid communication with the concrete mixer 10 and has a liquid flow meter 15 and a valve 16 controlling the flow of liquid through the liquid supply line. The liquid flow meter 15 and valve 16 are operably connected to the computer processing unit 12. The liquid flow meter 15 is preferably disposed within the liquid supply line 14 between the valve 16 and the concrete mixer 10.

[0075] It has been found by the inventor that there is a direct relationship between the angles that the sensor 100 is submerged and emerged and the slump. Therefore, the slump can be determined through the analysis of the strain measurement in both first and second axis, 122 and 124 respectively, from the sensor(s) 100.

[0076] It has been found by the inventor that there is a direct relationship between the electrical resistance of the concrete mixture, as measured between two sensing parts of the sensor (or one electrode and the mixing drum itself) for various frequencies and the concrete water/cement ratio. Therefore, the water/cement ratio can be determined through the analysis of the resistance data as collected from the data from the sensor 100.

[0077] It has been found by the inventor that there is a direct relationship between the electrical resistance of the concrete as measured between two sensing parts of the sensor 100 (or one electrode and the mixing drum itself) for various frequencies and the concrete permeability. Therefore, the permeability can be determined through the analysis of the resistance data as collected from the data from the sensor 100.

[0078] The computer processing unit 12 also analyzes the data from the sensor 100 to determine the amount of concrete mixture within the mixer 10 by measuring the angle difference between the angle at the point that sensor 100 was submerged and the angle in which it was emerged as mixer 10 rotates and the sensor 100 moves into the cement mixture and emerges from the cement mixture. The total number of degrees that sensor 100 was submerged inside the concrete mixture indicates the level of the concrete mixture within the mixer 10. As the concrete mixture is poured out, the concrete mixture level decreases within the mixer 10. The data from the sensors 100 is used to record a change in the level of the concrete mixture and time that the level changes. The change in the quantity is the amount of the concrete mixture poured and the start and end time of the pour is recorded.

[0079] The knowledge of the remaining amount and slump of concrete in the mixture allows an adjustment in the quantities of solids and liquid to refill the mixer 10 by the user. The knowledge of the amount poured permits accurate billing to the customer. The start and finish time allow the user to deter unauthorized pours by the mixer operator.

[0080] The knowledge of the remaining amount and permeability of the concrete solids in the mixture allows an adjustment in the quantities required to refill the mixer 10 by the user.

[0081] Further, the data is stored in a data storage unit 17 operably connected to the computer processing unit 12 to allow the use of the data as received or for the later retrieval of data.

[0082] Further, a pressure sensor (not shown) installed on the hydraulic system of the truck and connected to the system will provide data on the hydraulic system's "health", since there is a correlation between the hydraulic pressure, the slump and the quantity; any change in the hydraulic pressure for the same conditions will indicate that something is wrong with the hydraulic system.

[0083] A display means 18 preferably a computer monitor is operably connected to a computer processing unit 12. Also, an output means 19, preferably one of a printer, is operably connected to the computer processing unit.

[0084] Additionally, the presently preferred embodiment of the system includes a moisture sensor 20 and temperature sensor 21 that are operably connected to the computer processing unit 12. This additional sensors allow the user to further control the concrete mixture.

[0085] In the presently preferred embodiment, the system has a global positioning satellite receiver 30 with a digital output and a transmitter 40. The transmitter 40 is operatively connected to the flow meter 15 and sensor 100 to transmit the location, stress or pressure data and flow of liquid to a remote location. The input means 13, output means 19, computer processing unit 12, data storage unit 17, display means 18 and output means may separately or in combination be situated at a remote location from the mixer 10.

[0086] The moisture sensor 20 and temperature sensor 21, alone or in combination with each other, are operatively connected to a sensor display 22 that is at the pour location.

[0087] The input means 13 can be used by the user to override the computer processing unit 12 and said sensors 100 to manually control the process.

[0088] It is also contemplated to use of the data measured from the sensor 100 and displayed on display 22 to control the valve 16 manually.

[0089] The method of controlling the slump, includes the step of entering the slump mix characteristics, including the maximum water to cement ratio, the requested slump and the mixer characteristics. The force on a sensor within a mixer 10 is calculated in terms of pressure or stress. The sensor output is monitored and the amount if any of additional liquid to be added to the mix is calculated. Approximately 85% to 95% of the amount of liquid is added to the mix. The mixer can then leave the plant and any additional liquid can be added at the site of the pour. The stress sensors are monitored and if the force is generally the calculated value the method in complete.

[0090] The method also contemplates use of an optional moisture sensor so as to monitor the moisture monitor and to use this data in calculating any additional liquid.

[0091] Also, there is a method to maintain the consistency of the mixture. Rather than count mixer rotations, the present invention includes a method to maintain the consistency of the mixture by monitoring the electrical characteristics, the submerged and emerge angles and comparing them over several rotations. The mixture consistency is acceptable where the sensor data varies less than a predetermined range that varies by concrete application.

[0092] Another method is provided to determine the quantity of concrete mixture within the mixing drum comprising: monitoring if a sensor is submerged into the concrete within a mixing drum; rotating such mixing drum; recording the time difference between the point where the sensor is at the top and the time it is submerged within such concrete; recording the total revolution time, recording the time difference between that such sensor submerged and emerges from such concrete mixture; and calculating the volume of concrete within such mixing drum analyzing the measured periods.

[0093] Yet another method is provided to determine if the concrete mix within a mixing drum is consistent comprising: monitoring the rheological characteristics of the concrete by the sensor in the concrete per each revolution and calculating the variance between following revolutions, the lower the variance is, the better the concrete is mixed.

[0094] In order to improve the performance of the sensors/probes 100 and to increase their service period, a protection sleeve, generally designated as 150, is mounted onto an exterior surface 114 of the sensor body 110, as best shown in FIGS. 7-8. The protection sleeve 150 is preferably comprised of two layers, a soft material layer 152 that surrounds the exterior surface 114 of the sensor body 110 and is being manufactured from a first material, and a second layer 160 which surrounds an exterior surface of the first layer 152 and which is manufactured from a second material having a hardness thereof being greater than a hardness of the first material. The first material may be of an elastomeric type, such as rubber or the equivalent, to provide a protective layer to the sensor body 110 and dampen, cushion or absorb the shock onto the body 110 from high abrasion created by the aggregates, corrosive materials inside the concrete mixture and alkaline water and at least substantially reduce if not completely eliminate noise factor of the measurement. Such first material layer is between about 3 mm (1/8 inch) and about 2.5 cm (1 inch), preferably being about 1.3 cm (1/2 inch) in thickness.

[0095] The layers 152, 160 may be individually assembled onto the sensor body 110 or the sleeve 150 may be provided as a unitary, one-piece construction. In either form, it is presently preferred to size the interior surface 154 and select the durometer or hardness of the first layer 152 so as to allow ease of sliding the first layer of the exterior surface 114 of the sensor body 110. Then, the protective sleeve 150 can be easily replaced in the field so as to extend the service life of the sensor 100.

[0096] The hardness of the second material is sufficient to resist wear of the body 110 from contact with the aggregate concrete mixture. More specifically, the hardness of the second material is sufficient to resist a movement of the aggregate concrete mixture and allow the sensor 100 to measure rheological characteristics of the aggregate concrete mixture in a manner that substantially reduces if not completely eliminates signal/measurement noise. By way of one example only, the second material may be a metal or equivalent. The second material layer 160, which is the external layer, covers the sensing part of the sensor body 110 and is made out of a hard wear-resistant material that will resist the movement of the concrete and allow the sensor 100 to measure the rheological characteristics of the aggregate concrete mixture, if the material exposed for contact to the aggregate concrete mixture will be a soft material then the sensor 100 will measure the friction between the sensor and the concrete mixture and not the rheological characteristics. In other words, although being operable under some conditions, particularly, where the accuracy is not of a concern, the sensor 100 will not accurately measure the rheological characteristics of the aggregate concrete mixture when the soft layer 152 is not covered by the hard layer 160 due to abrasion of such layer 152 by the aggregate concrete mixture.

[0097] The inventor has discovered that the combination of a first layer 152 and second layer 160 materially improves the measurement of the rheological characteristics of the concrete mixture. It has been found that the combination acts as a filter, reducing the effect of the turbulence caused by the movement of the sensor 100 through the concrete mixture. The two layered structure gives the following advantages: the sensor 100 is less prone to damages caused by the environment; the service period of the sensor 100 is increased because the sleeve 150 and/or the sensor body 110 (being removably attached to the base 130) that comes in contact with the concrete mixture can be replaced at a much lower cost than the whole sensor 100; and the readings from such sensor 100 are more reliable and easier to process due to an improved noise to signal ratio. The performance improvements are demonstrated in FIG. 9, wherein the sensor 100 is used with the sleeve 150 vs. FIG. 10, wherein the sensor 100 is employed without a sleeve 150. In both figures, vertical axis defines force and horizontal axis defines times. FIG. 9 clearly shows an improved ratio between the signal and the noise.

[0098] Although, the sleeve 150 has been described for use with the above described sensor 100, the sleeve 150 can be used to improve any existing sensor/probe design, for example, of the type as described in the U.S. Pat. Pub. Number 2012/0204625 to Beaupre et al..

[0099] The instant invention contemplates that strain gauges 120a and 120b may be mounted on the exterior surface 114 of the sensor body 110, particularly, when the sensor 110 is adapted with the above described sleeve 150. In either form, the strain gauges 120a and 120b are sealed from environmental factors, particularly moisture, by any well known techniques, including but not being limited to sealed arrangement of the sensor body 110 and protective sleeve 150.

[0100] FIGS. 11-17 illustrate additional forms of another embodiments of the invention wherein the sensor, generally designated as 200, comprises at least a pair of sensing elements, such as electrically conductive members or electrodes 220, either positioned on an exterior surface 212 of the sensor body 210 in a spaced apart relationship with each other, as best shown in FIGS. 11-14 or imbedded into the sensor body 210, as best shown by sensing elements 224 in FIGS. 16-17.

[0101] The sensor 200 in these forms measures the electrical resistance and impedance between one electrode 220 and the mixer itself (in case the mixer 10 is made of metal) or between spaced electrodes 220 that come in contact with the concrete mixture.

[0102] In the form of FIGS. 11-14, the sensor body 210 is preferably hollow and is manufactured from an electrically non-conductive material. The sensing elements include two ring-shaped electrically conductive members or electrodes 220 mounted in a spaced apart relationship with each other on an exterior surface 212 of the hollow sensor body 210 and wherein the sensor 200 further comprises a base 230 attached to one end of the hollow sensor body 210 and a control circuit 240 disposed within a hollow interior 232 of the base 230, the control circuit 240 being at least configured to generate and apply voltage to the two ring-shaped electrically conductive members 220 and measure a current between the two ring-shaped electrically conductive members 220, the current being indicative of at least one of a resistance and impedance of a concrete mixture contained within the mixer 10. It would be understood that the electrically conductive members 220 can be provided in other shapes to match the peripheral shape of the sensor body 210. The sensor body 210 may be further provided with apertures 211 so as to physically connect electrical wires (not shown) from the control circuit 240 to the electrically conductive members 220, wherein the electrically conductive members 220 are ultimately coupled to a processor within the control circuit 240.

