(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 787 488 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.10.2014 Bulletin 2014/41

(51) Int Cl.:
G07D 5/00 *(2006.01)* ***G07D 5/02*** *(2006.01)*
G07D 5/10 *(2006.01)*

(21) Application number: **13161990.0**

(22) Date of filing: **02.04.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **Panzeri, Ezio**
Dubai (AE)

(72) Inventor: **Panzeri, Ezio**
Dubai (AE)

(74) Representative: **Hall, Matthew Benjamin**
Dehns
St. Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

(54) Coin checking

(57) A coin checking apparatus (2, 24, 34, 48, 56) comprises a coin path (4) and an optical sensor (8). The optical sensor (8) comprises a laser diode (10) configured to emit light, an optical guide (14) configured to direct the light from the laser diode (10) to the coin path (4), and a photodetector (12) configured to detect light from the laser diode (10) that is reflected by the coin (6) and returned along the optical guide (14). The laser diode (10) and the photodetector (14) are provided within a single package. The apparatus (2, 24, 34, 48, 56) can also include an array of photodetectors (22) arranged to detect light emitted by the laser diode (10) that has passed through the coin path (4) without being interrupted by the coin (6). A processing device (20) analyses an output of the optical sensor (8) and may determine a fingerprint of the coin (6). Based on this output the processing device may identify the coin (6) and/or determine if the coin (6) is genuine or fake.

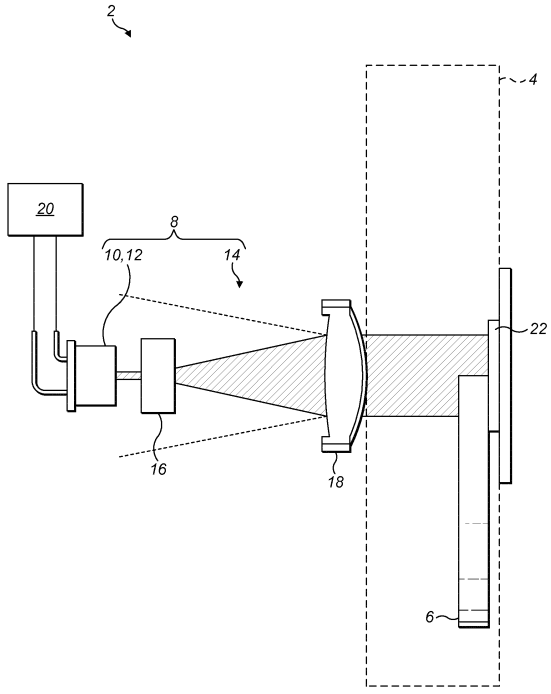


FIG. 1

EP 2 787 488 A1

Description

[0001] This invention relates to an apparatus for checking coins. It also relates to a method of checking coins.

[0002] Coin checking apparatuses are used to recognise and check automatically the authenticity of different coins. The term "coin" is used herein as an umbrella term encompassing all items that may pass through a coin checking apparatus. It should be taken to include without limitation not only coins having monetary value but also any type of similar item, such as tokens, casino chips, counterfeit coins, etc., that may end up in a coin checking apparatus. Coin checking apparatuses are found in vending machines, change machines, slot machines, change deposit machines, and any other machines that rely on coin based payments.

[0003] A known coin checking apparatus is described in GB-B-2369710. In this arrangement, two laser diodes are provided that each generate a collimated light beam directed onto a face of a coin. Respective CMOS based arrays of photodetectors behind the coin are used to detect where the beams are intercepted by the coin. A shadow cast by the coin is detected by the photodetectors to give an indication of certain characteristics of the coin, such as its diameter and the presence of milling on the edges of the coin, etc.. These characteristics can be used to identify the coin and check that it is not a forgery.

[0004] However, as technologies improve, so too does the quality of forgeries, and measures need to be put in place to stay one step ahead of the forgers.

[0005] Viewed from a first aspect, the present invention provides a coin checking apparatus comprising a coin path and an optical sensor arranged to scan a coin passing along the coin path. The optical sensor comprises a light source configured to emit light, an optical guide configured to direct the light from the light source to the coin path, and a photodetector configured to detect light from the light source that is reflected by the coin and returned by the optical guide. The light source and the photodetector may be provided within a single package.

[0006] The coin checking apparatus of the first aspect therefore provides a new technique for the checking of coins, namely the utilisation of light reflected from the surface of the coin allowing for surface features of the coin to be examined. This can be particularly useful for the identification of forged coins, as the surface features of forged coins may not be entirely consistent with those of genuine coins. Furthermore, the surface features of forged coins are often not as precise or accurately formed as those of genuine coins.

[0007] The term "package" is intended to mean a semiconductor package where the components of the light source and photodetector are mounted on a common header and/or share one or more common electrical leads. By providing the light source and photodetector within the same package, the apparatus may be made more compact as only a single, simple optical guide is required.

[0008] Preferably, the semiconductor light source is a laser diode. The highly collimated light emitted by a laser diode is easier to focus and collimate that other suitable light sources, such as light emitting diodes (LED). Therefore providing a much more accurate measurement of the features of the coin, without the need for a complex and expensive optical system.

[0009] The optical sensor is preferably arranged to scan a surface of the coin that is substantially perpendicular to the direction of light emitted from the optical guide, so as to maximise the degree of light reflected by the coin that is received by the photodetector. Preferably the optical sensor is arranged to scan a face of the coin, as the most distinguishing surface features of the coin are present on the coin face. However, the optical sensor may of course instead be arranged to scan the coin from other directions, for example, the edge of the coin.

[0010] The apparatus may further comprise a processing device configured to analyse an output from the photodetector as the coin moves along the coin path. The processing device may be configured to compare the output from the photodetector against stored outputs to determine if the coin is genuine and/or to analyse changes in reflectivity across a face of the coin as it moves along the coin path. The stored outputs preferably correspond to genuine coins, more preferably acceptable genuine coins, such as coins of the correct currency. The stored outputs may also include those of known forged coins and/or known non-acceptable coins, for example, genuine foreign coins.

[0011] By such analysis, the coin checking apparatus can accurately determine whether the coin matches the expected values for a genuine coin.

[0012] The processing device may further be configured to determine a diameter or a chord length of the coin based on the output of the photodetector. The diameter of an acceptable coin will be known to a high degree of precision. This step can therefore be useful either for the coin identification, e.g. of its denomination etc, as well as for identifying incorrect coins that do not match those dimensions of accepted coins, for example, forged coins or foreign coins.

[0013] The apparatus may further comprise a first array of photodetectors arranged to detect light emitted by the light source that has passed through a first region of the coin path without being interrupted by the coin. A second array of photodetectors may also be arranged to detect light emitted by the light source that has passed through a second region of the coin path without being interrupted by the coin. The optical guide may be arranged to split the light from the light source, for example, using an optical splitter, and to guide the split light through the first and second regions of the coin path to the respective array of photodetectors. Alternatively, a second optical sensor may be provided to illuminate the second array of photodetectors.

[0014] The array(s) of photodetectors may be arranged in any suitable manner, for example, in appropri-

ate positions for determining the diameter of a chord length of the coin. For example, the array(s) may be linear array(s) arranged along the direction of movement of the coin along the coin path. Alternatively the arrays may be arranged across the direction of movement. If the coin is rolling or sliding along a track, where the position of one edge portion of the coin will be known, the array may only need to capture one edge portion of the coin to determine its diameter.

[0015] The processing device may be configured to determine a diameter or a chord length of the coin, and/or to determine edge features of the coin, based on an output of the photodetectors provided in the array(s) of photodetectors.

[0016] The use of one or more arrays of photodetectors can provide a highly accurate indication of the diameter of the coin. As discussed above, this can be useful either for the identification of an acceptable coin as well as for identifying incorrect coins that do not match those dimensions of accepted coins. The use of such arrays of photodetectors may also be used to determine edge features of the coin, for example, milling. This arrangement allows a single light source to provide light for multiple types of sensors, i.e., the array(s) of photodetectors as well as the photodetector of the optical sensor. Hence, this synergistic combination of sensors provides a compact coin checking apparatus with few components.

[0017] Where the optical guide comprises a waveguide, the waveguide may be a substantially Y-shaped member, having an entry for light to enter the waveguide from a light source and first and second exits for light to exit the waveguide, wherein the first and second exits are separated by a space. An auxiliary sensor may be arranged within the space between the first and second exits of the waveguide and adjacent to the coin path, the auxiliary sensor being a sensor measuring electrical or magnetic properties of the coin. The auxiliary sensor may be selected from the group consisting of an inductive sensor, a capacitive sensor, and a hall effect sensor.

[0018] This arrangement allows for a more simplified configuration as there is no need to provide photodetectors corresponding with the middle of the coin, which will be completely in shadow. This combination allows for a more efficient use of the available space, whilst still allowing the diameter of the entire coin to be scanned using a single light source to illuminate both sensor arrays. As the same light source supplies light to both arrays of photodetectors, the beam of light to each sensor may be the same, improving repeatability of measurements.

[0019] The apparatus may be arranged to scan both sides of a coin passing along the coin path. This can be useful in the detection of forged coins for a number of reasons. First, it provides two different outputs, which of course provides twice the information for analysis. Secondly, the faces of forged coins may sometimes be misaligned. Thus, having scanned both sides of the coin, the processing device may be configured to determine an alignment of each face of the coin, and to compare the alignments of the coin faces, for example, to determine if they are misaligned.

[0020] In one arrangement, the optical guide may be arranged to direct light from the light source through one region of the coin path in a first direction, and to direct light through another region of the coin path from a second direction, such that light travelling in the first direction illuminates one side of the coin and light travelling in the second direction illuminates an opposite side of the coin.

[0021] In this arrangement, the first and second regions of the coin path are preferably sufficiently separated from one another such that a coin moving along the coin path does not simultaneously interrupt light in the first region and in the second region.

[0022] In an alternative arrangement, a second optical sensor may be provided, arranged to scan a coin passing along the coin path, wherein the first and second optical sensors are arranged to scan opposite sides of the coin. The second optical sensor may also comprise a light source configured to emit light, an optical guide configured to direct the light from the light source to the coin path, and a photodetector configured to detect light from the light source that is reflected by the coin and returned along the optical guide, wherein the light source and the photodetector are provided within a single package.

[0023] Preferably the light source is a vertical cavity surface emitting laser (VCSEL). A VCSEL provides an extremely high contrast ratio, which is much higher than that of other reflective sensors without expensive bulky optics. Furthermore, a VCSEL is highly efficient and has narrow divergence.

