

OPTICAL FIBER MAGNETIC SENSOR

TECHNICAL FIELD

The invention relates to an optical fiber magnetic sensor.

BACKGROUND ART

Methods for detecting magnetism through the utilization of the interference of an optical fiber can be classified into three methods:

(1) a method wherein a magnetostrictive element is utilized;

(2) a method wherein Faraday effect is utilized; and

(3) a method wherein electromagnetic force is utilized.

All the methods (1) to (3) utilize a phenomenon such that the application of magnetic fields causes a change in the state of light propagating through the optical fiber or creates a strain in the optical fiber. Among these methods, in principle, the method (3) utilizing electromagnetic force has been regarded as having the highest sensitivity.

Fig. 1 is a diagram showing an example of the conventional optical fiber magnetic sensor, and Fig. 2 a diagram showing the principle of the conventional optical fiber magnetic sensor.

As shown in Fig. 1, in the method utilizing electromagnetic force, a given current is allowed to flow into a closed circuit composed of: a metal-clad optical fiber 3 which has been linearly stretched using a metallic fixture 1, fixed to an insulating body 4 of equipment, and a fixing

material 2 and both ends of which have been fixed; an alternating-current power supply 5; and a lead 6. At that time, this method utilizes a phenomenon such that, as shown in Fig. 2, upon the application of an external magnetic field 7, vibratory electromagnetic force is generated in the metal-clad optical fiber 8 in a direction indicated by an arrow. Further, a system wherein both ends of the optical fiber have been fixed by means of clamps 10 so as to maintain a given tension and an alternating-current power supply 9 has been connected to both the clamps 10 through a lead 11, functions as a resonance system. Therefore, when an alternating current having a specific frequency is supplied, the sensitivity to magnetism becomes very good by virtue of the resonance effect of the system (Japanese Patent Laid-Open Nos. 520276/1988 and 35284/1989).

A dipping method, wherein a molten metal is added at the time of drawing, has been used as a method for applying a metal cladding, serving as a major portion through which a current is allowed to flow and which receives electromagnetic force, onto a material fiber for an optical fiber. Cladding materials include aluminum, copper, and nickel.

Although the method utilizing electromagnetic force has been regarded as having the highest sensitivity, the prior art technique, as shown in Fig. 1, using a magnetic detecting section with an optical fiber being linearly supported, had the following problems.

(1) Narrow frequency response

In Japanese Patent Laid-Open No. 52076/1988, there is no

description on the frequency response. Japanese Patent Laid-Open No. 35284/1989 describes that measurement at a frequency up to 100 Hz is possible because the mechanical resonance frequency is 170 kHz at a supporting interval of 115 mm. In fact, synchronous detection is performed at a mechanical resonance frequency around 170 kHz. Therefore, judging from Q value of resonance, the frequency response is as low as about 0.5% of the resonance frequency. This indicates that only a change in magnetism of about 0.8 Hz in terms of frequency can be detected. Therefore, only magnetism substantially close to direct current (DC) can be detected. This significantly limits applications of this method. For example, a supporting interval of 1/10 is required to provide a frequency response of 80 Hz which is satisfactory from the practical viewpoint. In this case, however, the sensitivity is significantly lowered to 10^{-5} , making it difficult to apply this method to ordinary applications.

(2) Dependency of characteristics upon tension

Tension occurs in an optical fiber which has been linearly held by supporting at two points. A change in the tension results in a significant change in sensitivity and resonance frequency. The fixtures used respectively in two points for supporting the optical fiber are generally fixed to a common body of equipment to apply a given tension to the optical fiber. However, when the optical fiber, the fixture, and the body of equipment do not have an identical coefficient of thermal expansion, the tension of the optical fiber varies depending upon the temperature, leading to a significant change

in characteristics of the sensor. On the other hand, in such a state that the optical fiber has been suspended, that is, in such a state that there is little or no tension, expansion of the optical fiber per se due to a temperature change leads to a change in tension.

