ALTERED SWEEP BELL-BLOOM MAGNETOMETER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of magnetometers. More specifically, the present invention relates to a Bell-Bloom magnetometer having an altered sweep.

2. Description of the Related Art

Magnetometers are used to measure the strength and direction of a magnetic field. They can be useful in measuring minute changes in the Earth's magnetic field that allow users to identify geological conditions under the Earth's surface, such as the location of oil and mineral deposits, as well as other conditions.

FIG. **1** is a diagram of a typical Bell-Bloom Magnetometer. A Bell-Bloom Magnetometer involves the use of a photon emitter **100** containing a cesium light emitter or lamp, an absorption cell **102** containing cesium vapor and sometimes a "buffer gas", and a photon detector **104**. The photon emitter **100** emits photons through the absorption cell **102** and the photo detector **104** detects changes in the photons that pass through the cesium vapor.

The basic principle that allows the device to operate is the fact that a cesium atom can exist in any of nine energy levels, which involve the placement of electron atomic orbital's around the atomic nucleus. When a cesium atom within the cell encounters a photon from the emitter, it jumps to a higher energy state and then re-emits a photon and falls to an indeterminate lower energy state. The cesium atom is "sensitive" to the photons from the emitter in three of its nine energy states, and therefore all of the atoms will fall into a state through which all the photons from the emitter will pass through unhindered and measured by the photon detector. At this state, the Cesium in the cell is saturated.

Once the Cesium is saturated, the system is prepared for the measurement procedure. The axis of the spin and orbital motion of the electrons precesses about the ambient magnetic field. This precession causes the alignment between the electron and the light to vary, in a cyclic manner, between an alignment that favors the absorption of light and one that reduces the absorption. If the light is pulsed on and off at the same frequency as the precession rate of the electrons, those electrons that are aligned such that they absorb the light will be drive to a higher energy level. These electrons will then fall back to the lower state. When the electrons return to the lower state, the phase of their precession will have been changed. If the precession is now such that the electron is aligned so as to not absorb light when the light pulses on, the electronic will remain in this state. Thus, when the light is pulsed on and off at a rate equal to the precession rate, the absorption in the cell is decreased.

The light from the emitter is typically swept on an off of what is called an absorption line. This is the wavelength at which the absorption in the cell is maximized. In existing Bell-Bloom systems, the absorption line is swept at a frequency known as the Larmor frequency, which is the resonate frequency of the underlying material and is proportional to the strength of the magnetic field. FIG. **2** is a diagram of the typical sweep on and off the absorption line at the Larmor frequency. As can be seen, the wavelength of light **200** from the emitter is varied in an attempt to approach right up to, and then come off, the center of the absorption line **202**, and the rate of variation is performed at the Larmor frequency **204**.

A Bell-Bloom magnetometer typically tracks the variation in the Larmor frequency, which can be used to track the

strength of the magnetic field, by slightly varying the rate at which the emitter is swept and observing the variation in absorption with the frequency of the sweeping.

The absorption line, however, is not a single line but a small group of lines that are wider than their spacing so as to appear as a single line. The Larmor frequency for the different sub lines is slightly different. As the emitter is swept off the line, it tends to bias towards the line on the side to which it is sweeping. As a result, the details of the sweeping waveform affect the absolute value of the reading, leading to drift and heading error. Additionally, the signal gain varies with the angle between the ambient field and the light path. This causes the frequency response of the system to vary, leading to inaccuracies.

Furthermore, a semiconductor laser emitter does not naturally produce the exact wavelength of light needed. The wavelength is controlled by varying the temperature of the laser. The laser is tuned to the center of the line by varying its own "on the line" point slightly and adjusting it so that the absorption decreases equally on each side. This variation in the tuning of the laser causes a variation in the Larmor frequency which appears a variation in the measured magnetic field.

What is needed is a solution that does not suffer from the drawbacks of the prior art.

SUMMARY OF THE INVENTION

A magnetometer is constructed wherein the sweeping is performed at one half the Larmor frequency and has as its center the absorption line. This allows the emitter to tune onto the absorption line twice per cycle as it passes through the line. This causes the increase in absorption as would the normal sweep of a Bell-Bloom magnetometer but avoids the drawbacks, such as drift and heading error.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram of a typical Bell-Bloom Magnetometer.

FIG. **2** is a diagram of the typical sweep on and off the absorption line at the Larmor frequency.

FIG. **3** is a diagram of a sweep through the absorption line at one half the Larmor frequency in accordance with an embodiment of the present invention.

FIG. **4** is a block diagram of an example a closed loop automatic gain control circuit in accordance with an embodiment of the present invention.

FIG. **5** is a diagram illustrating a signal composed of a small fundamental and a much larger even harmonic.

FIG. **6** is a flow diagram illustrating a method for approximation of a function for frequency response correction in a magnetometer in accordance with an embodiment of the present invention.

FIG. **7** is a block diagram illustrating a portion of a Bell-Bloom magnetometer in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

Reference will now be made in detail to specific embodiments of the invention including the best modes contemplated by the inventors for carrying out the invention. Examples of these specific embodiments are illustrated in the accompanying drawings. While the invention is described in conjunction with these specific embodiments, it will be understood that it is not intended to limit the invention to the described embodiments. On the contrary, it is intended to cover alternatives,