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(54) **LOCATION DEVICE WITH A GRAVITY MEASURING DEVICE**

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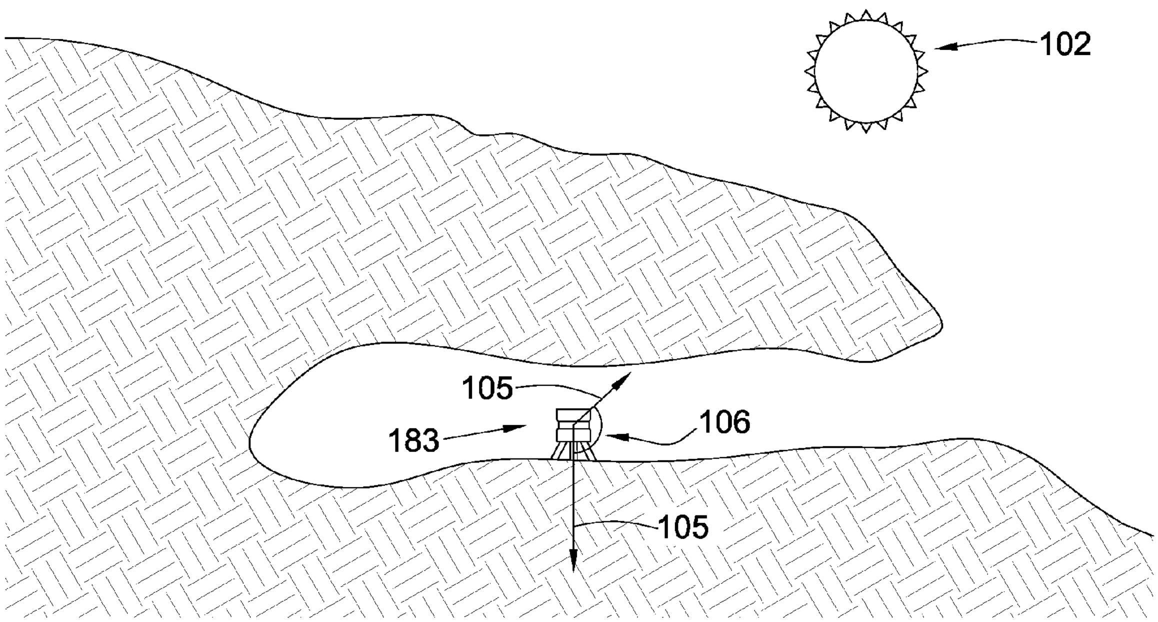
(57) **ABSTRACT**

A location device has a gravity measurement instrument in communication with a database which has the locations relative to time of an astronomical object. The location device also has a timepiece indicating the time which may be used to determine the location of the astronomical object.