(3) Low reliability

When the conventional dipping method is used in the formation of metal cladding on an optical fiber, at the time of cooling after drawing, the shrinkage of the metal is larger than that of glass. This causes the application of a large lateral pressure to the optical fiber, which is causative of increased loss and cracking. For this reason, the reliability is low. In order to provide good sensitivity, the thickness of the metal cladding should be large enough to permit a large current to flow. The thick metal cladding, however, causes an initial structural strain in the optical fiber per se or irreversible external deformation. This makes it difficult to provide stable characteristics.

Accordingly, it is an object of the invention to solve the above problems and to provide an optical fiber magnetic sensor which has good frequency response and sensitivity, excellent resistant to environments, such as temperature and vibration, and high reliability.

DISCLOSURE OF INVENTION

In order to attain the above object of the invention, according to the first feature of the invention, an optical fiber magnetic sensor comprises: a metal-clad optical fiber of

an optical fiber clad with a metal; an alternating-current power supply for allowing an alternating current to flow into the metal cladding in the metal-clad optical fiber; and an optical interferometer which detects, as a strong or weak light signal, a change in optical path difference attributable to expansion or contraction caused in the longitudinal direction of the optical fiber or a change in lateral pressure caused in the radial direction of the optical fiber, these changes having been caused by interaction with external magnetic flux, characterized in that the metal-clad optical fiber has been circularly or spirally formed so as to keep a constant radius which imparts, to the optical fiber, a bending stress large enough for a magnetic detecting section for detecting the external magnetic flux to dynamically regard the optical fiber substantially as a rigid body, and has been fixed so that the mechanical resonance frequency in a magnetic detecting section is determined by the radius of the circle or the spiral and the structure of the optical fiber and so that the circular shape or the spiral shape does not depend upon interval, regularity, and fixation method.

According to the second feature of the invention, an optical fiber magnetic sensor comprises: a metal-clad optical fiber of an optical fiber clad with a metal; an alternating-current power supply for allowing an alternating current to flow into the metal cladding in the metal-clad optical fiber; and an optical interferometer which detects, as a strong or weak light signal, a change in optical path difference attributable to expansion or contraction caused in the

longitudinal direction of the optical fiber or a change in lateral pressure caused in the radial direction of the optical fiber, these changes having been caused by interaction with external magnetic flux, wherein the metal-clad optical fiber has been elliptically formed so as to keep a radius which imparts, to the optical fiber, a bending stress large enough for a magnetic detecting section for detecting the external magnetic flux to dynamically regard the optical fiber substantially as a rigid body, and has been fixed so that the mechanical resonance frequency in a magnetic detecting section is determined by the major axis and minor axis of the ellipse and the structure of the optical fiber and so that the elliptical shape does not depend upon interval, regularity, and fixation method.

In addition to the above construction, in the optical fiber magnetic sensor according to the invention, preferably, the metal cladding provided on a material fiber for the optical fiber comprises a not more than 2 μm -thick nickel layer as a first layer formed by electroless plating and a not more than 5 μm -thick gold layer as a second layer formed by electroplating.

According to the invention, a metal-clad optical fiber for detecting external magnetic flux through which an alternating current is allowed to flow, is formed circularly or spirally so as to keep a constant radius which provides a satisfactorily large stress in the optical fiber. In order to hold this shape, a fixation point independently of interval, regularity, and fixation method is provided. An alternating current having a relatively high frequency (a frequency which

is higher by about two orders in a diameter substantially identical to the length of the conventional linear magnetic detecting section) is allowed to flow into the fixation point.

The prior art technique (Japanese Patent Laid-Open Nos. 52076/1988 and 35284/1989) is different from the invention in that, as shown in Fig. 2, in a string having a given Young's modulus defined between two fixation point clamps 10 as nodes, transverse waves (displacement occurs in a direction normal to the longitudinal direction of the optical fiber) are used as resonance points of the system. Fig. 3 is a diagram showing the principle of the optical fiber magnetic sensor according to the invention.

