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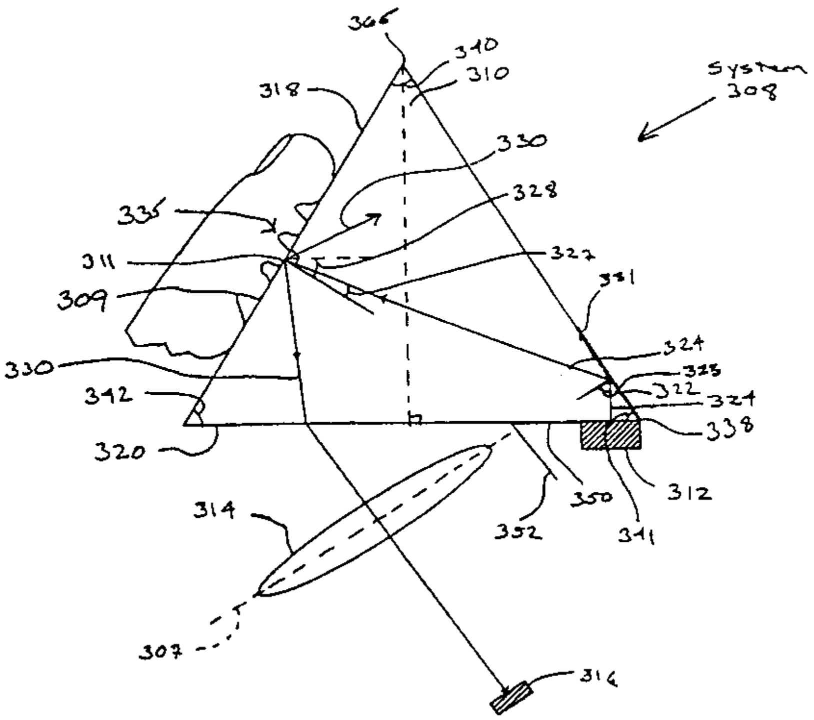
(54) Title: HIGH CONTRAST, LOW DISTORTION OPTICAL ACQUISITION SYSTEM FOR IMAGE CAPTURING

(57) Abstract

An apparatus and method for acquiring an image of a patterned object such as a fingerprint including a light refracting device, a focusing lens, and a light source. The light refracting device can, for example, be a prism and includes an imaging surface, a light receiving surface and a viewing surface. Incident light from the light source is projected through the light receiving surface and reflected off a surface other than the imaging surface. This reflected light is then projected onto the imaging surface to create an image of the patterned object from substantially all scattered light through the viewing surface. The lens is placed adjacent to the viewing surface to focus the light on an image sensor.



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HIGH CONTRAST, LOW DISTORTION OPTICAL ACQUISITION SYSTEM FOR IMAGE CAPTURING

Field of the Invention

The present invention relates to an optical acquisition apparatus for use with an image capturing and recognition system. In particular, the present invention includes an optical acquisition apparatus for obtaining high contrast, low distortion images of patterned objects.

Description of the Related Art

Patterned object recognition systems are becoming common in industrial and commercial settings and have a variety of uses. For example, such systems can be used in scanners for the scanning of text, drawings, and photographs. Recently, manufacturers have been attempting to reduce costs associated with pattern recognition systems to make them more viable for consumer use. One such consumer application for pattern recognition systems includes fingerprint acquisition and recognition. Such a system is useful, for example, to enhance computer security by reading a potential user's fingerprint to compare with the fingerprints of users authorized to use the computer or access certain files or functions of the computer. Such a system could, for example, take the place of a security system that uses a login name and password.

The first thing such a fingerprint recognition system, or any pattern recognition system, must be able to do is to accurately acquire the fingerprint, or other pattern, for analysis. A number of mechanisms exist for such acquisition of pattern data. For example, U.S. Patent Nos. 3,975,711; 4,681,435; 5,051,576; 5,177,435 and 5,233,404 all disclose apparatuses for acquiring an image of a patterned object.

Figure 1 shows a schematic diagram of one such prior art optical fingerprint capturing and recognition system. In Figure 1, an optical recognition system 108 includes an light source 112, an optical triangular prism 110, a lens assembly 114, an image sensor 116, and a storage and processing unit 125. The prism 110 includes an imaging surface 118, a light receiving surface 120, and an viewing surface 122. Imaging surface 118 is the surface against which a patterned object, such as a fingerprint, is placed for imaging. The light source 112, which may, for example, be a light emitting diode (LED), is placed adjacent to light receiving surface 120 and generates incident light 124 that is transmitted to the optical prism 110. The optical prism 110 is an isosceles right triangle, with the angle opposite the imaging surface 118 being approximately 90 degrees and the other two "base" angles (that is, the two angles of an isosceles prism that are equal) each being approximately 45 degrees.

Generally, incident light 124 strikes imaging surface 118 at an angle 126 with the incident surface normal line 115. Angle 126 is greater than the critical angle 128. In general, a critical angle is measured between an incident light ray and a normal line to a surface. Above the critical angle, the incident light will undergo total internal reflection off the surface, and below the critical angle the incident light will pass through the surface. Accordingly, critical angle 128 is the angle with the normal line to the imaging surface 118 above which incident light will totally internally reflect from imaging surface 118 and pass out of prism 110 as reflected light 130 through viewing surface 122. Reflected light 130 passes through lens assembly 114 located adjacent to viewing surface 122. Lens assembly 114 may contain one or more optical lenses. Thereafter, light from lens assembly 114 is captured by image sensor 116. Image sensor 116, which may, for example, be a charge coupled device (CCD) or a complementary metal oxide semiconductor (CMOS) device, captures optical light images and converts them to electrical signals. Such image sensors are well known to those skilled in the art. The electrical signals are then transmitted to the storage and processing unit 125.

Storage and processing unit 125 may include a memory unit, a processor and an analog to digital converter (not shown). The analog to digital converter converts the analog electrical signals from the image sensor 116 into digital data. The memory is used to store the digital data and algorithms for comparing a captured fingerprint image with a stored fingerprint image. The processor compares the captured digital data with data previously stored in memory based on an algorithm for comparing such data. The processor may also analyze the captured digital data for purposes different from comparison with stored data. Such storage and processing units are known to those skilled in the art and can include standard personal computers equipped with appropriate software. Algorithms for processing and comparison of image data are disclosed, for example, in U.S. Patent Serial Nos. 4,135,147 and 4,688,995 each of which is incorporated in its entirety by reference.

When a fingerprint is placed on the optical prism's imaging surface 118, ridges 111 of the fingerprint contact imaging surface 118, and valleys 109 of the fingerprint remain out of contact with imaging surface 118. Thus, in fingerprint valleys 109 incident light 124 entering the optical prism 110 from the light source 112 undergoes total internal reflection at imaging surface 118 if the incidence angle of the incoming light exceeds the critical angle of the optical prism 110. However, at ridges 111 of a fingerprint some of incident light 124 is absorbed and scattered off the fingerprint ridge. As used herein, the term "scattered" indicates light which, after striking an irregular surface, is radiated or irregularly reflected off the irregular surface in multiple directions.

As a result of this scattering and/or absorption, there is less than total internal reflection of incident light 124 at fingerprint ridges 111. Thus, the intensity of reflected light 130 leaving prism 110 from the valleys 109 of a fingerprint is of greater intensity than reflected light 130 leaving prism 110 from ridges 111. The lower intensity reflected light 130 from ridges 111 translate into darker regions to indicate the presence of an object at the point of incidence between the light beam and the fingerprinting surface. Conversely, higher intensity reflected light 130, such as that which undergoes total internal reflection, translates into brighter regions to indicate the absence of an object at the point of incidence between the incident light 124 and the imaging surface 118. This allows distinguishing the darker fingerprint ridges 111 from the relatively brighter fingerprint valleys 109. Because absorption of incident light at fingerprint ridges 111 is primarily responsible for creating a fingerprint image, system 108 is referred to as an "absorption" imaging system.

The above described system allows capturing an optical fingerprint image and processing the electrical representation of the optical fingerprint image. However, in regions of fingerprint ridges 111, incident light 124 still undergoes some total internal reflection and some scattering in a direction parallel to reflected light 130. Thus, the difference in intensity between reflected light 130 from fingerprint valleys 109 and fingerprint ridges 111 can be relatively low. That is, the contrast between fingerprint ridges 111 and valleys 109 in the fingerprint image can be relatively low. This can make image acquisition, processing, and comparison relatively difficult.

Additionally, the optical recognition system 108 tends to be relatively large due to the relatively large distance between the optical prism 110 and the lens assembly 114. The large distance between the optical prism 110 and the lens assembly 114 is caused by the fact that a fingerprint in imaging surface 118 is likely to be larger than the first lens in lens assembly 114. Thus, if lens assembly 114 is placed relatively close to viewing surface 122, lens assembly 114 will probably not capture the fingerprint image at points near the edges of the fingerprint. Therefore, a relatively large distance between the optical prism 110 and the lens assembly 114 is desirable in system 108 because it can provide better imaging near fingerprint edges. Thus, making image acquisition system 108 relatively compact can be problematic. Additionally, a relatively large distance between viewing surface 122 and lens assembly 114 can cause loss of contrast in the fingerprint image due to light interference.

Further, a phenomenon known as trapezoidal distortion can occur in pattern acquisition system 108. Trapezoidal distortion in an imaging system has the effect of making the image of a square created by the system appear as a trapezoid. Figure 2 is a schematic illustration showing why trapezoidal distortion arises in image acquisition system 108. Incident light 124 from light source 112 enters prism 110 and reflects off of imaging surface 118, imaging object AB. Reflected light 130 then passes out of viewing surface 122 and to lens assembly 114 at points A' and B' to form object A'B'. Viewing object AB through viewing surface 122, object AB would appear to be located at an "apparent image" object ab. Specifically, point A appears to be at point a, a distance aa' from viewing surface 122 and point B appears to be at point b, a distance bb' from viewing surface 122. The distance that an apparent image of an object appears from viewing surface 122 is given by the actual distance the object is from viewing surface 122 divided by the index of refraction n of prism 110. Specifically, the distance aa' is given by:

$$aa' = Aa'/n,$$

where "n" is the index of refraction of prism 110. Similarly,

$$bb' = Bb'/n.$$

Trapezoidal distortion occurs when the light path length from the apparent image of an object to the lens plane of lens assembly 114 is different for different parts of the imaged object. Specifically, trapezoidal distortion occurs in system 108 because the distance aA' is longer than the distance bB'. As the above equations make clear, trapezoidal distortion can only occur when light is passed through an object having an index of refraction that does not equal 1 (assuming the object is in air having an index of refraction of n=1).

To correct this distortion, prior art manufacturers have tilted the lens plane 107 of lens assembly 114 and image sensor 116 to increase the distance bB' and decrease the distance aA' to a point where the two distances are approximately equal. However, it is a property of an isosceles right prism (that is, a triangular prism in which the base angles measure approximately 45 degrees and the non-base angle, or apex angle, measures approximately 90 degrees), that reflected light 130 exits prism 110 substantially normal to viewing surface 122. That is, no refraction of reflected light 130 occurs as it exits viewing surface 122. Further, generally, the larger the angle of incidence on a surface of a transparent object, the greater the portion of incident light that is reflected from the surface. Thus, while tilting lens assembly 114 can reduce trapezoidal distortion, it also causes greater reflection of reflected light 130 off of the surface of lens assembly 114, and the surface of image sensor 116, because reflected light 130 strikes lens assembly 114 at a greater angle of incidence. This reduces the intensity of light entering image sensor 116, making image processing and comparison more difficult.

Additionally, the relative placement of light source 112 and lens assembly 114 make it possible for stray light 113 emitted by light source 112 to enter lens assembly 114. This can generate additional background "noise" light which can further reduce the quality of an captured image and make image processing more difficult.

To overcome some of the difficulties associated with the type of absorption image acquisition system described above, acquisition systems have been designed which are based primarily on scattering mechanisms rather than absorption mechanisms. One such acquisition system is disclosed by U.S. Patent No. 5,233,404 issued to J. Lougheed et al. on August 3, 1993 (Lougheed et al.). Figure 3 is a schematic diagram illustrating the image acquisition portion of the apparatus disclosed by Lougheed et al. As shown in Figure 3, a prior art image acquisition system 208 includes a trapezoidal prism 210, a light source 212, a lens assembly 214 and an image sensor 216. The trapezoidal prism 210 includes at least an imaging surface 218, a light receiving surface 220, and a viewing surface 222.

The imaging surface 218 is the surface against which an object to be imaged, such as a fingerprint, is placed. The light source 212 is located adjacent to and facing the light receiving surface 220 which is substantially parallel to imaging surface 218. Thus, incident light 224 emitted by light source 212 projects light through prism 210 and onto imaging surface 218 at an angle which is generally less than the critical angle 228 of imaging surface 210. Therefore, in the valleys 209 of a fingerprint placed against imaging surface 218 where the fingerprint is not in contact with imaging surface, total internal reflection does not occur and incident light 224 passes through imaging surface 218. At points where fingerprint ridges 211 are in contact with imaging surface 218, incident light 224 strikes the fingerprint ridge to generate scattered (or equivalently, irregularly reflected) light 230. Scattered light 230 propagates back into prism 210 in substantially all directions including the direction of lens assembly 214, located adjacent to viewing surface 222. Scattered light passes through viewing surface 222 and into lens assembly 214 to be detected by image sensor 216, which, as above, can be a CCD, CMOS or other type of detector.

In the region of a fingerprint valley 209, incident light 224 passes through imaging surface 218. And, in the area of a fingerprint ridge 211, incident light 224 scatters off imaging surface 218 to be picked up by lens assembly 214 and image sensor 216. Accordingly, the image of the fingerprint is relatively bright at fingerprint ridges 211 and relatively dark at fingerprint valleys 209. Because scattered light 230 is picked up by the image sensor 216, this type of system is referred to as a "scattering" system.

The difference in intensity between the ridges and valleys in a fingerprint image created by such a scattering system can be greater than the difference in intensity between the ridges and valleys of a fingerprint image created in an absorption system as shown in Figure 1. As a result, the fingerprint image created by such a scattering system can display higher contrast between fingerprint ridges and valleys than an image created by an absorption system. Thus, the image can be more accurately acquired by the image sensor 216. This can reduce errors in subsequent fingerprint comparisons performed by the system. However, a trapezoidal prism such as prism 210 can be more expensive to manufacture than a triangular prism such as prism 110, shown in Figure 1. This is because, among other reasons, there is an extra surface to polish. This can increase the price of an imaging system such as imaging system 208, making it less viable for consumer use. Further, a trapezoidal prism such as prism 210 which is large enough to be used for fingerprint imaging can be larger than a similarly suited triangular prism. Thus, use of a trapezoidal prism such as prism 110 can cause an imaging system to be relatively less compact.