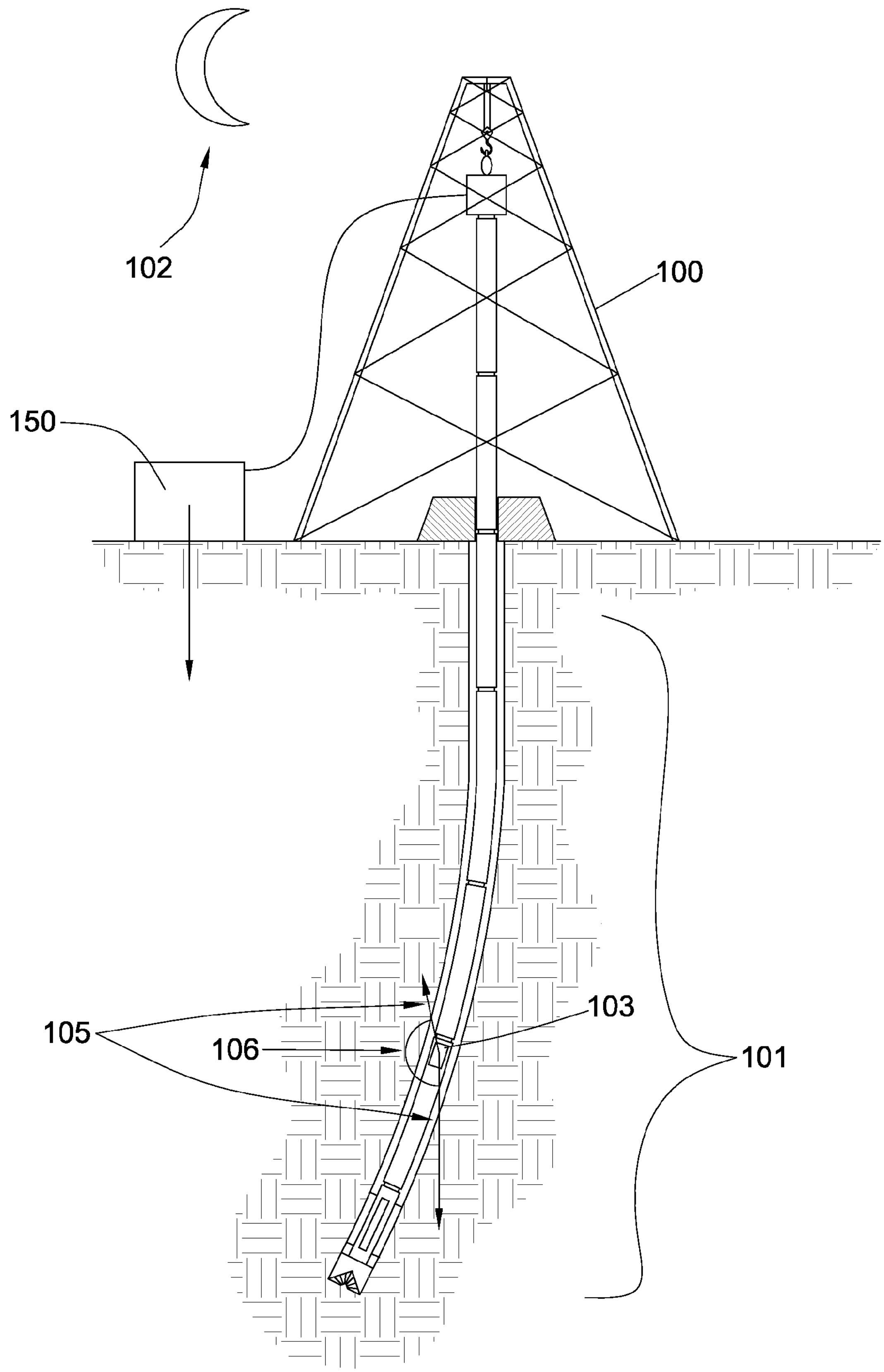


Fig. 1

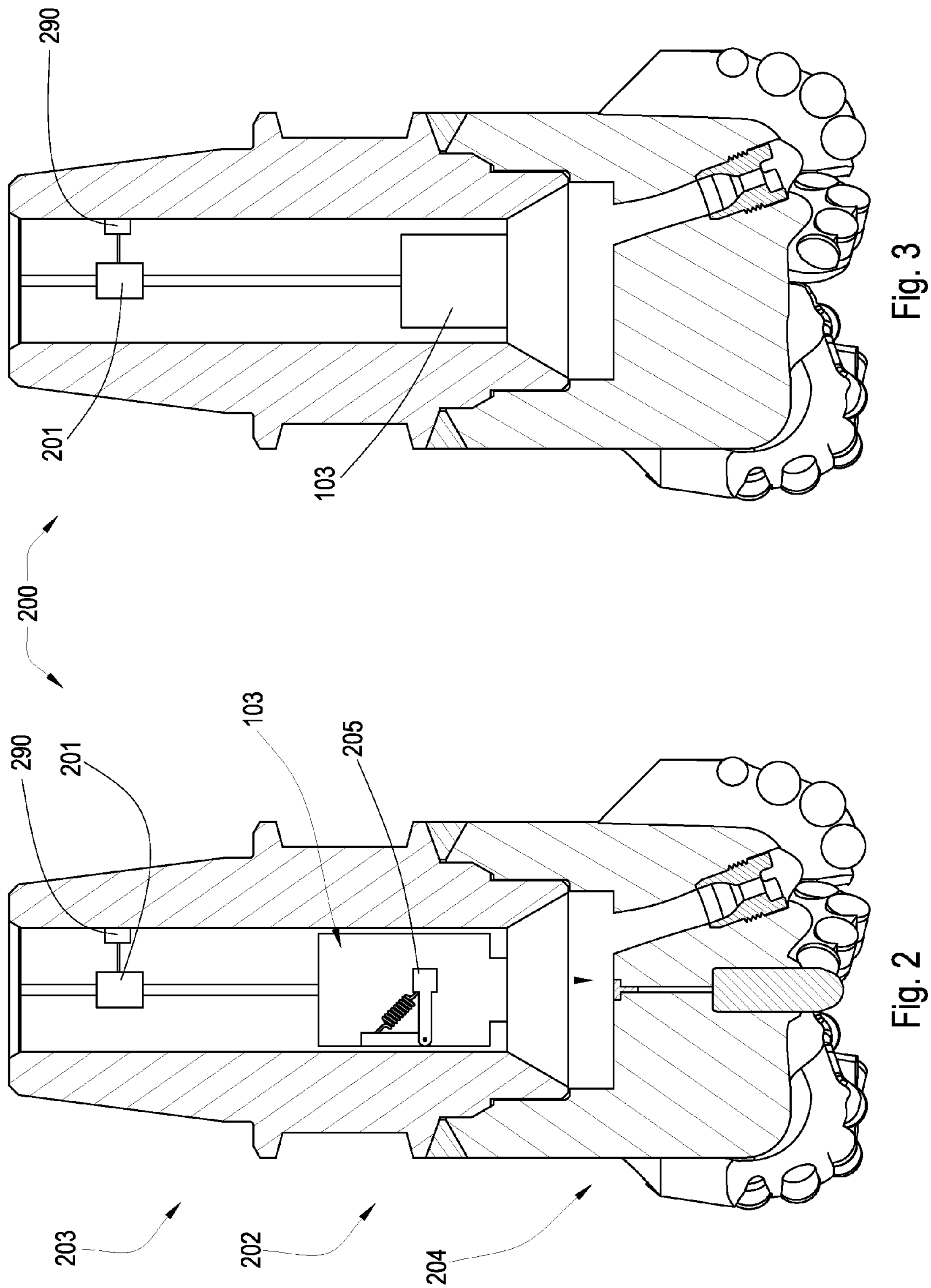


Fig. 3

Fig. 2

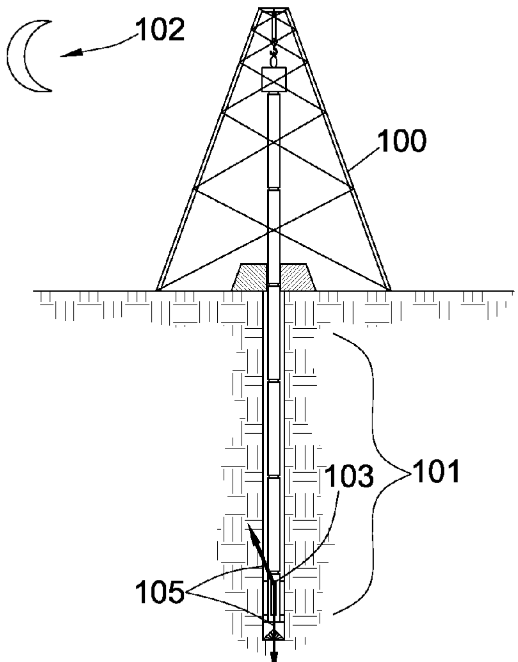


Fig. 4

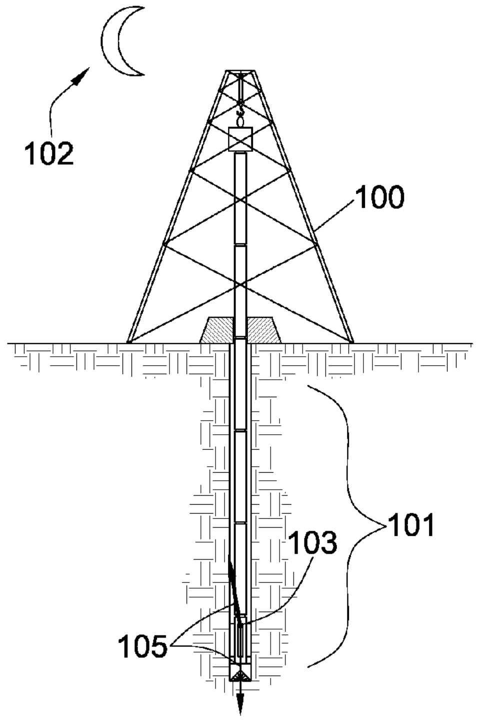


Fig. 5

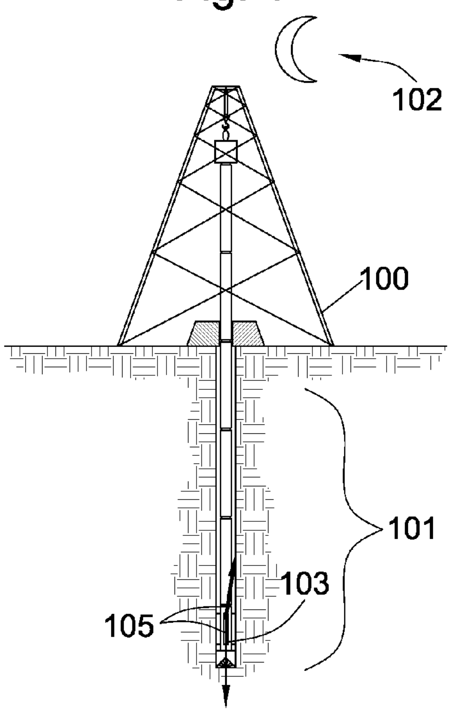


Fig. 6

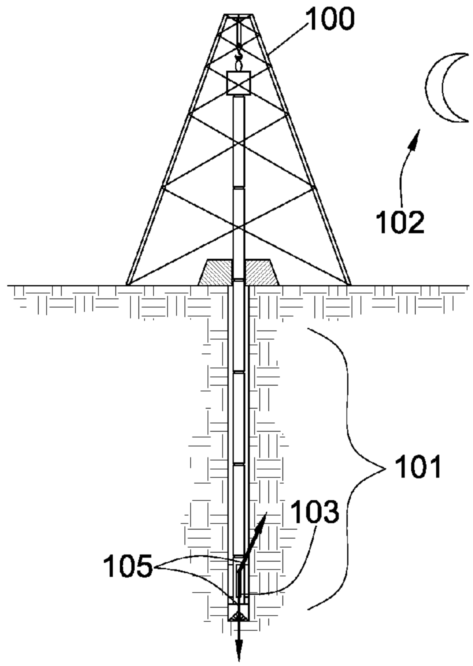


Fig. 7

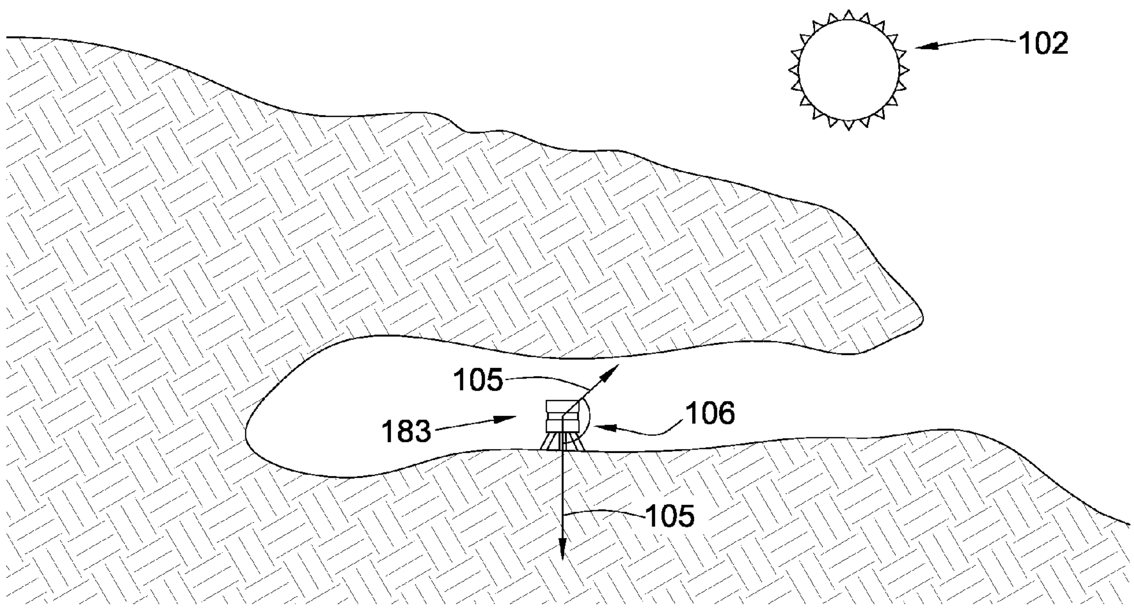


Fig. 8

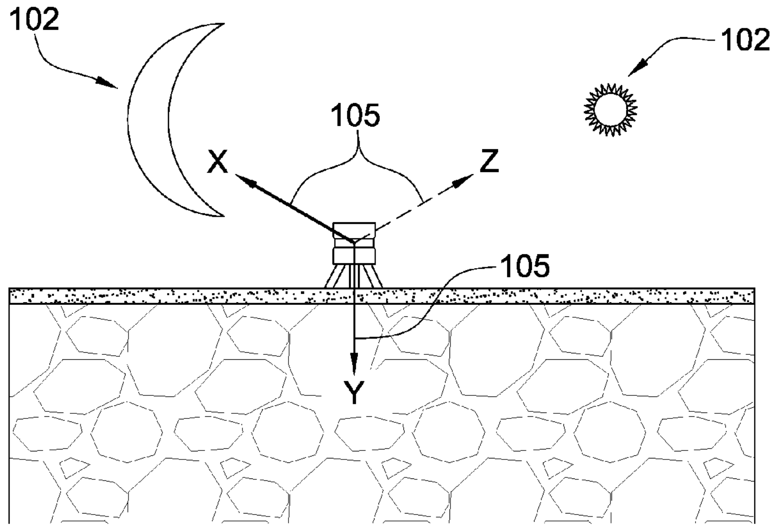


Fig. 9

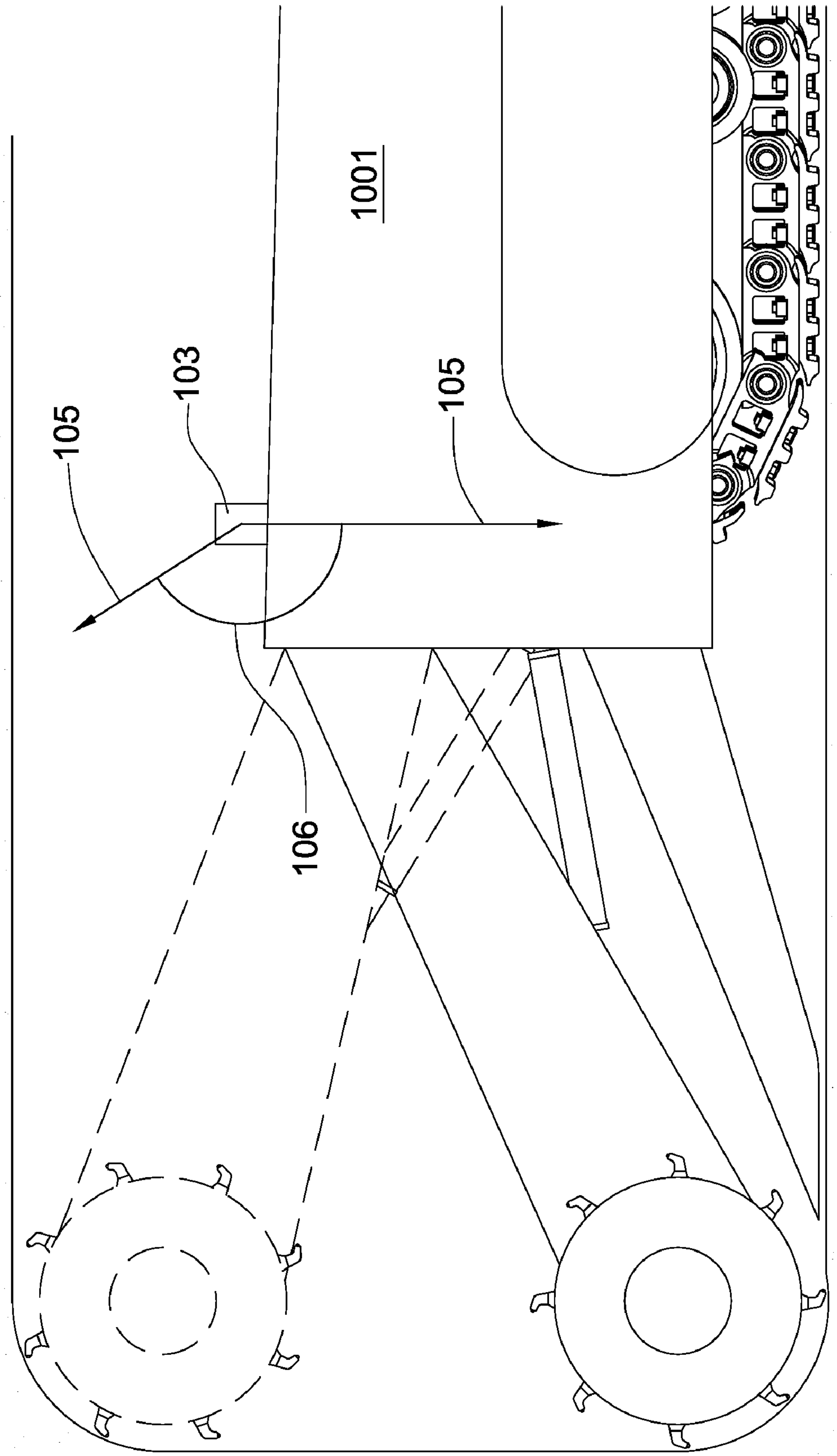


Fig. 10

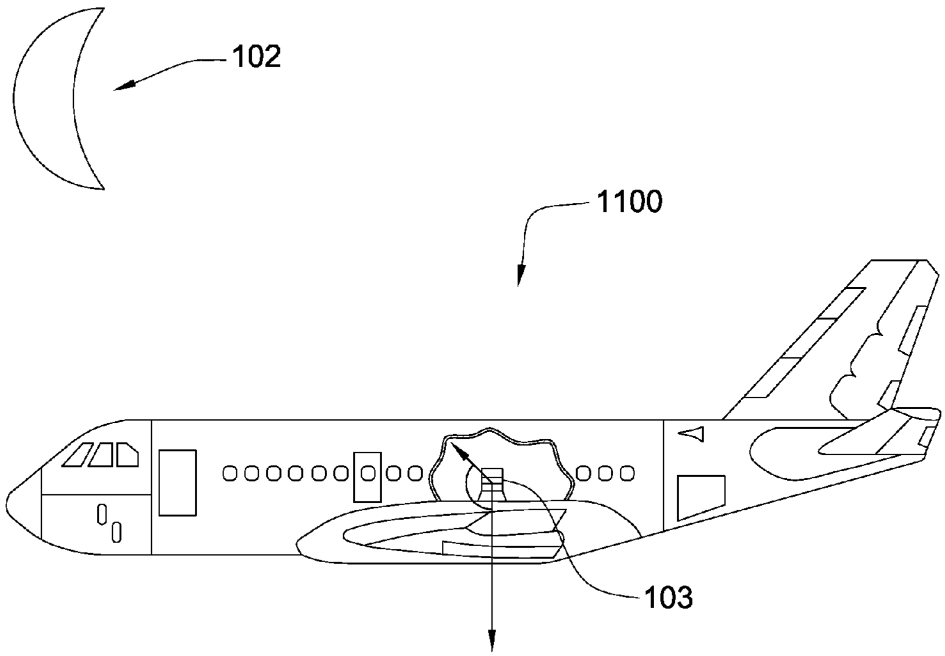


Fig. 11

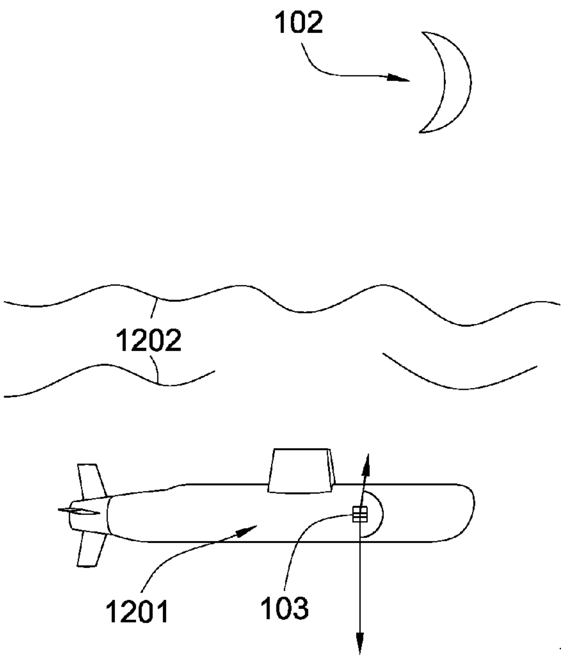


Fig. 12

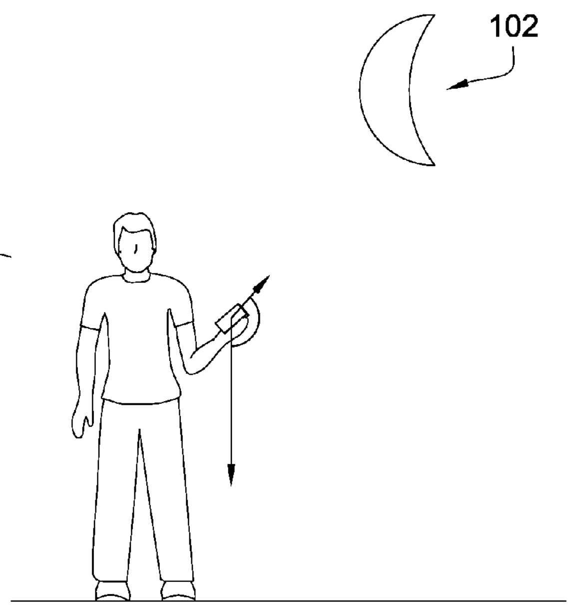


Fig. 13

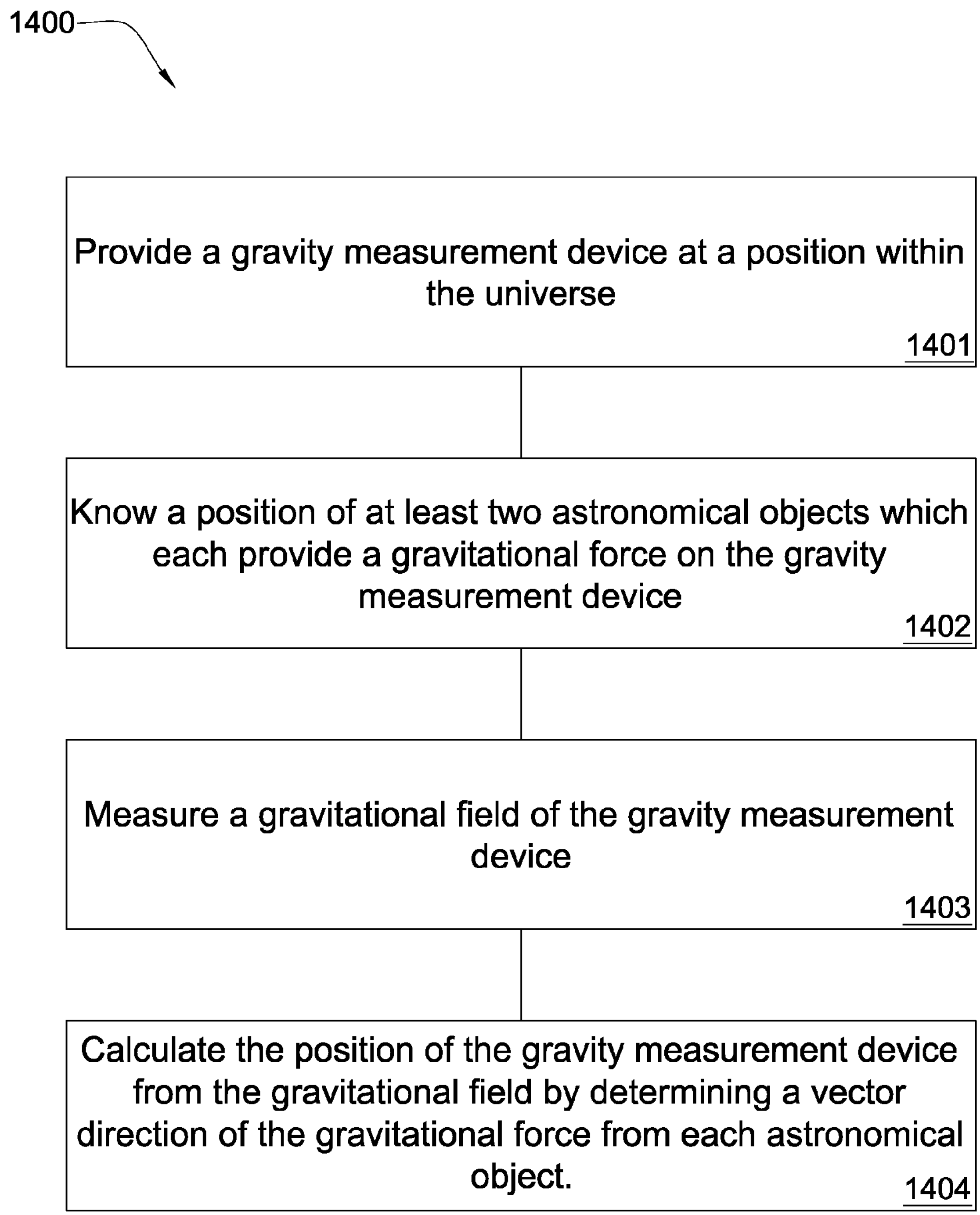

1400
Provide a gravity measurement device at a position within the universe
1401
Know a position of at least two astronomical objects which each provide a gravitational force on the gravity measurement device
1402
Measure a gravitational field of the gravity measurement device
1403
Calculate the position of the gravity measurement device from the gravitational field by determining a vector direction of the gravitational force from each astronomical object.
1404

Fig. 14

LOCATION DEVICE WITH A GRAVITY MEASURING DEVICE