As shown in Fig. 3, when there is a magnetic field 12 which is normal to the surface of paper and advances from the backside toward the front surface, a metal-clad optical fiber 13 is held in a circular or spiral form by two clamps 14 or other fixture so as to keep a given radius in such a manner that the circles or spirals do not come into contact with each other. An alternating-current power supply 15 is connected to both the clamps 14, and an optical interferometer (not shown) is connected to the metal-clad optical fiber 13.

The reason why the metal-clad optical fiber 13 should be held so that the circles do not come into contact with each other is to allow a current to properly flow through the metal cladding in the circular optical fiber. The stress in the curved portion of the metal-clad optical fiber 13 is much larger than that in the linear portion of the metal-clad optical fiber 13. Longitudinal waves (displacement occurs in

the longitudinal direction of the optical fiber) in a sound wave, which propagates through a medium of the optical fiber per se regarded substantially as a rigid body, causes the resonance of the metal-clad optical fiber 13 in its curved portion. This can provide a much higher resonance frequency than that in the conventional linear sensor even when the dimension is substantially the same as that of the conventional linear sensor. Thus, the measuring range can be broadened. This can be realized by allowing an alternating current having a high frequency according to the measuring range to flow into a closed circuit composed of a metal-clad optical fiber 13, an alternating-current power supply 15, and a lead 16. Further, since the resonance frequency is determined by the magnitude of the stress, when an identical optical fiber is used, decreasing the bend radius increases the resonance frequency and thus can improve the frequency response. In this case, the resonance frequency is determined by the bend radius. Therefore, when a spiral form is adopted while maintaining the identical bend radius to increase the number of turns, the sensitivity can be improved substantially in proportion to the number of turns while maintaining the resonance frequency. Thus, an improvement in sensitivity can be achieved.

Further, according to the invention, the displacement of the optical fiber occurs in the longitudinal direction (axial direction) of the optical fiber, and the displacement does not occur in a direction normal to the longitudinal direction (axial direction) of the optical fiber, that is, in the radial direction of the optical fiber. Therefore, changing the

interval or position of the fixation points does not cause a change in resonance frequency. Maintaining only the accuracy of the bend radius suffices for contemplated results, and the performance is less likely to be influenced by the position of the fixation points and the fixation method.

On the other hand, the metal-clad optical fiber used is such that a metal cladding has been provided on a material fiber for the optical fiber by forming a not more than 2 μm -thick nickel cladding as a first layer by electroless plating and forming a not more than 5 μm -thick gold cladding as a second layer by electroplating. In the case of the plating method, unlike the dipping method, substantially no lateral pressure is applied to the optical fiber after the completion of the cladding treatment. This can improve the reliability of the metal-clad optical fiber, and can significantly reduce loss and cracking. The use of gold in the outer cladding can provide a magnetic detecting section having excellent corrosion resistance.

When the thickness of the outer metal cladding in the optical fiber is increased, the mechanical properties of the metal-clad optical fiber is more governed by gold rather than glass. The larger the thickness of the gold layer, the larger the current which can be allowed to flow and the higher the sensitivity. In this case, however, initial structural strain or irreversible external deformation occurs in the optical fiber per se. Since the glass is highly elastic, the shape of the glass is returned to the original shape upon the elimination of the external force. The reliability of the

magnetic detecting section can be enhanced by limiting the thickness of the gold to a level (not more than 5 μm) such that the properties of the metal-clad optical fiber are satisfactorily governed by the properties of the glass.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an explanatory view of an example of the conventional optical fiber magnetic sensor;

Fig. 2 is a diagram showing the principle of the conventional optical fiber magnetic sensor;

Fig. 3 is a diagram showing the principle of an optical fiber magnetic sensor according to the invention;

Fig. 4 is a block diagram showing one embodiment of the optical fiber magnetic sensor according to the invention;

Fig. 5 is an explanatory view of a variant of the optical fiber magnetic sensor according to the invention; and

Fig. 6 is an explanatory view of an application example of the optical fiber magnetic sensor according to the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the invention will be described in more detail in conjunction with the accompanying drawings.