[0103] The control circuit 240, at least contains the above described processor 142 and, in addition to programming the AC generator 250 to specific frequency and voltage, is configured to measure the current consumed by the AC generator 250 (being a frequency generator or a sine wave), measure the voltage between the inner rings 220, calculate the resistance of the concrete based on the formula R=V/I, determine if the sensor body 210 is submerged in the concrete mixture or out of the concrete mixture, determine the location of the sensor 200 by using measurements from an optional accelerometer 170, and determine the entry and departure angles of the sensor 200. The control circuit 240 is further being either configured to calculate the slump and the volume of the concrete mixture based on the angles values and the water to cement ratio based on the resistance or transmit all relevant data to the computer processing unit 12 that will calculate the slump and the volume of the concrete mixture based on the angles values and the water to cement ratio based on the resistance and make any adjustments to the concrete mixture within the mixer 10 as/if required. It must be noted that the computer processing unit 12 may be configured to incorporate the control circuit 240 or the previously described control circuit 140.

[0104] It is presently preferred that the sensor body 210 is hollow and is manufactured from an electrically non-conductive material and wherein the sensing elements include four ring-shaped electrically conductive members 200 mounted in a spaced' apart relationship with each other on the exterior surface 212 of the hollow body 210. The sensor 200, in this form, also includes the above described base 230, preferably with the mounting apertures 231, and being preferably connected to the sensor body 210 by the above described rigid connection. Further, the control circuit 240 is preferably disposed within the hollow interior 232 of the base 230 and further includes the programmable AC generator 250 disposed within the hollow interior 232 of the base 230. The programmable AC generator 250 being operatively coupled to the control circuit 240 and to outer electrically conductive members 220. Further, two inner electrically conductive members 220 are operatively coupled to the control circuit 240, wherein the control circuit 240 is configured to program the programmable AC generator 250, measure a current generated by the programmable AC generator 250 and measure a voltage between the inner conductive members 220.

[0105] Although the voltage can be measured between the outer electrically conductive members 220, it has been found that some of the current will drift and the measured resistance is the combined resistance of the concrete mixture and additional noise. When the voltage is measured on the inner conductive members 220 and the current is known from feeding circuit, then it has been found that the voltage measured is only on the resistance of the concrete mixture.

[0106] In either embodiment, the electrical resistance is measured both in DC and in AC (in varying frequencies) the result is a spectrum of electrical resistances. The sensor 200 also measures the phase shift of the AC signal to measure the impedance.

[0107] The measurement is done while the mixer 10 is rotating and the sensor 200 travels along the circumference of the mixer 10 and measures the resistance/impedance. Once the sensor 200 is submerged into the concrete mixture, there is a huge reduction the electrical resistance as measured by the electrically conductive members 220. So the sensor 200 can distinguish between measurements done inside the concrete mixture and those outside the concrete mixture.

[0108] By using an accelerometer 170, the system can identify where the sensor 200 was submerged into the concrete mixture and where it went out of the concrete mixture. The analysis of both locations will give two angles as measured from the highest point of the sensor, entry angle (α1) and leave angle (α2) the difference between the two angles has direct correlation to the slump of the concrete mixture, and the average between the two angles has a direct correlation to the level of the concrete mixture in the mixer 10 and from there to the volume of the concrete mixture.

[0109] The presently preferred method of determining volume and slump is based on using sensor 200 to measure electrical resistance and is further based on finding the locations of the sensor 200 entering and leaving the concrete by measuring the total revolution time (T1), the total submerged time (T2), the time elapsed from the point the sensor 200 was at the highest point and the time it submerged into the concrete (T3) and the time elapsed since it went out of the concrete until it came back to the highest point (T4). Identifying the highest point can be done by using a simple weight attached to a load cell either vertically or horizontally, there are two points where the load cell will have the same value, at the top and at the bottom (this value can be obtained during a simple calibration process of mounting the sensor vertically and measuring the force applied on the load cell by the weight), the electrical resistance will determine if the sensor 200 is at the lowest point (submerged) or at the highest point (out of the concrete), if the sensor can't identify that it means the mixer is empty (the identification of this status will be used for identifying if the pouring process is over. Accordingly, the volume and slump can be calculated as follows:

$$\alpha 1 = Entry\_Angle$$

$$\alpha 2 = Exit\_Angle$$

$$Volume = f(\alpha 1 + \alpha 2)$$

$$Slump = g(\alpha 2 - \alpha 1)$$

$$W / C = w(R)$$

wherein:

f=function
g=function
W=Water
C=Cement
w=function
R=resistance

[0110] Functions f, g, and w can be obtained from translations tables developed, for example, by historical measurements.

[0111] In case we do not use an accelerometer and just use simple time calculations, the angles can be calculated in the following manner:

$$\alpha 1 = (T1/2 - T3)/(T1/2) * 180$$

$$\alpha 2 = (T1/2 - T4)/T1/2) * 180$$

[0112] The invention also contemplates use of predefined conversion tables, obtained during a calibration process, instead of using the above functions.

[0113] In yet another embodiment of FIG. 18, the invention provides a sensor, generally designated as 300, that includes a sensor body 310 having a hollow interior 312. The sensor 300 further includes a pair of pressure type load cells 320 mounted within the hollow interior 312 to measure forces in two directions, being generally perpendicular to each other. By way of one example only, the body 310 is provided as a hollow body and the sensor 300 further includes a pair of braces 314, 316 having each end thereof connected to the inner surface of the hollow body 310 but oriented generally perpendicular to each other.

[0114] The sensor 300 preferably includes a base 330 that is connected to one end of the body 310 by way of a flexible connection 338 allowing movement of the body 310 relative to the base 330. Such flexible connection could be of the type, for example as disclosed in U.S. Pat. Pub. Number 2012/0204625 to Beaupre et al.

[0115] In an alternative form of FIG. 19, the pair of sensing elements may be provided as beam load cells 370. Each beam load cell 370 will be mounted on the base 330, however, one of the two beam load cells will be also connected to a brace 372, while the second beam load cells 370 will be free standing on the base 330. The beam load cells 370 are also connected therebetween with a flexible connection that may be the above described flexible connection 338.

[0116] It would be understood that the instant invention can be configured with use of two sensors 300, each containing a single pressure type load cell 20 or a single beam load cells 370, wherein the sensors 300 are so mounted that each sensor 300 senses force in a distinct direction.

[0117] The reader is advised that the above described sensor 300 may be employed with the above described protective sleeve 150.

[0118] Furthermore, the method of measuring volume and slump of the concrete mixture with sensor(s) 300 is generally identical to a method employing the above described sensor(s) 100.

[0119] In the conventional mixing process, with either one of the above described embodiment, the mixer 10 is required to idle and count the mixer revolutions to attempt to achieve a consistent mixture. The present invention allows the user to charge the mixer 10 and leave the yard, monitoring of the slump and the electrical characteristics over several revolutions. The deviation from the average will indicate if the material is well mixed, the lower the deviation is the better the mix is mixed. Similarly comparison of this data to data obtained from "standard" or baseline batch configuration will indicate if this batch is similar to the "standard" batch.

[0120] Further, the change in the mix volume and the start and stop time of the change in volume are recorded. Thus, the user of the present invention will know the amount of concrete mixture poured, as well as the time of the pour, thus preventing a financial loss through unauthorized pours. The user may also receive an alert as to the need to recharge the mixer 10.

[0121] While a presently preferred and various alternative embodiments of the present invention have been described in sufficient detail above to enable a person skilled in the relevant art to make and use the same it should be obvious that various other adaptations and modifications can be envisioned by those persons skilled in such art without departing from the scope of the appended claims.

INDUSTRIAL USE

[0122] The invention has industrial use in the concrete production industry.

Claims

1. A sensor (100) for a concrete mixer (10), comprising:

   (a) a body (110);
   (b) one or more sensing elements (120a, 120b) mounted on an exterior surface or within an interior of said body and connectable to a control circuit (140); and
   (c) a sleeve (150), including:

      i. a first layer (152) surrounding said exterior surface of said body and manufactured from a first material,
      ii. a second layer (160) surrounding an exterior surface of said first layer **characterised in that** said second layer (160) surrounding an exterior surface of said first layer (152) is manufactured from a second material, and
      iii. wherein said second material has a hardness thereof being greater than a hardness of said first material.

2. The sensor of claim 1, wherein said hardness of said second material is sufficient to resist a wear of said second material layer from a contact with a concrete mixture.

3. The sensor of claim 1, wherein said hardness of said second material is sufficient to cushion shocks during a movement of said sensor through a concrete mixture and to reduce a noise factor therefrom while allowing said sensor to measure rheological characteristics of the concrete mixture.

4. The sensor of claim 1, wherein said sensing elements are so mounted that said sensor is configured, during a movement of said sensor through a concrete mixture, to measure a first force along a first axis being parallel to an axis of rotation of said concrete mixer and measure a second force along a second axis being disposed at an angle to said first axis, said second axis defined by a movement of a mixing helix within said concrete mixer.

5. The sensor of claim 1, wherein said body is hollow, wherein said sensing elements includes four strain gauges (120) mounted on an interior surface of said hollow body and wherein two of said four strain gauges are mounted, mediate ends of said hollow body, along a first axis being parallel to an axis of rotation of said concrete mixer and remaining two strain gauges are mounted along a second axis being disposed at an angle to said first axis when said sensor is attached to a wall of the concrete mixer, said second axis defined by a movement of a mixing helix within said concrete mixer.

6. The sensor of claim 5, wherein said sensor further comprises a base (130) attached to one end of said hollow body and said control circuit being disposed within a hollow interior of said base, said control circuit including a processor (142) and wherein said four strain gauges are connected with wires to said processor in a Wheatstone bridge arrangement.

7. The sensor of claim 1, wherein said body is manufactured from an electrically non-conductive material and wherein said sensing elements include four electrically conductive members mounted in a spaced apart relationship with each other along a length of said body on an exterior surface thereof.

8. The sensor of claim 7, further comprising a base (130) and a rigid connection between said base and one end of said body.

9. The sensor of claim 8, further comprising:

   (a) a hollow interior within said base;
   (b) a control circuit disposed within said hollow interior of said base;
   (c) a programmable AC generator disposed within said hollow interior of said base, said programmable AC generator operatively coupled to control circuit and to outer electrically conductive members;
   (d) wherein inner electrically conductive members are operatively coupled to said control circuit; and
   (e) wherein said control circuit is at least configured to program said programmable AC generator, measure a current generated by said programmable AC generator and measure a voltage between said inner electrically conductive members.