[0024] Viewed from a second aspect, the present invention also provides a method of checking a coin. The method comprises emitting light using a light source, directing the light from the light source to a coin path, moving a coin along the coin path so as to interrupt the light emitted by the light source, and detecting light reflected by the coin using a photodetector that is preferably provided within the same package as the light source.

[0025] The method preferably further comprises determining a diameter or chord length of the coin based on an output of the photodetector as the coin moves along the coin path. The method may include comparing an output from the photodetector against stored outputs to determine if the coin is genuine and acceptable.

[0026] The method may include detecting, using an array of photodetectors, light emitted by the light source that has passed through a first region of the coin path without being interrupted by the coin. Optionally, the method may also include detecting, using a second array of photodetectors, light emitted by the light source that has passed through a second region of the coin path without being interrupted by the coin. Then, directing the light from the light source to the coin path may comprise splitting the light from the light source and guiding the split light respectively through the first and second regions of the coin path to the respective array of photo-

detectors.

[0027] A diameter or chord length of the coin, and/or characteristics of edge features of the coin, may be determined based on an output of the sensor array(s).

[0028] The method may scan both sides of a coin passing along the coin path. This may be achieved by using two optical sensors, or by passing the light from one optical sensor through the coin path at two locations and in different directions.

[0029] In one arrangement, the method may further comprise emitting light using a second light source and directing the light from the second light source to a coin path, such that the light from the first light source illuminates a first side of the coin and light from the second light source illuminates a second opposing side of the coin.

[0030] In an alternative arrangement, directing the light from the light source to a coin path and moving a coin along the coin path so as to interrupt the light emitted by the light source comprises: directing the light from the light source through a first portion of the coin path in a first direction; directing the light to a second portion of the coin path from a second direction; and moving the coin along the coin path so as to interrupt the light emitted by the light source at the first portion of the coin path, but not at the second portion; and moving the coin along the coin path so as to interrupt the light emitted by the light source at the second portion of the coin path, but not at the first portion.

[0031] Preferably the semiconductor light source in these methods of coin checking is a vertical cavity surface emitting laser (VCSEL).

[0032] In addition to the above, there also exists an ongoing need to provide cheaper and more consistent coin checking.

[0033] Viewed from a third aspect, the present invention provides a coin checking apparatus comprising: a coin path; a laser diode configured to emit light; an optical guide arranged to split the light from the laser diode and to guide the split light through first and second regions of the coin path respectively; a first array of photodetectors arranged to detect light emitted by the laser diode that has passed through the first region of the coin path without being interrupted by the coin; and a second array of photodetectors arranged to detect light emitted by the laser diode that has passed through the second region of the coin path without being interrupted by the coin.

[0034] Illuminating a single array of photodetectors which is sufficiently wide to scan the entire diameter of all standard coins presents problems when using a single light source, because of the power available from commercial laser diodes. Thus, prior art arrangements have instead provided two or more, spaced apart arrays of sensors to detect opposing edges of a coin as it passes over the sensors. Using the apparatus of the third aspect, a single laser diode may emit a beam of light, which is then split and guided to respective first and second exits where it can be used to illuminate those two arrays of photodetectors. Not only does this halve the number of laser diodes required but it also can provide a longer measuring region along the coin path or a wider measuring region across the coin path than was previously possible using a single light source. The latter can improve the handling of coins where they are being checked as they fall through the apparatus because greater coin misalignment can be accommodated.

[0035] The two arrays are preferably spaced apart from each other by at least 5mm, more preferably 7.5mm and more preferably still 10mm. This is because there is less benefit to scanning for light in the middle region, as even small coins will obscure this region. For example, the smallest Euro coin (1 cent) has a diameter of 16.25 mm. By not providing sensors in this region, the central region does not need to be illuminated, and therefore greater light intensity can be focused on the side regions, where the opposite edge portions of the coin will pass.

[0036] A distance between the outermost edge of the first array of photodetectors and the outermost edge of the second array of photodetectors is preferably at least 26 mm, and more preferably at least 30 mm.

[0037] This ensures that even large coins passing over the arrays will still allow light to reach the edges of the array, allowing for an accurate measurement. The largest Euro coin (2 euro coin) has a diameter of 25.75 mm. Larger sensor arrays may be required for certain countries having wider coins, for example, the UK 2 pound coin has a diameter of 28.4 mm.

[0038] Preferably, the optical guide is a waveguide having an entry for receiving the light from the laser diode and two exits for emitting light, respectively, to the first and second array of photodetectors, the waveguide including a splitter arranged to split the light from the laser diode.

[0039] The waveguide may be substantially Y-shaped, having a space between the first and second exits. An auxiliary sensor may be arranged within the space between the first and second exits of the waveguide and adjacent to the coin path, the auxiliary sensor being a sensor measuring electrical and/or magnetic properties, preferably selected from the group consisting of an inductive sensor, a capacitive sensor, and a hall effect sensor.

[0040] This arrangement allows for a more compact configuration as there is no need to provide photodetectors in the middle of the coin, which will be completely in shadow when both edge portions of a coin are being scanned. Thus, this combination allows for efficient use of the available space, reducing the number of light sources whilst still allowing the diameter of the entire coin to be scanned using a single laser diode to illuminate both sensor arrays.

[0041] Preferably the optical guide is arranged to illuminate the first array of photodetectors and second arrays of photodetectors with substantially equal light from the laser diode.

[0042] The use of a single laser diode allows for more

consistent light conditions, as compared for example to using two laser diodes, across both arrays of photodetectors.

[0043] Preferably the laser diode is a vertical cavity surface emitting laser (VCSEL).

[0044] The apparatus of the third aspect may also be combined with any preferred features of the first aspect, insofar as they are compatible, i.e. without the photodetector housed in the same package as the laser diode.

[0045] In this and the previous aspects, the array(s) of photodetectors may comprise any suitable form of photodetector, such as CMOS based devices, CCD devices, etc.

[0046] Certain preferred embodiments of the present invention will now be described in greater detail by way of example only and with reference to the accompanying drawings, in which:

Figure 1 is a side view of a coin checking apparatus according to a first embodiment;
Figures 2A and 2B show an exemplary output of the photodetector of the coin checking apparatus as a coin moves along the coin path;
Figure 3 is a side view of a coin checking apparatus according to a second embodiment;
Figure 4 is a cut-away top view of a coin checking apparatus according to a third embodiment;
Figure 5 is a perspective view of the coin checking apparatus according to the third embodiment;
Figure 6 is a perspective view of the coin checking apparatus according to the third embodiment in combination with a conveyor;
Figure 7 is a cut-away top view of a coin checking apparatus according to a fourth embodiment;
Figure 8 is a perspective view of the coin checking apparatus according to the fourth embodiment in combination with a conveyor;
Figure 9 is a perspective view of an optical guide for the coin checking apparatus according to the fourth embodiment;
Figure 10 is a sectional top-view of the optical guide shown in Figure 9;
Figure 11 is a perspective view of the coin checking apparatus according to the fifth embodiment;
Figure 12 is a cut-away top view of the coin checking apparatus according to the fifth embodiment; and
Figure 13 is a cut-away top view of a coin checking apparatus according to a sixth embodiment.

First Embodiment

[0047] Figure 1 shows a coin checking apparatus 2 according to a first embodiment.

[0048] The coin checking apparatus 2 includes a coin path 4 that a coin 6 passes along as it is being checked. The coin path 4 is a space through the apparatus 2 where the face of the coin 6 can be scanned on one side or preferably both sides, and/or possibly at an edge of the coin. The coin can be moved along the coin path by any suitable means. This may include, for example, a conveyor, where the coin may be moved along the coin path 4 by supports on the conveyor or by friction. It may also include the coin 6 moving under the action of gravity, for example, the coin 6 free-falling down through a gap in the apparatus, or rolling or sliding along a track that defines the coin path 4. The coin path 4 may be provided in an assembly that comprises a housing and is part of a much larger device, for example, where it is desirable to check the authenticity of the coin 6 before it is paid out to a user or deposited into a coin store.

[0049] The coin checking apparatus 2 also comprises an optical sensor 8, which comprises a laser diode 10 and a photodetector 12 housed within the same package. By "package" it is meant a semiconductor package where the components of the laser diode 10 and photodetector 12 might share one or more common electrical leads, for example, a transistor outline (TO) package complying with the JEDEC standard. The laser diode 10 thus has a photodetector 12 integrated within a common housing. The laser diode 10 is preferably a vertical cavity surface emitting laser (VCSEL). Suitable laser diodes 10 having an integral photodetector 12 are commercially available.

[0050] Advances in laser diodes 10 of this type has resulted in significant improvements in the resolution of the photodetector 12, and this combined with recent improvements in real-time processing power has allowed this apparatus to be developed.

[0051] The optical sensor 8 also includes an optical guide 14 that is configured to direct light from the laser diode 10 to the coin path 4. The optical guide 14 also conveys light which is reflected from a surface of a coin 6 back towards the photodetector 12, which is housed in the same package as the laser diode 10.

[0052] The optical guide 14 may be in the form of collimating optics, for example, as a set of lenses for producing a collimated beam of light. The collimating optics may include a diverging lens 16 to spread the light emitted by the laser diode 10, and a converging lens 18 to collimate the spread light. The optical guide 14 may also be in the form of one or more prisms that modify the path of the light, preferably to produce a collimated beam, as it is guided to the coin path 4. In one example, the optical guide 14 is a single prism. Preferably the light from the laser diode 10 emerges from the optical guide 14 to pass through the coin path 4 as a collimated beam in a direction substantially perpendicular to the direction in which the coin passes.

[0053] As a coin 6 passes along the coin path 4, it interrupts the collimated light beam. The light impinging on the surface of the coin 6 is scattered by the surface relief of that portion of the coin 6, and some of the light is reflected back towards the laser diode 10 via the optical guide 14. The photodetector 12, which is housed in the same package as the laser diode 10, generates an output based on the intensity of light it receives. As the coin 6 progresses along the coin path 4, the output generated

by the photodetector 12 will vary according to the changes in the surface relief and the variations in reflectivity these changes provide.

