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(54) Abstract Title: **Reflective optical encoders**

(57) Optical encoders having one or more of a number of disclosed features are disclosed. The features of the optical encoder in accordance with the present invention include a symmetrical (for example, circular) emitter; baffle between the emitter and a detector; double-dome or single-dome encapsulant; multiple detector; and multiple (at least three) data channels.

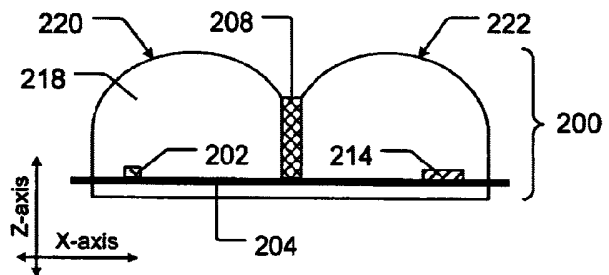


FIG. 2A

GB 2 432 209 A

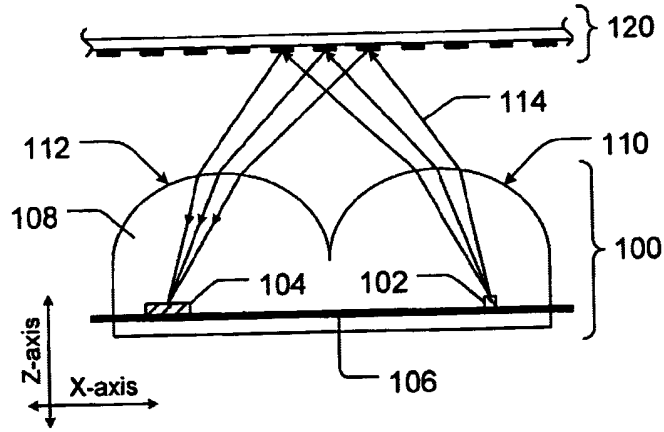


FIG. 1A (PRIOR ART)

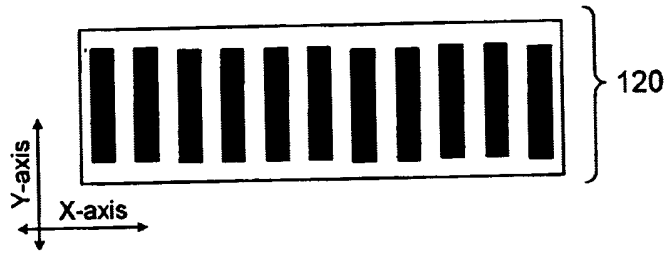


FIG. 1B (PRIOR ART)

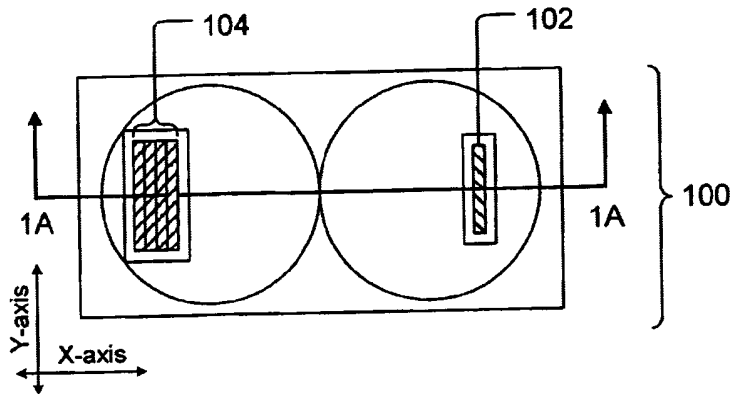


FIG. 1C (PRIOR ART)