10. The sensor of claim 1, wherein said body is manufactured from an electrically non-conductive material, wherein said sensing elements include two electrically conductive members mounted in a spaced apart relationship with each other on an exterior surface of said body and wherein said sensor further comprises a base attached to one end of said body and a control circuit disposed within a hollow interior of said base, said control circuit is configured to generate and apply voltage to said two electrically con-

ductive members and measure a current between said two electrically conductive members, said current being indicative of at least one of a resistance and impedance of a concrete mixture contained within the concrete mixer.

11. The sensor of claim 1, further comprising:

(a) a base (130) attached to one end of said body;
(b) a control circuit disposed within a hollow interior of said base;
(c) said sensing elements defining two elongated electrically conductive members integrated in a spaced apart relationship within said body and electrically connected to said control circuit;
(d) wherein said body is manufactured from an electrically non-conductive material; and
(e) wherein said control circuit is configured to generate and apply voltage to said two elongated electrically conductive members and measure a current between said two elongated electrically conductive members, said current being indicative of at least one of a resistance and impedance of a concrete mixture contained within the concrete mixer.

12. The sensor of claim 1, wherein said body is hollow, wherein said sensor further includes a base (130), a flexible connection between said base and one end of said hollow body and two brace members (314, 316) mounted, generally perpendicular to each other, within said hollow body wherein each end of each brace member is attached to an interior surface of said hollow body; wherein said sensing elements include a pair of pressure load cells (320), and wherein one of said pair of pressure load cells is mounted on one of said two brace members and another one of said pair of pressure load cells is mounted on another one of said two brace members; and wherein said; whereby said sensor is configured to measure a first force along a first axis being parallel to an axis of rotation of said concrete mixer and further measure a second force along a second axis being disposed at an angle to said first axis when said sensor is attached to a wall of said concrete mixer.

13. The sensor of any one of the preceding claims, wherein said first layer is manufactured of an elastomeric material.

14. The sensor of any one of the preceding claims, wherein said second layer is manufactured of a metal material.

15. A method comprising:
measuring at least one of rheological characteristics, volume, water cement ratio, consistency, temperature and slump of a concrete mixture using a sensor (100) comprising:

(a) a body (110);
(b) one or more sensing elements (120a, 120b) mounted on an exterior surface or within an interior of said body and connectable to a control circuit (140); and
(c) a sleeve (150), including:

i. a first layer (152) surrounding said exterior surface of said body and manufactured from a first material,
ii. a second layer (160) surrounding an exterior surface of said first layer and manufactured from a second material, and
iii. wherein said second material has a hardness thereof being greater than a hardness of said first material.

Patentansprüche

1. Sensor (100) für einen Betonmischer (10), wobei der Sensor aufweist:

(a) einen Körper (110);
(b) ein oder mehrere Erfassungselemente (120a, 120b), die an einer Außenoberfläche oder in einem Innenraum des Körpers angebracht sind und mit einer Steuerschaltung (140) verbunden werden können; und
(c) eine Hülse (150), die enthält:

i. eine erste Schicht (152), die die Außenoberfläche des Körpers umgibt und die aus einem ersten Material hergestellt ist,
ii. eine zweite Schicht (160), die eine Außenoberfläche der ersten Schicht umgibt, **dadurch gekennzeichnet, dass** die zweite Schicht (160), die eine Außenoberfläche der ersten Schicht (152) umgibt, aus einem zweiten Material hergestellt ist, und
iii. wobei das zweite Material eine Härte aufweist, die größer als eine Härte des ersten Materials ist.

2. Sensor nach Anspruch 1, wobei die Härte des zweiten Materials ausreicht, um einen Verschleiß der zweiten Materialschicht von einem Kontakt mit einem Betongemisch auszuhalten.

3. Sensor nach Anspruch 1, wobei die Härte des zweiten Materials ausreicht, um während einer Bewegung des Sensors durch ein Betongemisch Stöße abzufangen und einen Geräuschfaktor davon zu verringern, während ermöglicht wird, dass der Sensor rheologische Eigenschaften des Betongemischs misst.

4. Sensor nach Anspruch 1, wobei die Erfassungselemente so angebracht sind, dass der Sensor dafür konfiguriert ist, während einer Bewegung des Sensors durch ein Betongemisch eine erste Kraft entlang einer ersten Achse, die parallel zu einer Drehachse des Betonmischers ist, zu messen, und eine zweite Kraft entlang einer zweiten Achse, die unter einem Winkel zu der ersten Achse angeordnet ist, wobei die zweite Achse durch eine Bewegung einer Mischwendel in dem Betonmischer definiert ist, zu messen.

5. Sensor nach Anspruch 1, wobei der Körper hohl ist, wobei die Erfassungselemente vier Dehnmessstreifen (120) enthalten, die an einer Innenoberfläche des Hohlkörpers angebracht sind, und wobei zwei der vier Dehnmessstreifen entlang einer ersten Achse, die parallel zu einer Drehachse des Betonmischers ist, zwischen den Enden des Hohlkörpers liegend angebracht sind und die verbleibenden zwei Dehnmessstreifen entlang einer zweiten Achse, die unter einem Winkel zu der ersten Achse angeordnet ist, angebracht sind, wenn der Sensor an einer Wand des Betonmischers befestigt ist, wobei die zweite Achse durch eine Bewegung einer Mischwendel in dem Betonmischer definiert ist.

6. Sensor nach Anspruch 5, wobei der Sensor ferner einen Fuß (130) aufweist, der an einem Ende des Hohlkörpers befestigt ist, und wobei die Steuerschaltung in einem hohlen Innenraum des Fußes angeordnet ist, wobei die Steuerschaltung einen Prozessor (142) enthält und wobei die vier Dehnmessstreifen mit Drähten in einer Wheatstone-Brücken-Anordnung mit dem Prozessor verbunden sind.

7. Sensor nach Anspruch 1, wobei der Körper aus einem elektrisch nichtleitenden Material hergestellt ist und wobei die Erfassungselemente vier elektrisch leitfähige Glieder enthalten, die in einer voneinander beabstandeten Beziehung zueinander entlang einer Länge des Körpers auf einer Außenoberfläche davon angebracht sind.

8. Sensor nach Anspruch 7, der ferner einen Fuß (130) und eine starre Verbindung zwischen dem Fuß und einem Ende des Köpers aufweist.

9. Sensor nach Anspruch 8, der ferner aufweist:

(a) einen hohlen Innenraum in dem Fuß;
(b) eine Steuerschaltung, die in dem hohlen Innenraum des Fußes angeordnet ist;
(c) einen programmierbaren Wechselstromgenerator, der in dem hohlen Innenraum des Fußes angeordnet ist, wobei der programmierbare Wechselstromgenerator mit der Steuerschaltung und mit elektrisch leitfähigen Außengliedern funktional gekoppelt ist;
(d) wobei mit der Steuerschaltung elektrisch leitfähige Innenglieder funktional gekoppelt sind; und
(e) wobei die Steuerschaltung wenigstens dafür konfiguriert ist, den programmierbaren Wechselstromgenerator zu programmieren, einen durch den programmierbaren Wechselstromgenerator erzeugten Strom zu messen und eine Spannung zwischen den elektrisch leitfähigen Innengliedern zu messen.

10. Sensor nach Anspruch 1, wobei der Körper aus einem elektrisch nichtleitenden Material hergestellt ist, wobei die Erfassungselemente zwei elektrisch leitfähige Glieder enthalten, die in einer voneinander beabstandeten Beziehung zueinander auf einer Außenoberfläche des Körpers angebracht sind, und wobei der Sensor ferner einen Fuß, der an einem Ende des Körpers befestigt ist, und eine Steuerschaltung, die in einem hohlen Innenraum des Fußes angeordnet ist, aufweist, wobei die Steuerschaltung dafür konfiguriert ist, eine Spannung zu erzeugen und an die zwei elektrisch leitfähigen Glieder anzulegen und einen Strom zwischen den zwei elektrisch leitfähigen Gliedern zu messen, wobei der Strom einen Widerstand und/oder eine Impedanz eines in dem Betonmischer enthaltenen Betongemischs angibt.

11. Sensor nach Anspruch 1, der ferner aufweist:

(a) einen Fuß (130), der an einem Ende des Körpers befestigt ist;
(b) eine Steuerschaltung, die in einem hohlen Innenraum des Fußes angeordnet ist;
(c) wobei die Erfassungselemente zwei langgestreckte elektrisch leitfähige Glieder definieren, die in einer voneinander beabstandeten Beziehung in den Körper integriert sind und mit der Steuerschaltung elektrisch verbunden sind;
(d) wobei der Körper aus einem elektrisch nichtleitenden Material hergestellt ist; und
(e) wobei die Steuerschaltung dafür konfiguriert ist, eine Spannung zu erzeugen und an die zwei langgestreckten elektrisch leitfähigen Glieder anzulegen und einen Strom zwischen den zwei langgestreckten elektrisch leitfähigen Glieder zu messen, wobei der Strom einen Widerstand und/oder eine Impedanz eines in dem Betonmischer enthaltenen Betongemischs angibt.

12. Sensor nach Anspruch 1, wobei der Körper hohl ist, wobei der Sensor ferner einen Fuß (130), eine biegsame Verbindung zwischen dem Fuß und einem Ende des Hohlkörpers und zwei Verstrebungsglieder

(314, 316), die allgemein senkrecht zueinander in dem Hohlkörper angebracht sind, enthält, wobei jedes Ende jedes Verstrebungsglieds an einer Innenoberfläche des Hohlkörpers befestigt ist; wobei die Erfassungselemente ein Paar Druckmessdosen (320) enthalten und wobei eine des Paars von Druckmessdosen an einem der zwei Verstrebungsglieder angebracht ist und eine andere des Paars von Druckmessdosen an einem anderen der zwei Verstrebungsglieder angebracht ist; wobei der Sensor dafür konfiguriert ist, eine erste Kraft entlang einer ersten Achse, die parallel zu einer Drehachse des Betonmischers ist, zu messen und ferner eine zweite Kraft entlang einer zweiten Achse, die unter einem Winkel zu der ersten Achse angeordnet ist, zu messen, wenn der Sensor an einer Wand des Betonmischers befestigt ist.

13. Sensor nach einem der vorhergehenden Ansprüche, wobei die erste Schicht aus einem Elastomermaterial hergestellt ist.

14. Sensor nach einem der vorhergehenden Ansprüche, wobei die zweite Schicht aus einem Metallmaterial hergestellt ist.

15. Verfahren, das aufweist:
Messen rheologischer Eigenschaften und/oder des Volumens und/oder des Wasser-Zement-Verhältnisses und/oder der Konsistenz und/oder der Temperatur und/oder des Ausbreitmaßes eines Betongemischs unter Verwendung eines Sensors (100), der aufweist:

(a) einen Körper (110);
(b) ein oder mehrere Erfassungselemente (120a, 120b), die an einer Außenoberfläche oder in einem Innenraum des Körpers angebracht sind und mit einer Steuerschaltung (140) verbunden werden können; und
(c) eine Hülse (150), die enthält:

i. eine erste Schicht (152), die die Außenoberfläche des Körpers umgibt und die aus einem ersten Material hergestellt ist,
ii. eine zweite Schicht (160), die eine Außenoberfläche der ersten Schicht umgibt und die aus einem zweiten Material hergestellt ist, und
iii. wobei das zweite Material eine Härte aufweist, die größer als eine Härte des ersten Materials ist.

