[0024] **FIG. 7** is a side elevation view of the haptic interface device shown in **FIG. 6**;

[0025] **FIG. 8** is a schematic perspective view of a haptic interface device according to the present invention;

[0026] **FIG. 9A** shows a physical relationship between a coil and a magnet in the haptic interface device shown in **FIG. 8** viewed from above;

[0027] **FIG. 9B** shows a side elevation view of the haptic interface device with a part of its housing removed; and

[0028] **FIG. 10** is a schematic perspective view of a variation of the haptic interface device shown in **FIG. 8**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0029] Preferred embodiments of the present invention will now be described with reference to the drawings.

[0030] First Embodiment

[0031] **FIG. 1** shows a simplified perspective view of one embodiment of a haptic interface device according to the present invention. **FIG. 2** is a plan view of the haptic interface device shown in **FIG. 1** with the top of its housing removed. **FIG. 3** is a side elevation view of the haptic interface device shown in **FIG. 2**. **FIG. 4** shows the haptic interface device **2** installed in the underside of a vehicle steering wheel.

[0032] Shown in **FIG. 1** are the main unit of the haptic interface device **2** of the present embodiment and a state sensor unit **4**, which is provided separately from the main unit and connected with the main unit through a connection line **6**. The main unit of the haptic interface device **2** is installed in the underside of the steering wheel **8**, with only an operating member **12**, which is operated by an operator (typically a driver of the vehicle), projecting from the steering wheel **8**. The state sensor unit **4** consists of various sensors for sensing the state of the vehicle. The state of the vehicle represents an event or a current condition which should preferably be indicated to the driver, such as, for example, vehicle lights being left on, fuel running low, or low tire pressure. Basically, the phenomena are those at an alert level or higher. For example, the state sensor unit **4**, which has an illumination meter that senses light intensity outside the vehicle to sense an on-state of lights, detects light intensity exceeding a reference intensity and, if lights stay on for a predetermined period of time or longer, sends a signal indicating a possible "failure to turn off lights". The state sensor unit **4** may also include fuel level sensing means and tire pressure sensing means for the case of fuel shortage and tire pressure decrease and, if the fuel level or tire pressure decreases below a predetermined amount or pressure, sends a signal indicating the "fuel low" or "tire pressure low". In this way, the state sensor unit **4** includes one or more sensors, depending on the vehicle information to be indicated. If an event can be sensed by a sensor provided as a factory-installed component of the vehicle, such as a fuel level indicated by an alert indicator lamp on the instrument panel, output from that factory-installed sensor may be shared. Alternatively, the state sensor unit **4** may be arranged so as to be able to obtain required information from on-vehicle electronic controllers into which sensor signals are input from various sensors. The state of the vehicle detected by the state sensor unit **4** configured as described above is input into the main unit of the haptic interface device **2** via the connection line **6**. When, as is not uncommon, the state sensing means is provided in a place other than the steering wheel, the connection line **6** is routed into the steering post. The haptic interface device in the present embodiment comprises the main unit embedded in the steering wheel **8** and the state sensor unit **4** connected to the main unit through the connection line **6**, as can be seen from the description above. However, for simplicity, the main unit of the haptic interface device excluding the state sensor unit **4** and connection line **6** will be simply referred to as a haptic interface device in the following description unless otherwise stated.

[0033] The haptic interface device **2** embedded in the steering wheel **8** can be roughly divided into an operating section **10**, a driving section **20**, and a control section **40** as shown in **FIG. 3**. The operating section **10** includes an operating member **12** operated by an operator. A light emitter **16** that emits light in the opposite direction of the operating member **12** is attached in the center of a base **14** supporting the operating member **12**. The light emitter **16** is not shown in **FIG. 2** for clarity.

[0034] The driving section **20** provides an electromagnetic driving force to the operating member **12** in order to provide a reactive force to the operator operating the operating member **12**. The driving section **20** includes magnets **22**, **23**, **24**, and **25** disposed on the bottom surface of a case **21**, which provides the base for the magnets, in such a manner that their polarities are alternately oriented. The magnets **22-25** are polarized in the thickness direction of the device **2** so that a magnetic field is generated between adjacent magnets. Coils **26**, **27**, **28**, and **29** and a frame **30** in which the coils **26-29** are mounted are provided over the magnets **21-25** in such a manner that the coils **26-29** are located between the magnets **21-25**. An electric current is passed through the coils **26** and **28**, which are provided in parallel along the X-axis in a magnetic field, in a predetermined direction according to Fleming's left-hand rule to drive the movable frame **30** along the Y-axis. Similarly, an electric current is passed in a predetermined direction through the coils **27** and **29**, which are provided in parallel along with the Y-axis to drive the frame **30** along the X-axis. Accordingly, the frame **30** can be moved along a one-dimensional axis by passing a current through one of the pairs of coils, or moved in two dimensions expressed by a vector sum of one-dimensional directions by passing a current through both of a pair of coils. In this way, the driving section **20** has a structure in which the frame **30** is provided as a moving member in the center of the case **21**. The base **14** of the operating section **10** is mounted on the frame **30**. An opening **32** is formed in the center of the frame **30** so that the light emitter **16** mounted on the base **14** is not covered with the frame **30**. The control section **40**, which will be described later, causes a current to pass through the coils **26-29** via a signal line **31** to control the driving section **20** to move the frame **30**. The operating member **12** mounted on the frame **30** moves together with the movement of the frame **30**. The driving section **20** electromagnetically provides a driving force to the operating member **12** under the control of the control section **40** in order to give a reactive force to the operator. The driving section **20** may be implemented by a two-dimensional actuator described in Japanese Patent Laid-Open Publication No. 2000-330688, for example.