Additionally, image acquisition system 208 can cause trapezoidal distortion of a fingerprint image in a manner similar to that of image acquisition system 108. This is especially the case if imaging surface 218 and viewing surface 222 form an angle with each other of approximately 45 degrees. If this is the case, then image acquisition system 208 will cause trapezoidal distortion for the same reasons, discussed above, that image acquisition system 108 does. Such an image acquisition system using a trapezoidal prism having a 45 degree angle between the imaging surface and viewing surface is disclosed, for example, in U.S. Patent No. 5, 210, 588.

As the above discussion makes clear, there is a need for improved image acquisition apparatus for use with patterned object recognition systems. Specifically, an image acquisition apparatus that produces a high contrast, low distortion image would be desirable. Additionally, the apparatus should be relatively compact. Also, the apparatus should be relatively low cost to manufacture, making it affordable for consumer use.

Summary of the Invention

The present invention includes a compact image acquisition apparatus which produces a high contrast, low distortion image and which can be relatively low cost to manufacture. The apparatus includes a light refractor having an imaging surface against which a patterned object is to be placed, a light entrance surface, and a viewing surface. The light entrance surface is adjacent to the imaging surface and allows light to enter the refractor. The viewing surface is also adjacent to the imaging surface and an image of the patterned object is projected through the viewing surface. The apparatus also includes a focusing lens adjacent to the viewing surface for receiving and focusing an image of a patterned object. A light source is located adjacent to the light receiving surface and emits incident light which enters the refractor to create an image of the patterned object at the viewing surface. The focusing lens then focuses the image. The light source is positioned such that the light emitted therefrom strikes at least one other surface before striking the imaging surface. In this way, an image from the imaging surface and projected through the viewing surface is generated by substantially all scattered light. Such a scattered light image is advantageously relatively high contrast and evenly illuminated.

In a second aspect of the present invention, the refractor is an isosceles triangular prism having base angles which are greater than 45 degrees. Additionally, the lens plane of the focusing lens is tilted with respect to a plane defined by the viewing surface. In this way, trapezoidal distortion in an image of the patterned object is advantageously reduced.

In a third aspect of the present invention, an apparatus for forming an image of a patterned object includes a first lens, an objective lens or lens assembly, and a light source. The first lens includes an imaging surface against which a patterned object is to be placed, and a viewing surface opposite to the light entrance surface, through which an image of the object is projected. The first lens also includes a light receiving surface adjacent to the imaging surface. The apparatus further includes a light source for projecting incident light into the lens. The light source is located adjacent to the light entrance surface to project incident light between the imaging surface and the viewing surface. The incident light can undergo total internal reflection between the imaging surface and the viewing surface without passing through the viewing surface. In this way an image of the patterned object projected through the viewing surface is generated by substantially all scattered light. The apparatus also includes an objective lens or lens assembly adjacent to the viewing surface which focuses the image of the patterned object projected through the viewing surface.

The imaging surface of the first lens can be concave to better fit the contour of a fingerprint placed on the imaging surface. Additionally, the first lens and objective lens can be formed unitarily as a single piece. This can ease assembly, reduce manufacturing costs, and allow the image acquisition apparatus to be more compact.

In a fourth aspect of the present invention, an apparatus for forming an image of a patterned object includes a triangular prism, a focusing lens and a light source. The triangular prism includes an imaging surface, a light receiving surface adjacent to the imaging surface and a viewing surface adjacent to the light receiving surface. The lens is adjacent to the viewing surface and is for receiving and focusing an image of the patterned object. The light source is for projecting incident light into the triangular prism and is located adjacent to the light receiving surface to project light between the imaging surface and the viewing surface. Most of the incident light undergoes total internal reflection between the imaging surface and the viewing surface without passing through the viewing surface. In this way, an image of the patterned object projected through the viewing surface into the objective lens is generated by substantially all scattered light from the imaging surface.

In this fourth aspect of the present invention, a first light source can be placed on a first end triangular surface of the prism and a second light source can be placed on a second end triangular surface of the prism opposite to the first triangular end surface. This configuration advantageously provides even illumination of the imaging surface to generate a relatively uniform patterned object image.

A method of generating an image of a patterned object in accordance with the present invention includes providing a light refractor having an imaging surface, a light receiving surface and a viewing surface. A patterned object is placed against the imaging surface. Incident light is projected from a light source through the light receiving surface of the light refractor and reflected off at least one surface of the refractor other than the imaging surface before the incident light strikes the imaging surface. The incident light is scattered off the imaging surface and patterned object and through the viewing surface. A lens is provided adjacent to the viewing surface and the scattered light is projected into the lens which focuses the scattered light to form an image of the patterned object.

Brief description of the Drawings

Figure 1 is a schematic of a prior art image acquisition apparatus which utilizes an absorption image acquisition technique.

Figure 2 is a schematic of the image acquisition apparatus of Figure 1 illustrating trapezoidal distortion.

Figure 3 is a schematic of a second prior art image acquisition apparatus which utilizes a scattering image acquisition technique.

Figure 4 is a schematic diagram of an image acquisition system including a prism, light source, lens assembly, and image sensor, in accordance with the present invention and wherein the viewing surface of the prism includes the light receiving surface thereof.

Figure 5 is a perspective view of the prism and light source shown in Figure 4.

Figure 6A is a schematic diagram of the image acquisition system shown in Figure 4 illustrating how trapezoidal distortion is reduced.

Figure 6B is a schematic diagram showing a lens assembly which can be used with the image acquisition system shown in Figure 4.

Figure 7 is a schematic diagram of a second embodiment of an image acquisition system including a prism, light source, lens assembly, and image sensor in accordance with the present invention and wherein the viewing surface of the prism is adjacent to the light receiving surface.

Figure 8 is a schematic diagram of a third embodiment of an image acquisition system including a prism and light sources in accordance with the present invention and wherein a light source is adjacent to each triangular end face of the prism.

Figure 9 is a perspective view of the prism and light sources shown in Figure 8.

Figure 10A is a front view of the prism and light source shown in Figure 8.

Figure 10B is a partial perspective view of the prism and light sources shown in Figure 8.

Figure 11 is a schematic diagram of a fourth embodiment of a partial image acquisition system including light sources and a prism in accordance with the present invention and wherein each light source includes a strip light source adjacent to a triangular end face of the prism.

Figure 12 is an end view of the prism and light source shown in Figure 11.

Figure 13 is a schematic diagram of a fifth embodiment of an image acquisition system including a prism, light source, lens assembly, and image sensor in accordance with the present invention and wherein incident light undergoes total internal reflection.

Figure 14 is a perspective view of the prism and light source shown in Figure 13.

Figure 15 is a schematic diagram of a sixth embodiment of a light acquisition system including a first lens, a lens assembly, a light source and an image sensor in accordance with the present invention.

Figure 16 is a top view of the first lens and light source shown in Figure 15.

Figure 17 is a schematic diagram of a seventh embodiment of an image acquisition system including a lens assembly, a light source and an image sensor in accordance with the present invention.

Figure 18 is schematic diagram of an alternate embodiment of the lens shown in Figure 17 in accordance with the present invention.

Figure 19 is a top view of a computer mouse and computer connection cables therefore, the mouse for housing an image acquisition system in accordance with the present invention.

Figure 20 is a perspective view of the computer mouse shown in Figure 19.

Figure 21 is a side view of the computer mouse shown in Figure 19.

Figure 22 is a top, partially cut away view of the computer mouse shown in Figure 19 housing an image acquisition system in accordance with the present invention.

DETAILED DESCRIPTION

Figures 4 and 5 show a patterned object image acquisition system 308 in accordance with the present invention. Acquisition system 308 preferably includes a triangular prism 310, a light source 312, a lens assembly 314, and an image sensor 316. Prism 310 is a five faced isosceles triangular prism the length of which extends into the plane of Figure 4. Prism 310 includes a rectangular imaging surface 318 against which an object to be imaged, such as a fingerprint 335, is placed. Prism 310 also includes a rectangular viewing surface 320 through which an image of a fingerprint 335 placed against imaging surface 318 passes out of prism 310. In the embodiment of Figures 4 and 5, viewing surface 320 also serves as a light receiving surface for allowing light to pass into prism 310. A light scattering surface 322 of prism comprises a third rectangular surface of prism 310. For reasons detailed below, light scattering surface 322 is preferably a diffusive.

Light source 312 is preferably an elongated LED array consisting of a single row of light emitting diodes (LEDs) extending the length (into the plane of Figure 4) of prism 310. If such LEDs are used as light source 312, a diffusive cover can be placed between the LEDs and viewing surface 320 to provide more even illumination of imaging surface 318. It is also within the ambit of the present invention, however, for light source 312 to be any other type of light source to provide incident light into prism 310. Preferably, light source 312 is placed along an edge 338 of prism 310 which is opposite imaging surface 318.

Lens assembly 314 is for receiving scattered light 330 from fingerprint 335 and focusing scattered light 330 onto image sensor 316. Lens assembly 314 can be a single lens or, preferably, can consist of multiple lenses. Most preferably, lens assembly 314 has a focal length of approximately 13.48 mm and is located approximately 13.5 mm from viewing surface 320. Additionally, as shown in Figure 6B which is a schematic diagram of one embodiment of lens assembly 314, lens assembly most preferably consists of three lenses 904, 906, and 908 whose respective optical axes are aligned on a common optical axis 902. Lens 904 most preferably has a diameter of approximately 17.8 mm, and both lenses 906 and 908 most preferably have a diameter of approximately 6 mm. It is considered that any number of lenses be included in lens assembly 314.

Image sensor 316 captures optical light images from lens assembly 314 and converts them to electrical signals. Image sensor 316 can be a charge couple device ("CCD") or any other means of converting a light signal into either an analog or digital electrical signal. Preferably, image sensor 316 is a complementary metal oxide semiconductor device. CCD and CMOS image sensors are well known by those skilled in the art. The electrical signals generated by image sensor 316 can be processed using known means and used to compare input patterns, such as fingerprints. As noted in the Background section, such signal processing means are disclosed, for example, in U.S. Patent Nos. 4,135,147 and 4,688,995, which have been incorporated by reference.

To create an optical image of fingerprint 335 on image sensor 316, fingerprint 335 is placed against imaging surface 318. Incident light 324 from light source 312 passes through viewing surface 320 and into prism 310. Because light source 312 is located adjacent to edge 338, incident light 324 strikes scattering surface 322. As noted above scattering surface 322 is preferably diffusive. As such, a relatively high portion of incident light 334 striking scattering surface 322 is internally scattered in prism 310. This scattered light then strikes imaging surface 318. Even if light scattering surface 322 is not diffusive, substantially all of incident light 324 will strike scattering surface 322 at an angle 323 which is greater than the critical angle for scattering surface 322. Thus, incident light will reflect off scattering surface 322 and strike imaging surface 318. To enhance reflection of incident light off of scattering surface 322 it is contemplated to place a mirrored face of a reflecting surface 381 towards scattering surface 322.

Because incident light 324 has been scattered or directly reflected off of scattering surface 322, a relatively large percentage of incident light 324 will strike imaging surface 318 at an angle 327 less than the critical angle 328 of imaging surface 318. Accordingly, incident light 324 which strikes imaging surface 318 at a region thereof where there is a fingerprint valley 309 will not undergo total internal reflection and will substantially pass through imaging surface 318 such that substantially no light hitting an area of imaging surface 318 where there is a fingerprint valley 309 will be directed through imaging surface 322. However, incident light 324 that strikes a region of imaging surface 318 where there is a fingerprint ridge 311 touching imaging surface 318 will substantially scatter, producing scattered light 330. A portion of scattered light 330 will exit prism 310 via viewing surface 320. Upon exiting prism 310, scattered light 330 will diffract into lens assembly 314 which will focus scattered light 330 into image sensor 316.

Because incident light 324 can be scattered by scattering surface 322, incident light 324 provides relatively uniform illumination over imaging surface 318 which produces a relatively uniform image. Such a uniform image is desirable because it is easier to process and compare with other stored fingerprint data. To further increase the uniformity of illumination over imaging surface 318, the portion of viewing surface 320 facing light source 312 can be streaked by etching lines 370, shown in Figure 5, in viewing surface 320. Lines 370 run the length of prism 310 and parallel to apex 338. Lines 370 act to diffuse light emitted from light source 312 as is passes through viewing surface 320. As noted above, this diffusion enhances the uniformity of illumination over imaging surface 318.

In addition to the components discussed above, image acquisition system 308 preferably also includes a light blocking shield 350 on a portion of light receiving surface adjacent to light source 312. Preferably, light blocking shield runs the entire length of prism 310 (into the plane of Figure 4). Light blocking shield 350 is to reduce the amount of stray light from light source 312 which might enter lens assembly 314 and interfere with or cloud a fingerprint image. It is also considered that the surface of light blocking shield 350 facing the interior of prism 310 be mirrored. This mirroring can act to desirably increase the intensity of scattered light incident on imaging surface 318. In addition to, or instead of, light blocking surface 350, a second light blocking surface 352 can be placed between light source 312 and lens assembly 314. Light shield 352 preferably extends from viewing surface 320 at an angle to block stray light from light source 312 from entering lens assembly 314.

Because light source 312 is relatively narrow and located adjacent to edge 338 opposite from imaging surface 318, substantially all incident light 324 reaching imaging surface 318 is reflected or scattered off of scattering surface 322. That is, almost no incident light 324 strikes imaging surface 318 directly from light source 312. To further reduce the likelihood of incident light 324 directly striking imaging surface 318, light source 312 is preferably configured not to extend past a line 360, shown in Figure 5, extending the length of prism 310 and defined by the intersection of a plane normal to viewing surface 320 and intersecting with edge 365, adjacent to imaging surface 318. If light source 312 is kept on the same side of this line as apex 338, then substantially no incident light 324 emitted perpendicularly from light source 312 will directly strike imaging surface 318.