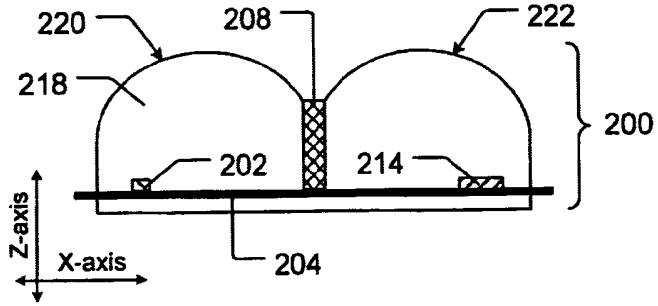


FIG. 2A

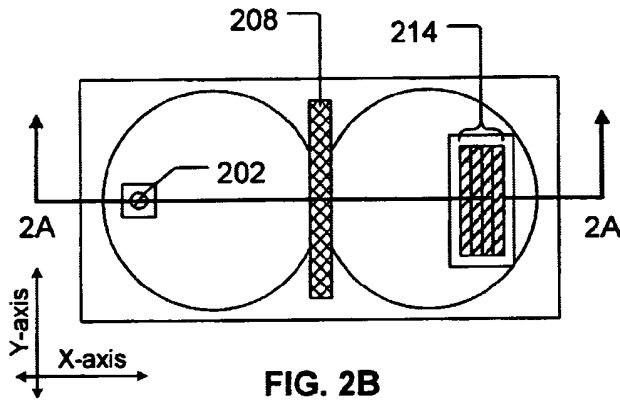


FIG. 2B

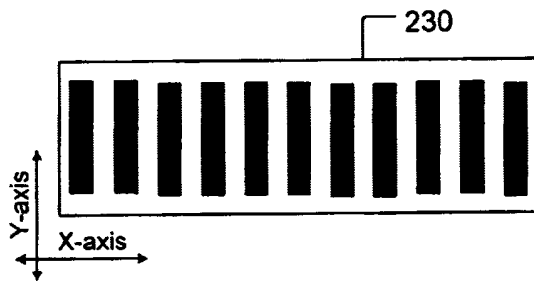


FIG. 2C

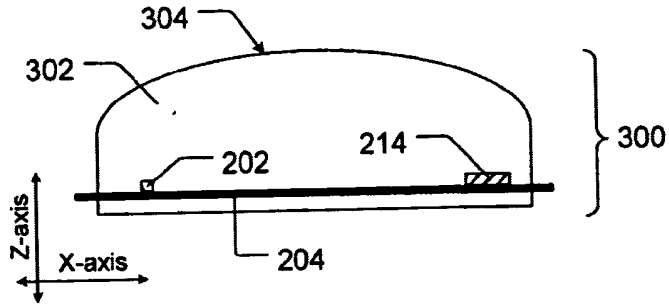


FIG. 3A

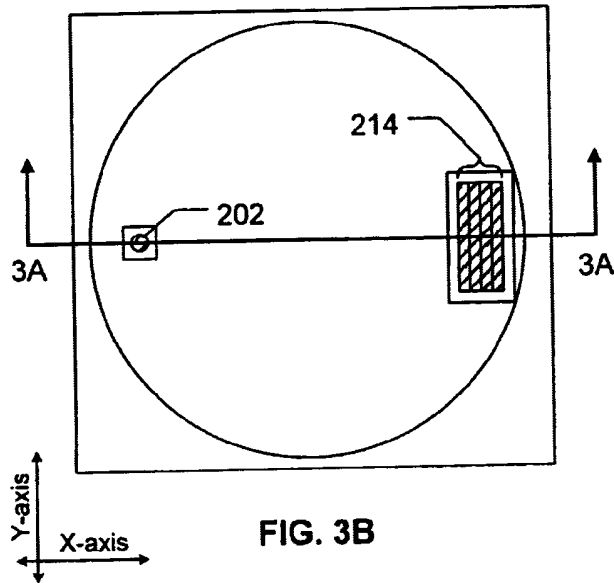


FIG. 3B

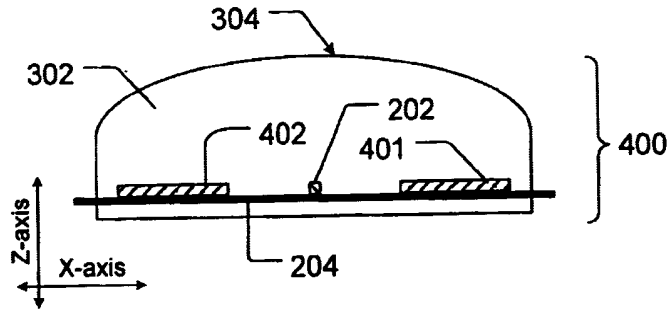


FIG. 4A

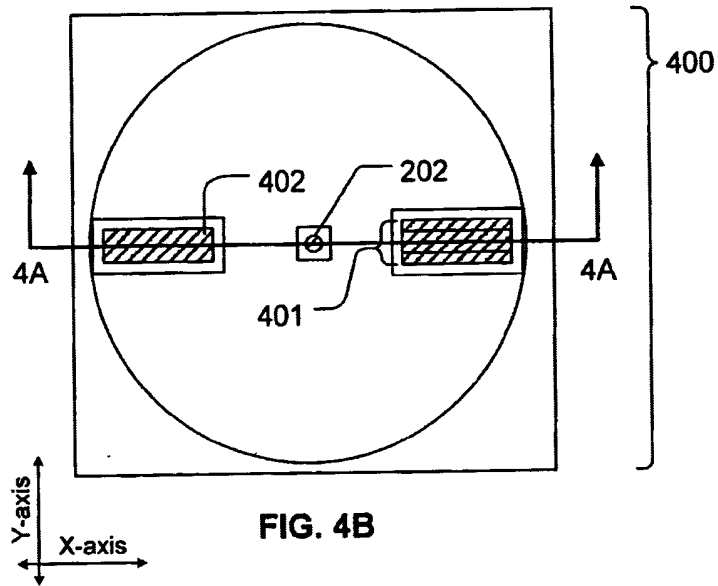


FIG. 4B

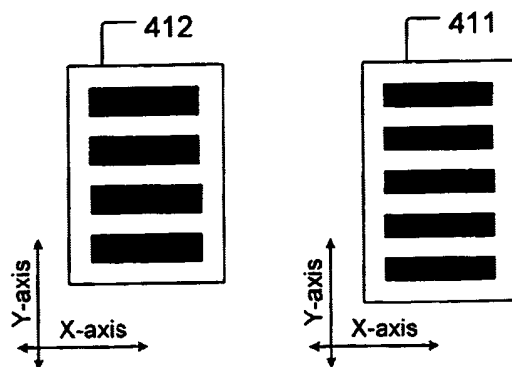


FIG. 4C

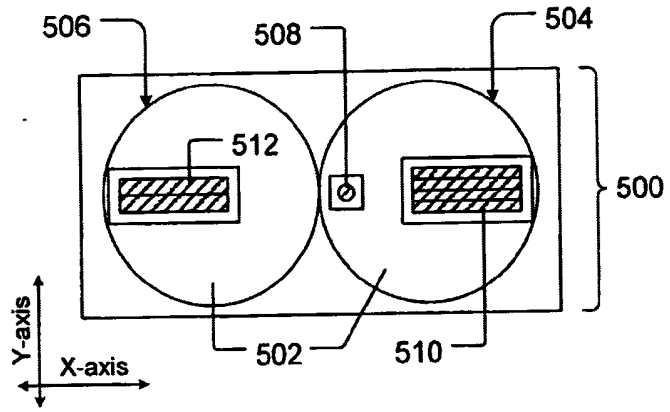


FIG. 5

REFLECTIVE ENCODERS WITH VARIOUS EMITTER-DETECTOR CONFIGURATIONS

BACKGROUND

- [0001] The present invention relates generally to optical encoders. More particularly, the present invention relates to optical encoders having various orientations.
- [0002] Optical encoders detect motion and typically provide closed-loop feedback to a motor control system. When operated in conjunction with a code scale, an optical encoder detects motion (linear or rotary motion of the code scale), converting the detected motion into digital signal that encode the movement, position, or velocity of the code scale. Here, the phrase "code scale" includes code wheels and code strips.
- [0003] Usually, motion of the code scale is detected optically by means of an optical emitter and an optical detector. The optical emitter emits light impinging on and reflecting from the code scale. The reflected light is detected by the optical detector. A typical code scale includes a regular pattern of slots and bars that reflect light in a known pattern.
- [0004] Figures 1A through 1C illustrate a known optical encoder 100 and a code scale 120. Figure 1A is a cutaway side view of the optical encoder 100 and the code scale 120. Figure 1B is the code scale 120 as viewed from the optical encoder 100. Figure 1C is the optical encoder 100 as viewed from the optical encoder 100. Figures 1A through 1C include orientation axes legend for even more clarity.