Revendications

1. Capteur (100) pour une bétonnière (10), comprenant :

(a) un corps (110) ;
(b) un ou plusieurs éléments de détection (120a, 120b) montés sur une surface extérieure ou au sein d'un intérieur dudit corps et pouvant être connectés à un circuit de commande (140) ; et
(c) un manchon (150) incluant :

i. une première couche (152) entourant ladite surface extérieure dudit corps et fabriquée en un premier matériau,
ii. une seconde couche (160) entourant une surface extérieure de ladite première couche, **caractérisé en ce que** ladite seconde couche (160) entourant une surface extérieure de ladite première couche (152) est fabriquée en un second matériau, et
iii. dans lequel ledit second matériau a sa dureté qui est supérieure à une dureté dudit premier matériau.

2. Capteur selon la revendication 1, dans lequel ladite dureté dudit second matériau est suffisante pour résister à une usure de ladite seconde couche de matériau résultant d'un contact avec un mélange de béton.

3. Capteur selon la revendication 1, dans lequel ladite dureté dudit second matériau est suffisante pour amortir des chocs au cours d'un mouvement dudit capteur à travers un mélange de béton et pour réduire un facteur de bruit provenant de celui-ci tout en permettant audit capteur de mesurer des caractéristiques rhéologiques du mélange de béton.

4. Capteur selon la revendication 1, dans lequel lesdits éléments de détection sont montés de sorte que ledit capteur est configuré, au cours d'un mouvement dudit capteur à travers un mélange de béton, pour mesurer une première force le long d'un premier axe qui est parallèle à un axe de rotation de ladite bétonnière et mesurer une seconde force le long d'un second axe qui est disposé à un angle par rapport audit premier axe, ledit second axe étant défini par un mouvement d'une hélice de mélange au sein de ladite bétonnière.

5. Capteur selon la revendication 1, dans lequel ledit corps est creux, dans lequel lesdits éléments de détection incluent quatre extensomètres (120) montés sur une surface intérieure dudit corps creux et dans lequel deux desdits quatre extensomètres sont montés, des extrémités médiates dudit corps creux, le long d'un premier axe qui est parallèle à un axe de rotation de ladite bétonnière et deux extensomètres restants sont montés le long d'un second axe qui est disposé à un angle par rapport audit premier axe lorsque ledit capteur est relié à une paroi de la bétonnière, ledit second axe étant défini par un mouvement d'une hélice de mélange au sein de ladite bétonnière.

6. Capteur selon la revendication 5, dans lequel ledit capteur comprend en outre une base (130) reliée à une extrémité dudit corps creux et ledit circuit de commande étant disposé au sein d'un intérieur creux de ladite base, ledit circuit de commande incluant un processeur (142), et dans lequel lesdits quatre extensomètres sont connectés avec des fils audit processeur dans un agencement de pont de Wheatstone.

7. Capteur selon la revendication 1, dans lequel ledit corps est fabriqué en un matériau électriquement non conducteur et dans lequel lesdits éléments de détection incluent quatre éléments électriquement conducteurs montés dans une relation espacée les uns avec les autres le long d'une longueur dudit corps sur une surface extérieure de celui-ci.

8. Capteur selon la revendication 7, comprenant en outre une base (130) et une connexion rigide entre ladite base et une extrémité dudit corps.

9. Capteur selon la revendication 8, comprenant en outre :

(a) un intérieur creux au sein de ladite base ;
(b) un circuit de commande disposé au sein dudit intérieur creux de ladite base
(c) un générateur CA programmable disposé au sein dudit intérieur creux de ladite base, ledit générateur CA programmable étant couplé de manière opérationnelle au circuit de commande et à des éléments externes électriquement conducteurs ;
(d) dans lequel des éléments internes électriquement conducteurs sont couplés de manière opérationnelle audit circuit de commande ; et
(e) dans lequel ledit circuit de commande est au moins configuré pour programmer ledit générateur CA programmable, mesurer un courant généré par ledit générateur CA programmable et mesurer une tension entre lesdits éléments internes électriquement conducteurs.

10. Capteur selon la revendication 1, dans lequel ledit corps est fabriqué en un matériau électriquement non conducteur, dans lequel lesdits éléments de détection incluent deux éléments électriquement conducteurs montés dans une relation espacée l'un avec l'autre sur une surface extérieure dudit corps, et dans lequel ledit capteur comprend en outre une base reliée à une extrémité dudit corps et un circuit de commande disposé au sein d'un intérieur creux de ladite base, ledit circuit de commande est configuré pour générer et appliquer une tension auxdits deux éléments électriquement conducteurs et mesurer un courant entre lesdits deux éléments électriquement conducteurs, ledit courant étant indicateur d'au moins un élément parmi une résistance et une impédance d'un mélange de béton contenu au sein de la bétonnière.

11. Capteur selon la revendication 1, comprenant en outre :

(a) une base (130) reliée à une extrémité dudit corps ;
(b) un circuit de commande disposé au sein d'un intérieur creux de ladite base ;
(c) lesdits éléments de détection définissant deux éléments allongés électriquement conducteurs intégrés dans une relation espacée au sein dudit corps et connectés électriquement audit circuit de commande ;
(d) dans lequel ledit corps est fabriqué en un matériau électriquement non conducteur ; et
(e) dans lequel ledit circuit de commande est configuré pour générer et appliquer une tension auxdits deux éléments allongés électriquement conducteurs et mesurer un courant entre lesdits deux éléments allongés électriquement conducteurs, ledit courant étant indicateur d'au moins un élément parmi une résistance et une impédance d'un mélange de béton contenu au sein de la bétonnière.

12. Capteur selon la revendication 1, dans lequel ledit corps est creux, dans lequel ledit capteur inclut en outre une base (130), une connexion flexible entre ladite base et une extrémité dudit corps creux et deux éléments de tirant (314, 316) montés, généralement perpendiculairement l'un à l'autre, au sein dudit corps creux, dans lequel chaque extrémité de chaque élément de tirant est reliée à une surface intérieure dudit corps creux ; dans lequel lesdits éléments de détection incluent une paire de cellules de charge de compression (320), et dans lequel une de ladite paire de cellules de charge de compression est montée sur un desdits deux éléments de tirant et une autre de ladite paire de cellules de charge de compression est montée sur un autre desdits deux éléments de tirant ; et dans lequel ledit ; moyennant quoi ledit capteur est configuré pour mesurer une première force le long d'un premier axe qui est parallèle à un axe de rotation de ladite bétonnière et mesurer en outre une seconde force le long d'un second axe qui est disposé à un angle par rapport audit premier axe lorsque ledit capteur est relié à une paroi de ladite bétonnière.

13. Capteur selon l'une quelconque des revendications précédentes, dans lequel ladite première couche est fabriquée en un matériau élastomère.

14. Capteur selon l'une quelconque des revendications précédentes, dans lequel ladite seconde couche est fabriquée en un matériau métallique.

15. Procédé comprenant :
mesurer au moins un élément parmi des caractéristiques rhéologiques, le volume, le rapport eau ciment, la consistance, la température et le coulage d'un mélange de béton en utilisant un capteur (100) comprenant :

(a) un corps (110) ;
(b) un ou plusieurs éléments de détection (120a, 120b) montés sur une surface extérieure ou au sein d'un intérieur dudit corps et pouvant être connectés à un circuit de commande (140) ; et
(c) un manchon (150) incluant :

i. une première couche (152) entourant ladite surface extérieure dudit corps et fabriquée en un premier matériau,
ii. une seconde couche (160) entourant une surface extérieure de ladite première couche et fabriquée en un second matériau, et
iii. dans lequel ledit second matériau a sa dureté qui est supérieure à une dureté dudit premier matériau.

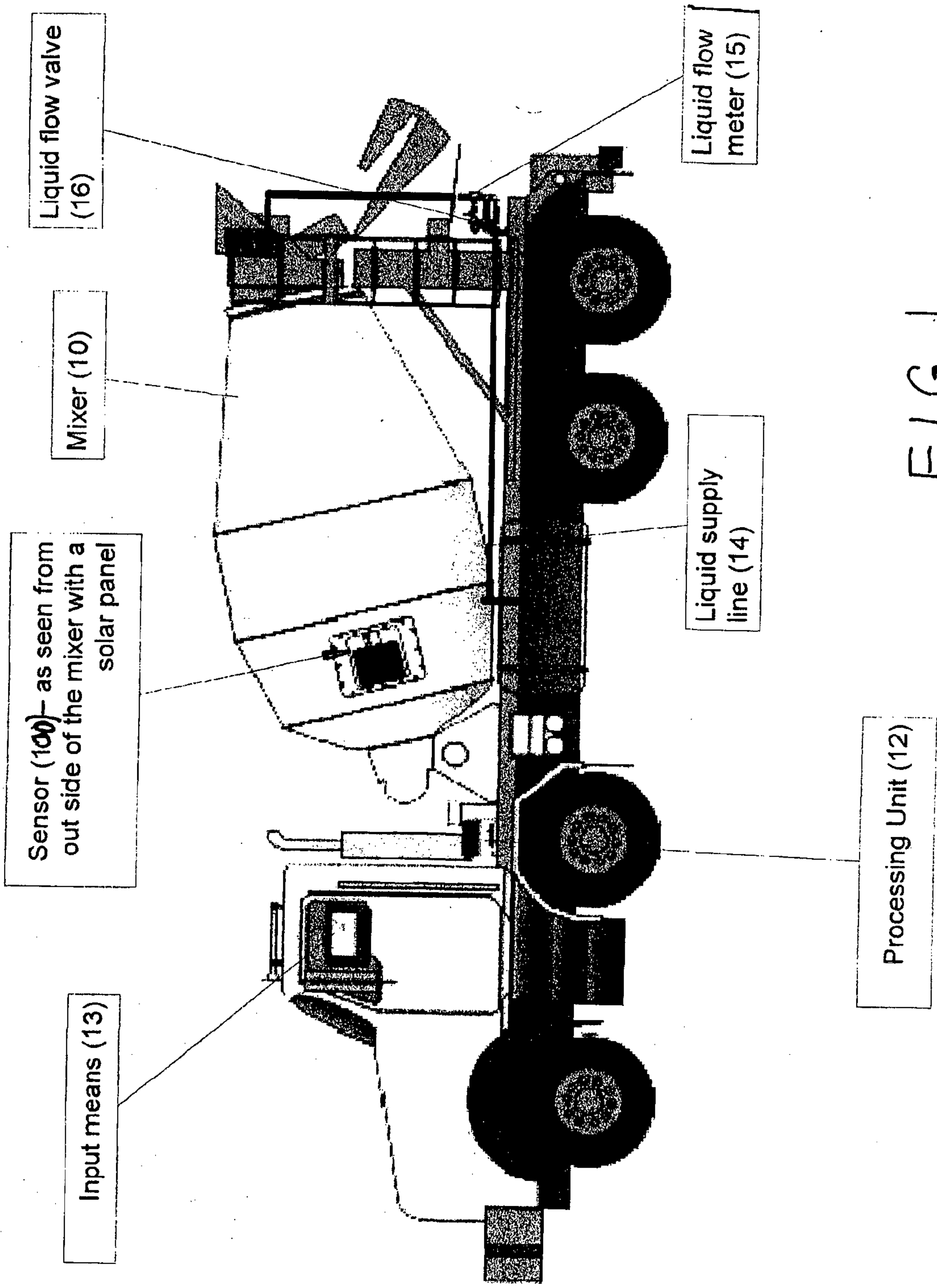
Liquid flow valve (16)
Mixer (10)
Sensor (100) - as seen from out side of the mixer with a solar panel
Input means (13)
Liquid flow meter (15)
Liquid supply line (14)
Processing Unit (12)