[0054] The intensity of the reflected light received by the photodetector 12 is affected by a number of factors. These include, among others, the overall reflectivity of the metal of the coin 6, the surface finish of the coin 6, which will include areas where the coin 6 may have a mirrored finish ("mirror face") or a textured finish, the uniformity of any surface features, the sharpness of the surface features and, of course, which side or area of the coin 6 that is being checked. Some coins 6 include a middle section which is made of a different metal to an outer section that provides a rim of the coin 6. The orientation of the surface features on one side of the coin 6 compared to an opposite side may also provide a useful indication to determine genuine coins from fake coins. The sharpness of the edge features can also be a good reference.

[0055] The use of a laser diode 10 with an integrated photodetector 12 for this surface scanning process has been surprising in terms of the detail the reflectivity of the surface features is able to reveal and the precision with which the coin checking apparatus can discriminate between genuine and fake coins 6.

[0056] The use of a laser diode 10 is advantageous since, whilst some LED may be packaged with a photodetector in a single package, a significant disadvantage to these devices is the amount of optical crosstalk between the LED and the photodetector that degrades the signal to noise ratio of the photodetector. Cross talk comes from the fact that LEDs emit from all surfaces and the emission subtends nearly 90 degrees. Conversely, a laser diode is more easily collimated and focused to increase the amount of reflected light.

[0057] A single mode VCSEL offers the advantages of being the most efficient, narrowest divergence, and most coherent device. Using a VCSEL as the laser diode 10 and integrating the photodetector 12 in the package, provides all of the advantages of the VCSEL as well providing a very robust reflective sensor. Depending on the application, a single mode or multimode VCSEL can be chosen. In some cases, where coherence of the light beam is desired, a single mode VCSEL might be the best choice, but in other cases where total output power is more important, a multimode VCSEL might be more beneficial.

[0058] In this embodiment, a multimode VCSEL is used at the laser diode 10. The package housing the laser diode 10 and the photodetector 12 includes a header having at least four leads and a ceramic spacer adapted for mounting of the laser diode 10 and the photodetector 12 within the package. The ceramic spacer, which can be fabricated as part of the header, is adapted to mount the laser diode 10 at a level higher than the photodetector 12 within the package. Alternatively, the laser diode 10 can be located within a recess in the ceramic spacer such that the laser diode 10 is located beneath the surface of the photodetector 12, therefore light from the laser diode 10 does not directly impinge on the photodetector 12 during operation. Thus, only returned light is captured by the photodetector 12.

[0059] The coin checking apparatus 2 is preferably provided with a processing device 20 for analysing an output from the photodetector 12 as the coin 6 moves along the coin path 4. This may comprise a processor or a set of processors configured to perform an algorithm on the output. The processing device 20 may analyse the whole of the output, or select a portion or portions of the output that is/are considered to be the most indicative for the checking. This may be a portion of the output that corresponds with an edge region of the coin 6, as sharpness of the surface features in this region can be a useful indicator. It may correspond to a portion where the coin 6 has an area with a mirror finish, since the precision of the surface finish of genuine coins 6 can be difficult to emulate in a forgery. The portion may also correspond with a portion of the coin 6 where a distinctive or characteristic feature is present.

[0060] The processing device 20 may generate a "fingerprint" of the coin 6 from the output of the photodetector 12 that can be used to assist with identifying the type of coin 6 or, more particularly, gauging whether the coin 6 is genuine or fake. This fingerprint may be stored within an internal memory. The fingerprint may be compared to known fingerprints when checking the coin 6. The fingerprint or output may also be processed to determine if the amplitude of the reflectivity is within certain threshold limits and/or whether fluctuations exceed predetermined threshold limits, for example, that might be indicative of a fake coin 6.

[0061] The processing device 20 may use the output to calculate other parameters of the coin 6, to determine edge patterning, or gauge a coin 6 diameter or a chord length at a particular part of the coin 6, the size of surface features, etc., any of which can be used in conjunction with other measurements taken by other sensors to verify the coin 6.

[0062] The output may correspond to the whole face of a coin 6 or a strip across a face of the coin 6. That strip might be a linear strip, e.g., where the coin 6 is being carried by a conveyor and remains in a fixed orientation, or it may comprise an area taken across the surface of a coin 6 as it is rolling. The strip may be aligned with a centre of the coin 6 or it may be off-set from the centre.

[0063] Figure 2A and 2B shows an exemplary output of the photodetector 12 of the optical sensor 8 at a point where the coin 6 is moving along the coin path 4 through the collimated beam, reflecting light from the laser diode 10 back to the photodetector 12. The exemplary output shown in Figure 2A might indicate a genuine coin. The exemplary output shown in Figure 2B might indicate a fake coin.

[0064] Furthermore, the processing device 20 may be configured to determine a diameter of the coin 6 based on the output from the photodetector 12. As the speed

of the coin 6 is known when it interrupts the collimated beam, the diameter of the coin 6 may be determined from the output of the photodetector 12 or based on a fingerprint generated for the coin 6.

[0065] Returning to Figure 1, the coin checking apparatus 2 may also include an array of photodetectors 22, such as CMOS based sensors, where the array of photodetectors 22 is positioned to receive light from the laser diode 10 that has passed through the coin path 4, i.e., on the side of the coin path 4 opposite to a light emitting part of the optical guide 14. The array of photodetectors 22 is activated by the light from the laser diode 10 that has not been obscured by the coin 6. As a coin 6 moves along the coin path 4, it interrupts the collimated beam and a "shadow" is cast on the array of photodetectors. Thus, the laser diode 10 may be arranged to provide light not only for its integral photodetector 12 but also for the array of photodetectors arranged across the coin path 4 from the light emitting part of the optical guide 14.

[0066] The array of photodetectors 22 may output a signal or signals in accordance with how the array is obscured by the coin 6 at a given point in time. The processing device 20 preferably also analyses the signal(s) of the array of photodetectors to determine coin 6 diameter (or a coin 6 chord length) and edge profiling such as milled ridges. This type of processing is discussed for example in EP-B-0900431 and the above mentioned GB-B-2369710.

[0067] The coin checking apparatus 2 may include a device to deflect the course of a coin 6 if it is believed to be a fake. This may be in the form of an ejector to remove a coin 6 from the coin path 4 (e.g., a pin that is fired at the coin 6) or a deflector that sends the coin 6 along a different path (e.g., a plate that pivots across the coin path 4 to direct the coin 6 along another path). This device may be positioned an appropriate distance downstream of where the checking operations are conducted.

Second embodiment

[0068] Figure 3 shows a coin checking apparatus 24 according to a second embodiment of the present invention. The coin checking apparatus 24 includes a processing device 20, an optical sensor 8 comprising a laser diode 10, a photodetector 12 and a light guide 14, and a coin path 4, similar to those of the first embodiment. Description of features that are the same as in the first embodiment has not been repeated, though for the avoidance of all doubt, their description in the first embodiment applies equally to the second embodiment.

[0069] The coin checking apparatus 24 of the second embodiment further includes a second optical sensor 26 comprising a laser diode 28 and a photodetector 30 housed within a single package, and an optical guide 32 to provide a collimated beam of light.

[0070] The second optical sensor 26 operates in substantially the same manner as the first optical sensor 8; however, it is arranged such that the light from the respective laser diode 28 is directed so as to pass through the coin path 4 in a direction opposite to the direction of the light from the first optical sensor 8. This is so that light from the first and second optical sensors 8, 26 illuminate opposing faces of the coin 6. The first and second optical sensors 8, 26 are offset with respect to one another along the coin path 4 so that the light from one laser diode 10, 28 does not interfere with the photodetector 12, 30 of the other optical sensor 8, 26.

[0071] As a coin 6 to be identified passes along the coin path 4, it interrupts first the collimated light beam of the first optical sensor 8 and then the collimated light beam of the second optical sensor 26. Each photodetector 12, 30 may generate a "fingerprint" of the respective face, or portion of a respective face, of the coin 6 as it moves across the particular collimated light beam. Thus, a fingerprint of the coin 6 may be obtained for both sides of the coin 6. A diameter (or chord length) may be determined from either fingerprint or both for verification purposes.

[0072] The processing device 20 may be configured to identify the type of the coin 6 based on the output of the photodetectors 12, 30 of both the first optical sensor 8 and the second optical sensor 26. The processing device 20 may compare the detected fingerprints of the coin 6 and the determined diameter of the coin 6 with corresponding values from a database of known coin fingerprints and diameters stored in the memory of the controller. The processing device 20 may use the fingerprints to check whether the coin 6 is genuine or fake. The fingerprints of the surface features may be used in conjunction with other measurements taken of the coin 6. These may comprise further optical measurements, or may comprise electrical measurements, such as measuring the inductance or capacitance of the coin 6 or the Hall effect as the coin 6 moves along the coin path 4.

[0073] As with the first optical sensor 8, the second optical sensor 26 may also be arranged to illuminate an array of photodetectors 33, such as CMOS based sensors, where the array of photodetectors 33 that is positioned on the side of the coin path 4 opposite to a light emitting part of the optical guide 33 of the second optical sensor 26. This array of photodetectors 33 operates in substantially the same manner as the array of photodetectors 22 cooperating with the first optical sensor 8 and its output may also be processed by the processing device 20 as mentioned above.

Third embodiment

[0074] Figures 4 and 5 show a coin checking apparatus 34 according to a third embodiment. Description of features that are the same as in the first and second embodiments have not been repeated, though for the avoidance of all doubt, their previous description applies equally to this third embodiment, and vice versa.

[0075] The coin checking apparatus 34 includes a processing device (not shown), first and second optical

sensors 8, 26, a coin path 4, and an array of photodetectors 22 in cooperation with the first optical sensor 8, similar to those of the second embodiment. The coin checking apparatus 34 further includes an inductive sensor 36, and a Hall effect sensor 38. A capacitive sensor (not shown) may also be included.

[0076] The array of photodetectors 22 is a linear array of photodetectors 22 and is positioned adjacent to the coin path 4 and is elongate in the direction in which coins 6 move along the coin path 4. The light guide 14 of the optical sensor 8 is arranged to collimate the light into an elongate collimated light beam that illuminates all, or most, of the array of photodetectors 22.

[0077] The inductive sensor 36 is provided adjacent to the coin path 4 and serves to detect an inductive characteristic of the coin 6 approximately at its core as it passes in front of the inductor sensor 36. The processing device 20 analyses the output of the inductive sensor 36, which is indicative of the thickness of the coin 6. Hence, a coin thickness may be determined by the processing device 20.

[0078] The Hall effect sensor 38 is also provided adjacent to the coin path 4 to measure further electromagnetic properties of the coin 6 and to provide more information to the processing device 20.