- [0005] Referring to Figures 1A through 1C, the encoder 100 includes an optical emitter 102 and an optical detector 104 mounted on a substrate 106 such as a lead frame

106. The optical emitter 102 and the optical detector 104 as well portions of the lead frame 106 are encapsulated in an encapsulant 108 including, for example, clear epoxy. The encapsulant 108 defines a first dome-shaped surface 110 (first lens 110) over the optical emitter 102 and a second dome-shaped surface 112 (second lens 112) over the optical detector 104.

[0006] The optical emitter 102 emits light that leaves the encapsulant 108 via the first lens 110. The first lens 110 concentrates or otherwise directs the light toward the code scale 120, the light reflecting off of the code scale 120. The reflected light reaches the optical detector 104 via the second lens 112. The second lens 112 concentrates or otherwise directs the reflected light toward the optical detector 104. The optical detector 104 can be, for example only, photo detector that converts light into electrical signals.

[0007] In the illustrated example, the optical emitter 102 is a slit-type light emitter, the slit along the Y-axis. As illustrated, the optical detector 104 is placed along the Y-axis. Further, the slots and bars of the code scale 120 runs along the Y-axis. Accordingly, the optical encoder 100 and the code scale 120 are oriented and positioned relative to each other in order to detect movements of the code scale 120 in the X-axis direction.