FIG. 1

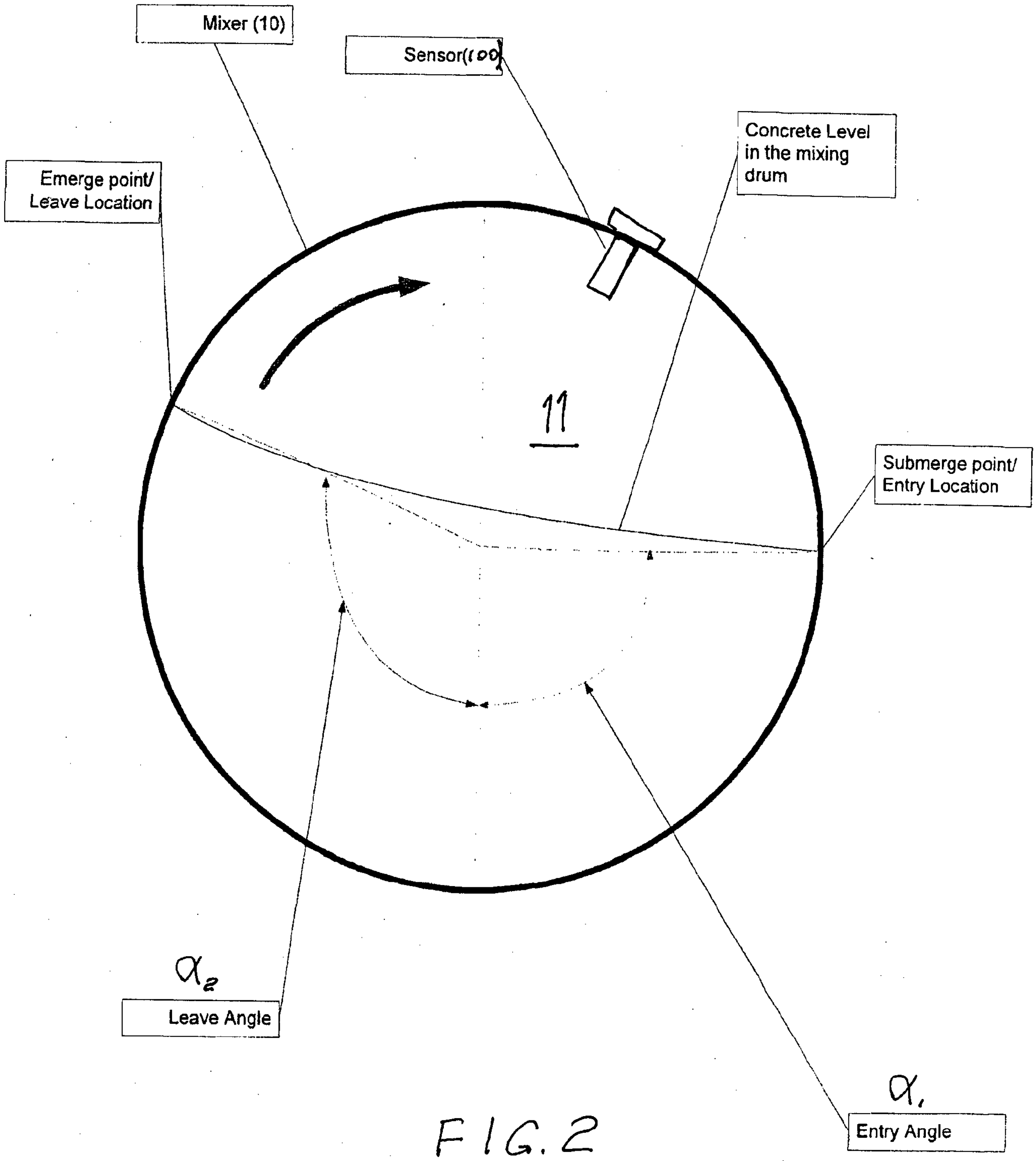
Mixer (10)
Sensor(100)
Concrete Level in the mixing drum
Emerge point/ Leave Location
11
Submerge point/ Entry Location
α2
Leave Angle
α1
Entry Angle