[0079] The capacitive sensor (not shown) may be provided adjacent to the coin path 4 in the form of capacitor plates positioned on either side of the coin path 4. The capacitive sensor measures the capacitance of coins 6 passing between the capacitor plates. The processing device 20 analyses the output of the capacitive sensor, which helps to indicate the material of the coin 6.

[0080] The optical and electrical/magnetic checks are each performed on the coin 6, since one may help to identify a coin 6 or prove its authenticity better than another; together they provide a particularly useful coin checking apparatus 34.

[0081] Figure 6 is a perspective view of the coin checking apparatus 34 in combination with a housing 40. The housing 40 comprises a track 42 and a cover plate 44, which together substantially define the coin path 4. The track 42 includes a conveyor 46 comprises a belt passing up through the coin path 4. The belt may include supports, for example, in the form of pairs of pegs arranged along the belt, for moving the coins 6 with the belt. The pairs of pegs also help to position the coins 6 centrally within the coin path 4.

Fourth embodiment

[0082] Figures 7 to 10 show a coin checking apparatus 48 according to a fourth embodiment. The coin checking apparatus 48 is similar to that of the third embodiment. Description of features that are the same as in the third embodiment have not been repeated, though for the avoidance of all doubt, their description applies equally to this fourth embodiment. Only the differences between these embodiments will now be described.

[0083] In addition to a first array of photodetectors 22, the coin checking apparatus 48 is provided with a second array of photodetectors 50 which is also activated in cooperation with the first optical sensor 8. As with the first array of photodetectors 22, the second array of photodetectors 50 comprises a linear array of photodetectors 50 and may include, for example, CMOS based sensors. The second array of photodetectors 50 is positioned adjacent to the coin path 4 and is elongate in the direction in which coins 6 move along the coin path 4. The first and second arrays of photodetectors 22, 50 and the first optical sensor 8 are positioned so that both the first and second arrays of photodetectors 22, 50 are illuminated by light from the laser diode 10 of the first optical sensor 8 (when the light is not interrupted by a coin 6).

[0084] In this embodiment, the optical guide 14 is in the form of a prism or waveguide 52 that is arranged to collimate and split the light emitted from the laser diode 10. An example of the optical guide 14 for the coin checking apparatus 48 is shown in Figures 9 and 10.

[0085] The illustrated optical guide 14 is arranged to collimate and split the light into two collimated light beams that illuminate all, or most, of the first and second arrays of photodetectors. The collimated light beams may be elongated in the direction of the coin 6 movement, corresponding to the shape of the arrays, or provided in some other orientation.

[0086] The optical guide 14 comprises a substantially Y-shaped prism 52, providing an entry for the emitted light and two exits. A splitter 54, arranged between the entry and exits, splits the light into first and second light beams and the optical guide 14 directs these respectively to the first and second exits. The splitter additionally spreads the first and second light beams to provide an elongate area of illumination for each array. A prismatic lens at each exit, which is preferably formed as part of this Y-shaped prism, collimates the respective light beam and directs it to the coin path 4 (in this embodiment, by reflecting it through 90° as the light passes from the splitter 54 to an exit). The exits of the optical guide 14 correspond to the first and second arrays of photodetectors 22, 50.

[0087] As a coin 6 moves along the coin path 4, it interrupts the light beams and a "shadow" is cast on the arrays of photodetectors. An output or outputs from the arrays is supplied to the processing device 20. The processing device 20 analyses the shadow cast by the coin 6 on each of the arrays to determine one or more dimensional characteristics of the coin 6, in the same manner as the previous embodiments.

[0088] The first and second arrays of photodetectors are arranged so that when the coin 6 moves along the coin path 4, a leading edge of the coin 6 can interrupt the light from the laser diode 10 to the second array of photodetectors 50 and a trailing edge of the coin 6 can interrupt the light from the laser diode 10 to the first array of photodetectors 22. Thus, an accurate measurement of the diameter or a chord length of the coin may be deter-

mined. The inductive sensor 36 may be positioned between the two arrays of photodetectors 22, 50.

Fifth Embodiment

[0089] Figures 11 and 12 show a coin checking apparatus 56 according to a fifth embodiment. The coin checking apparatus 56 is similar to that of the third embodiment. Description of features that are the same as in the third embodiment have not been repeated, though for the avoidance of all doubt, their description applies equally to this fifth embodiment. Only the differences between these embodiments will be described.

[0090] In this embodiment, the second optical sensor 26 has been removed. The first optical sensor 8 has instead been positioned and configured such that light from the laser diode 10 passes through the coin path 4 twice, but in opposing directions.

[0091] The light from the laser diode 10 is collimated and directed through a first portion of the coin path 4 in a first direction. The light is then received by a further portion of the optical guide 14 in the form of a prismatic waveguide 58 that directs the light, by internal reflection, to a second portion of the coin path 4 and turns it through 180°. The light is then emitted from an exit of the waveguide 58 and used to illuminate a second portion of the coin path 4, the light being directed in a second direction opposite to the first. Thus, the light may be used to illuminate opposing faces of the coin 6, respectively, when the coin 6 is passing through the first and second portions of the coin path 4. These first and second portions of the coin path 4 are offset with respect to one another in the direction of travel of the coin 6, so that a coin 6 clears or substantially clears the second portion before it interrupts the light at the first portion of the coin path 4.

[0092] Thus, as with the second embodiment, as a coin 6 passes along the coin path 4, it interrupts the collimated light beam at one portion of the coin path 4 and then the collimated light beam at the other portion of the coin path 4. The photodetector 12 of the optical sensor 8 may generate a "fingerprint" of each face of the coin 6 as it moves across the respective collimated light beam, i.e., a fingerprint for each side. A diameter (or chord length) of the coin 6 may be determined from either fingerprint, or from both for verification purposes.

[0093] The processing device 20 may be configured to identify the type of the coin 6 by comparing the detected fingerprints of the two faces of the coin 6 and/or a determined diameter of the coin 6 with corresponding values from a database of known coin 6 fingerprints and/or diameters stored in the memory of the processing device 20.

Sixth Embodiment

[0094] Figure 13 shows a coin checking apparatus 60 according to a sixth embodiment. The coin checking apparatus 60 is similar to that of the fourth embodiment. Description of features that are the same as in the fourth embodiment have not been repeated, though for the avoidance of all doubt, their description applies equally to this sixth embodiment. Only the differences between these embodiments will be described.

[0095] In this embodiment, the coin 6 moves along the coin path 4 under the effect of gravity. The coin 6 is preferably in freefall as it interrupts the collimated light from the first laser diode 10. Such a coin checking system 60 is well suited to providing fast identification and detection, as is required in applications where a user may rapidly insert a stream of coins 6, such as gaming and amusement machines. By moving the coins 6 in freefall, the coin checking system 60 reduces the likelihood of a coin jam occurring due to the inability of a large number of coins 6 to pass through the coin checking apparatus 60 in a short period of time.

[0096] In this embodiment the first and second arrays of photodetectors 22, 50 are arranged so as to extend across the coin path 4, i.e., in a direction substantially perpendicular to the direction in which the coin 6 moves along the coin path 4 (vertically in this embodiment). This provides a benefit over embodiments where the first and second arrays of photodetectors 22, 50 are aligned with the direction of the coin path 4 as the coin 6 need not be centrally aligned in order to determine the diameter of the coin 6.

[0097] As with the fourth embodiment, the waveguide 52 is configured to split light from the laser diode 10 of the first optical sensor 8 to illuminate the first and second arrays of photodetectors 22, 50.

[0098] The coin checking apparatus 60 may optionally also include alignment means for aligning the coin 6 with respect to the first and second arrays of photodetectors 22, 50, and stabilizing means for stabilising the coin in the direction of the collimated light from the laser diode 10. Typically the aligning means will be arranged to align the coin 6 centrally with respect to the first and second arrays of photodetectors 22, 50.

[0099] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various modification may be made without departing from the scope of the invention, which is defined by the claims. For example, whilst the optical sensors 8, 26 of the preferred embodiments each use a laser diode 10, 28 to emit light, any suitable light source may instead be used, such as a high-power light emitting diode (LED).

[0100] Furthermore, whilst the described second, third and further embodiments include a first optical sensor 8 and a second optical sensor 26, the second optical sensor 26 may be omitted from any of these embodiment if desired.

[0101] Furthermore, whilst the fifth embodiment has been described with reference to a coin checking apparatus 56 using only a single array of photodetectors 22, as in the third embodiment, those skilled in the art will

understand that a suitable optical guide 14 may instead be provided so as to utilise two or more arrays of photodetectors 22, 50, as in the fourth embodiment. Alternatively, the arrangement of the optical sensor 8 of this embodiment may be used on its own to scan both sides of the coin 6 without any additional tests, as in the second embodiment.

[0102] The following clauses set out features of the invention which may not presently be claimed in this application but which may form the basis for future amendment or a divisional application.

1. A coin checking apparatus comprising:

a coin path;
a light source configured to emit light;
an optical guide arranged to split the light from the light source and to guide the split light through first and second regions of the coin path, respectively;
a first array of photodetectors arranged to detect light emitted by the light source that has passed through the first region of the coin path without being interrupted by the coin;
a second array of photodetectors arranged to detect light emitted by the light source that has passed through the second region of the coin path without being interrupted by the coin.

2. An apparatus according to clause 1, wherein a distance between the outermost edge of the first array of photodetectors and the outermost edge of the second array of photodetectors is at least 25 mm.

3. An apparatus according to clause 1 or 2, wherein the optical guide is a waveguide having an entry for receiving the light from the light source and two exits for emitting light, respectively, to the first and second array of photodetectors, the waveguide including a splitter arranged to split the light from the light source.

4. An apparatus according to clause 3, wherein the waveguide is substantially Y-shaped, having a space between the first and second exits.

5. An apparatus according to clause 4, further comprising:

an auxiliary sensor arranged within the space between the first and second exits of the waveguide and adjacent to the coin path, the auxiliary sensor being a sensor for measuring an electrical and/or magnetic property of the coin, preferably selected from the group consisting of an inductive sensor, a capacitive sensor, and a hall effect sensor.

6. An apparatus according to any preceding clause, wherein the optical guide is arranged to illuminate the first array of photodetectors and second arrays of photodetectors with substantially equal light from the light source.