By minimizing incident light 324 from light source 312 that is directly incident on imaging surface, there is substantially no total internal reflection of incident light 324 from regions of imaging surface 318 where there are fingerprint valleys 309. This means that relatively little light from these valley regions passes through viewing surface 320 and into lens assembly 314. Rather, substantially all the light passing into lens assembly 314 from imaging surface 318 is scattered from fingerprint ridges 311 on imaging surface 318. This provides a fingerprint image having relatively high contrast between fingerprint ridges 311 and valleys 309. Such a high contrast fingerprint image is relatively easy to process and compare with other fingerprint images and can, therefore, advantageously increase processing accuracy.

Further, use of this scattering technique for image acquisition is achieved with a triangular prism, as opposed to a trapezoidal prism as disclosed in Lougheed, discussed in the Background section. Because triangular prisms can be more efficient to manufacture than trapezoidal prisms, image acquisition system 308 can advantageously be relatively less expensive to manufacture.

Moreover, scattered light generally scatters from an object in many directions, as opposed to substantially one direction. Thus, scattered light from an object can be picked up and focused by a lens over a wide range of distances without any significant degradation in quality of the image near the edges of the image. Accordingly, lens assembly 314 can be placed relatively close to viewing surface 320 without significant loss of image quality. This advantageously allows the image acquisition system 308 to be relatively compact.

Additionally, the image acquisition system of the current invention can reduce trapezoidal distortion. As discussed in the Background section, trapezoidal distortion is manifested in an image having dimensions distorted from those of the actual object being imaged. Trapezoidal distortion is caused by variation in path length of light from the apparent image of an object to lens assembly 314 from one part of the imaged object to another. As shown in Figure 6A, however, in image acquisition system 308, the path length of scattered light 330 from different points on the apparent image 335′ of fingerprint 335 to lens assembly 314 is substantially the same. Specifically, path AA' is substantially equal to path BB' and path CC'. Thus, trapezoidal distortion can advantageously be reduced. As shown in Figure 6A, substantial equalization of paths AA', BB' and CC' is facilitated by tilting lens assembly 314 with respect to viewing surface 320. However, unlike image acquisition system 108, shown in Figure 1, such tilting of lens assembly 314 does not reduce the intensity of the image reaching image sensor 316. As noted in the background section with respect to image acquisition system 108, tilting lens assembly 114 causes reflected light 130 to strike the first element of lens assembly 314 at an angle to normal line thereof. This causes greater reflection of reflected light 130 from the surface of lens assembly 114, thereby undesirably reducing image intensity at image sensor 116.

However, as noted above, prism 310 is an isosceles prism and preferably has base angles 340 and 341 which measure above 45 degrees. The base angle 340 is the angle at edge 365, between imaging surface 318 and scattering surface 322, and base angle 341 is the angle at edge 338, which is opposite to imaging surface 318. Further, prism 310 preferably has an index of refraction not equal to 1. Thus, scattered light 330 which strikes viewing surface 320 refracts away from the normal to viewing surface 320 as it exits prism 310. As such, by tilting the lens plane 307 of lens assembly 314, scattered light 330 strikes lens assembly 314 at substantially 90 degrees. Thus, there is no loss in image intensity due to undue reflection of scattered light at the surface of lens assembly 314, and trapezoidal can be reduced without loosing image intensity at image sensor 316. Preferably, base angles of prism 310 at edges 365 and 338 preferably measure between 50 and 65 degrees inclusive and most preferably measure either 62 degrees or 63 degrees. If prism 310 has base angles of approximately 62 degrees, the index of refraction of prism 310 is preferably between 1.71 and 1.72 and most preferably approximately 1.713. If prism 310 has base angles of approximately 63 degrees, prism 310 preferably has an index of refraction of between 1.68 and 1.70, and most preferably approximately 1.6935 or 1.6968. However, it is contemplated that prism 310 have any index of refraction higher than 1.

Prism 310 can be made of glass, acrylic or any other transparent material having an index of refraction different from 1 (that of air). Prisms having the preferred index of refraction and angles are commercially available from Shinkwang Ltd. of Seoul, Korea and are fabricated of glass having the designation LaK-7 or LaK-8.

Lens assemblies such as lens assembly 314 are commercially available from Seoul Optical Systems Ltd. of Seoul, Korea and are preferably fabricated from a glass having the commercial designation of BK7. If more than one element is used in lens assembly 314, as shown in Figure 6A, the individual elements can be aligned and spaced by placing them in a frame fabricated by plastic molding or any other fabrication means as is known in the art.

Light source 312 preferably consists of four standard LEDs positioned in a straight array on a circuit board. Powering of LEDs is well known by those skilled in the art. Image sensor 316 is preferably a CMOS type sensor and is commercially available from Hyudai Electronics of Seoul, Korea, VLSI Vision, Ltd. of San Jose, California, or Omnivision Technologies Inc. of Sunnyvale, California.

To secure the components of image acquisition into the relative positions as shown in Figure 4, a frame having holding slots for each component can be plastic molded or otherwise fabricated. Light source 312 can be either placed in a holding slot adjacent to viewing surface 320 or attached direction to viewing surface 320 using translucent adhesive as known in the art.

In the embodiment of the present invention shown in Figures 4-6, light source 312 is located adjacent to viewing surface 320 which is also the light receiving surface. However, it is within the scope of the present invention to move light source 312 to other surfaces of the triangular prism. One such embodiment wherein the light source is located adjacent to a surface other than the viewing surface, is illustrated in Figure 7. As shown, a image acquisition system 408 includes an isosceles triangular prism 410, a light source 412, a lens assembly 414, and a image sensor 416. As with prism 310 of image acquisition system 308, prism 410 includes an imaging face 418 against which a fingerprint 435 is placed, and a viewing surface 420 through which an image of fingerprint 435 is projected onto lens assembly 414.

However, as shown, light source 412 is placed adjacent to a light receiving surface 422, which is different from viewing surface 420. Light source 412 is a relatively narrow light source and can be, for example, a single row of LEDs. Light source 412 is preferably placed directly adjacent to edge 448, opposite viewing surface 418 and runs the length of prism 418 (into the plane of Figure 7). As with light source 312 of image acquisition system 308, preferably, no part of light source 412 crosses a line in light receiving surface 422 defined by the intersection light receiving surface 422 and a plane which is normal to light receiving surface 422 and intersects edge 465 opposite to light receiving surface 422.

Incident light 424 from light source 412 passes through light receiving surface 422 and strikes viewing surface 420. Because the angle of incidence of a substantial portion incident light 424 on viewing surface 420 is greater than the critical angle for surface 420, incident light 424 will reflect or scatter off of surface 420 and strike imaging surface 418. At this point, the operation of image acquisition system 408 is substantially the same as that of image acquisition system 308. Incident light 424 strikes imaging surface at an angle less than the critical angle for imaging surface 418 projects an image of fingerprint 435 through viewing surface 420 and onto lens assembly 414. Lens assembly 414 then focuses this image onto image sensor 416.

As noted, incident light 424 scatters or reflects off of viewing surface 420 before striking imaging surface 418. This advantageously provides for relatively even illumination of imaging surface 418. Additionally, substantially all incident light 424 strikes imaging surface 418 at an angle which is less than the critical angle of imaging surface 418. Thus, as discussed above with respect to image acquisition system 308, the image of fingerprint 435 projected through viewing surface 420 is created by substantially all scattered light 430. This advantageously allows lens assembly 414 to be placed relatively close to viewing surface 420 without substantial image degradation and provides a relatively high contrast image of fingerprint 435.

As with image acquisition system 308, image acquisition system 408 can also include a light blocking shield 450 on viewing surface 420 running the length thereof (into the plane of Figure 7) and adjacent to apex 438. The surface of light blocking shield 424 facing viewing surface 420 can be opaque, diffusive or mirrored. Additionally, or alternatively, image acquisition system 408 can include a second light blocking shield 452 extending running the length of viewing surface 420 and extending at an angle therefrom. Both light blocking shields 450 and 452 serve to prevent degradation of an image of fingerprint 435 by diminishing the amount of stray light from light source 412 which might enter lens assembly 414.

Further, as with image acquisition system 308, the surface of light receiving surface 422 in the region where light source 412 faces light receiving surface 422, can be streaked with lines running the length of surface 422 and parallel to apex 438. Such lines serve to make incident light 424 more diffuse. As explained above, this provides for more even illumination of imaging surface 418.

Moreover, isosceles prism 410 preferably includes base angles 440 and 441 which are greater than 45 degrees. More preferably, base angles 440 and 441 are between 50 and 65 degrees, inclusive, and most preferably measure either 62 degrees or 63 degrees. Also, index of refraction of prism 410 is preferably greater than 1.5. As such, when scattered light 430 passes through viewing surface 420, scattered light 430 will refract away from a line normal to viewing surface 420. Thus, as shown in Figure 7, the lens plane of lens assembly 414 can be tilted with respect to viewing surface 420 to advantageously reduce trapezoidal distortion and scattered light 430 will still enter lens assembly 420 substantially normal to the lens plane. Thus, as with image acquisition system 308, the intensity of the image of fingerprint 435 can remain relatively high.

The components of image acquisition system 408, including prism 410, light source 412, lens assembly 414 and image sensor 416, can all be the same components as those of image acquisition system 308. Also, image system 408 can be fabricated in substantially the same manner as image acquisition system 308. In particular, to secure the components of image acquisition into the relative positions as shown in Figure 7, a frame having holding slots for each component can be plastic molded or otherwise fabricated. Light source 412 can be either placed in a holding slot adjacent to light receiving surface 422 or attached direction to light receiving surface 422 using translucent adhesive as known in the art.

It is contemplated that the frame and holding slots discussed above be part of a standard computer user input device such as, for example, a keyboard, trackball or mouse. This is to allow the optical acquisition system of the present invention to be housed in such a device. Figures 19-22 show an embodiment of the present invention wherein an optical acquisition system, such as system 308 or 408, is housed in an otherwise conventional computer mouse.

Figure 19 is a top view of a computer mouse 910 housing an optical acquisition system, such as acquisition system 408. Attached to mouse 910 is a parallel port connector 920 and a conventional computer mouse connector 930. It is also considered that mouse 910 include a serial port connector instead of a parallel port connector. As can be seen in Figures 20 and 21, which show a perspective view and a side view, respectively, of mouse 910, imaging surface 418 of prism 410 can be exposed on one edge of mouse 910. This allows a user to place a thumb or finger against imaging surface 418 when using mouse 910 to allow a fingerprint image to be captured by a computer to which mouse 910 is connected. Figure 22 is a partially cut away, top view of mouse 910 showing image acquisition system 408 housed therein. As shown, image acquisition system 408 is held in place in mouse 910 by frames 917 retaining prism 410, lens assembly 414, and image sensor 416. Additionally, a signal conduit 406, which can be an electrical wire, runs from image sensor 416 to detection electronics (not shown).

As noted above, image acquisition system 308 can advantageously be made relatively compact. This facilitates placement of image acquisition system 308 in mouse 910. In a presently preferred embodiment, computer mouse 910 includes both a horizontal guide 911 and a vertical guide 912 for insuring that a finger whose fingerprint image is to be taken is properly aligned in the horizontal and vertical directions, respectively, with respect to imaging surface 318. In some embodiments of the computer mouse, use of only one of the horizontal and vertical guides may be sufficient for aligning the finger with the optical prism. In Figure 21, vertical guide 912 is shown as being near the bottom of the computer mouse 910. In an alternative embodiment, vertical guide 912 may be located near the top of computer mouse 910 (or, equivalently, imaging surface 418) rather than the bottom as shown in Figure 21.

As noted above, mouse 910 is coupled to a parallel connector 920 and a conventional computer mouse connector 930. The parallel connector 920 transmits fingerprint capture data from the optical structure to a computer to which the pointing device is coupled. The conventional mouse port connector transfers power and other signals related to conventional mouse operation, between the computer mouse 910 and a computer (not shown) to which the computer mouse 910 is coupled. The conventional mouse port connector 930 may be a PS/2 port connector. It is also contemplated that the mouse port connector 930 not be used and that only a universal serial bus connector be used in place of the parallel connector 920.

Although the above description has been made in relation to a computer mouse, it is to be noted that the optical structure of the present invention may be used in conjunction with numerous other devices. Specifically, the optical structure may be incorporated into telephones, televisions, cars, doors, and other items. The fingerprint image may be used as a security access key by the aforementioned items and may be used as a security access key or password for accessing a computer system, either upon booting the computer or when reentering a computer system from a screen saver.

Another embodiment of the present invention having the light source in yet a different location is shown in Figures 8-10. Figure 8 is a side view of an image acquisition system 508 which, like image acquisitions systems 308 and 408, includes an isosceles triangular prism 510, a lens assembly 514, and a image sensor 516. As with prism 310 of image acquisition system 308, prism 510 includes an imaging face 518 against which a fingerprint 535 is placed, and a viewing surface 520 through which an image of fingerprint 535 is projected onto lens assembly 514. However, as can best be seen in Figures 9 and 10A, which are, respectively, a perspective view and a front view of prism 510, image acquisition system 508 preferably includes at least two separate light sources 512a and 512b each of which are placed over triangular end surfaces 519 and 521 (shown in Figure 9), respectively, of prism 510. Light sources 512a and 512b are preferably each an array of LEDs. However light sources 512a and 512b can be any light sources that will illuminate the interior of prism 510. It is also contemplated that image acquisition system 508 include only one or more than two light sources.

Operation of light acquisition system 508 is shown in Figure 10A and 10B. As shown, incident light 524 emitted from a region of light source 512a near imaging surface 518 is incident on imaging surface 518 at an angle greater than the critical angle of imaging surface 518. Thus, in regions of imaging surface 518 where there are fingerprint valleys 509 incident light 524 undergoes total internal reflection and reflected light 530a will strike triangular surface 521 of prism 510. Reflected light will then either pass through surface 521, or scatter off of surface 521. On the other hand, incident light 524 which strikes a fingerprint ridge 511 will primarily undergo scattering, though a relatively small portion of such incident light 524 will be absorbed. Scattered light 530b will radiate in the direction of viewing surface 520 and pass therethrough and into lens assembly 514. As shown in Figure 10B, which is a partial perspective view of prism 510 and light sources 512a and 512b, the incident light 524 emitted by light source 512a or 512b near prism edge 557 between imaging surface 518 and viewing surface 520 will first be totally internally reflected off imaging surface 518. Then, because of the proximity of viewing surface 520 to imaging surface 518 near edge 557, will totally internally reflect off of viewing surface 520, and not enter lens assembly 514. Thus, near edge 557, prism 510 acts as a light guide and light which exits viewing surface 520 near edge 557 is substantially all scattered light from imaging surface 518.