FIG. 2

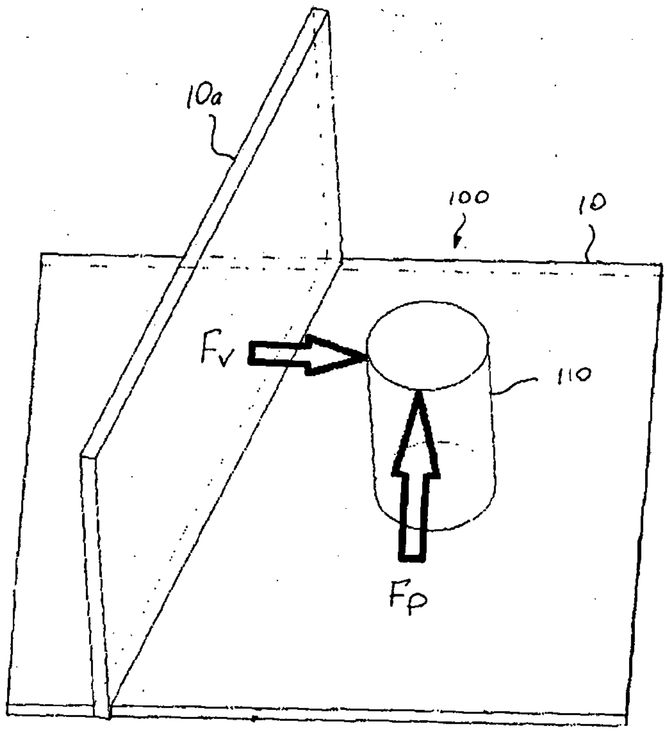

FIG. 3

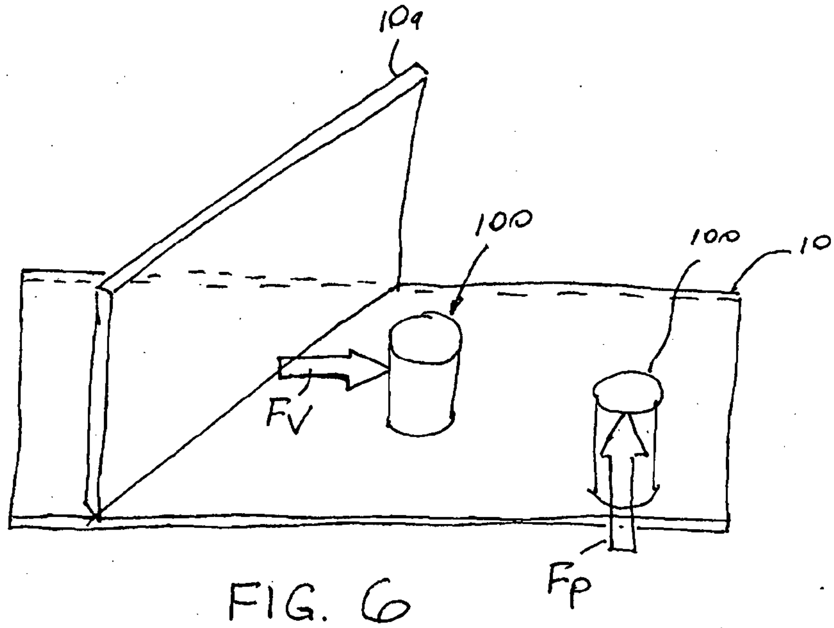

FIG. 6

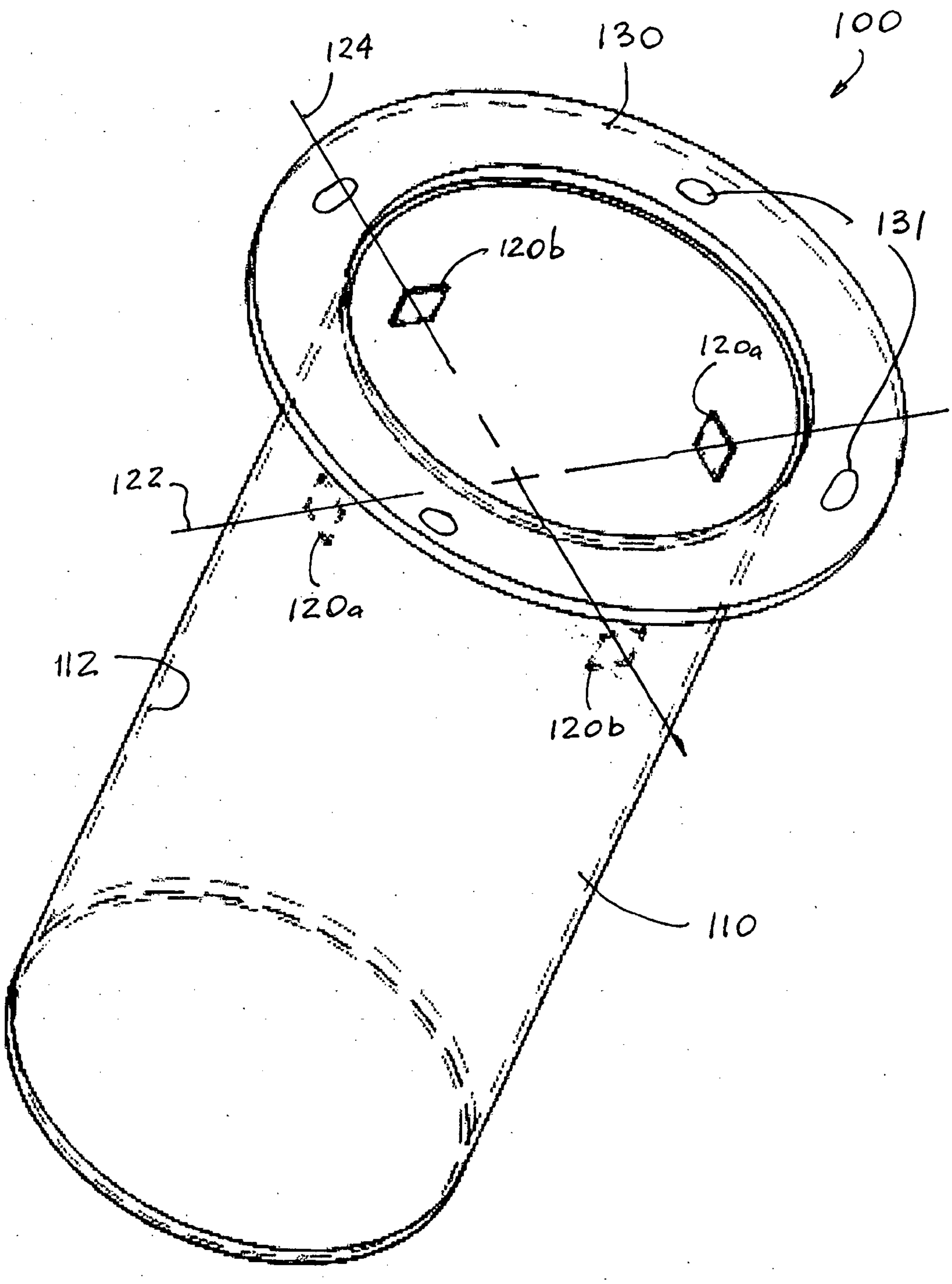

FIG. 4

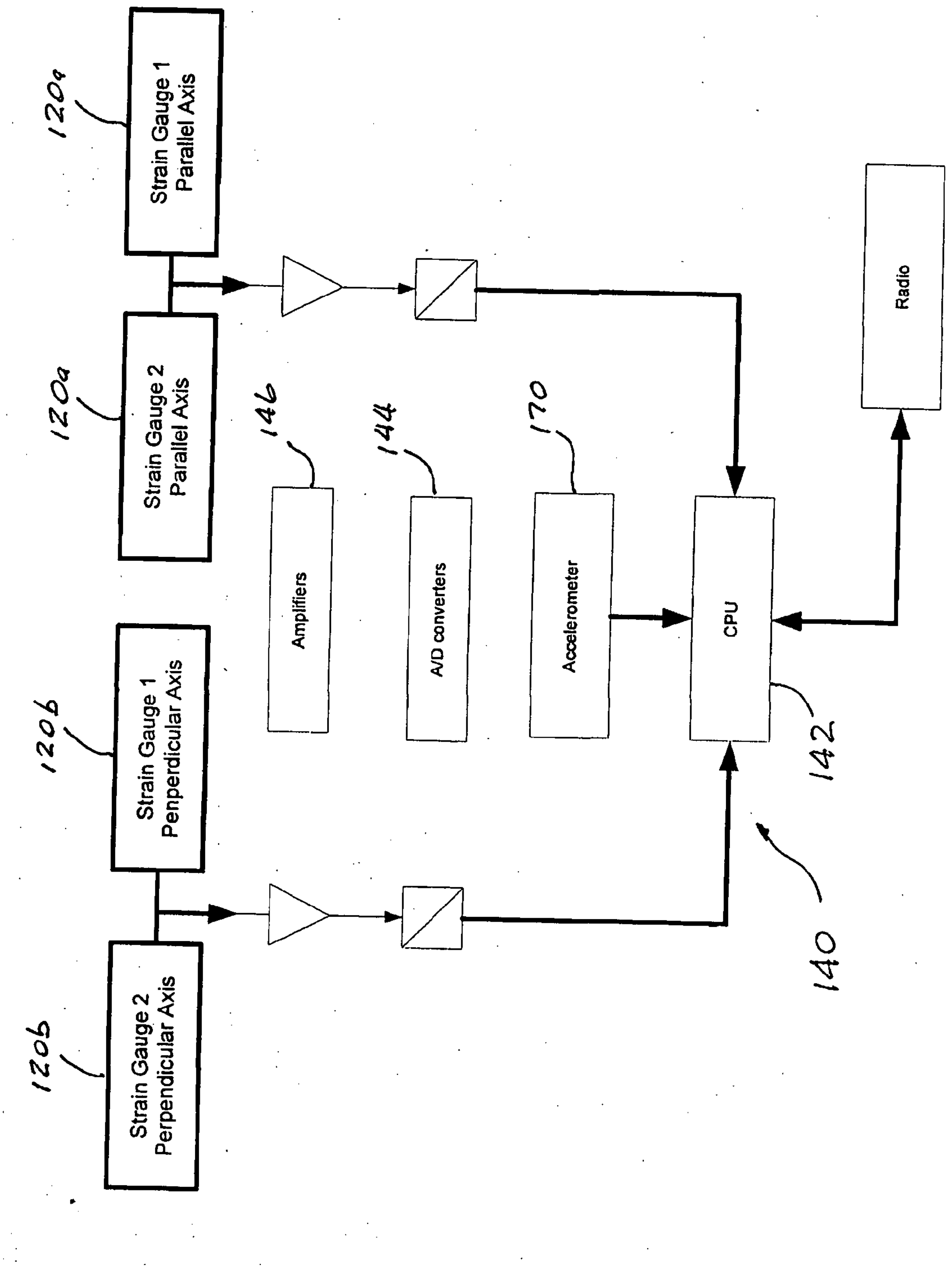
120a
Strain Gauge 1
Parallel Axis
120a
Strain Gauge 2
Parallel Axis
120b
Strain Gauge 1
Penperdicular Axis
120b
Strain Gauge 2
Perpendicular Axis
146
Amplifiers
144
A/D converters
170
Accelerometer
CPU
142
140
Radio

FIG. 5

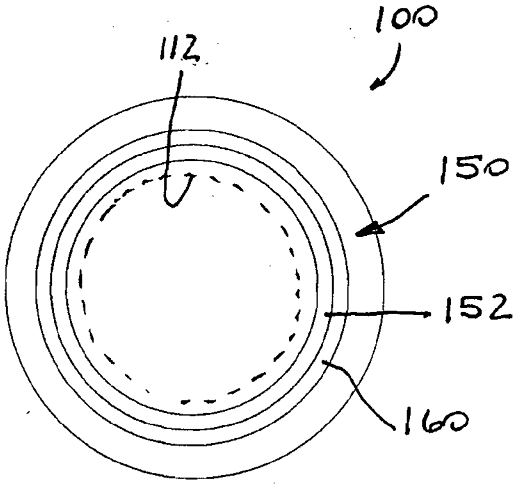

FIG. 8

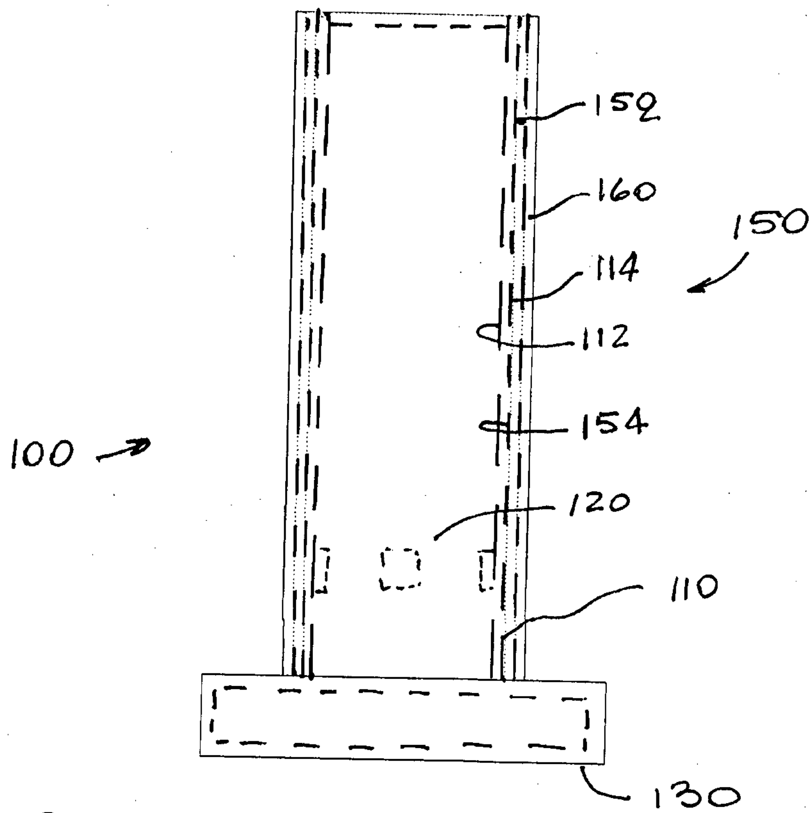

FIG. 7

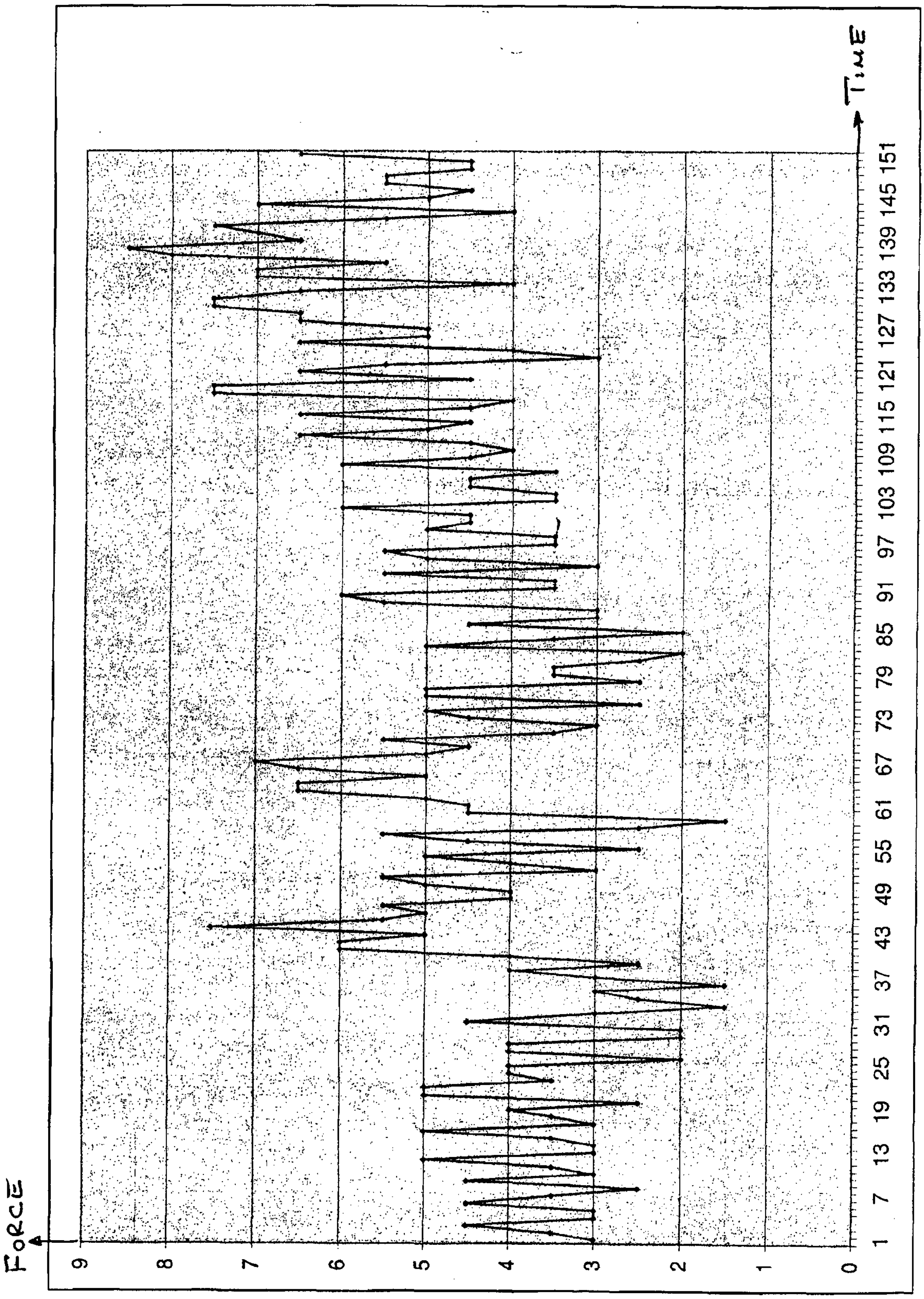
FORCE
TIME
0
1
2
3
4
5
6
7
8
9
1 7 13 19 25 31 37 43 49 55 61 67 73 79 85 91 97 103 109 115 121 127 133 139 145 151