7. An apparatus according to any preceding clause, wherein the light source emitting light is a laser diode.

8. An apparatus according to clause 7, wherein the laser diode is a vertical cavity surface emitting laser (VCSEL).

9. A method of checking a coin, comprising:

emitting light using a semiconductor light source;
splitting the light emitted from the light source;
directing a first portion of the light to a first region of a coin path provided with a first array of photodetectors;
directing a second portion of the light to a second region of the coin path provided with a second array of photodetectors;
moving a coin along the coin path so as to interrupt the first and/or second portions of light; and
analysing outputs of the first and/or second arrays of photodetectors.

10. A method according to clause 9, wherein the light is emitted from a vertical cavity surface emitting laser (VCSEL).

Claims

1. A coin checking apparatus (2, 24, 34, 48, 56, 60) comprising:

a coin path (4); and
an optical sensor (8) arranged to scan a coin (6) passing along the coin path, the optical sensor comprising:

a semiconductor light source (10) configured to emit light;
an optical guide (14) configured to direct the light from the light source to the coin path; and
a photodetector (12) configured to detect light from the light source that is reflected by the coin and returned by the optical guide,
wherein the light source and the photodetector are provided within a single package.

2. An apparatus according to claim 1, further comprising:

a processing device (20) configured to analyse an output from the photodetector as the coin moves along the coin path.

3. An apparatus as claimed in claim 2, wherein the processing device is configured to compare the output from the photodetector against stored outputs to determine if the coin is genuine.

4. An apparatus as claimed in claim 2 or 3, wherein the processing device is configured to analyse the changes in reflectivity across a face of the coin as it moves along the coin path.

5. An apparatus according to claim 2, 3 or 4, wherein the processing device is further configured to determine a diameter or a chord length of the coin based on the output of the photodetector.

6. An apparatus according to any of claims 2 to 5, further comprising:

an array of photodetectors (22) arranged to detect light emitted by the light source that has passed through a first region of the coin path without being interrupted by the coin.

7. An apparatus according to claim 6, further comprising:

a second array of photodetectors (50) arranged to detect light emitted by the light source that has passed through a second region of the coin path without being interrupted by the coin,
wherein the optical guide is arranged to split the light from the light source and to guide the split light through the first and second regions of the coin path to the respective array of photodetectors.

8. An apparatus according to any preceding claim, wherein the optical guide is arranged to direct light from the light source through one region of the coin path in a first direction, and to direct light through another region of the coin path from a second direction such that light travelling in the first direction illuminates one side of the coin and light travelling in the second direction illuminates an opposite side of the coin.

9. An apparatus according to any preceding claim, wherein the light source is a laser diode, and more preferably wherein the light source is a vertical cavity surface emitting laser (VCSEL).

10. A method of checking a coin, comprising:

emitting light using a semiconductor light source (10);
directing the light from the light source to a coin path (4);
moving a coin (6) along the coin path so as to interrupt the light emitted by the light source; and
detecting light reflected by the coin using a photodetector (12) provided within the same package as the light source.

11. A method according to claim 10, further comprising:

analysing an output from the photodetector as the coin moves along the coin path.

12. A method according to claim 11, wherein analysing an output from the photodetector comprises:

determining a diameter or chord length of the coin based on an output of the photodetector as the coin moves along the coin path.

13. A method according to claim 11 or 12, wherein analysing an output from the photodetector comprises:

comparing an output from the photodetector against stored outputs to determine if the coin is genuine.

14. A method according to any of claims 10 to 12, further comprising:

detecting, using an array of photodetectors (22), light emitted by the light source that has passed through a first region of the coin path without being interrupted by the coin.

15. A method according to any of claims 9 to 14, wherein the light source is a laser diode, and more preferably wherein the light source is a vertical cavity surface emitting laser (VCSEL).