Additionally, referring again to Figure 10A, incident light 524' from a region of light source 512a further away from imaging surface 518 will likely strike imaging surface 518 at an angle less than the critical angle of imaging surface 518. Accordingly, incident light 524' will create an image of fingerprint 535 in the same way that incident light 324 and 424 of image acquisition systems 308 and 408, respectively, does. Incident light 524' tends to provide illumination for a region of imaging surface 518 equidistant between light source 512a and light source 512b and incident light 524 tends to provide illumination for a regions near the edges of imaging surface 518 which are adjacent to end triangular surfaces 519 and 521. In this way, light sources 512a and 512b provide relatively even illumination over the entirety of imaging surface 518. Thus, image acquisition system 508 can advantageously generate a relatively uniform image of fingerprint 535.

As discussed above, image acquisition system generates an image of fingerprint 535 with substantially all scattered light. Thus, as with image acquisition system 308 and 408, the image produced by image acquisition system 508 is relatively high contrast. Additionally, as shown in Figure 10A, lens assembly 514 is preferably wide enough to extend from triangular face 519 to triangular face 521. Thus, lens assembly 514 can be placed relatively close to viewing surface 520. This advantageously allows acquisition system 508 to be relatively more compact.

Further, prism 510 has base angles 540 and 541 that preferably measure above 50 degrees and more preferably measure between 50 degrees and 65 degrees and most preferably measure 62 degrees of 63 degrees. Accordingly, as with image acquisition systems 308 and 408, scattered light 530a and 530b refracts as it exits viewing surface 520. This allows lens assembly to be tilted with respect to viewing surface 520 to reduce trapezoidal distortion without substantial loss of image intensity.

Though as shown in Figures 8 through 10, light sources 514a and 514b can essentially be co-extensive with end triangular surfaces 519 and 521, respectively, it is also contemplated that light sources located on end triangular surfaces 519 and 521 of prism 510 cover only a portion of each surface 519 and 521. For example, as shown in Figures 11 and 12, the light sources can be relatively narrow strip light sources. Figures 11 and 12 show prism 510 with strip light sources 572a and 572b attached to triangular surfaces 519 and 521, respectively. Strip light sources 572a and 572b run along edges 518a and 518b, respectively, where end triangular surfaces 519 and 521, respectively, meet imaging surface 518. Light sources 572a and 572b are each preferably a single row of LEDs. However, any relatively narrow strip light sources that will illuminate the interior of prism 510 can be used.

Light sources 572a and 572b operate in a manner similar to light sources 512a and 512b, respectively, to illuminate imaging surface 518. However, because there is no portion of light sources 572a and 572b at a region of end triangular surface relatively distal from imaging surface 518, illumination by light sources 572a and 572b may not be as uniform as with light sources 512a and 512b. However, light sources 572a and 572b otherwise illuminate imaging surface 518 in substantially the same way as light sources 512a and 512b, thus, all the additional advantages of image acquisition system 508 are retained. Further, because light sources 572a and 572b are smaller than light sources 512a and 512b, respectively, light sources 572a and 572b can advantageously be relatively less costly to manufacture and can consume relatively less power. Image acquisition system 508 can be fabricated in substantially the same manner and with substantially the same components as image acquisition systems 308 and 408.

Another embodiment of the present invention which utilizes, as image acquisition apparatus 508 does, totally internally reflected light to generate a scattered light image of a fingerprint, is shown in Figures 13 and 14. Figure 13 is a side view of an image acquisition apparatus 608 including an isosceles triangular prism 610, a light source 612, a lens assembly 614 and an image sensor 616. Like prisms 310, 410 and 510, prism 610 includes an imaging surface 618 against which a fingerprint 635 is placed, a viewing surface 620 through which an image of fingerprint 635 is projected, and a light receiving surface 622 through which the interior of prism 608 is illuminated. Light source 612 is located adjacent to light receiving surface 622 and, as shown in Figure 14 which is a perspective view of prism 610 including light source 612, can be essentially co-extensive therewith. Lens assembly 614 picks up an image of fingerprint 635 and focuses the image onto image sensor 616.

In a manner similar to that of image acquisition apparatus 508, incident light 624 from light source 612 strikes either a region of image surface 618 where there is a fingerprint ridge 611 or a fingerprint valley 609. Preferably, apex angle 642 of prism 610 opposite light receiving surface 622 is small enough such that imaging surface 618 is close enough to viewing surface 620 to create a light-guide effect in prism 610. That is, if imaging surface 518 is close enough viewing surface 620, incident light 624 striking a region of image surface 618 where there is a fingerprint valley 609 will strike imaging surface 618 at an angle greater than the critical angle and undergo total internal reflection. Totally internally reflected light 630a will then strike viewing surface 620 and rather than passing through viewing surface 620 and into lens assembly 614, will once again undergo total internal reflection. This will continue until the totally internally reflected light 630a is either entirely attenuated or exits prism 610 through apex 665 opposite to light receiving surface 622. However, incident light 624 striking a region of image surface 618 where there is a fingerprint ridge 611 will primarily scatter off fingerprint ridge 611. A portion of this scattered light 630b will exit prism 610 through viewing surface 620 and be picked up by lens assembly 614 which will focus scattered light 630b onto image sensor 616. Thus, the image of fingerprint 635 will be relatively bright at fingerprint ridges 611 and relatively dark at fingerprint valleys 609.

In the manner described above, prism 610 acts essentially as a light guide to contain incident light 624 which is not scattered by a fingerprint ridge 611 and creates an image of fingerprint 635 using primarily scattered light. Accordingly, an image generated by image acquisition system 608 will have relatively high contrast and can be made relatively compact by placing lens assembly 614 relatively close to viewing surface 620.

Moreover, isosceles prism 610 preferably includes base angles 640 and 641 which are greater than 50 degrees. Also, index of refraction of prism 410 is preferably greater than 1. As such, when scattered light 630 passes through viewing surface 620, scattered light 630 will refract away from a line normal to viewing surface 620. Thus, as shown in Figure 13, the lens plane of lens assembly 614 can be tilted with respect to viewing surface 620 to advantageously reduce trapezoidal distortion and scattered light 630 can still enter lens assembly 620 substantially normal to the lens plane. Thus, as with image acquisition system 308, 408 and 508 the intensity of the image of fingerprint 635 can remain relatively high.

It is not necessary that an image acquisition system using a light-guide type refractors such as prism 510 or prism 610 be limited to using a triangular prism. Other light refractors which act as light guides can also be used in an image acquisition system. For example, Figures 15 and 16 shows a side and top view, respectively, of an image acquisition system 708 including a circular concave lens 710; light sources 712a, 712b, and 712c; lens assembly 714; and image sensor 716. Concave lens 710 includes a concave imaging surface 718, a flat viewing surface 720, and a circular light receiving surface 722. Light sources 712a, 712b and 712c are preferably equidistantly spaced about the circumference of light receiving surface 722. It is also contemplated that image acquisition device include only one, two or more than three lights sources.

In a manner similar to prism 610, concave lens 710 acts a light-guide. In particular incident light 724 from light sources 712a, 712b, and 712c strikes imaging surface 718 at an angle greater than the critical angle for imaging surface 718. Accordingly, in regions of imaging surface 718 where there is a fingerprint valley 709, incident light 724 undergoes total internal reflection. Reflected light 730 then propagates through concave lens 710 without passing through viewing surface 722 to enter lens assembly 714. When incident light 724 strikes an area of imaging surface 718 where there is a fingerprint ridge 711, incident light 724 is primarily scattered and some of scattered light 730 passes through viewing surface 718 and is focused by lens assembly 714 onto image sensor 716. In this way, image acquisition system 708 generates an image of fingerprint 735 wherein fingerprint ridges 711 are relatively bright and fingerprint valleys 709 are relatively dark.

When using an image acquisition surface having a flat imaging surface, a two dimensional image of a fingerprint could be placed on the imaging surface rather than an actual fingerprint. In this way, it could be possible to "trick" the processing and comparison apparatus connected to an image acquisition system into registering a false match between the two dimensional copy of a fingerprint and a real fingerprint. However, imaging surface 718 of lens 710 is concave. Thus, it would advantageously be more difficult to place a two-dimensional image of a fingerprint on imaging surface 718 and thereby "trick" the processing and comparison apparatus connected to image acquisition system 708. Additionally, concave imaging surface 718 will more closely match the curved contour of a thumb or finger which fingerprint is being imaged. This means that it is likely that a higher portion of the surface of a fingerprint will come into contact with imaging surface 718, thereby allowing a larger area of a fingerprint to be imaged. This can advantageously reduce errors in processing and comparison of fingerprints.

Although the object lens assembly 714 of image acquisition system 708 is separate from concave lens 710, it is within the ambit of the present invention for the first object lens in lens assembly 714 and concave lens such as lens 710 to be formed as a single unit. Such an image acquisition system is shown in Figure 17. Image acquisition system 808 includes a lens 810 which has an imaging surface 818 which is concave and a viewing surface 822 which is convex. Image acquisition system 808 also includes light sources 812a, 812b, which are substantially the same as light sources 712a, 712b, and can include a third light source substantially the same as light source 712c. Image acquisition system 808 also includes an image sensor 816 and a lens assembly 814 which may or may not include an object lens. It is also contemplated that image acquisition system 808 not include a lens assembly separate from lens 810. Rather, it is within the scope of the present invention to incorporate the lens assembly 814 into lens 810 as a single unit.

Image acquisition system 808 functions in substantially the same manner as image acquisition system 708 and, thus, includes all the advantages thereof. It is also contemplated that imaging surface 818 of lens 810 be flat rather than concave, as shown in Figure 18.

Many widely different embodiments of the present invention may be constructed without departing from the spirit and scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in the specification. For example, though the above disclosed embodiments of the present invention are described with reference to imaging a fingerprint, any other type of patterned object is contemplated to be imaged with the present invention.

CLAIMS

What is claimed is:

1. A compact apparatus for forming a high contrast, low distortion image of a patterned object including:

a light refractor for reflecting and refracting light, the light refractor including:

an imaging surface against which a patterned object to be imaged is to be placed;

at least one light entrance surface adjacent to the imaging surface and through which light enters the refractor; and

a viewing surface adjacent to the imaging surface and through which an image of the object to be imaged is projected;

at least one focusing lens adjacent to the viewing surface and for receiving and focusing an image of a patterned object projected through the viewing surface; and

at least one light source located adjacent to the light receiving surface and for emitting incident light which enters the light refractor to create an image of the patterned object at the viewing surface, the image focused by the at least one focusing lens, the light source positioned such that light emitted therefrom and entering the light refractor strikes at least one other surface of the light refractor before striking the imaging surface such that the image of the patterned object from the imaging surface and projected through the viewing surface is generated by substantially all scattered light from the imaging surface.

2. The apparatus of claim 1 wherein the light refractor is a five faced triangular prism and the imaging surface includes a first rectangular face of the triangular prism different from both the viewing surface and the light entrance surface.

3. The apparatus of claim 2 wherein the light reflected from the at least one other surface strikes the imaging surface at an angle less than a critical angle of the imaging surface.

4. The apparatus of claim 3 wherein the triangular prism is an isosceles prism.

5. The apparatus of claim 4 wherein:

the triangular prism includes:

a first edge opposite the imaging surface and adjacent to the light entrance surface; and

a second edge adjacent to the imaging surface; and

the light source is a strip of light emitting diodes (LEDs) oriented towards and parallel with the light entrance surface and adjacent to the first edge such that the LED strip does not pass through a plane normal to the light entrance surface and intersecting with the second edge.

6. The apparatus of claim 5 wherein the viewing surface includes the light entrance surface.

7. The apparatus of claim 6 wherein a light shield is located between the light source and the image sensor.

8. The apparatus of claim 5 wherein a further surface of the triangular prism is located between the imaging surface and the light entrance surface, the further surface including a light diffusing face.

9. The apparatus of claim 8 wherein a portion of the light receiving surface is mirrored towards the interior of the triangular prism.

10. The apparatus of claim 9 wherein a portion of the light receiving surface includes a light absorbing surface.

11. The apparatus of claim 10 wherein a portion of the further surface adjacent to the first edge is mirrored towards the interior of the triangular prism.

12. The apparatus of claim 11 wherein:

a lens plane of the focusing lens is tilted with respect to a plane defined by the viewing surface so as to reduce a difference in image light path lengths between different portions of an object to be imaged; and

the base angles of the isosceles triangular prism are greater than 45 degrees, such that trapezoidal distortion of an image is reduced.

13. The apparatus of claim 12 wherein the angle between the base angles of the isosceles triangular prism are between 50 degrees and 65 degrees, inclusive.

14. The apparatus of claim 5 wherein a portion of the light receiving surface adjacent to the first edge and facing the light source is streaked to cause diffusion of light passing through the light receiving surface.

15. The apparatus of claim 5 wherein the viewing surface is between the light entrance surface and the imaging surface.

16. The apparatus of claim 15 wherein a portion of the viewing surface adjacent to the first edge is mirrored towards the interior of the triangular prism.

17. The apparatus of claim 16 wherein a light shield is placed between the light source and the image sensor.

18. The apparatus of claim 17 wherein a portion of the light receiving surface adjacent to the first edge and facing the light source is streaked to cause diffusion of light passing through the light receiving surface.

19. An apparatus for forming a high contrast image of a patterned object comprising:

a first lens including;

an imaging surface against which a patterned object to be imaged is to be placed;

at least one light receiving surface adjacent to the imaging surface and through which light enters the first lens; and a viewing surface opposite to the light entrance surface and through which an image of the patterned object to be imaged is projected;

a second lens adjacent to the viewing surface and for receiving and focusing an image of the patterned object projected through the viewing surface; and

at least one light source for projecting incident light into the first lens and located adjacent to the light entrance surface to project incident light between the viewing surface and the imaging surface wherein the incident light can undergo total internal reflection between the imaging surface and the viewing surface without passing through the viewing surface such that the image of the patterned object is generated by substantially all scattered light from the imaging surface.

20. The apparatus of claim 19 wherein the first lens is circular and the light entrance surface includes a circumferential edge of the first lens.