BACKGROUND OF THE INVENTION

[0001] In many instances the location of an object may be critical to the success of a project. Many locating systems such as Global Positioning Systems have been implemented to assist in the location of objects.

[0002] U.S. Pat. No. 5,379,224 which is herein incorporated by reference for all that it contains, discloses a Global Positioning system used in applications involving radiosondes, sonobuoys, and other objects. The GPS data is processed in a data processing workstation where the position and velocity of a sensor, at the time the data was sampled, is computed. A data buffer in the sensor is periodically refreshed, and the workstation periodically computes the new position and velocity of the sensor.

[0003] U.S. Pat. No. 5,983,161 which is herein incorporated by reference for all that it contains, discloses GPS satellite ranging signals at one of a plurality of vehicles/aircraft/automobiles that are computer processed to continuously determine the one's kinematic tracking position on a pathway with centimeter accuracy.

[0004] These types of systems have been useful in the locating of certain objects. However, these types of systems generally depend on satellite communication to function appropriately. In places where satellite communication may be impeded alternatives may be useful.

BRIEF SUMMARY OF THE INVENTION

[0005] A location device has a gravity measurement instrument in communication with a database which has the locations according to time of an astronomical object. The location device also has a timepiece indicating the time which may be used to determine the location of the astronomical object.

[0006] The location device may measure the gravitational force of least two astronomical objects creating two vector directions. Between these two vector directions an angle is formed that may be used in finding the position of the location device.

[0007] In another aspect of the invention a method comprising the steps of providing a gravity measurement instrument at a position within the universe may be used to locate the position of the gravity measurement instrument. The gravity measurement instrument may be in communication with a database that comprises the locations of at least two astronomical objects. Each astronomical object may provide a gravitational force on the gravity measurement device, creating a gravitational