FIG. 9

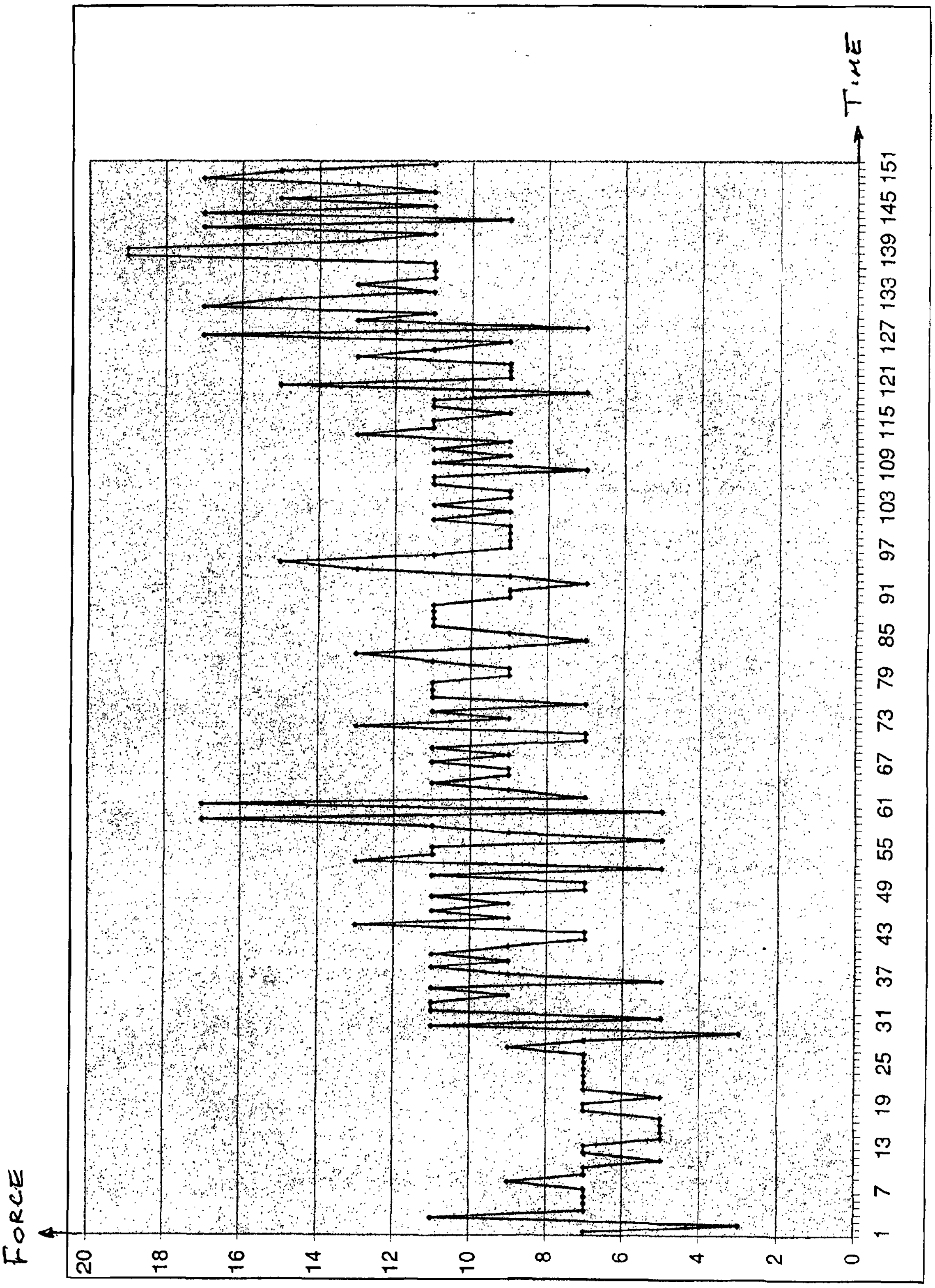
FORCE
TIME
20
18
16
14
12
10
8
6
4
2
0
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97
103
109
115
121
127
133
139
145
151