21. The apparatus of claim 20 wherein the imaging surface is concave.

22. The apparatus of claim 21 including three light sources placed adjacent to the light receiving surface.

23. The apparatus of claim 22 wherein the first lens and the second lens are a single unitary lens.

24. The apparatus of claim 23 wherein the viewing surface is convex.

25. The apparatus of claim 20 wherein the first lens and the second lens are a single unitary lens.

26. The apparatus of claim 25 wherein the imaging surface is flat and the viewing surface is convex.

27. An apparatus for forming a high contrast image of a patterned object comprising:

a triangular prism including;

an imaging surface against which a patterned object to be imaged is to be placed;

at least one light receiving surface adjacent to the imaging surface and through which light enters the triangular prism; and

a viewing surface adjacent to the light receiving surface and through which an image of the patterned object is projected;

at least one lens adjacent to the viewing surface and for receiving and focusing an image of a patterned object projected through the viewing surface; and

at least one light source for projecting incident light into the triangular prism and located adjacent to the light receiving surface to project light between the imaging surface and the viewing surface wherein at least a portion of the incident light can undergo total internal reflection between the imaging surface and the viewing surface without passing through the viewing surface such that the image of the patterned object is generated by substantially all scattered light from the imaging surface.

28. The apparatus of claim 27 wherein:

the light receiving surface includes a first rectangular surface of the triangular prism;

the imaging surface includes a second rectangular surface of the triangular prism; and

the viewing surface includes a third rectangular surface of the triangular prism.

29. The apparatus of claim 28 wherein the triangular prism includes an isosceles prism.

30. The apparatus of claim 27 wherein a first light source is located adjacent to a first triangular surface of the triangular prism and a second light source is located adjacent to a second triangular surface of the triangular prism.

31. The apparatus of claim 30 wherein the first light source is co-extensive with the first triangular surface and the second light source is co-extensive with the second triangular surface.

32. The apparatus of claim 31 wherein the at least one lens adjacent to the viewing surface is at least as wide as the viewing surface.

33. The apparatus of claim 30 wherein the first light source is relatively narrow and located adjacent to a first edge of the triangular prism between the image surface and the first triangular surface and the second light source is relatively narrow and located adjacent to a second edge of the triangular prism between the image surface and the second triangular surface.

34. The apparatus of claim 33 where the at least one lens adjacent to the viewing surface is at least as wide as the viewing surface.

35. A method of imaging a patterned object comprising:

providing a light refractor having an imaging surface, a light receiving surface and a viewing surface;

placing the patterned object against the imaging surface of the light refractor;

projecting incident light from a light source through the light receiving surface of the light refractor;

reflecting the incident light off at least one surface of the light refractor other than the imaging surface before the incident light strikes the imaging surface; and

scattering the incident light off the imaging surface and patterned object and through the viewing surface.

36. The method of claim 35 further including the steps of:

providing a lens adjacent to the viewing surface; and

projecting the scattered light from the viewing surface into the lens to form an image of the patterned object.

37. The method of claim 36 wherein providing a light refractor includes providing an isosceles triangular prism has base angles which measure greater than 45 degrees.

38. The method of claim 37 wherein reflecting the incident light off at least one surface of the triangular prism includes scattering the incident light off the at least one surface of the triangular prism.

39. The method of claim 38 wherein the step of providing a lens includes tilting the lens plane of the lens with respect to a plane of the viewing surface to reduce trapezoidal distortion in the image of the patterned object.

40. A method of imaging a patterned object comprising:

providing a triangular prism having an imaging surface, a light receiving surface, a viewing surface and first and second triangular end surfaces;

placing the patterned object against the imaging surface of the triangular prism;

projecting incident light from a first light source through the first triangular end surface;

scattering the incident light off the imaging surface and patterned object and through the viewing surface;

providing a lens adjacent to the viewing surface; and

projecting the scattered light from the viewing surface into the lens to form an image of the patterned object.

41. The method of claim 40 further including projecting incident light from a second light source through the second triangular end surface.

42. A computer input device having an image acquisition system housed therein, the image acquisition system for forming a high contrast image of a patterned object and including:

a light refractor for reflecting and refracting light, the light refractor including:

an imaging surface against which a patterned object to be imaged is to be placed;

at least one light entrance surface adjacent to the imaging surface and through which light enters the refractor; and

a viewing surface adjacent to the imaging surface and through which an image of the object to be imaged is projected;

at least one focusing lens adjacent to the viewing surface and for receiving and focusing an image of a patterned object projected through the viewing surface; and

at least one light source located adjacent to the light receiving surface and for emitting incident light which enters the light refractor to create an image of the patterned object at the viewing surface, the image focused by the at least one focusing lens, the light source positioned such that the light emitted therefrom and entering the light refractor strikes at least one other surface before striking the imaging surface such that the image of the patterned object from the imaging surface and projected through the viewing surface is generated by substantially all scattered light from the imaging surface.

43. The device of claim 42 wherein the computer input device includes a mouse and the image acquisition system is housed inside the mouse.

44. The device of claim 43 wherein the refractor includes a isosceles triangular prism.

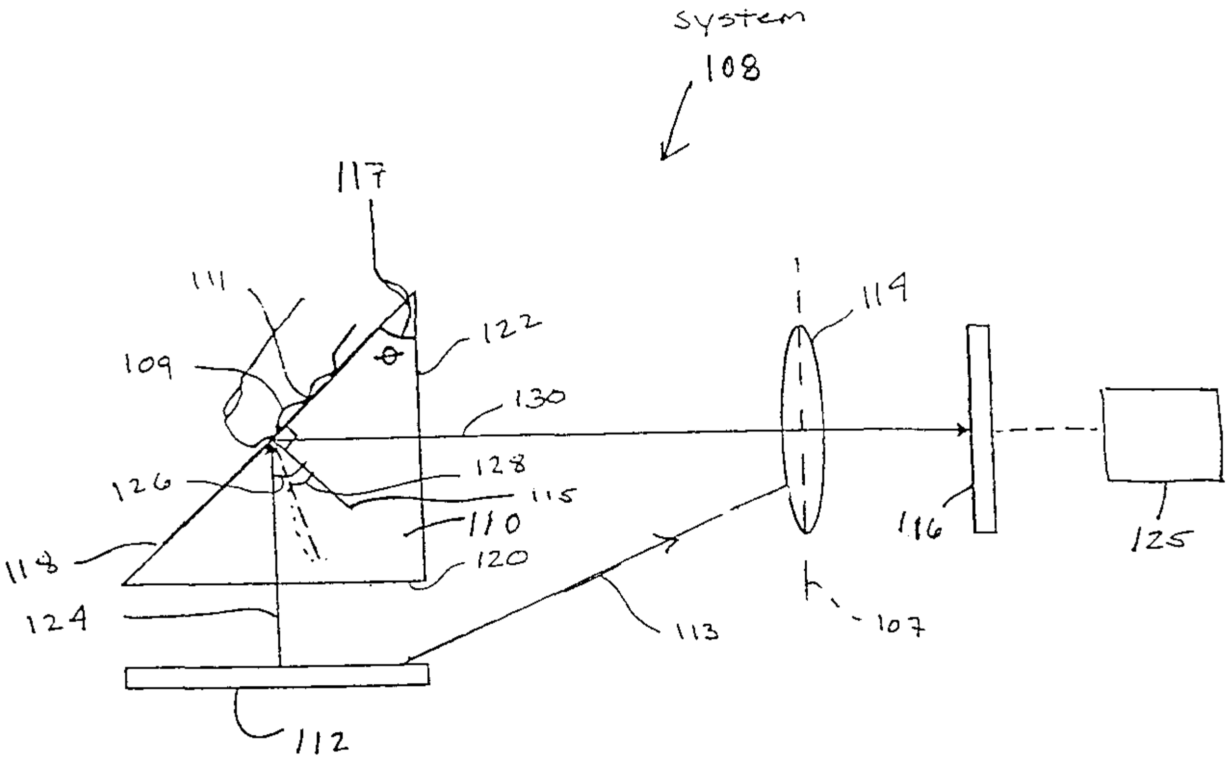

Fig. 1 (Prior Art)

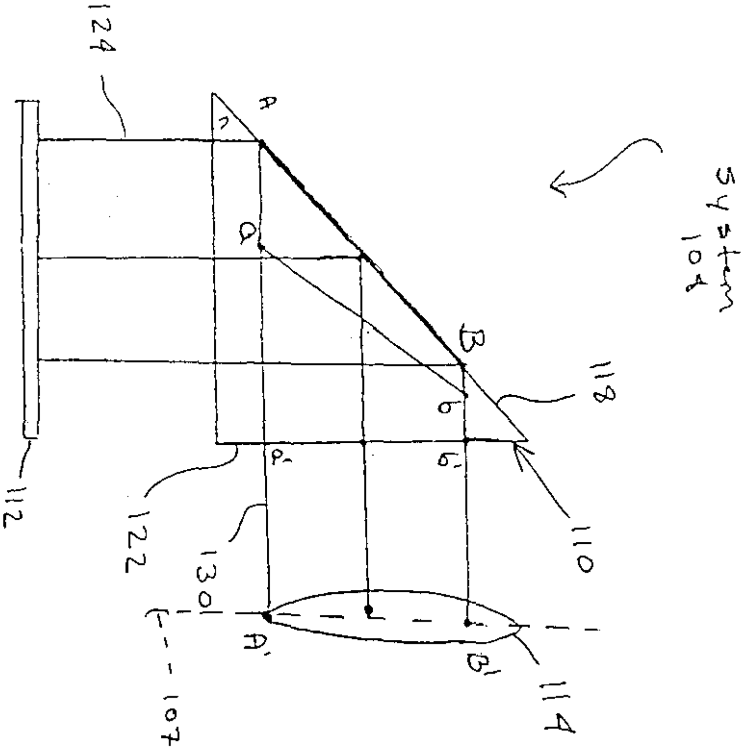

Fig. 2 (Prior Art)

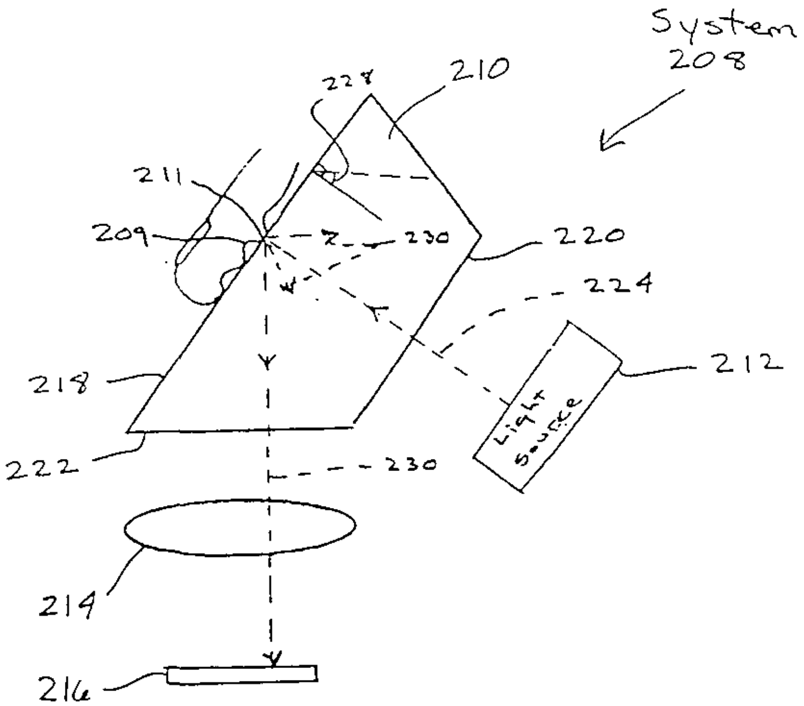

Fig. 3 (Prior Art)

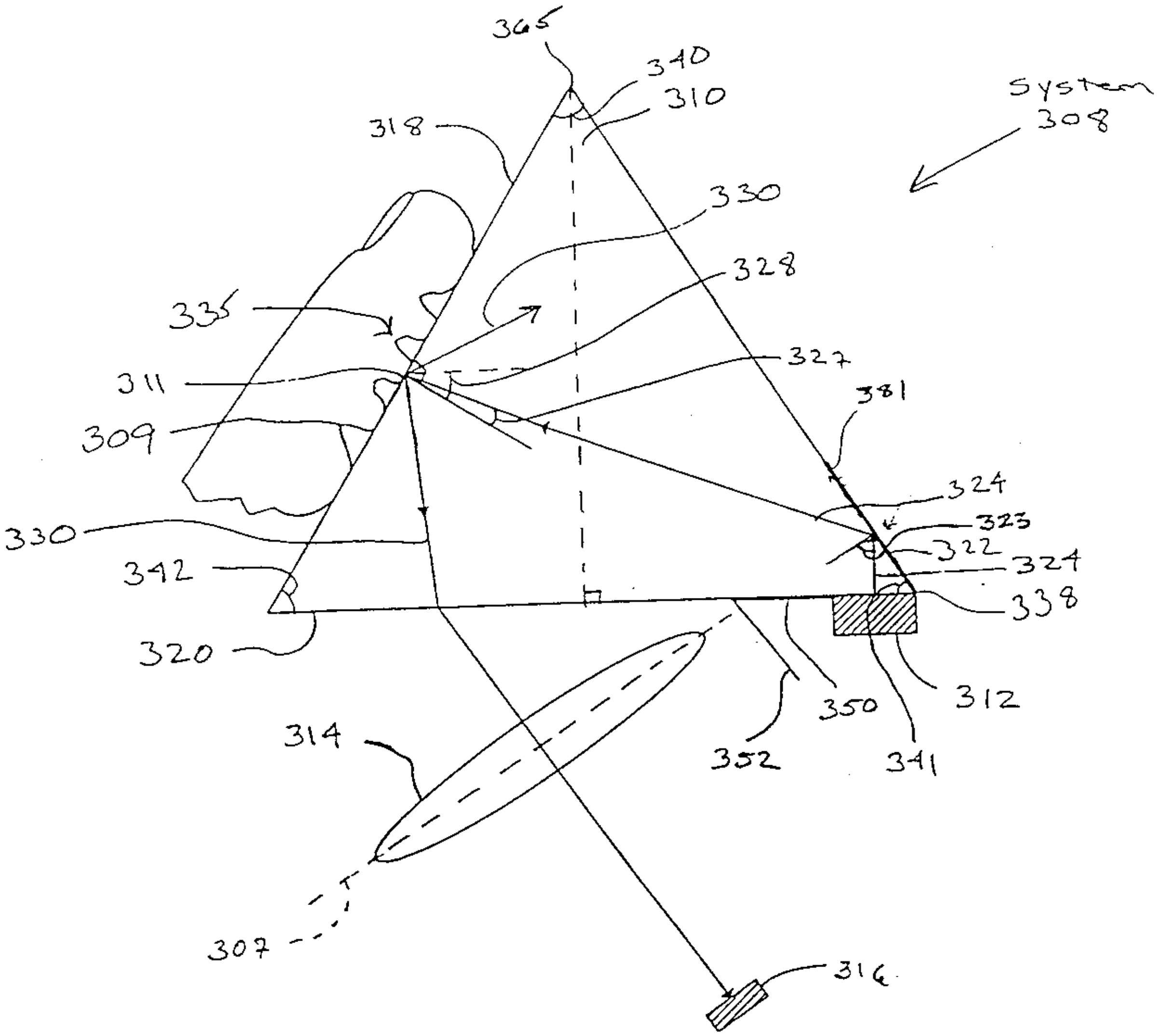

Fig. 4

(First Embodiment)

