ROTARY CAM DRIVEN FREE FALL DROPPING CHAMBER MECHANISM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is filed pursuant to Provisional Application Serial No. 60/109,423 filed on Nov. 19, 1998 and entitled, ROTARY CAM DRIVEN FREE FALL DROPPING CHAMBER MECHANISM.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to instruments for measuring gravity. More particularly, the invention relates to a cam mechanism for creating the free fall for a measuring mass of a gravimeter.

2. Description of the Prior Art

A gravimeter is an instrument which measures the local acceleration due to gravity. The variations of the acceleration due to gravity at various points of the surface of the earth, or at various elevations may be used to make determinations of the underlying geologic structure. To accomplish such ends, it is necessary to make extremely small measurements of the acceleration due to gravity with high accuracy, on the order of 10^{-9}. To this end, typical gravimeters, which are relative instruments (they only measure differences in gravity). have a measuring mass suspended by a spring assembly. Deflection of the measuring mass from a zero position may be sensed by a photo-electric pick-off, and a restoring force generator moves the mass to the zero position, with the required adjusting movements providing an indication of the local gravity. These types of gravimeters suffer from several drawbacks, the most significant of which is that the springs in the spring assembly are subject to variations in their spring constant which affects the accuracy of any measurement made by the system.

Another (and absolute) type of gravimeter measures the free fall rate of a measuring mass to determine the local acceleration due to gravity. The free fall rate of the mass, which is dropped in an evacuated chamber called a dropping chamber, may be determined using various types of photoelectric assemblies such as an interferometer to generate signals from which the free fall rate, and thus the value of acceleration due to gravity may be determined.

Modern absolute gravimeters apply the methods of optical interferometry to the motion of a freely falling test mass containing a corner cube. This corner cube, or optical retro-reflector, serves as a rotation insensitive mirror in a Michelson type of interferometer. The position, and therefore the rate of free fall, of the mass may be accurately monitored by closely observing the optical fringes generated by the motion of the corner cube. A freely falling test mass from which the local acceleration due to gravity can be obtained is created by employing a mechanical apparatus within the dropping chamber. The mechanical apparatus must perform the following functions to create a falling mass from which error free measurements can be made. First the apparatus must have a platform or cart upon which the mass may be stably supported. Second, the cart must be capable of smooth acceleration to a downward velocity sufficient to effect a release of the mass from the cart. Third, the cart must decelerate at a velocity effective to cause a soft catch of the mass. Finally, the cart must lift the mass back to the starting position so that the procedure may be repeated. Prior art gravimeters of the free fall type have created drops of varying lengths using an opto-electronic motor belt drive assembly, with a typical drop length of about 20 cm. The maximum repetition rate is about twenty to thirty repetitions per minute although in practice a repetition rate of about 2 to 3 per minute is common. This allows for settling down of the mechanism after completing a cycle to avoid inaccurate measurements.

These systems suffer from additional drawbacks. The lift-off creating mechanism may impart rotational or other undesired movement to the measuring mass thereby affecting the accuracy of the measurement. Finally, the assemblies are relatively large and heavy, making them difficult for use in the field or in any application where portability is required.

Accordingly, it would be desirable to provide an instrument for measuring the local acceleration due to gravity which does not suffer from the drawbacks of the prior art gravimeters.

SUMMARY OF THE INVENTION

Briefly, the invention comprises an improved gravimeter mechanism having a mass balanced cam with mutually opposed camming surfaces for controlling the free fall of a measuring mass. The cam is attached to a camshaft which turns at a constant rate, the rate being selected so that the drop time appropriate to achieve lift-off of the dropped object together with the time required to return to the start position equals the cam's rotational period. The mutually opposed camming surfaces cooperate to drive both a cart which supports a measuring mass and a compensating mass which is built into the gravimeter mechanism. The cam drives the cart, the measuring mass, and the compensating mass so that the time varying reduction in weight produced when the measuring mass is in free fall is exactly compensated by the compensating mass which is driven by the opposing camming surface. The opposing camming surface is displaced from the lift off region of the camming surface which drives the cart and measuring mass by 180 degrees. The measuring mass contains a mirror element of a Michelson interferometer, and the interferometer produces a signal indicative of the rate of free fall, which is directly proportional to the local gravity.

It is a major object of this invention to provide an improved gravimeter apparatus.

It is another object of this invention to provide an improved mechanism for causing the free fall of an object.

It is another object of the invention to provide an improved mechanism for causing the free fall of an object which utilizes a cam to initiate the free fall of the object, effect release of the object, and provide a soft catch of the object before returning it to the start position.

It is another object of the invention to provide an improved mechanism for causing the free fall of an object which includes a compensating mass for canceling any weight change caused by the acceleration and the free fall of the object.

It is another object of the invention to provide an improved mechanism for causing the free fall of an object which utilizes a double cam for causing free fall of the object as well as effecting an opposing weight compensating motion of a compensating mass.

It is another object of the invention to provide an improved mechanism for causing the free fall of an object which is capable of providing up to three measurements per second.