[0008] This design has several weaknesses. For example, the optical encoder 100 is sensitive to misalignments. Even slight misalignments of the slit emitter 102 lead to contrast degradation, thus degradation of the performance of the optical encoder 100. Further, the optical encoder 100 detects movements in only one direction (for example, along the X-axis direction in the illustrated example), limiting flexibility in orientation of the encoder package. Moreover the existing optical encoder has limited number (typically at most two) of data channels on one side of the emitter.

[0009] Accordingly, there remains a need for improved optical encoder that alleviates or overcomes these shortcomings.

SUMMARY

[0010] In a first embodiment of the present invention, an optical encoder includes an emitter and a detector. The emitter is adapted to emit light in a circular pattern wherein the emitter operable to provide

light to a code scale for reflection. The detector is adapted to detect reflected light from the code scale.

[0011] In a second embodiment of the present invention, an optical encoder includes an emitter, a detector, and encapsulant. The emitter is adapted to emit light, the emitted light directed toward a code scale for reflection. The detector is adapted to detect reflected light from the code scale. The encapsulant encapsulating the emitter and the detector, the encapsulant forming a single dome over the emitter and the detector.

[0012] In a third embodiment of the present invention, an optical encoder includes an emitter, a detector, and a baffle between the emitter and the detector. The emitter is adapted to emit light, the emitted light directed toward a code scale for reflection. The detector is adapted to detect reflected light from the code scale. The baffle between the emitter and the detector prevents stray light from the emitter from reaching the detector.