Fig. 4 is a block diagram showing one embodiment of the optical fiber magnetic sensor according to the invention.

This optical fiber magnetic sensor comprises: metal-clad optical fiber coils 18, 19 each comprising an optical fiber clad with a metal; an oscillator 25 as an alternating-current power supply for allowing an alternating current to flow into

the metal cladding in the metal-clad optical fiber coil 19; and an optical interferometer which detects, as a strong or weak light signal, a change in optical path difference attributable to expansion or contraction caused in the longitudinal direction of the optical fiber or lateral pressure caused in the radial direction of the optical fiber, these changes having been caused by interaction with external magnetic flux.

The metal-clad optical fiber coils 18, 19 is circularly (or spirally) formed so as to keep a given radius which imparts, to the optical fiber, a bending stress large enough for a magnetic detecting section for detecting the external magnetic flux to dynamically regard the optical fiber substantially as a rigid body, and is fixed so that the mechanical resonance frequency in the magnetic detecting section is determined by the radius of the circle (or the spiral) and the fiber structure and so that the circular shape (or the spiral shape) does not depend upon interval, regularity, and fixation method.

An elliptical shape may be adopted instead of the circular shape. In this case, the mechanical resonance frequency of the magnetic detecting section is determined by the major axis and minor axis of the ellipse and the fiber structure. Mach-Zehnder interferometer may be used as the optical interferometer.

The optical interferometer comprises: a light source 17; an optical fiber coupler 30 for branching light from the light source 17 into signal light and reference light; a metal-clad optical fiber coil 19 which is connected to one output terminal (lower side in the drawing) of the optical fiber coupler 30 and

through which signal light propagates; a metal-clad optical fiber coil 18 which is connected to the other output terminal (upper side in the drawing) of the optical fiber coupler 30 and through which reference light propagates; phase modulators 20, 21 which are connected respectively to the metal-clad optical fiber coils 18, 19; an optical fiber coupler 31 which is connected to the phase modulators 20, 21 and functions to superimpose the signal light and the reference light on each other; photodetectors 22, 23 which are connected to the optical fiber coupler 31 and function to convert light to an electric signal; a differential amplifier 27 which receives electric signals from both the photodetectors 22, 23 and differentially amplifies the signals; synchronous detectors 28, 29 which synchronously detect signals output from the differential amplifier 27; an amplifier 24 which amplifies a signal output from the synchronous detector 28 and sends the amplified signal to the phase modulator 21; and an oscillator 26 for sending a signal to the phase modulator 20 and the differential amplifier 27.

Light from the light source 17 is introduced through the optical fiber into the optical fiber coupler 30. In the optical fiber coupler 30, the light is separated into two parts which advance through respective light paths. One light as reference light is passed through the metal-clad optical fiber coil 18 and the phase modulator 20 and enters the optical fiber coupler 31.

On the other hand, light branched as signal light in the optical fiber coupler 30 is passed through the metal-clad

optical fiber coil 19 and the phase modulator 21 and enters the optical fiber coupler 31 where the signal light is superimposed on the reference light. From the oscillator 25 having a frequency substantially identical to the resonance frequency of the metal-clad optical fiber coil 19, an alternating current having a given effective value is allowed to flow through the metal cladding in the metal-clad optical fiber coil 19 through which the signal light propagates.

An alternating signal having a voltage of a given effective value for detecting a drift of the Mach-Zehnder interferometer is applied from the oscillator 26 to the phase modulator 20.

In the photodetectors 22, 23, the light signals are converted to electric signals which are sent to the differential amplifier 27 where the DC component is removed from the electric signals which are then sent to the synchronous detectors 28, 29.