field. The method may further comprise measuring the gravitational field of the gravity measurement instrument; and calculating the position of the gravity measurement instrument from the gravitational field by determining a vector direction of the gravitational force from each astronomical object. Generally, a gravitometer is used in the measurement of gravitational forces. Types of gravitometer may include a zero length spring, a Lacoste gravitometer, a relative gravitometer, an absolute gravitometer, a superconducting gravitometer, or a combination thereof. Generally, the gravity measurement instrument comprises a quartz material, metallic material, elastomeric material, plastic material, or a combination thereof.

[0008] The location device may be placed in various places such as caves, cities, jungles, a plane, a submergible machine, a space shuttle, or beneath the surface of an astronomical object. In some embodiments, the location device may be used as an alternative to the commonly used GPS such as in cases where the communication between the location device and GPS satellite is blocked, or in other embodiments it may be used as a primary locating device. The location device may also be placed on a plane, a submergible machine, a space shuttle, a person, or on or in the surface of an astronomical object. The location device may be of particular importance in downhole operations such as mining and drilling operations. The location device may be deployed within a tool string or on a mining machine. The location device may further be placed within a housing that may protect it from harsh conditions. It may be of importance that the gravity measurement instrument be stationary relative to the astronomical object upon which it is positioned. Astronomical objects that may create a gravitational force on the gravity measurement instrument may include the Earth, the sun, the moon, a comet, a star, or a combination thereof. The database may comprise the locations of the astronomical objects which may be previously known or predictable. The astronomical object may move relative to the gravity measurement instrument. The gravity measurement instrument may be able to measure the gravitational forces as the astronomical object moves. The various gravitational forces and locations of the astronomical object at various positions may be recorded to the database.