[0013] In a fourth embodiment of the present invention, an optical encoder includes an emitter, a detector, and an index detector. The emitter is adapted to emit light, the emitted light directed toward a code scale. The detector is adapted to detect light reflected from the code scale. The detector provides two data channels. The index detector provides an index channel.

[0014] Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Figures 1A and 1C illustrate differing views of a prior art optical encoder and a sample code scale;

[0016] Figure 1B illustrates the sample code scale of Figure 1A as viewed from the optical encoder of Figures 1A and 1C;

[0017] Figures 2A and 2B illustrate differing views of an optical encoder package according to one embodiment of the present invention;

[0018] Figure 2C illustrates sample code scales as viewed from the optical encoder package of Figures 2A and 2B;

[0019] Figures 3A and 3B illustrate differing views of an optical encoder according to another embodiment of the present invention;

[0020] Figures 4A and 4B illustrate differing views of an optical encoder according to yet another embodiment of the present invention;

[0021] Figure 4C illustrates sample code scales as viewed from the optical encoder package of Figures 4A and 4B;

[0022] Figure 5 illustrates an optical encoder according to yet another embodiment of the present invention.

DETAILED DESCRIPTION

[0023] The present invention will now be described with reference to the Figures which illustrate various embodiments of the present invention. In the Figures, some sizes of structures or portions may be exaggerated and not to scale relative to sizes of other structures or portions for illustrative purposes and, thus, are provided to illustrate the general structures of the present invention. Furthermore, various aspects of the present invention are described with reference to a structure or a portion positioned "on" or "above" relative to other structures, portions, or both. Relative terms and phrases such as, for example, "on" or "above" are used herein to describe one structure's or portion's relationship to another structure or portion as illustrated in the Figures. It will be understood that such relative terms are intended to encompass different orientations of the device in addition to the orientation depicted in the Figures.

[0024] For example, if the device in the Figures is turned over, rotated, or both, the structure or the portion described as "on" or "above" other structures or portions would now be oriented "below," "under," "left of," "right of," "in front of," or "behind" the other structures or portions. References to a structure or a portion being formed "on" or "above" another structure or portion contemplate that additional structures or portions may intervene. References to a structure or a portion being formed on or above another structure or portion without an intervening structure or portion are described herein as being formed "directly on" or "directly above" the other structure or the other portion. Same reference number refers to the same elements throughout this document.

Symmetrical Emitter

- [0025] Referring again to Figure 1A, the optical emitter 102 is a slit emitter that emits light in an elongated oval shape, or a slit. In this design, performance of the optical encoder 100 is sensitive to slight misalignment errors of emitter relative to the code scale 120. To reduce the misalignment sensitivity, an emitter having symmetrical radiation pattern can be used as illustrated in Figures 2A and 2B. Figure 2B is a top view of the optical encoder 200. Figure 2A is a cutaway side view of the optical encoder 200 cut along line 2A—2A of Figure 2B. Figures 2A and 2B illustrate an optical encoder package 200 according to one embodiment of the present invention.
- [0026] Referring to Figures 2A and 2C, the optical encoder 200 includes a symmetrical emitter 202 (for example, an LED (light emitting diode)) adapted to provide light in a symmetrical (for example, circular) pattern viewed from the top. The symmetrical emitter 202 emits uniform, symmetrical light for reflecting off a code scale such as the code scale 230. Due to the uniformity and the symmetry of the emitted light, the optical encoder 200 is less sensitive to misalignments between the optical encoder 200 and the code scale 230 compared to the sensitivity to misalignments of the prior art encoder 100 of Figures 1A and 1C.
- [0027] The optical encoder 200 is operable to provide light from the symmetrical emitter 202 to the code scale 230. The code scale 230 includes slots and bars in the first orientation (in the y-axis in the illustrated sample embodiment). Thus, the code scale 230 reflects light from the symmetrical emitter 202. The reflected light is detected by a detector 214 and converted to electrical signal to be translated into information representing position or motion of the code scale 230.
- [0028] The symmetrical emitter 202 and the detector 214 are fabricated on the substrate 204 (for example, lead frame 204). The symmetrical emitter 202 and the detector 214 as well portions of a substrate 204 (for example, lead frame 204) are encapsulated in an encapsulant 218 including, for example, clear epoxy. Here, the encapsulant 218 defines a dual-domed surface including a first dome-shaped surface 220 (first lens 220) over the symmetrical emitter 202 and a second dome-shaped surface 222 (second lens 222) over the optical detector 214.
- [0029] The symmetrical emitter 202 emits light that leaves the encapsulant 218 via the first lens 220. The first lens 220 concentrates, collimates, or otherwise directs the