In the synchronous detector 28, the drift of the Mach-Zehnder interferometer, that occurs in a component of which the frequency is twice that of the oscillator 26, is extracted by synchronous detection. The drift signal is sent through the amplifier 24 to the phase modulator 21, and feedbacked to the Mach-Zehnder interferometer. As a result, the component, of which the frequency is twice that of the oscillator 26, unlimitedly becomes close to zero. That is, a feedback control loop is established that can realize a stable working point which maximizes the sensitivity of the Mach-Zehnder interferometer, whereby the drift is removed.

In the synchronous detector 29, a magnetic information signal having a frequency component of the oscillator 25 is extracted by synchronous detection. This output becomes sensor output.

Next, variants of the optical fiber magnetic sensor according to the invention will be described.

(1) Two-point (tandem) magnetic sensor

In the optical fiber magnetic sensor shown in Fig. 4, for convenience, two optical paths of the Mach-Zehnder interferometer were fixed respectively as the reference light path and the signal light path. However, when a signal source is provided in each of the light paths, mutually, the optical path on the counter side can be regarded as a reference light path. Specifically, a current is allowed to flow into the metal-clad optical fiber coil 18, through which any current is not allowed to flow in the optical fiber magnetic sensor shown in Fig. 4. This variant is shown in Fig. 5.

Fig. 5 is a block diagram showing a variant of the optical fiber magnetic sensor according to the invention. In the Figs. 4 and 5, like parts of the optical fiber magnetic sensor have the same reference numerals.

The optical fiber magnetic sensor shown in Fig. 5 is such that, in addition to the oscillator 25, the metal-clad optical fiber coil 19, and the synchronous detector 29 as the signal system of the optical fiber magnetic sensor shown in Fig. 4, a new signal system of an oscillator 32 and a synchronous detector 33 was provided to constitute a new signal system. In these two signal systems, the frequency may be set by the

following two methods (a) and (b).

(a) The oscillation frequencies of the oscillators 25, 32 are made substantially identical respectively to the resonance frequencies of the metal-clad optical fiber coils 18, 19. When the oscillation frequency of the oscillator 25 is substantially identical to that of the oscillator 32, that is, when the resonance frequency of the metal-clad optical fiber coil 18 is substantially identical to that of the metal-clad optical fiber coil 19, a two-fold output can be realized in the same intensity of magnetism, thus enabling an enhancement in sensitivity.

(b) When the oscillation frequency of the oscillator 25 is different from that of the oscillator 32, that is, when the resonance frequency of the metal-clad optical fiber coil 18 is different from that of the metal-clad optical fiber coil 19, two sensors are simultaneously operated. That is, in spite of the fact that only one Mach-Zehnder interferometer is used, the same results as obtained by using two sensors can be obtained.

(2) Highly sensitive magnetic sensor

When the number of turns are increased while maintaining the bend radius at a given value, the sensitivity is increased substantially in proportion to the number of turns. When the resonance frequencies of the turns fall within a given accuracy range, the sensitivity is superimposed. Even in the case of 50 turns (60ϕ), about 1/100 of geomagnetism can be detected in a response of several tens of Hz. Increasing the number of turns can realize a magnetic sensor having an unprecedentedly high sensitivity.

(3) Broad-band magnetic sensor

A magnetic sensor with a broader bandwidth can be provided by winding, by a large number of turns, the metal-clad optical fiber using a tapered fixture or the like while gradually shifting the radius of the turn. For example, in the case of one turn, when the bandwidth (a point at which the value is halved) of the sensor is 20 Hz, a bandwidth of (number of turns x 40 Hz) can be provided by varying the bend radius so as to shift the resonance frequency 40 Hz by 40 Hz. In the case of 25 turns, the band reaches 1 kHz.

This optical fiber magnetic sensor can be used instead of the conventional magnetic sensors, and, in addition, can be applied to application fields, where the conventional magnetic sensors could not have hitherto been applied, through the utilization of the features of high sensitivity and high response.