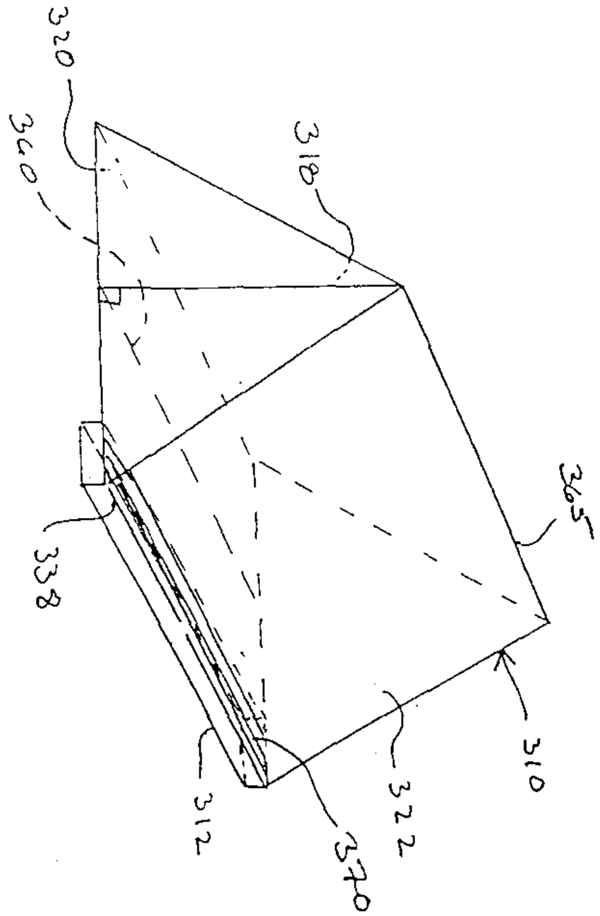

Fig. 5

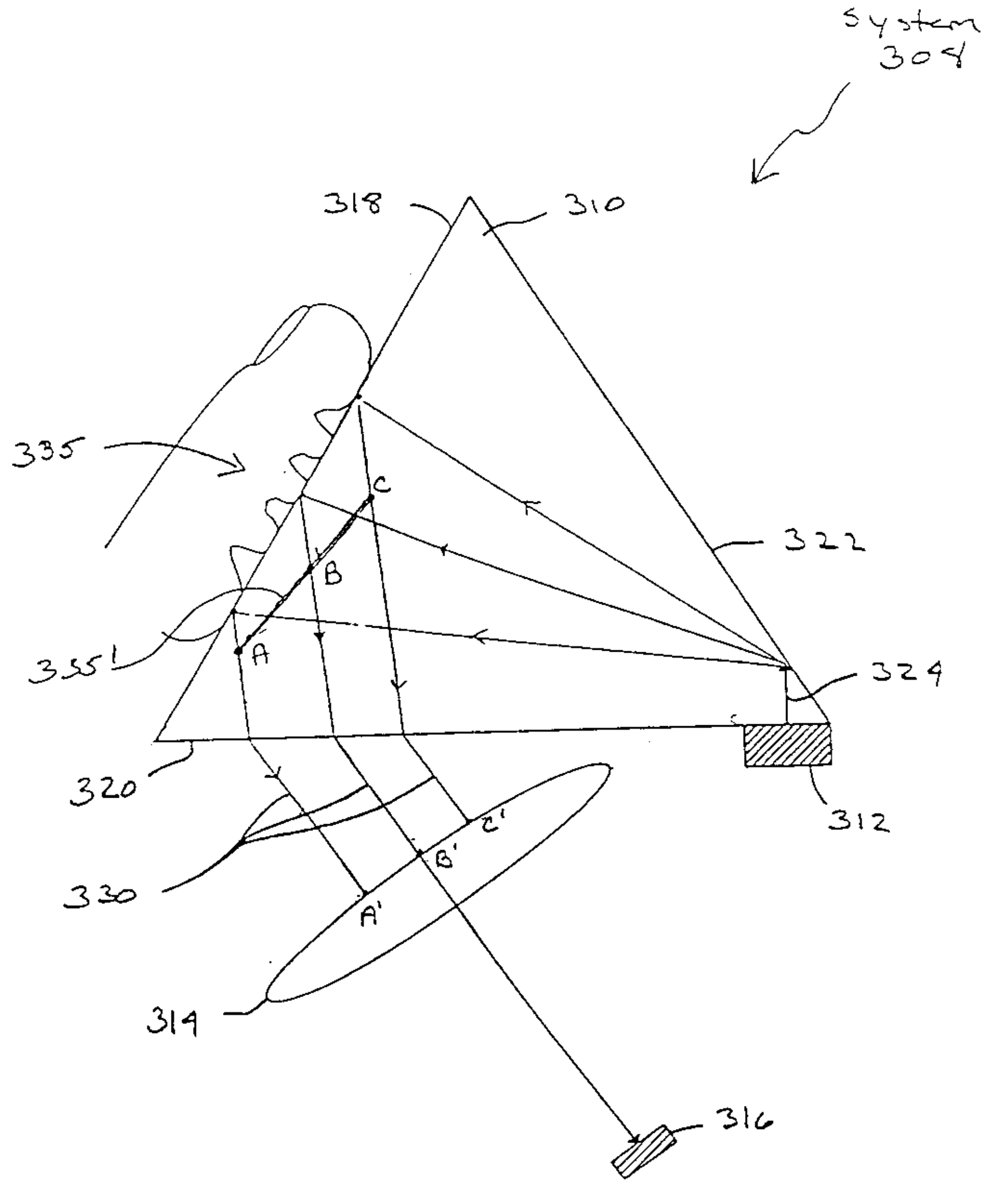

Fig. 6A

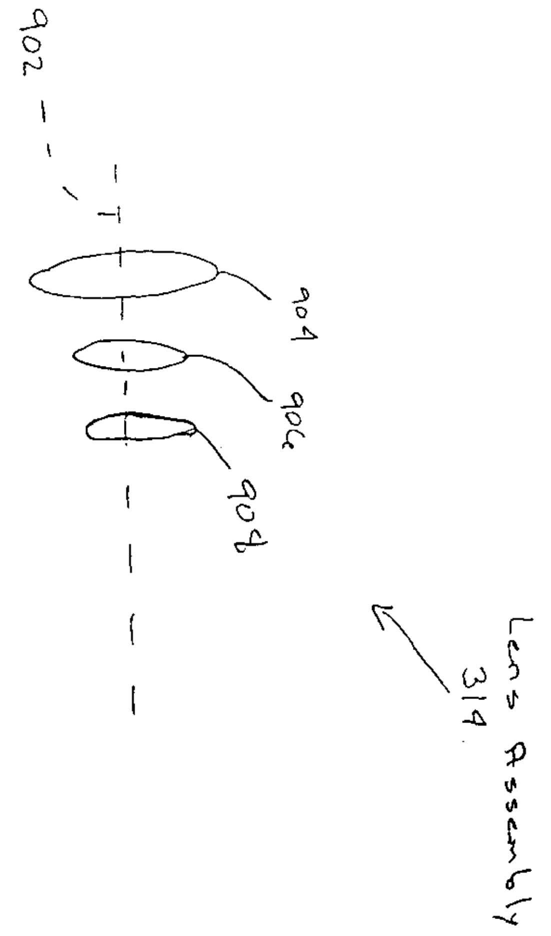

Fig 6B

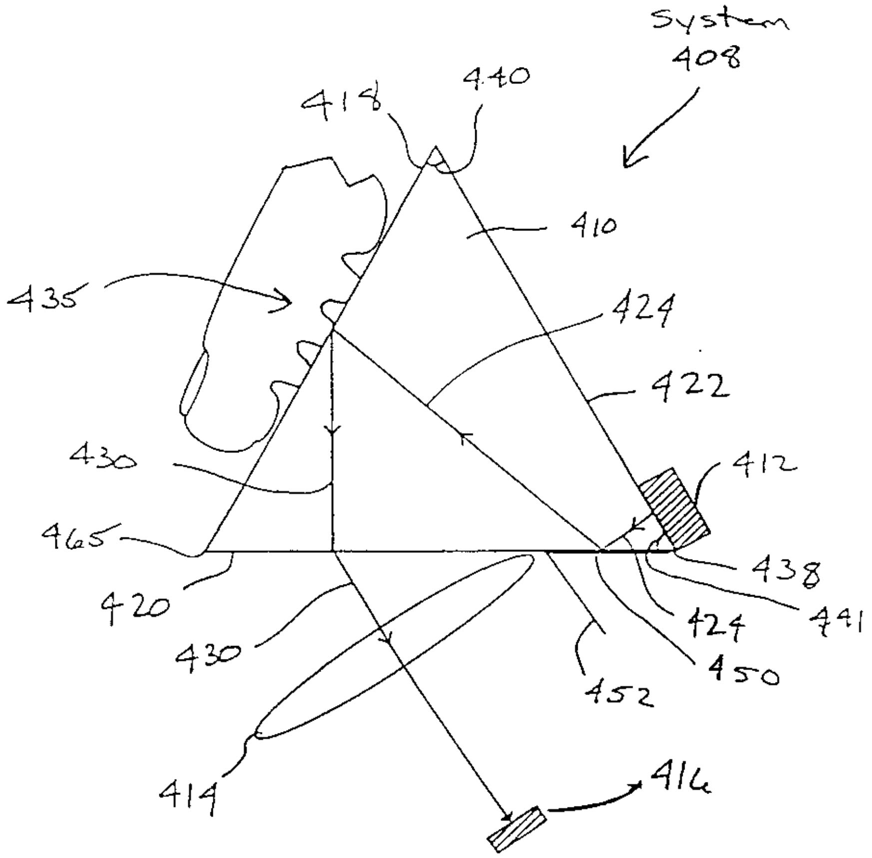

Fig. 7
(Second Embodiment)

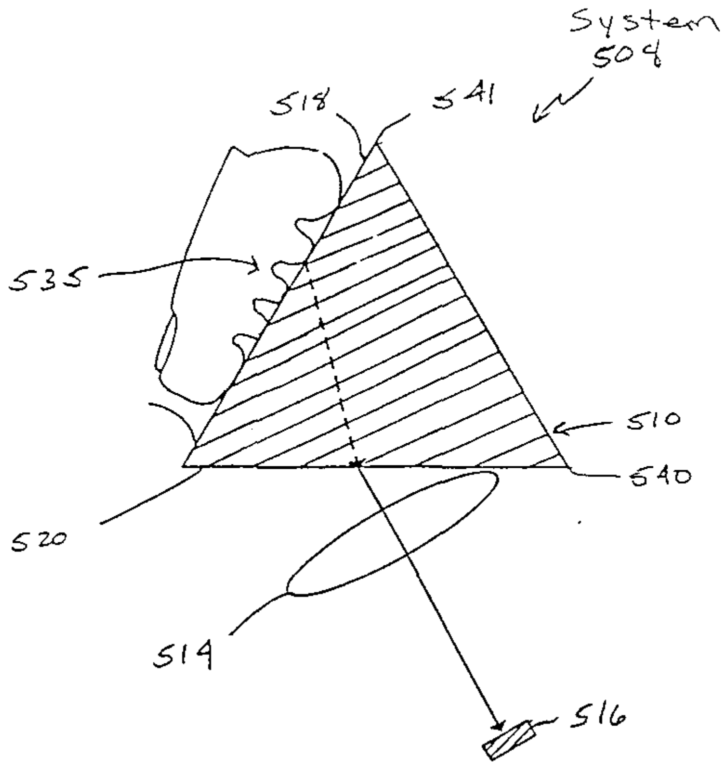

Fig. 8
(Third Embodiment)

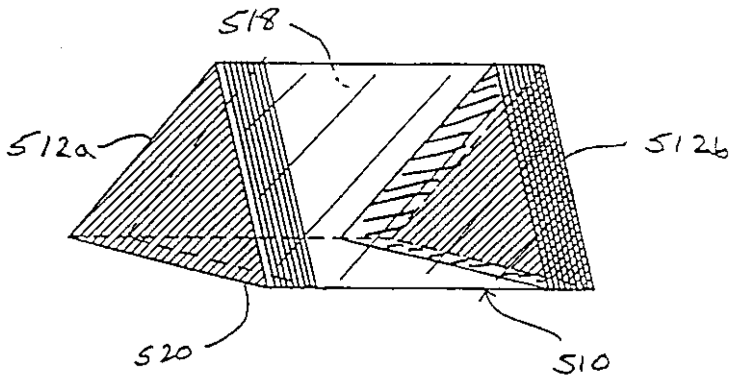

Fig. 9

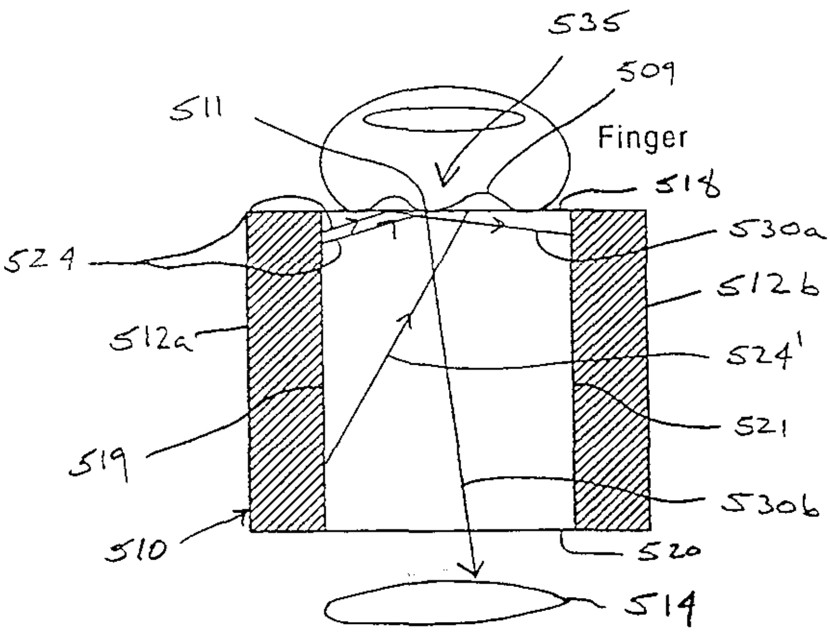
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Fig. 10A