[0009] In some embodiments of the present invention, the gravity measuring device may be part of an array of gravity measuring devices which may also be used to aid in determining a size, a boundary, a volume and/or a density of an astronomical object in part or in whole, such as mineral accumulations or hydrocarbon deposits. In some embodiments, tides or other local effects may be determine through the use of multiple gravity measuring devices.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is an orthogonal diagram of a derrick attached to a tool string comprising a location device.

[0011] FIG. **2** is a cross-section of a drill bit comprising a location device.

[0012] FIG. **3** is a cross-section of a drill bit comprising another embodiment of a location device.

[0013] FIG. **4** is an orthogonal diagram of derrick attached to a tool string comprising a location device.

[0014] FIG. **5** is an orthogonal diagram of derrick attached to a tool string comprising a location device.

[0015] FIG. **6** is an orthogonal diagram of derrick attached to a tool string comprising a location device.

[0016] FIG. **7** is an orthogonal diagram of derrick attached to a tool string comprising a location device.

[0017] FIG. **8** is an orthogonal diagram of a location device positioned within an under ground enclosure.

[0018] FIG. **9** is an orthogonal diagram of a location device with more than two vector directions.

[0019] FIG. **10** is an orthogonal diagram of a location device located on a mining machine.

[0020] FIG. **11** is an orthogonal diagram of a location device located within an aircraft.

[0021] FIG. **12** is an orthogonal diagram of a location device located within a submergible machine.

[0022] FIG. **13** is an orthogonal diagram of a location device on a person.

[0023] FIG. **14** is a diagram of an embodiment of a method for locating the position of the gravity measuring device.

DETAILED DESCRIPTION OF THE INVENTION AND THE PREFERRED EMBODIMENT

[0024] FIG. **1** is an orthogonal diagram of a derrick **100** attached to a tool string **101** comprising a location device **103**. In FIG. **1** the location device **103** is placed downhole in the tool string **101** beneath the surface of the Earth and may continue downhole as the tool string **101** proceeds. An astronomical object **102** may create a sufficient gravitational force that may be sensed by the location device **103** and may create a vector direction **105** toward the astronomical object **102**. The astronomical object **102** may be the Earth, the moon, a comet, the sun, stars, or a combination thereof as long as its position and mass are accurately known. A second vector direction may be generated from an astronomical object, such as a planet, upon which the location device **103** is placed. FIG. **1** shows one vector direction **105** generated by the moon and another vector direction **105** generated by the Earth upon which the location device is placed. With at least two vector directions **105** an angle **106** between the vectors **105** may be measured and may aid in locating the device **103**. Multiple location points may be taken and recorded as the location device proceeds downhole. The inclination, rotation, and direction of the tool string may also be taken into account by the location device. Measurements, such as those taken from instruments such as accelerometers, gyroscopes, magnetometers, or other inclination and direction instrumentation may add data which may be used to help determine the location of the location device. In some embodiments, a second gravity measuring device **150** may be located uphole on the earth's surface which may be in communication with the downhole gravity measuring device and may be used to determine changes in gravity readings at the surface. These changes may be compared to the readings taken downhole to determine if an uphole or downhole anomaly is affecting the gravity measuring device. The gravity measuring devices may be in communication with each other through tool string telemetry systems such as wired pipe, mud pulse, radio wave, or short hop. In a preferred embodiment, a telemetry system such as the one described in U.S. Pat. No. 6,670,880, which is herein incorporated by reference for all that it discloses, may be incorporated with the present invention.

[0025] FIG. **2** and FIG. **3** are cross-sectional diagrams of a drill bit **200** comprising a location device **103** in communication with a database **201**. In some embodiments the database may be located uphole. The drill bit **200** comprises a body **202** intermediate a shank **203** and a working surface **204**. The location device **103** may be placed in a housing and in the drill bit **200** or farther up the tool string. The location device **103** may also be in communication with a timepiece **290** that may indicate the location time of an astrological object, and may be located uphole or downhole. The database **201** may comprise the locations relative to time of an astronomical object. The location device **103** may comprise a gravity measurement instrument **205** such as a relative gravimeter similar to the one shown in FIG. **2**. The gravimeter in FIG. **2** is a weight on a spring, and by measuring the amount by which the weight stretches the spring, local gravity may be measured. It is believed that by knowing the direction of the gravitational forces on the location device **103** one may calculate an angle **106** between the vector directions from which a location of the device **103** may be derived.

[0026] FIGS. **4-7** are orthogonal diagrams of a derrick **100** attached to a tool string **101** comprising a location device **103**. In FIGS. **4-7** the location device **103** is stationary relative to the Earth upon which it is positioned. Another astronomical object **102** that may create a vector direction **105** may move relative to the location device **103**. As the astronomical object **102** moves relative to the location device **103** it may continue to exert a gravitational force on the location device **103**. This gravitational force may be continuously measured by the location device **103** as the astronomical object **102** moves. FIGS. **4-7** shows a constant vector direction **105** toward the center of the Earth while the other vector direction **105** generated by the moon moves with the moon throughout FIGS. **4-7**. The location device **103** may be in communication with the database that may record this data. Knowledge of this data is believed to be important in downhole applications due to the unpredictability of the location of a drill bit during the drilling process. It is also believed that by knowing the location of the drill bit it may aid in locating substances such as oil, natural gas, coal methane, hydrocarbons, minerals, or a combination thereof. Other applications may arise where the location device **103** is placed on astronomical bodies such as the moon. As the location device is stationary relative to the moon the gravitational force of another astronomical object such as the Earth may be measured as it moves relative to the location device **103**, which may be useful for drilling or exploration applications on the moon.