(4) Current distribution sensor

The spatial distribution of current generating magnetism can be learned by measuring the magnetism. For example, multi-stage arrangement of small-size sensors of the invention around a superconducting coil conductor enables the application of the sensors to the determination of the spatial distribution of current in the superconducting conductor.

(I) Observation of natural magnetism

(a) Geomagnetism

Detection of a change in geomagnetism through the utilization of the high sensitivity performance can lead to a possibility of the detection of crustal alteration, a change in

active fault and the like. Further, the detection of a change in geomagnetism in a high frequency region, which could not have been performed by the conventional sensor due to its poor response, is also possible. This can provide useful information for the prediction of earthquakes.

(b) Magnetic organisms

For example, the detection of the presence of magnetic bacteria, which live in water, through the utilization of high sensitivity performance enables the application of the sensor to the detection of groundwater in field non-open-cut state, the detection of water leakage of a water supply, and the detection of wetting of the ground in a non-contact manner.

(c) A magnetic field occurs around the stream of charged particles. The detection of the magnetic field enables the measurement of the direction, flow rate, flow velocity, or composition of the flow of a fluid containing charged particles and the like in a non-contact manner. There is a possibility of the application of the sensor to rivers, groundwater, the ocean and the like.

(II) Observation of magnetism of human body

(a) Magnetism generated by internal current of brain and nervous system

Minute and pulsed current flows in cerebral nerve or the like. Therefore, the current should cause a minute change for a short period of time in magnetic field. The measurement of the change in magnetic field through the utilization of good sensitivity and response performance permits the waveform of current flowing through brain or nerve to be indirectly

learned without inserting an electrode into the body.

(b) Magnetism generated by blood stream

Blood contains charged particles such as ions, and the flow of the charged particles through blood vessels results in the generation of magnetism. Further, the blood contains magnetic substances, and the movement of these magnetic substances through blood vessels possibly changes the magnetism. The detection of the change in magnetism can provide information, for example, on a pulsation in the circulatory system and the flow rate and components of a body fluid.

(c) Other magnetism within body

When a magnetic substance harmful to the human body has been accumulated in some internal organ, the investigation of the magnetic properties of the organ enables the assay of the accumulation level. Likewise, when a magnetic object has entered or stayed within the body by an accident or the like, the position of the object can be detected without an incision.

Further, for example, when a contrast radiograph of a digestive system is taken, a contrast medium containing a magnetic component is administered followed by magnetic photographing can eliminate the need to perform conventional radiographing and thus can prevent the exposure of a subject.

(III) Detection of metals and magnetic substances

(a) Detection of buried metal bodies

Magnetic metal bodies buried in the ground can be detected, and the position thereof can be specified. The sensor can be applied to the investigation of piping of iron pipes in the ground, the detection of mineral resources, and

the detection of metallic dangerous materials, such as land mines and misfires.

(b) Detection of running vehicles

When an object containing a magnetic body, such as a vehicle, passes around the sensor, the geomagnetism around there is disturbed, and this appears as an output of a change in magnetism in the optical fiber magnetic sensor. Therefore, the detection of vehicles can be realized. An embodiment of the application of the sensor to the detection of running vehicles is shown in Fig. 6.

Fig. 6 is an explanatory view of an embodiment of the application of the optical fiber magnetic sensor according to the invention and corresponds to the block diagram shown in Fig. 5.

A vehicle 50 runs on a road 47 and passes over an optical fiber magnetic sensor 48 (a metal-clad optical fiber coil 19) and an optical fiber magnetic sensor 49 (a metal-clad optical fiber coil 18) in that order. In this embodiment, the optical fiber magnetic sensors 48, 49 are buried in the road 47. Alternatively, these magnetic sensors may be provided at the upper part or on the side of the road 47.