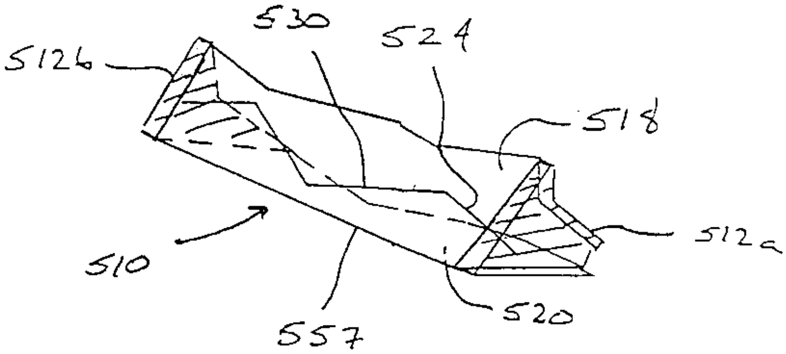

Fig. 10B

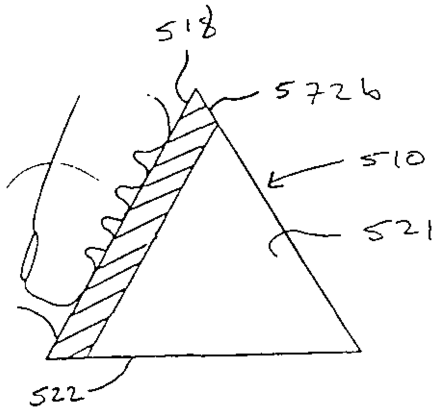

Fig. 11
(Fourth Embodiment)

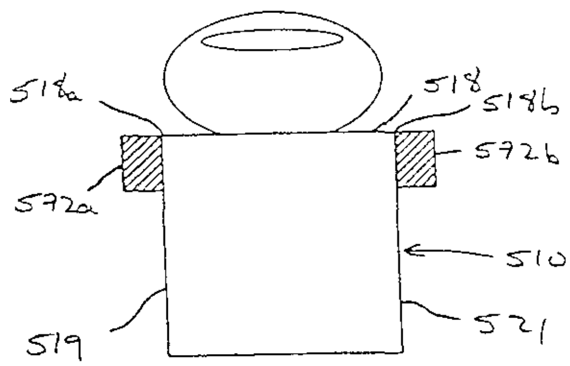

Fig. 12

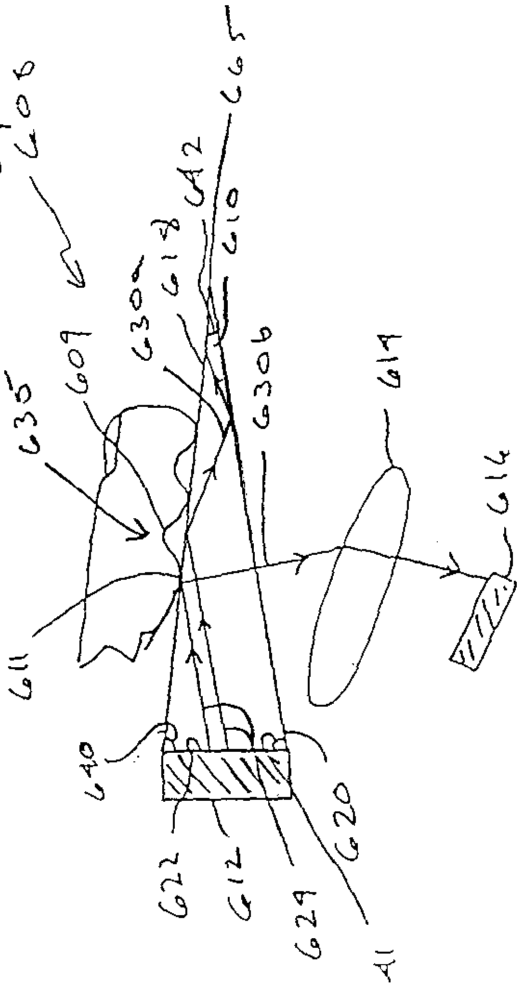

Fig. 13
(Fifth embodiment)

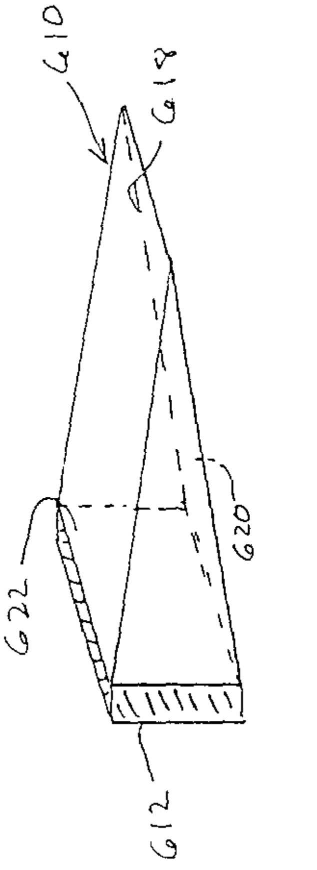

Fig. 14

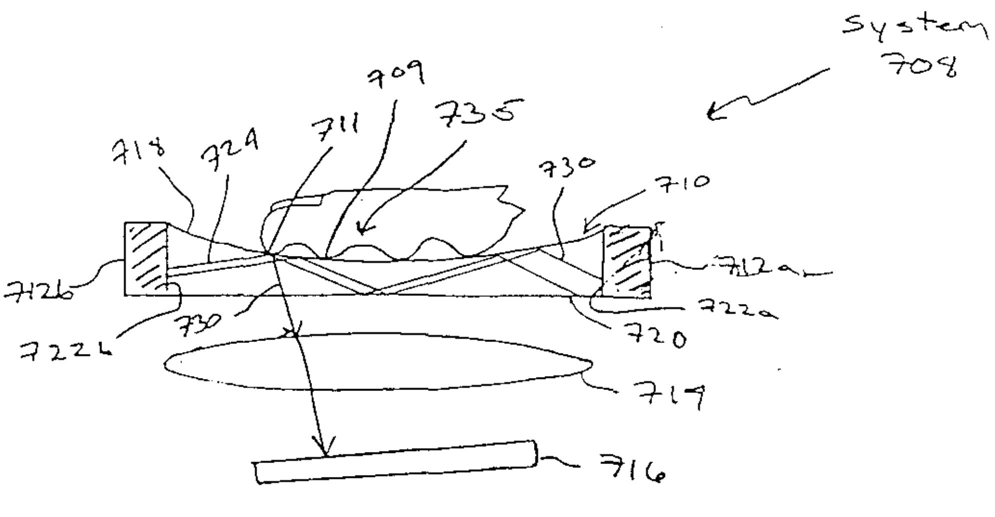

Fig. 15
(Sixth Embodiment)