[0027] FIG. **8** is an orthogonal diagram of a location device **103** situated within an underground enclosure, such as a cave. The location device **103** may be able to sense the gravitational forces that may create the vector directions **105** through a formation. The formation may be rock, limestone, mud, concrete, or a combination thereof. An angle **106** is formed by the two vector directions **105** and may be used to locate the device **103**.

[0028] FIG. **9** is an orthogonal diagram of a location device **103**. The location device **103** may measure the force of gravity from more than two astronomical objects **102** creating more than two vector directions **105**. FIG. **9** shows three vector directions caused by three astronomical objects. The astronomical objects **102** may be the Earth, the moon, a comet, the sun, stars, or a combination thereof.

[0029] FIG. **10** is an orthogonal diagram of a location device **103** on a mining machine **1001**. The location device **103** may be placed in or on the mining machine **1001**. The location device may travel with the mining machine and may take periodic or occasional readings while the mining machine is stopped to find its location. The location device **103** may be able to sense the gravitational forces of astronomical objects during the mining process creating at least two vector directions **105**. An angle **106** is formed by at least two vector directions **105** which may aid in locating the mining machine **1001**.

[0030] FIG. **11** is an orthogonal diagram of an airplane **1100** comprising a location device **103**. The location device **103** may be able to sense the gravitational pull and vector direction **105** of at least two astronomical objects **102**. As the plane **1100** moves the location device **103** may be in communication with a database that comprises the location of an astrological object **102**. In such embodiments, the gravity measurement device will take into account the movement of the airplane. Accelerometers, gyroscopes, magnetometers, may be used to take into account the movement of the airplane. In some embodiments, the altitude may also be taken into account.

[0031] FIG. **12** is an orthogonal diagram of a submergible object **1201** comprising a location device **103**. The location device **103** may be able to sense the gravitational force while submerged in a liquid **1202** of at least two astronomical objects **102**. The submergible object may be a submarine, a mine, a fish trap, a SCUBA diver, a scientific instrument or combinations thereof. In some embodiments, a depth may be used in conjunction with the gravity measuring device to help determine the location.

[0032] FIG. **13** is an orthogonal diagram of a person possessing a location device **103**. The location device **103** may be in wireless communication with a database. The database may comprise the location of an astronomical object **102** relative to time. The location device **103** may be in the form of a handheld device.

[0033] FIG. **14** is a method **1400** of locating the position of an object. The method **1400** comprises a step **1401** providing a gravity measurement instrument at a position within the universe. The method **1400** further comprises a step **1402** of knowing a position of at least two astronomical objects which each provide a gravitational force on the gravity measurement device. The method **1400** further comprises a step **1403** of measuring a gravitational field of the gravity measurement device. The method **1400** further comprises a step **1404** of calculating the position of the gravity measurement instrument from the gravitational field by determining a vector direction of the gravitational force from each astronomical object. In some embodiments, the method may comprise an additional step of including other information, such as information from another gravity measuring device or another sensor, as necessary to determine the location.

[0034] Whereas the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications apart from those shown or suggested herein, may be made within the scope and spirit of the present invention.

What is claimed is:

1. A location device, comprising;

a gravity measurement instrument in communication with a database;

the database comprising the locations relative to time of an astronomical object; and

a timepiece for indicating the time which may be used to determine the location of the astronomical object.

2. The location device of claim **1**, wherein the location device measures the gravitational force of at least two astronomical objects.

3. The location device of claim **1**, wherein the location device measures an angle created by the two gravitational vectors.

4. The location device of claim **3**, wherein the angle locates the position of the gravity measurement device.

5. The location device of claim **1**, wherein the timepiece is a clock, a digital time system, a watch, or a combination thereof.

6. A method for locating the position of an object, comprising the steps of;

providing a gravity measurement instrument at a position within the universe;

knowing a position of at least two astronomical objects which each provide a gravitational force on the gravity measurement device;

measuring a gravitational field of the gravity measurement instrument; and

calculating the position of the gravity measurement instrument from the gravitational field by determining a vector direction of the gravitational force from each astronomical object.

7. The method of claim **6**, wherein the gravity measurement instrument is a gravitometer, zero length spring, a Lacoste gravimeter, an absolute gravimeter, a superconducting gravimeter, or a combination thereof.

8. The method of claim **6**, wherein the location device is placed in caves, cities, jungles, a plane, a submergible machine, a space shuttle, satellite, or beneath the surface of an astronomical object.

9. The method of claim **6**, wherein the location device is placed on a plane, a submergible object, a space shuttle, a person, or on the surface of the astronomical object.

10. The method of claim **6**, wherein the location device is deployed downhole in a tool string.

11. The method of claim **6**, wherein the location device is placed within or on a mining machine.

12. The method of claim **6**, wherein the location device comprises quartz, metallic, elastomeric, plastic or a combination thereof.

13. The method of claim **6**, wherein the location device is stationary relative to the astronomical object upon which it is positioned.

14. The method of claim **6**, wherein the astronomical object is the Earth, the moon, a comet, the sun, stars, or a combination thereof.

15. The method of claim **6**, wherein the movement of the astronomical object is known or predictable.

16. The method of claim **6**, wherein a gravitational force from a third astronomical object is measured by the gravity measurement instrument.

17. The method of claim **6**, wherein the gravity measurement instrument is able to determine the gravitational force of the astronomical object as it moves.

18. The method of claim **6**, wherein the location of the gravity measurement instrument is recorded to the database at various points in a process.

19. The method of claim **1**, wherein the gravity measuring device in is communication with a second gravity measuring device.

20. The method of claim **1**, wherein the gravity measuring device is downhole one of the astronomical objects and incorporated in a tool string and the second gravity measuring device is on a surface of the astronomical object.

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