FIG. 1D

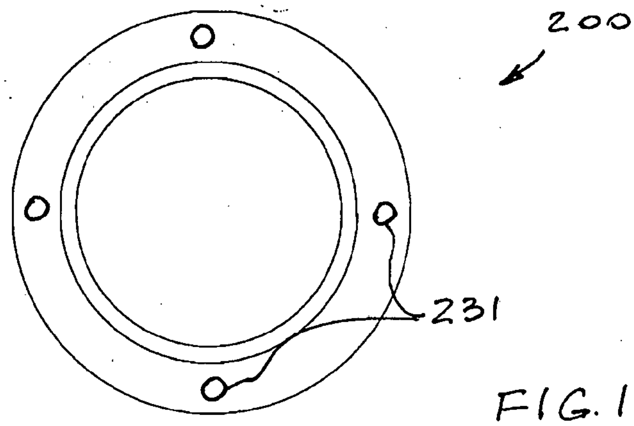

FIG. 12

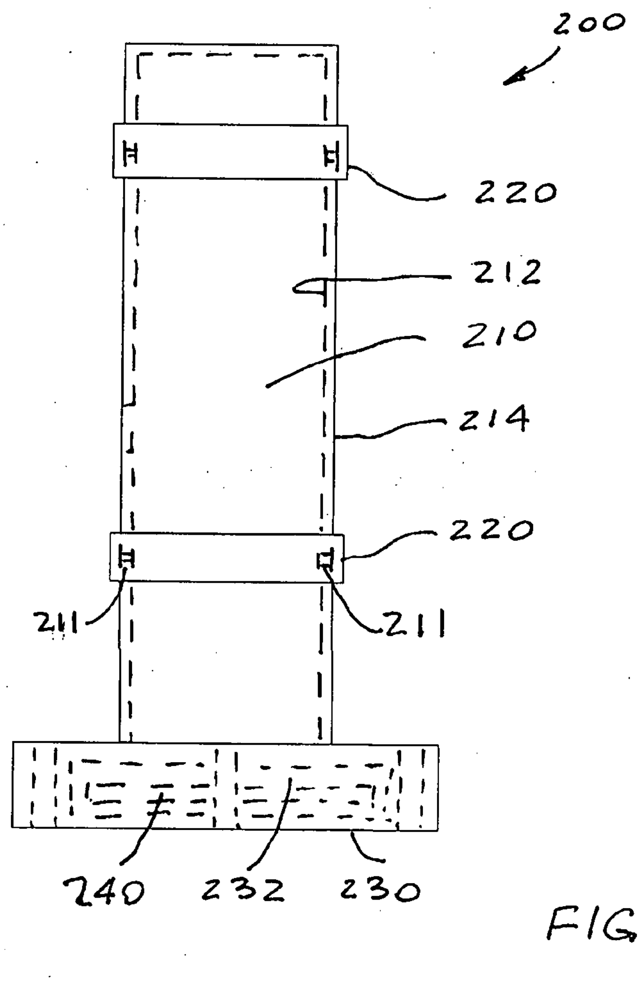

FIG. 11

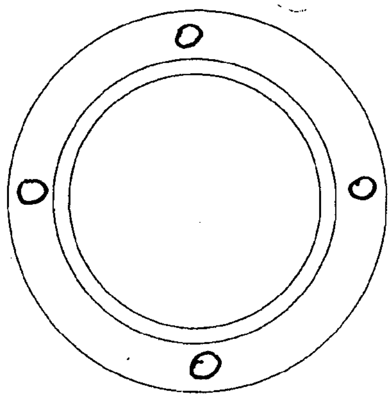

FIG. 14

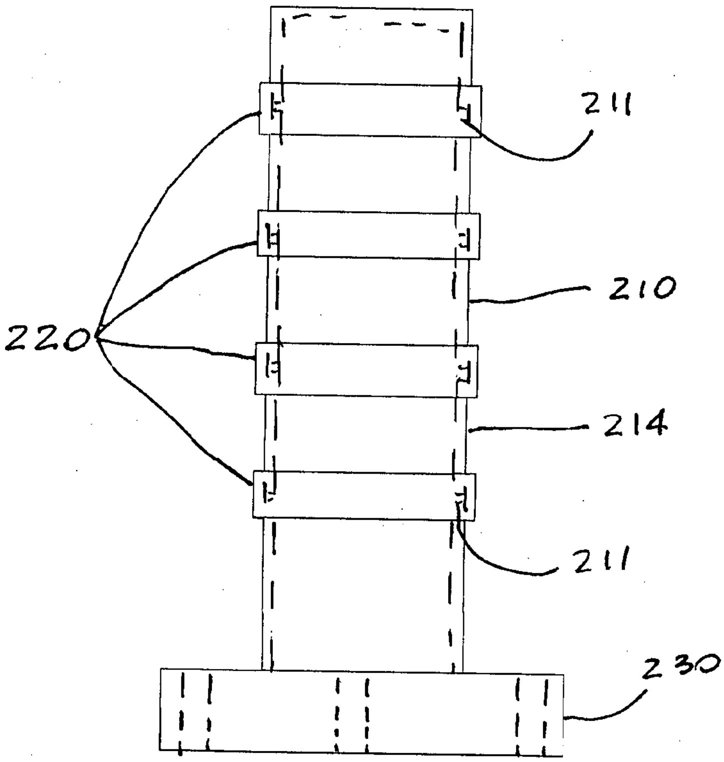

FIG. 13

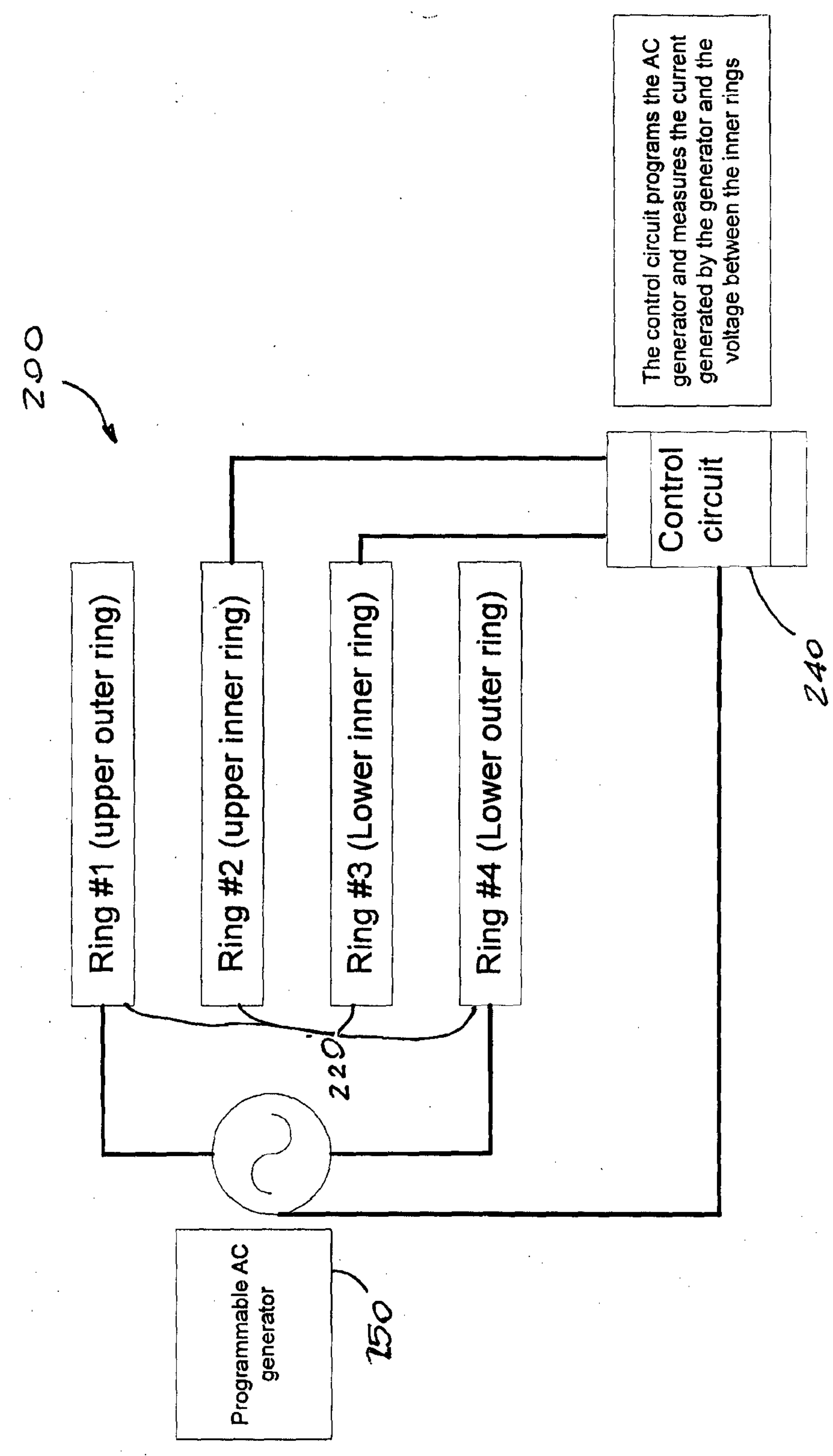
200
The control circuit programs the AC generator and measures the current generated by the generator and the voltage between the inner rings
Control circuit
240
Ring #1 (upper outer ring)
Ring #2 (upper inner ring)
Ring #3 (Lower inner ring)
Ring #4 (Lower outer ring)
220
Programmable AC generator
250

FIG. 15

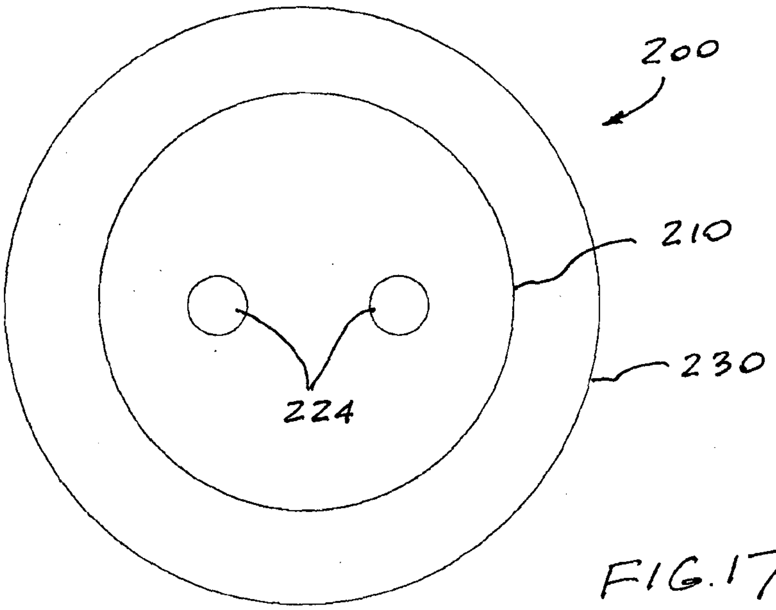

FIG.17

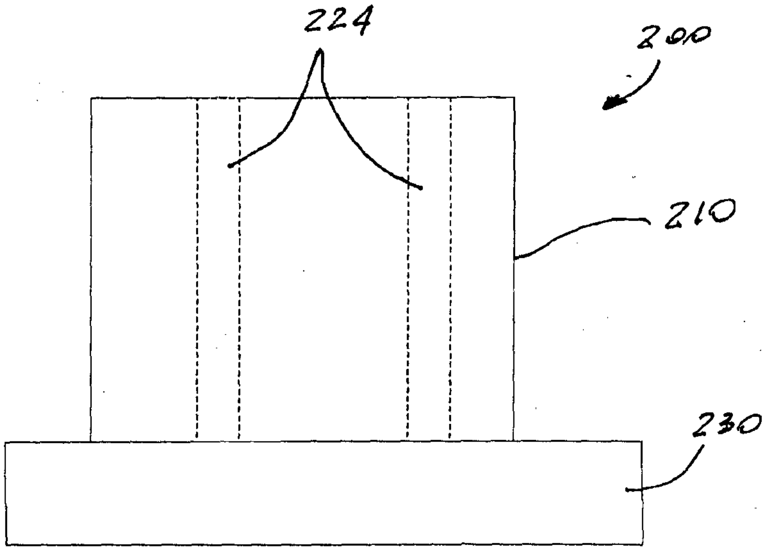

FIG.16

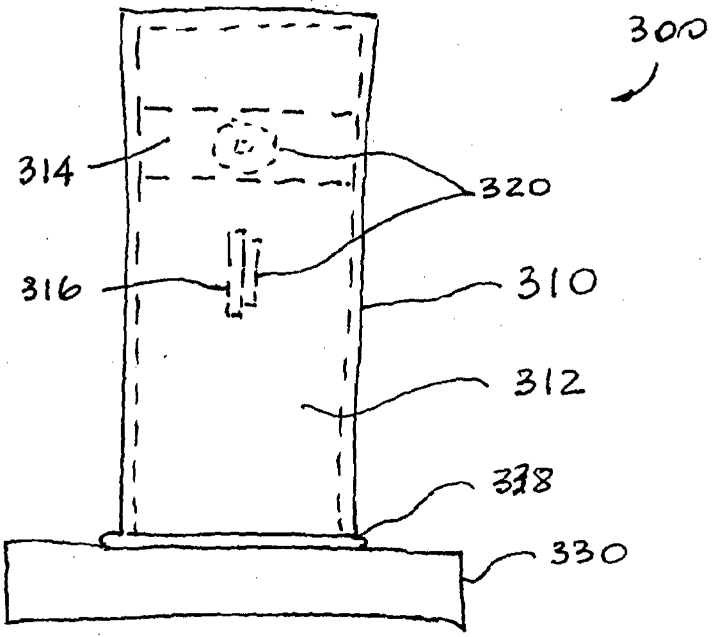

FIG. 18

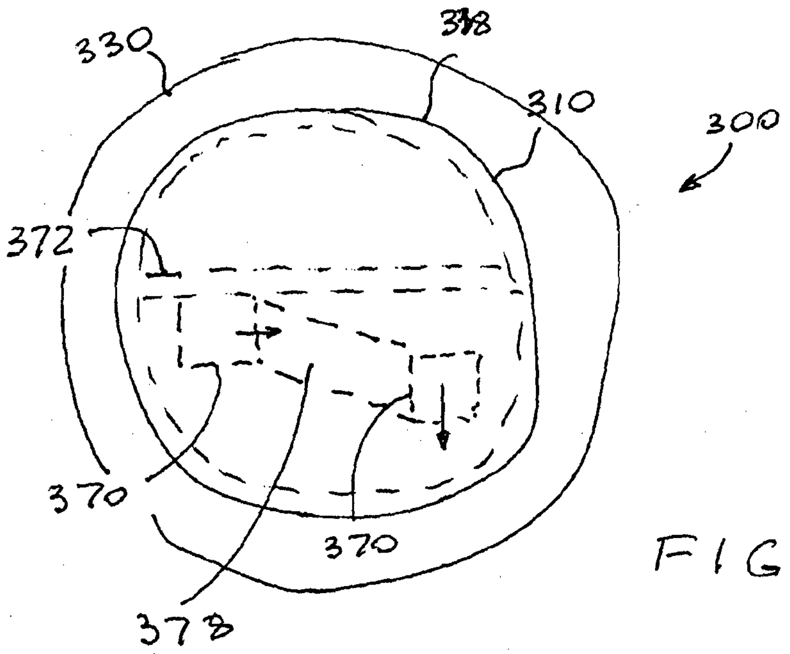

FIG. 19

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6484079 B, Buckelew **[0005]**
- US 5713663 A, Zandberg **[0005]**
- US 20120204625 A, Beaupre **[0005] [0098] [0114]**
- EP 1961538 A2 **[0005]**
- EP 0924040 A **[0005]**
- US 3631712 A **[0010]**