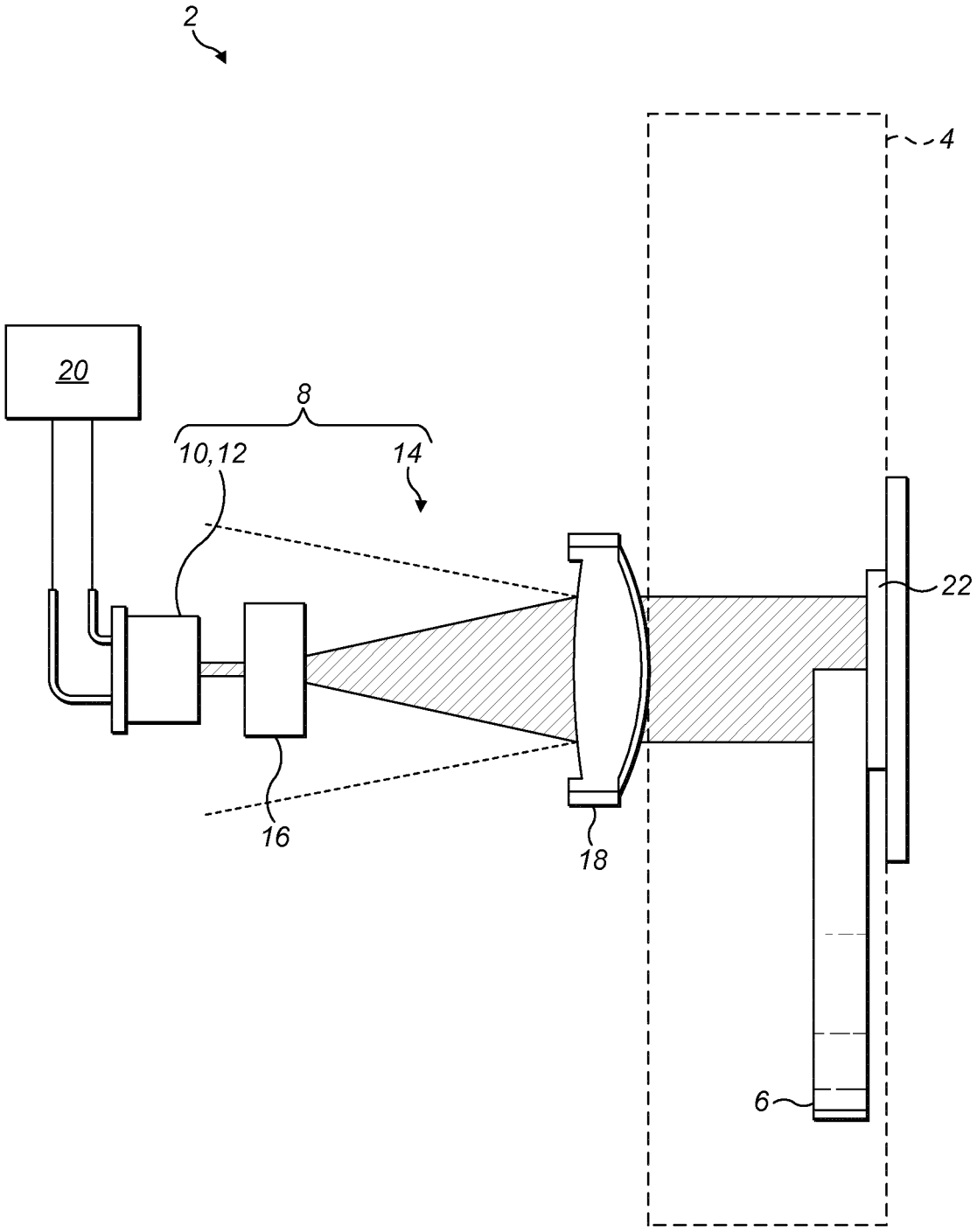


FIG. 1

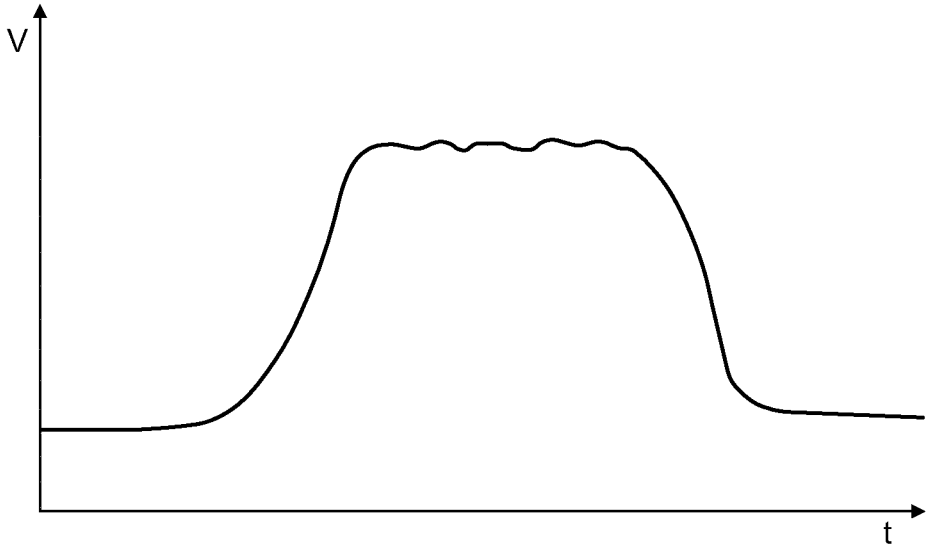


FIG. 2A

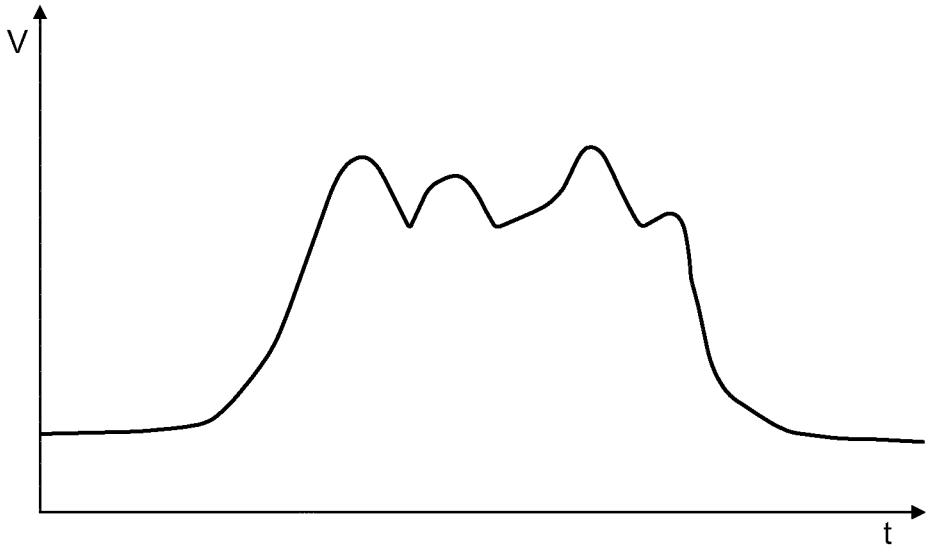


FIG. 2B

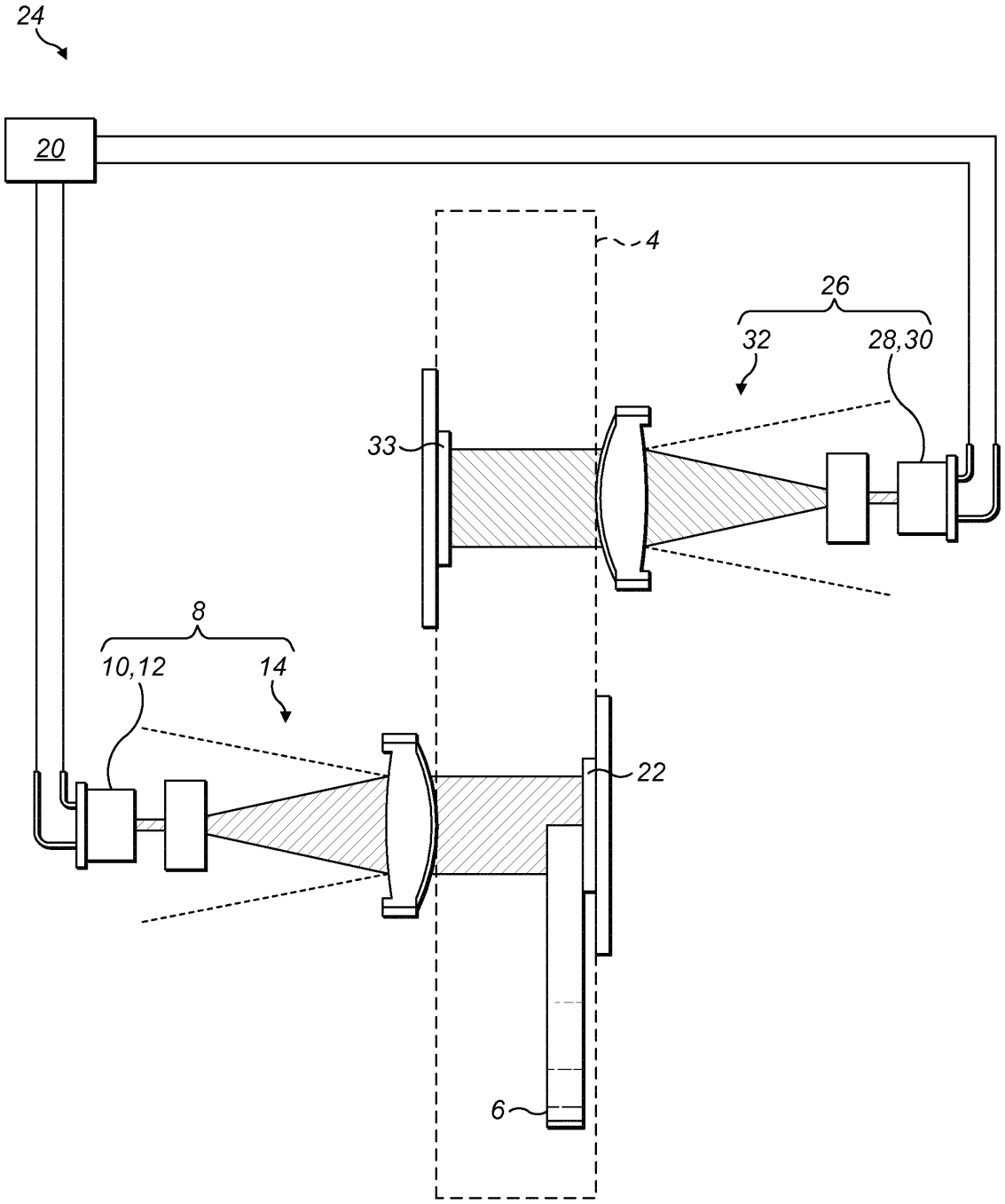


FIG. 3

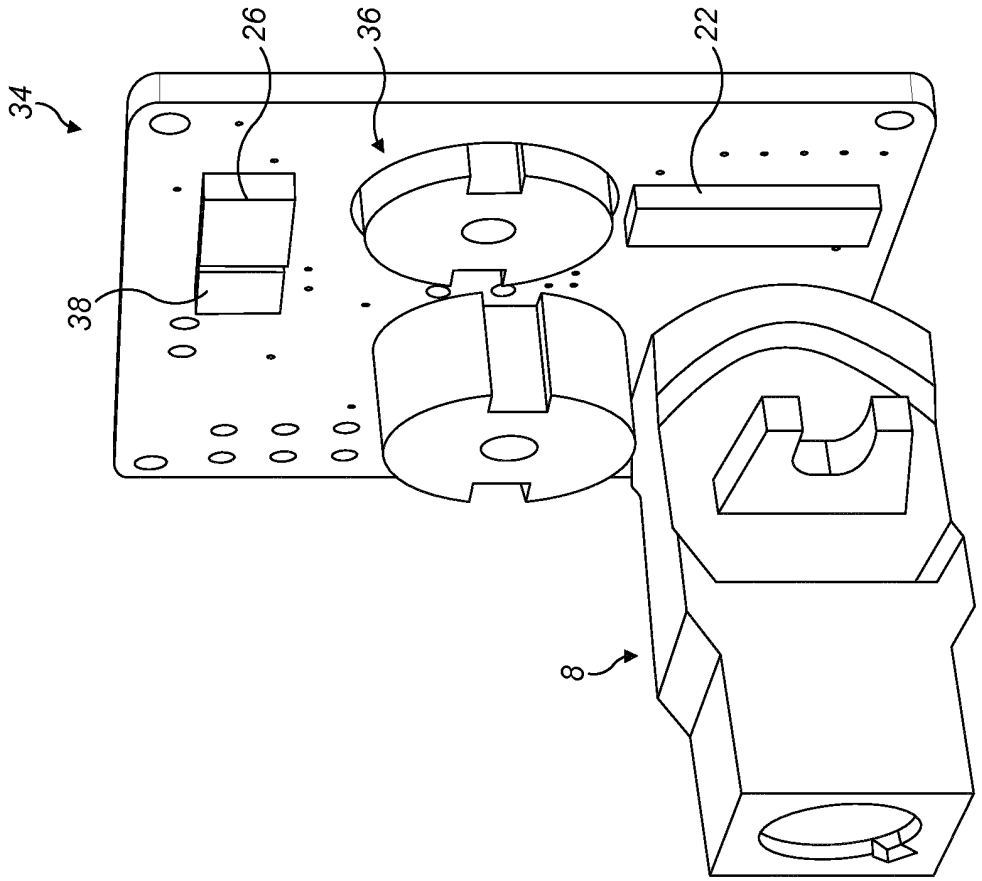


FIG. 5

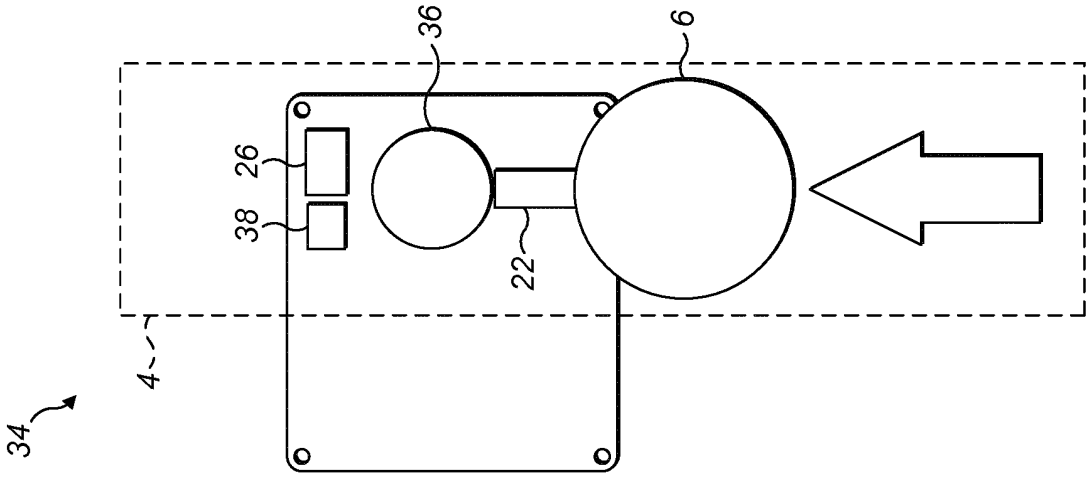


FIG. 4

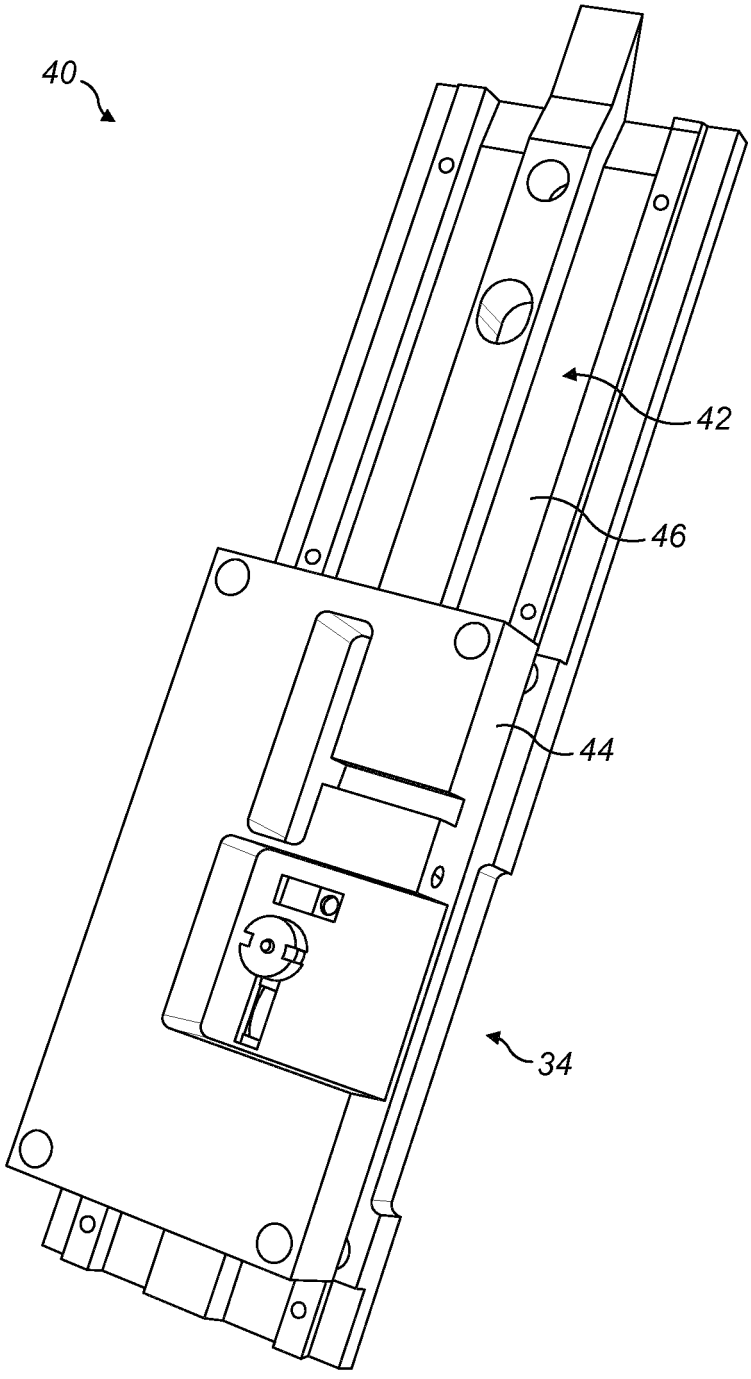


FIG. 6

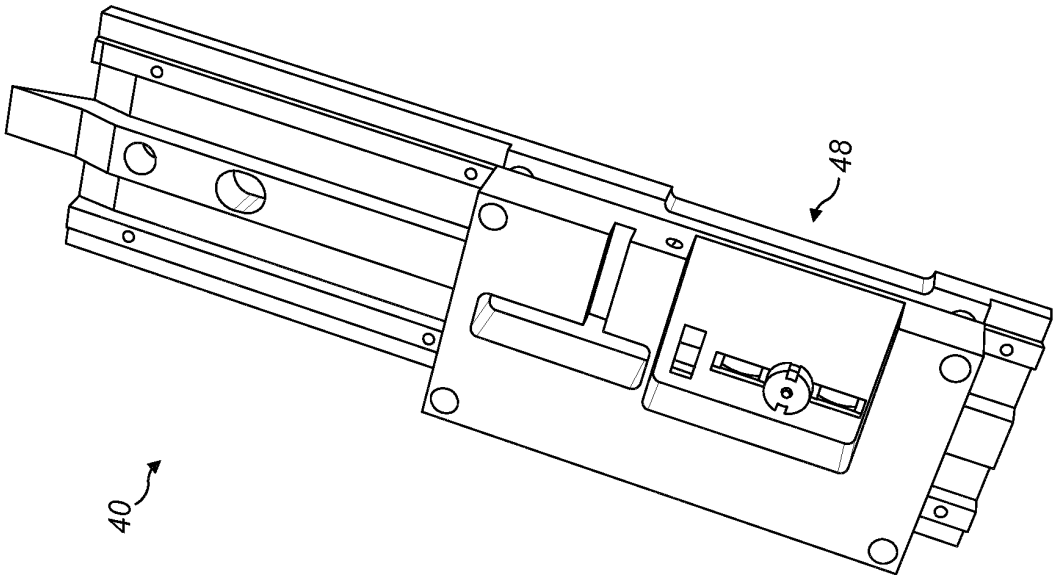


FIG. 8

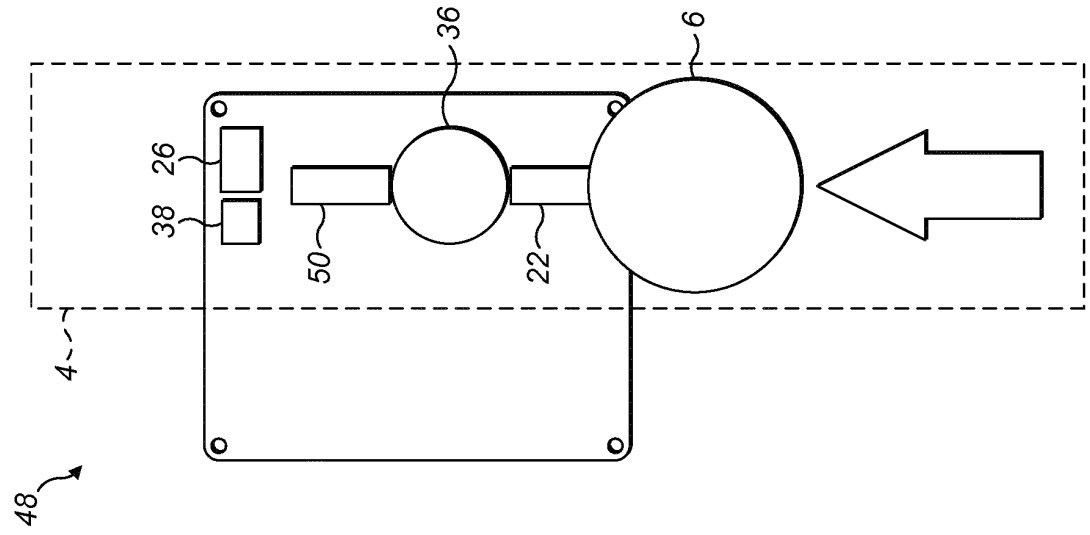


FIG. 7

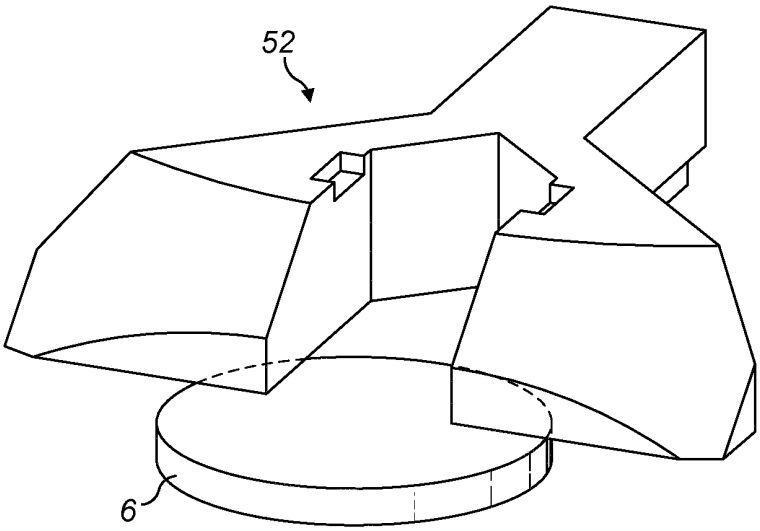


FIG. 9

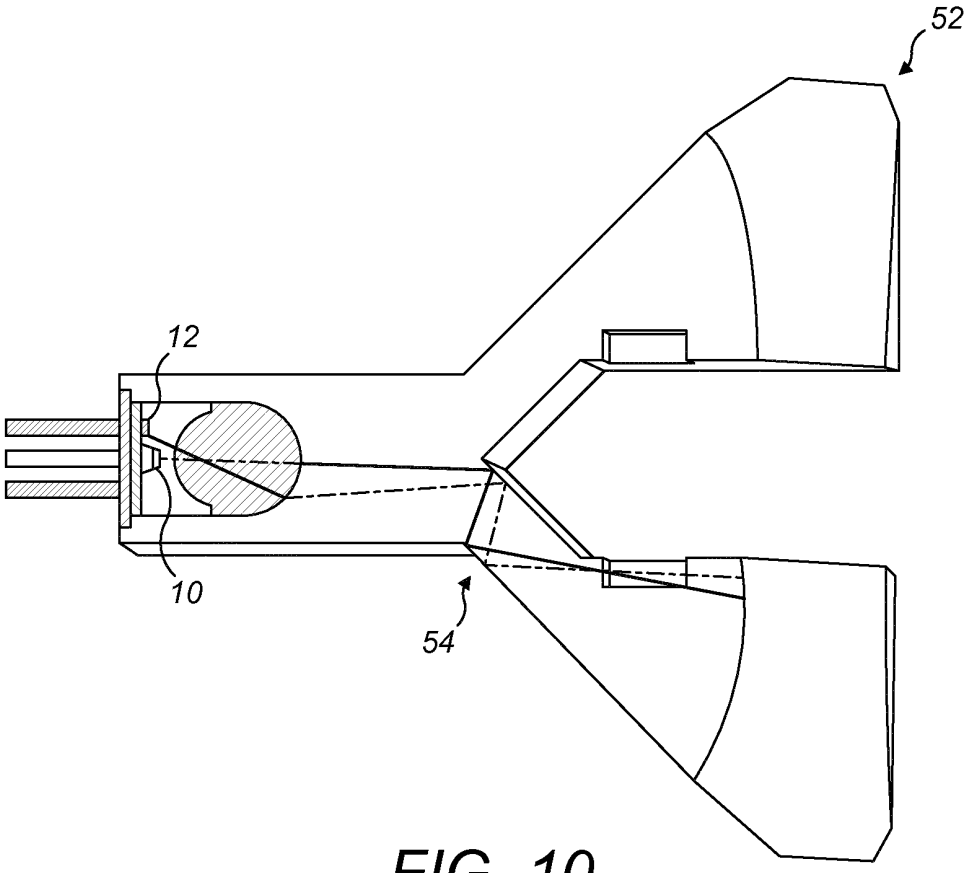


FIG. 10

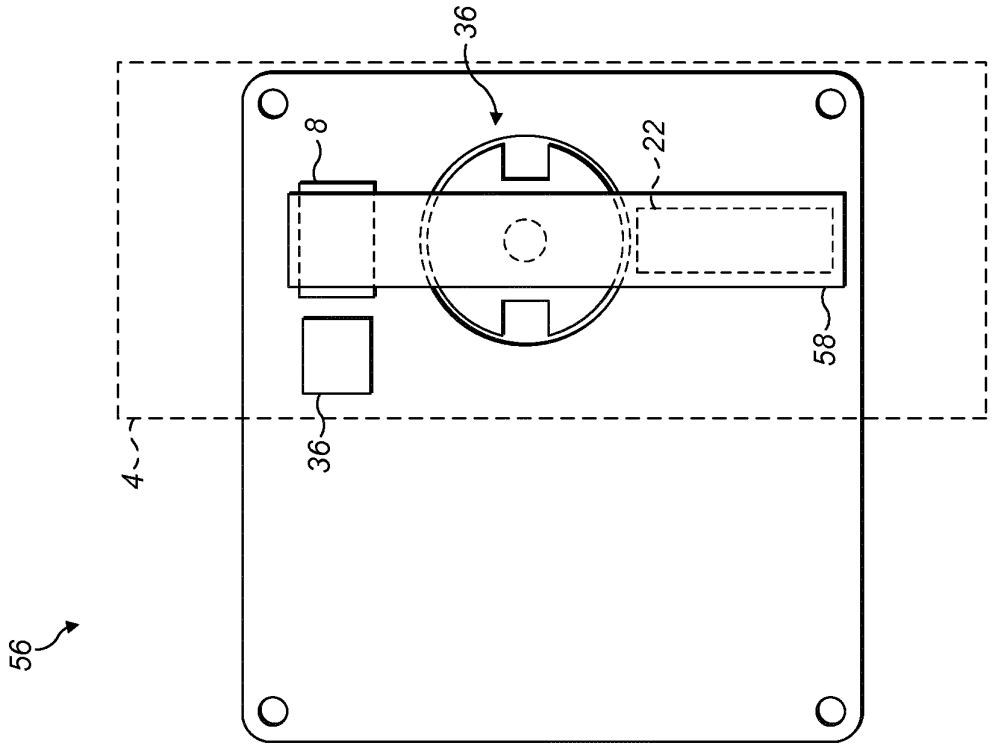


FIG. 12

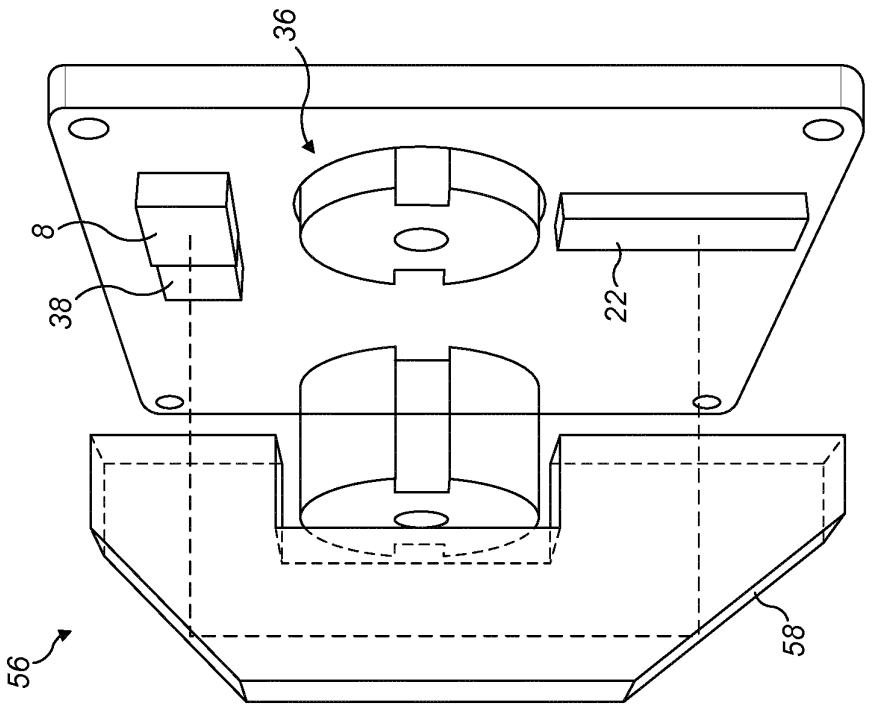


FIG. 11

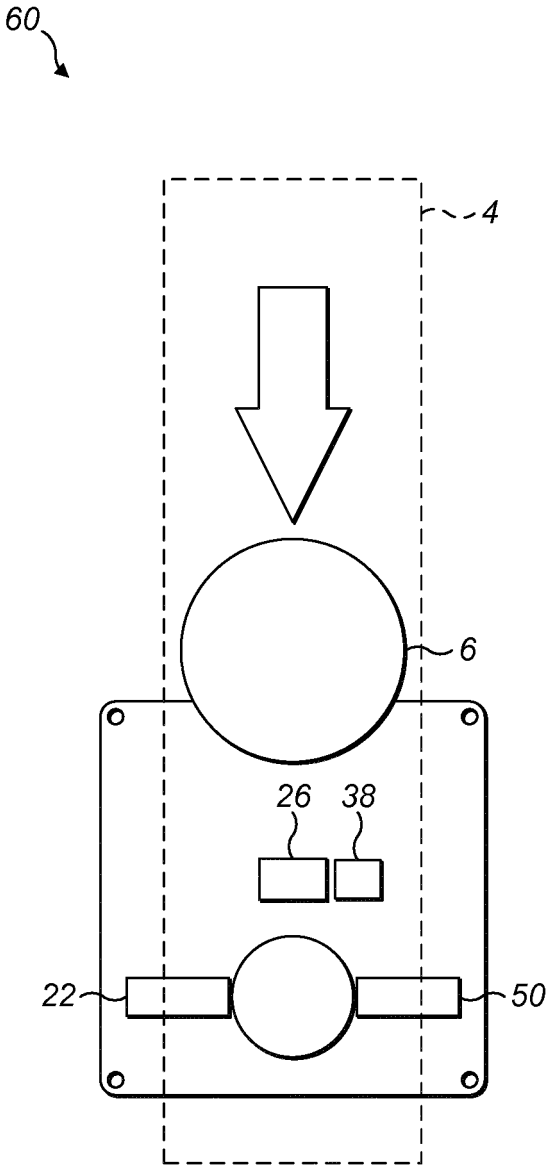


FIG. 13

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 13 16 1990

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	FR 2 965 389 A1 (PARKEON [FR]) 30 March 2012 (2012-03-30) * page 4, line 1 - line 8 * * page 4, line 12 - line 13 * * page 4, line 20 - page 6, line 3; figures 1-5 *	1-5, 10-13 6-9,14, 15	INV. G07D5/00 G07D5/02 G07D5/10
X Y	US 6 305 523 B1 (HOUSE LARRY J [US] ET AL) 23 October 2001 (2001-10-23) * column 5, line 22 - line 31 * * column 12, line 18 - column 14, line 8; figures 12-15 *	1-5, 10-13 6-9,14, 15	
X Y	WO 00/41143 A1 (SCAN COIN IND AB [SE]; ANDERSSON PER [SE]) 13 July 2000 (2000-07-13) * page 3, line 23 - page 5, line 2 * * page 5, line 26 - line 32; figure 1 *	1-5, 10-13 6-9,14, 15	
