CLAIMS

Claim 1. A magnetic marker to be laid so as to be spaced in or on a traveling road where a vehicle travels, the magnetic marker comprising:

a magnet as a magnetism generation source and a reflecting part which retroreflects at least part of incident electromagnetic waves, wherein

of an outer peripheral side surface, at least part of the side surface is formed of the reflecting part, and said at least part of the side surface formed of the reflecting part is over an entire perimeter, and

when the magnetic marker is laid in or on the traveling road, the side surface formed of the reflecting part faces an incident direction of electromagnetic waves projected ahead by the vehicle.

Claim 2. The magnetic marker in claim 1, wherein the reflecting part is a reflective layer formed on an outer surface side of the magnet, and

said at least part of the side surface is formed of the reflective layer.

Claim 3. The magnetic marker in claim 2 or 9, wherein the reflective layer is a layer formed of a small-piece-shaped sheet body.

Claim 4. The magnetic marker in claim 1, wherein the magnetic marker has pulverulent body made of a magnetic material forming the magnet and pulverulent body or particles forming the reflecting part dispersed in the base material, and

part of the pulverulent body or particles forming the reflecting part are exposed to said at least part of the side surfaces.

Claim 5. A method of detecting and using, by a traveling vehicle, a magnetic marker including a magnet as a magnetism generation source and a reflecting part which retroreflects at least part of incident electromagnetic waves and laid in or on a traveling road of the vehicle, wherein

the vehicle includes a distance-measurement device which acquires an azimuth and a distance of a subject based on a direction of emitting the electromagnetic waves and a time required for reflection of the electromagnetic waves, a magnetic device which magnetically detects the magnetic marker and identifies a lateral shift amount of the vehicle with respect to the magnetic marker, and a processing circuit which calculates a target steering angle for the vehicle to travel along a target path and controls the vehicle so that the vehicle travels along the target path,

the method comprises:

a process of detecting the magnetic marker by emitting the electromagnetic waves ahead of the vehicle, and measuring an azimuth and a distance of the magnetic marker;

a process of estimating a predicted arrival time point when the vehicle arrives at the magnetic marker detected by using the electromagnetic waves or a predicted lateral shift amount, which is a deviation (lateral shift amount) of the vehicle in a vehicle-width direction predicted for the magnetic marker; and

a process of identifying an actual detection time point, which is a time point when the magnetic marker is actually detected, or an actual deviation (lateral shift amount) of the vehicle with respect to the magnetic marker, and

the method performs an accuracy improvement process in which, of a result of comparison between the actual detection time point and the predicted arrival time point and a result of comparison between the actual deviation (lateral shift amount) and the predicted lateral shift amount, at least either one of the results is used to achieve an improvement in at least any of: measurement accuracy by the distance-measurement device, accuracy of detection of the magnetic marker by the magnetic device, accuracy of the target steering angle calculated by the processing circuit, and following accuracy of the vehicle with respect to the target path.

Claim 6. The method of using the magnetic marker in claim 5, wherein the accuracy improvement process includes a process of achieving the improvement in the accuracy of detection of the magnetic marker by determining that an erroneous detection of the magnetic marker has occurred when, of a difference between the actual detection time point and the predicted arrival time point and a difference between the actual deviation (lateral shift amount) and the predicted lateral shift amount, at least either one of the differences is larger than a threshold value.

Claim 7. The method of using the magnetic marker in claim 5 or 6, wherein the accuracy improvement process includes a process of achieving the improvement in the measurement accuracy by the measurement-distance device by calibrating an axis serving as a reference for identifying the direction of emitting the electromagnetic waves by the distance-measurement device.

Claim 8. The method of using the magnetic marker in any one of claims 5 to 7, wherein the accuracy improvement process includes a process of achieving the improvement in the accuracy of the target

steering angle calculated by the processing circuit or the following accuracy of the vehicle with respect to the target path by calibrating a neutral point of a steering angle corresponding to rectilinear traveling of the vehicle.

Claim 9. The magnetic marker in claim 2, wherein the magnet is a magnet containing iron oxide as a magnetic material as a raw material, the outer peripheral side surface is a cut surface of the magnetic marker punched from an intermediate sheet including a layer forming the magnet and the layer forming the reflective layer.

Claim 10. The magnetic marker in claim 3, wherein an RFID tag is disposed between the magnet and the reflective layer.

Claim 11. The magnetic marker in claim 4, wherein the pulverulent body or particles forming the reflecting part exposed to said at least part of the side surface are residues of melting by a process of melting the base material applied on the outer peripheral side surface.

Claim 12. A method of detecting and using, by a traveling vehicle, a magnetic marker including a magnet as a magnetism generation source and a reflecting part which retroreflects at least part of incident electromagnetic waves and laid in or on a traveling road of the vehicle, wherein

the vehicle includes a distance-measurement device which acquires an azimuth and a distance of a subject based on a direction of emitting the electromagnetic waves and a time required for reflection of the electromagnetic waves, a magnetic device which magnetically detects the magnetic marker and identifies a lateral shift amount of the vehicle with respect to the magnetic marker,

and a processing circuit which calculates a target steering angle for the vehicle to travel along a target path and controls the vehicle so that the vehicle travels along the target path,

the method comprises:

a process of detecting the magnetic marker by emitting the electromagnetic waves ahead of the vehicle, and measuring an azimuth and a distance of the magnetic marker; and

a process of estimating a predicted arrival time point when the vehicle arrives at the magnetic marker detected by using the electromagnetic waves,

the magnetic device performs a detection process of magnetically detecting the magnetic marker in a temporal period with reference to the predicted arrival time point, and

when the temporal period elapses, suspends the detection process even if the magnetic marker is not detected.

Claim 13. A method of detecting and using, by a traveling vehicle, a magnetic marker including a magnet as a magnetism generation source and a reflecting part which retroreflects at least part of incident electromagnetic waves and laid in or on a traveling road of the vehicle, wherein

the vehicle includes a distance-measurement device which acquires an azimuth and a distance of a subject based on a direction of emitting the electromagnetic waves and a time required for reflection of the electromagnetic waves, a magnetic device which magnetically detects the magnetic marker and identifies a lateral shift amount of the vehicle with respect to the magnetic marker, and a processing circuit which calculates a target steering angle for the vehicle to travel along a target path and controls the vehicle so that the vehicle travels along the target path, and

the method comprises:

a process of detecting the magnetic marker by emitting the

electromagnetic waves ahead of the vehicle, and measuring an azimuth and a distance of the magnetic marker;

a process of setting a path passing over a plurality of magnetic markers ahead of the vehicle detected by using the electromagnetic waves as the target path and calculating the target steering angle; and

a process of correcting the target steering angle by the lateral shift amount of the vehicle with respect to the magnetic marker magnetically detected by the magnetic device.