light toward the code scale 230, the light reflecting off of the code scale 230. The reflected light reaches the optical detector 214 via the second lens 222. The second lens 222 concentrates, collimates, or otherwise directs the reflected light toward the optical detector 214. In the illustrated example, the slots and bars of the code-scale 230 runs along the Y-axis. Accordingly, the optical encoder 200 and the code scale 230 are oriented in the orientation to detect movements of the code scale 230 in the X-axis direction.

[0030] Another aspect of the optical encoder 200 is a baffle 208, or an optical barrier 208, between the optical emitter 202 and the optical detector 214. The baffle 208 prevents stray light from reaching the optical detector 214. The baffle 208 may be coated with black absorptive materials that absorb part of the undesired optical radiation thereby reducing noise caused by undesired optical radiation. For example only, the baffle 208 may include or be coated with dummy black electronic component, anodized metal, separate piece of black plastic, black absorptive epoxy, black-polymer, carbon-filled polymer, black resin, black ink marks, coats of epoxy, laser burned surfaces and other similar types of materials capable of absorbing optical radiation. The baffle 208 may be fabricated having any suitable shape such, for example only, rectangular shape or trapezoidal shape.

Single Dome

[0031] Another aspect of the present invention is illustrated in Figures 3A and 3B. Figure 3B is a top view of an optical encoder 300. Figure 3A is a cutaway side view of the optical encoder 300 cut along line 3A—3A of Figure 3B. Portions of the optical encoder 300 are similar to corresponding portions of the optical encoder 200 of Figures 2A and 2B. For convenience, the portions of the optical encoder 300 that are similar to corresponding portions of the optical encoder 200 of Figures 2A and 2B are assigned the same reference numerals.

[0032] Referring to Figures 3A and 3B, the optical encoder 300 includes an emitter 202 and a detector 214 on a substrate lead frame 204. Encapsulant 302 encapsulates the emitter 202, the detector 214, and portions of the lead frame 204. Here, the encapsulant 302 forms a single-dome 304 that covers both the emitter 202 and the detector 214. In some applications, the single-dome configuration may be more

desirable than the double-domed configuration for requiring less space, complexity of manufacture, or both.

MultiChannel Encoder

- [0033] Referring again to Figures 1A and 1C, the optical encoder 100 typically includes the single optical detector 104 having one or at most two channels. For applications where additional channels are desired, two prior art optical encoders 100 are used. To overcome this problem, Figures 4A and 4B illustrate an optical encoder 400 including an optical emitter 202 and two optical detectors. Figure 4B is a top view of an optical encoder 400. Figure 4A is a cutaway side view of the optical encoder 400 cut along line 4A—4A of Figure 4B.
- [0034] Portions of the optical encoder 400 are similar to corresponding portions of the optical encoder 200 of Figures 2A and 2B, corresponding portions of the optical encoder 300 of Figures 3A and 3B, or both. For convenience, the portions of the optical encoder 400 that are similar to corresponding portions of the optical encoder 200 of Figures 2A and 2B, corresponding portions of the optical encoder 300 of Figures 3A and 3B, or both are assigned the same reference numerals.
- [0035] Referring to Figures 4A and 4B, the optical encoder 400 includes an emitter 202 and a detector 401. The detector 401 can include up to two channels. The detector 401 is configured to operate with the code scale 411 of Figure 4C. In the illustrated embodiment, the detector 401 is placed along the X-axis, lengthwise of each individual photodiode, orthogonal to the orientation which is along the Y-axis (as illustrated by Figure 4C). This orientation is for the purposes of illustrating alternative embodiment of the present invention.
- [0036] The optical encoder 400 further includes another detector 402 including another, third, channel. In the illustrated embodiment, the second detector 402 is an index detector 402 and may be configured to work with another code scale 412 illustrated in Figure 4C. The index code scale 412 is configured to operate with the index detector 402 and may have resolution (of slots and bars) different than resolution of the code scale 411. In the illustrated embodiment, the optical encoder 400 has three channels of data – two from its first detector 401 and index channel from the index detector 402. Further, in the illustrated embodiment, the optical encoder 400 is a single-dome configuration.