X Y	EP 0 060 392 A2 (SODECO COMPTEURS DE GENEVE [CH]) 22 September 1982 (1982-09-22) * page 11, line 15 - page 12, line 8; figure 7 *	1-5, 10-13 6-9,14, 15	TECHNICAL FIELDS SEARCHED (IPC) G07D
X Y	GB 1 553 752 A (LANDIS & GYR AG) 26 September 1979 (1979-09-26) * page 3, line 122 - page 4, line 3 * * page 4, line 12 - line 18; figure 4 *	1-5, 10-13 6-9,14, 15	
Y A	US 5 576 825 A (NAKAJIMA TOHRU [JP] ET AL) 19 November 1996 (1996-11-19) * column 3, line 42 - column 4, line 18 * * column 6, line 15 - line 36 * * column 7, line 30 - line 36 * * column 8, line 1 - line 59 * * column 8, line 66 - column 9, line 7 * * column 9, line 36 - line 40; figures *	6,7,14 1,10	
	-/--		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	11 September 2013	Neville, David

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 13 16 1990

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	EP 0 017 428 A1 (MARS INC [US]) 15 October 1980 (1980-10-15) * page 6, line 16 - page 7, line 7; figure 2 *	8	
Y	US 2006/032726 A1 (VOOK DIETRICH W [US] ET AL) 16 February 2006 (2006-02-16)	9,15	
A	* paragraph [0028] *	1,10	
A,D	GB 2 369 710 A (PANZERI EZIO [IT] PANZERI EZIO [IT]; PANZERI EZIO [IE]) 5 June 2002 (2002-06-05) * page 5, line 7 - page 6, line 2; figures 1, 2 *	7	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	11 September 2013	Neville, David