The output of the optical fiber magnetic sensor 48 and the output of the optical fiber magnetic sensor 49 are shown respectively in output data 52 (sensor output 1) and output data 54 (sensor output 2), wherein the initiation point of the abscissa represents an identical time. The abscissa represents the time with the identical time being the initiation point, and the ordinate represents the output of the optical fiber

magnetic sensor.

As soon as the vehicle 50 has passed over the optical fiber magnetic sensor 48, a vehicle detection waveform 55 is first output. After the elapse of a given time, the vehicle 50 passes over the optical fiber magnetic sensor 49, and a vehicle detection waveform 53 is output. The amounts 51, 56 of geomagnetism detected are those in the case where the vehicle 50 is absent in these points. The use of the sensor outputs enables the running speed of the vehicle 50 to be calculated based on the difference in rise time between the two output waveforms 53, 55. Further, the type of the vehicle can be distinguished from the output waveform pattern. Moreover, the length of the vehicle can be calculated based on the speed and the time period of the output waveforms.

(c) Measurement of fluid

A magnetic field occurs around the stream of charged particles. The detection of this magnetic field enables the measurement of, for example, the flow direction, flow rate, flow velocity, or composition of a fluid containing charged particles in a non-contact manner. This can be extensively applied to water and sewage, exhaust pipes and the like.

INDUSTRIAL APPLICABILITY

As described above, the invention has the following excellent effects.

The invention can provide an optical fiber magnetic sensor which has good frequency response and sensitivity, excellent resistance to environments such as temperature and

vibration, and high reliability.

CLAIMS



1. An optical fiber magnetic sensor comprising: a metal-clad optical fiber of an optical fiber clad with a metal; an alternating-current power supply for allowing an alternating current to flow into the metal cladding in the metal-clad optical fiber; and an optical interferometer which detects, as a strong or weak light signal, a change in optical path difference attributable to expansion or contraction caused in the longitudinal direction of the optical fiber or a change in lateral pressure caused in the radial direction of the optical fiber, these changes having been caused by interaction with external magnetic flux, characterized in that the metal-clad optical fiber has been circularly or spirally formed so as to keep a constant radius which imparts, to the optical fiber, a bending stress large enough for an electrical detecting section for detecting the external magnetic flux to dynamically regard the optical fiber substantially as a rigid body, and has been fixed so that the mechanical resonance frequency in a magnetic detecting section is determined by the radius of the circle or the spiral and the structure of the optical fiber and so that the circular shape or the spiral shape does not depend upon interval, regularity, and fixation method.

2. The optical fiber magnetic sensor according to claim 1, characterized in that the metal cladding provided on a material fiber for the optical fiber comprises a not more than 2 μm -thick nickel layer as a first layer formed by electroless plating and a not more than 5 μm -thick gold layer as a second



layer formed by electroplating.

3. An optical fiber magnetic sensor comprising: a metal-clad optical fiber of an optical fiber clad with a metal; an alternating-current power supply for allowing an alternating current to flow into the metal cladding in the metal-clad optical fiber; and an optical interferometer which detects, as a strong or weak light signal, a change in optical path difference attributable to expansion or contraction caused in the longitudinal direction of the optical fiber or a change in lateral pressure caused in the radial direction of the optical fiber, these changes having been caused by interaction with external magnetic flux, characterized in that the metal-clad optical fiber has been elliptically formed so as to keep a radius which imparts, to the optical fiber, a bending stress large enough for a magnetic detecting section for detecting the external magnetic flux to dynamically regard the optical fiber substantially as a rigid body, and has been fixed so that the mechanical resonance frequency in a magnetic detecting section is determined by the major axis and minor axis of the ellipse and the structure of the optical fiber and so that the elliptical shape does not depend upon interval, regularity, and fixation method.

4. The optical fiber magnetic sensor according to claim 3, characterized in that the metal cladding provided on a material fiber for the optical fiber comprises a not more than 2 μm -thick nickel layer as a first layer formed by electroless plating and a not more than 5 μm -thick gold layer as a second layer formed by electroplating.