Combination

[0037] In other embodiments of the present invention, various techniques and aspects of the present invention can be combined. For example, the circular emitter 202 (Figures 2A and 2B), the baffle 208 (Figures 2A and 2B), dual dome 220 and 222 construction (Figures 2A and 2B), single dome (304) construction (Figures 3A and 3B), multiple-detector/channel (401 and 402) construction (Figures 4A and 4B) can be combined in any combination within the scope of the present invention.

[0038] Figure 5 illustrates one of the combination embodiments in an optical encoder 500. Referring to Figure 5, the optical encoder includes encapsulant 502 forming a first dome 504 and a second dome 506 in a dual-domed configuration. Here, the first-dome portion encapsulates an optical emitter 508 and a detector 510 while the second-dome portion encapsulates a second, index, detector 512. The optical emitter 508, here for instance, is a circular emitter. The optical emitter 508 can be a slit emitter, which is placed along the X-axis, lengthwise of each individual photodiode. It is apparent from Figure 5 as well as preceding figures and discussions that positions of the emitter 508 and the detectors 510 and 512 relative to the two domes 504 and 506 can be rearranged to achieve other configuration. Alternatively, the emitter 508 and the detectors 510 and 512 or any combination of these can be placed within encapsulant having a single dome.

Conclusion

[0039] From the foregoing, it will be apparent that the present invention is novel and offers advantages over the current art. Although specific embodiments of the invention are described and illustrated above, the invention is not to be limited to the specific forms or arrangements of parts so described and illustrated. For example, differing configurations, sizes, or materials may be used but still fall within the scope of the present invention. The invention is limited by the claims that follow.

[0040] In embodiments described above, the optical emitters 202, 508 were symmetrical, for example circular. In other embodiments, the optical emitter is not symmetrical but the optical emitter is sufficiently small (compared to the detectors 214, 401, 402, 510, 512) that the optical emitter can be regarded as a point source and is thus substantially circularly symmetrical. In embodiments where the detectors are rectangular, where the length of the detector(s) is greater than the width of the detector(s), the optical emitter can be regarded as a point source if the size of the optical emitter is comparable with, or is smaller than, the width of the detector(s).

[0041] The disclosures in United States patent application no. 11/259,419, from which this application claims priority, and in the abstract accompanying this application are incorporated herein by reference.

CLAIMS

1. An optical encoder comprising:
 - an emitter adapted to emit light in a substantially circular pattern wherein said emitter is operable to provide light to a code scale for reflection; and
 - a detector adapted to detect reflected light from the code scale.
2. The optical encoder recited in claim 1 further comprising a baffle between said emitter and said detector.
3. The optical encoder recited in claim 1 or 2 wherein said optical encoder comprises encapsulant forming one of the following: a double-dome surface, one dome surface over said emitter and the other dome surface over said detector; and a single-dome surface over both said emitter and said detector.
4. The optical encoder recited in claim 1, 2 or 3 wherein said detector further comprises an index detector.
5. The optical encoder recited in claim 1, 2, 3 or 4 wherein said detector comprises two data channels.
6. An optical encoder comprising:
 - an emitter adapted to emit light, wherein said emitter is operable to provide light to a code scale for reflection;
 - a detector adapted to detect reflected light from the code scale; and
 - encapsulant encapsulating said emitter and said detector, said encapsulant forming a single dome over said emitter and said detector.
7. The optical encoder recited in claim 6 wherein said emitter is one of the following: a slit emitter, and a substantially circular emitter.