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 16 1990

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-09-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2965389 A1	30-03-2012	FR 2965389 A1	30-03-2012
		WO 2012038670 A1	29-03-2012
US 6305523 B1	23-10-2001	CN 1339143 A	06-03-2002
		DE 10083659 T1	24-01-2002
		JP 2001126106 A	11-05-2001
		TW 420792 B	01-02-2001
		US 6305523 B1	23-10-2001
		WO 0129784 A1	26-04-2001
WO 0041143 A1	13-07-2000	SE 523567 C2	27-04-2004
		SE 9900022 A	09-07-2000
		WO 0041143 A1	13-07-2000
EP 0060392 A2	22-09-1982	DE 3267960 D1	30-01-1986
		EP 0060392 A2	22-09-1982
GB 1553752 A	26-09-1979	AT 355357 B	25-02-1980
		DK 337277 A	30-01-1978
		FR 2360138 A1	24-02-1978
		GB 1553752 A	26-09-1979
		JP S5317035 A	16-02-1978
		NL 7708356 A	31-01-1978
US 5576825 A	19-11-1996	DE 4338780 A1	19-05-1994
		GB 2272762 A	25-05-1994
		JP H06208613 A	26-07-1994
		US 5576825 A	19-11-1996
EP 0017428 A1	15-10-1980	DE 3067606 D1	30-05-1984
		EP 0017428 A1	15-10-1980
		GB 2044972 A	22-10-1980
		HK 74285 A	11-10-1985
		JP H0238990 B2	03-09-1990
		JP H0426751 B2	08-05-1992
		JP H02168376 A	28-06-1990
		JP S56500315 A	12-03-1981
		MY 8700056 A	31-12-1987
		US 4413718 A	08-11-1983
		WO 8002081 A1	02-10-1980
US 2006032726 A1	16-02-2006	NONE	
GB 2369710 A	05-06-2002	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- GB 2369710 B **[0003] [0066]**
- EP 0900431 B **[0066]**