8. The optical encoder recited in claim 6 or 7 further comprising a baffle between said emitter and said detector.
9. The optical encoder recited in claim 6, 7 or 8 wherein said detector further comprises an index detector.
10. The optical encoder recited in claim 6, 7, 8 or 9 wherein said detector comprises two data channels.
11. An optical encoder comprising:
 - an emitter adapted to emit light, wherein said emitter is operable to provide light to a code scale for reflection;
 - a detector adapted to detect reflected light from the code scale; and
 - a baffle between said emitter and said detector to prevent stray light from said emitter from reaching said detector.
12. The optical encoder recited in claim 11 wherein said emitter is one of the following: a slit emitter, and a substantially circular emitter.
13. The optical encoder recited in claim 11 or 12 wherein said optical encoder comprises encapsulant forming one of the following: a double-dome surface, one dome surface over said emitter and the other dome surface over said detector; and a single-dome surface over both said emitter and said detector.
14. The optical encoder recited in claim 11, 12 or 13 wherein said detector further comprises an index detector.
15. The optical encoder recited in claim 11, 12, 13 or 14 wherein said detector comprises two data channels.

16. An optical encoder comprising:
 - an emitter adapted to emit light wherein said emitter is operable to provide light to a code scale;
 - a detector adapted to detect light reflected from the code scale, said detector providing two data channels; and
 - an index detector providing an index channel.
17. The optical encoder recited in claim 16 wherein said optical encoder comprises encapsulant forming one of the following: a double-dome surface and a single-dome surface.
18. The optical encoder recited in claim 16 or 17 wherein said emitter is one of the following: a slit emitter, and a substantially circular emitter.
19. The optical encoder recited in claim 16, 17 or 18 wherein said optical encoder comprises encapsulant forming a double-dome surface wherein said emitter and said detector is under a first dome and said index detector is under a second dome.
20. The optical encoder recited in claim 16, 17, 18 or 19 wherein said optical encoder comprises encapsulant forming a double-dome surface wherein said emitter and said index detector is under a first dome and said detector is under a second dome.
21. The combination of an optical encoder according to any preceding claim with a code scale.
22. An optical encoder as herein described and/or illustrated by any one of Figures 2A to 5.



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Application No: GB0621258.3

Examiner: Mr Tony Oldershaw

Claims searched: 1

Date of search: 9 March 2007

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1	GB2386416 A (HATTERSLEY) - see e.g. figures 1 and 2
X	"	GB2369184 A (AOKI) - see e.g. figure 1
X	"	WO01/73379 A1 (SOUTHAM) - see e.g. figure 7
X	"	US2005/0087681 A1 (CHIN) - see abstract
X	"	US2001/0013765 A1 (YAMAMOTO) - see e.g. figure 5
X	"	US5006703 A (SHIKUNAMI) - see e.g. figure 1B
X	"	US4987301 A (NAKAMURA) - see e.g. figure 1B
X	"	US4929822 A (NAKAMURA) - see e.g. figure 5B
X	"	JP59224514 A (YAMADA) - see e.g. figures 7 and 9
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X	"	JP58184549 A (KATAGIRI) - see e.g. figure 1



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X	"	JP57149912 A (TSUKADA) - see e.g. figures 1 and 2
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Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Field of Search:

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Worldwide search of patent documents classified in the following areas of the IPC

G01D

The following online and other databases have been used in the preparation of this search report

Online: WPI, EPODOC