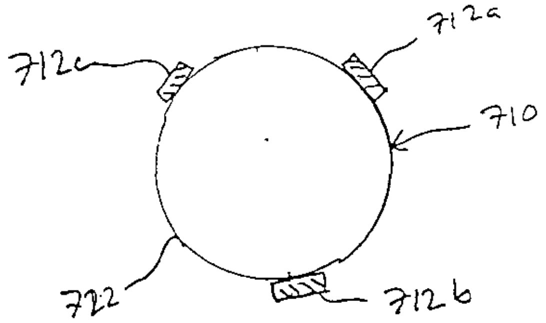

Fig. 16

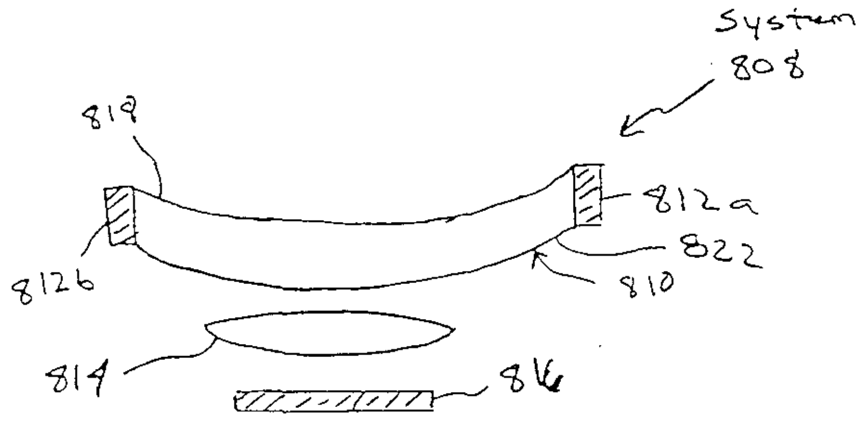

Fig. 17

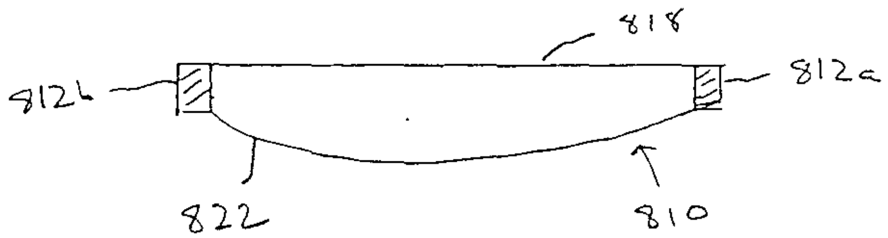

Fig. 18

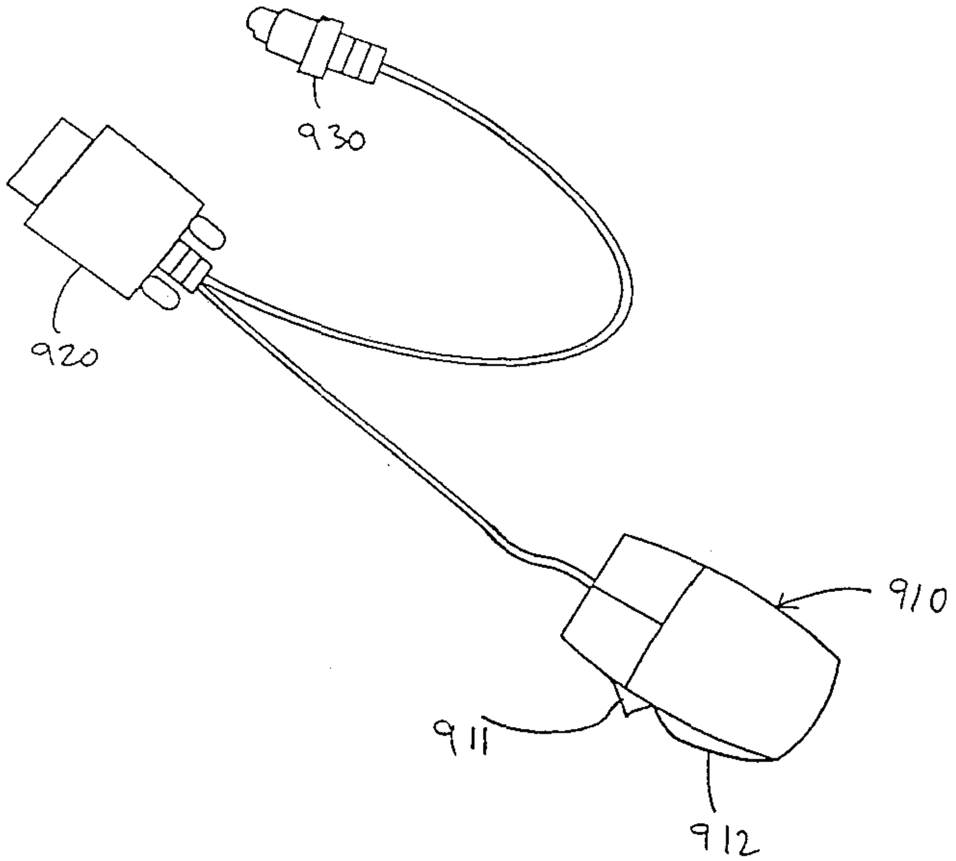

Fig 19

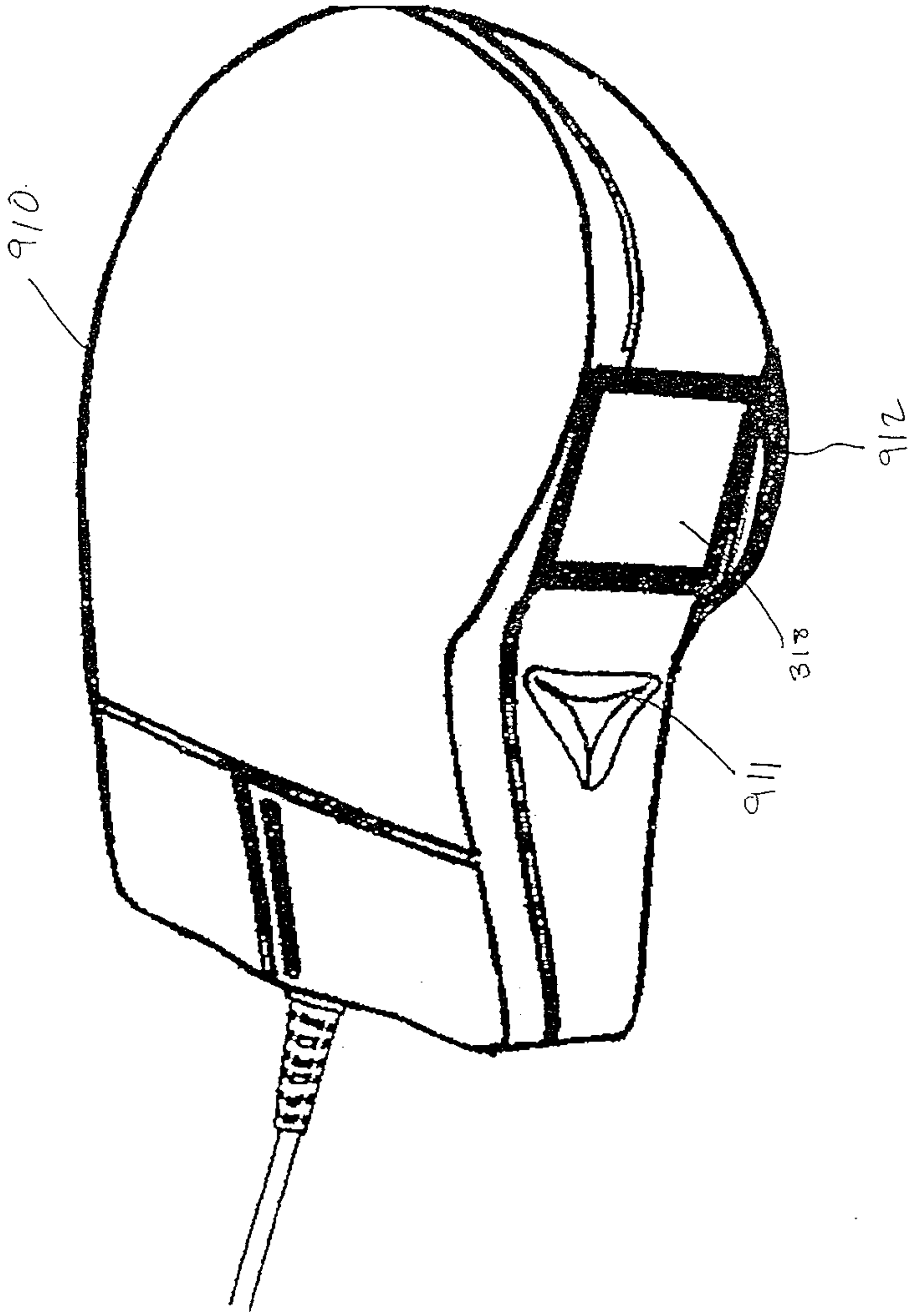

Fig. 20

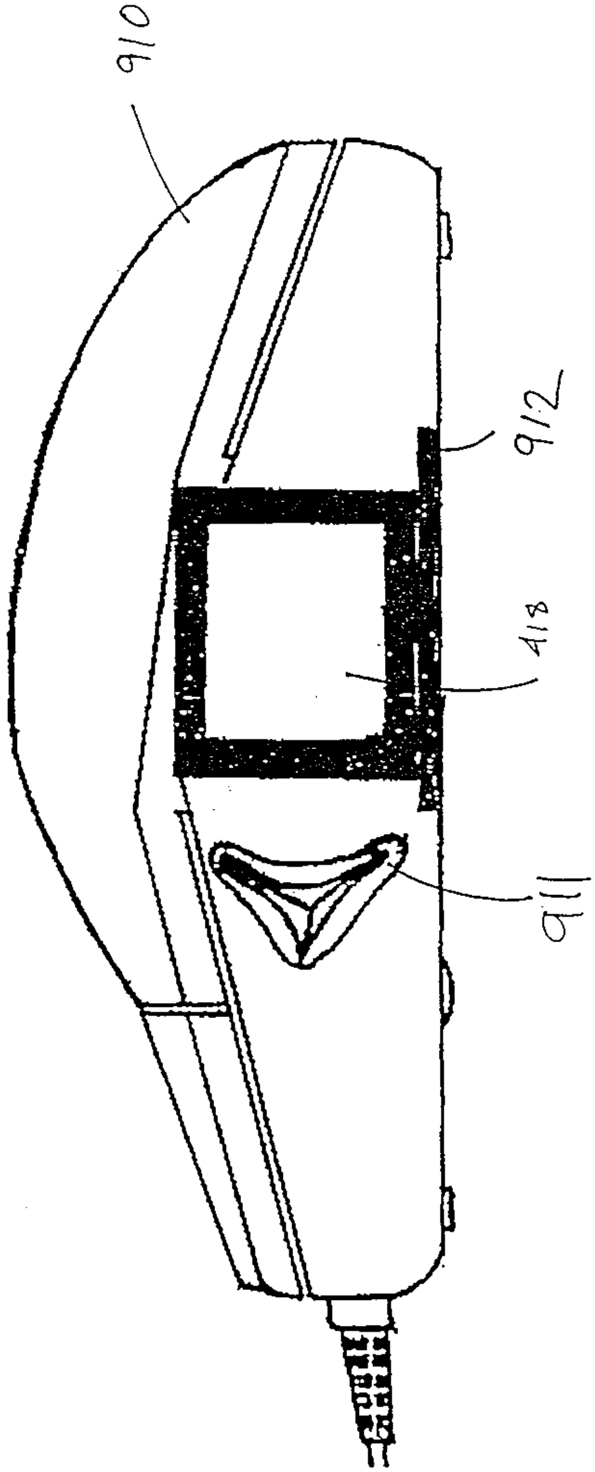

Fig 21

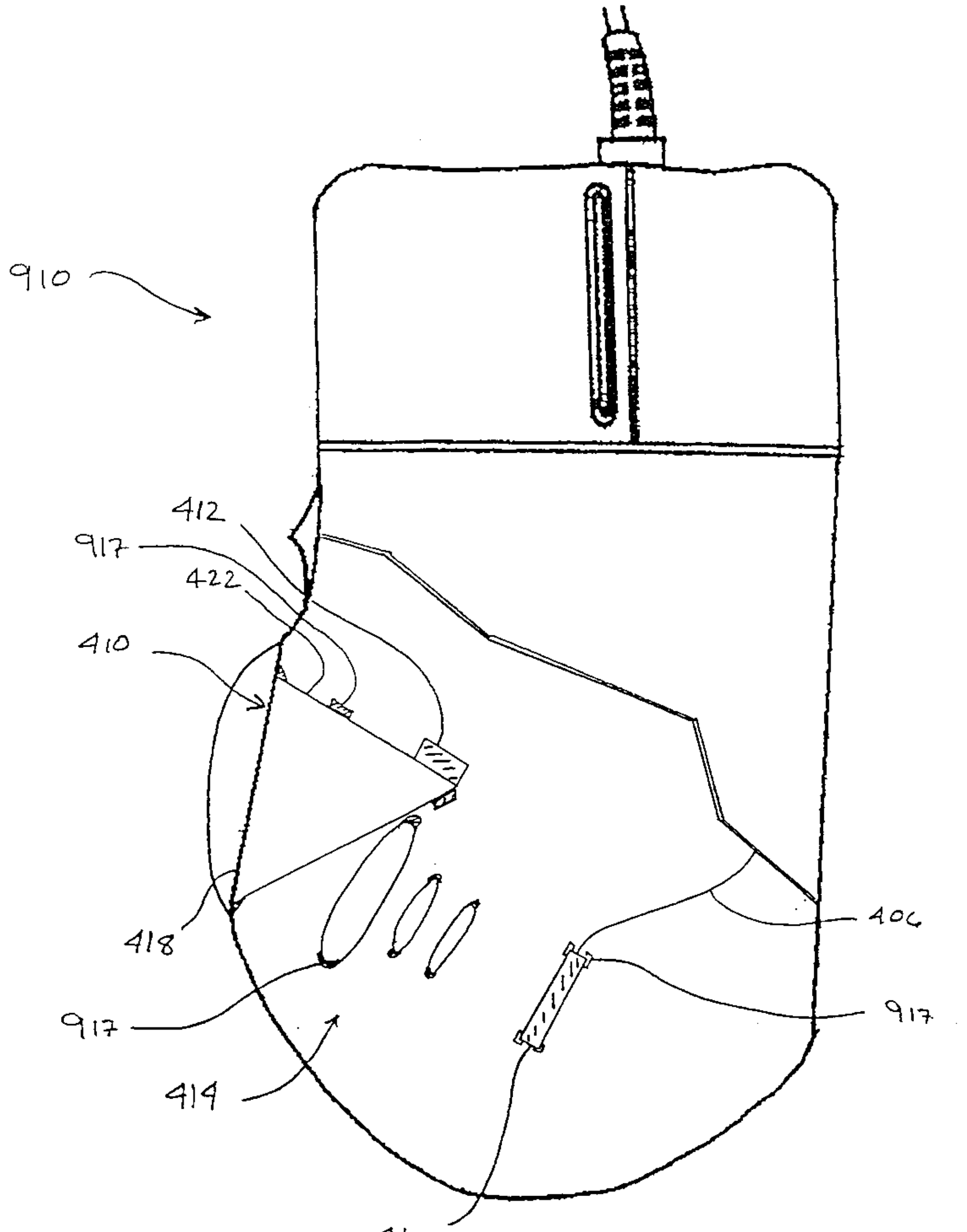

Fig. 22

[19]中华人民共和国国家知识产权局

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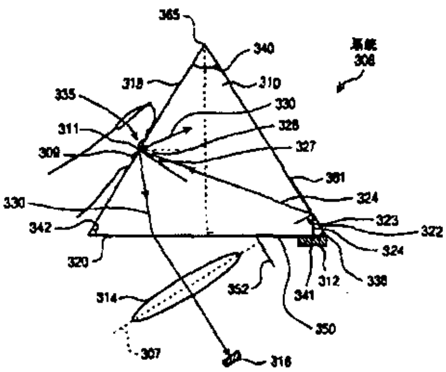
代理人 武玉琴 朱登河

权利要求书7页 说明书23页 附图页数12页

[54]发明名称 用于图像捕获的高对比度、低失真的光学捕获系统

[57]摘要

用于捕获图形化物体如指纹的图象装置和方法，包括一个光折射 装置、一个聚焦透镜和一个光源。光折射装置例如可以是一个棱镜，并且包括成象面、光接收面和观察面。光源的入射光经光接收面投影 并反射离开非成象面的面。然后此反射光投射到成象面上，基本上由 所有经观察面的散射光产生图形化物体的图象。透镜邻近观察面放 置，把光聚焦到图象传感器上。



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权 利 要 求 书

1.一种用于对图形化物体形成高对比度、低失真图象的袖珍装置，包括：

一个用于反射和折射光线的光折射器，该光折射器包括：

待成象的图形化物体靠着其放置的成象面；

至少一个邻近成象面的光入射面，光从其穿过进入折射器；和

邻近成象面的观察面，光从其穿过对待成象物体的图象进行投影；

至少一个聚焦透镜，该透镜邻近观察面，用于接收并聚焦经观察面投影的图形化物体的图象；和

至少一个光源，邻近光接收面布置并发射入射到光折射器的入射光，在观察面产生图形化物体的图象，该图象由至少一个聚焦透镜聚焦，光源放置在使从其发射并进入光折射器的光在照射到成象面之前照射到至少一个光折射器的其它面的位置，使得基本上由来自成象面的所有的散射光产生来自成象面并经观察面投影的图形化物体的图象。

2. 如权利要求 1 所述的装置，其特征在于光折射器是一个五个面的三角棱镜，成象面包括不同于观察面和光入射面的三角棱镜的第一矩形面。

3. 如权利要求 2 所述的装置，其特征在于从至少一个其它的面反射的光以小于成象面临界角的角度照射到成象面。

4. 如权利要求 3 所述的装置，其特征在于三角棱镜是等腰棱镜。

5. 如权利要求 4 所述的装置，其特征在于：

三角棱镜包括：

第一边，与成象面相对并邻近光入射面；和

第二边，邻近成象面；且

光源是一个朝着光入射面取向并平行于光入射面的发光二极管（LED）带，邻近第一边，使得 LED 带不通过垂直于光入射面的平面并与第二边相交。

6. 如权利要求 5 所述的装置，其特征在于观察面包括光入射面。

7. 如权利要求 6 所述的装置，其特征在于光屏蔽位于光源和图象传感器之间。

8. 如权利要求 5 所述的装置，其特征在于三角棱镜的另一个面位于成象面和光入射面之间，该面包括一个光散射面。

9. 如权利要求 8 所述的装置，其特征在于光接收面的一部分是向着三角棱镜内部的镜面。

10. 如权利要求 9 所述的装置，其特征在于光接收面的一部分包括光吸收面。

11. 如权利要求 10 所述的装置，其特征在于邻近第一边的另一面是向着三角棱镜内部的镜面。

12. 如权利要求 11 所述的装置，其特征在于：

聚焦透镜的透镜平面相对于观察面确定的平面倾斜，从而可以减小待成象物体的不同部分之间图象光程之差；和

等腰三角棱镜的底角大于 45 度，由此减小图象的梯形失真。

13. 如权利要求 12 所述的装置，其特征在于等腰三角棱镜的底角在 50～65 度之间，包括 50 度和 65 度。

14. 如权利要求 5 所述的装置，其特征在于光接收面邻近第一边并面向光源的一部分上形成线条，以致使通过光接收面的光散射。

15. 如权利要求 5 所述的装置，其特征在于观察面位于光入射面和成象面之间。

16. 如权利要求 15 所述的装置，其特征在于观察面邻近第一边的部分是向着三角棱镜内部的镜面。

17. 如权利要求 16 所述的装置，其特征在于光屏蔽放置在光源和图象传感器之间。

18. 如权利要求 17 所述的装置，其特征在于光接收面邻近第一边并面向光源的一部分上形成线条，以致使通过光接收面的光散射。

19. 一种用于形成图形化物体高对比度图象的装置，包括：

第一透镜，它包括：

成象面，待成象的图形化物体靠着其放置；

至少一个光接收面，邻近成象面，光穿过其进入第一透镜；和

观察面，与光入射面相对，待成象的图形化物体的图象经该观察面投影；

第二透镜，与观察面相邻并用于接收和聚焦经观察面投影的图形化物体的图象；和

至少一个光源，用于把入射光投射到第一透镜上，与光入射面相邻，在观察面和成象面之间投射入射光，其中，入射光在成象面和观察面之间发生全内反射，不透过观察面，使得基本上由成象面的所有散射光产生图形化物体的图象。

20. 如权利要求 19 所述的装置，其特征在于第一透镜是圆形的，光入射面包括第一透镜的圆周边。

21. 如权利要求 20 所述的装置，其特征在于成象面是凹状。

22. 如权利要求 21 所述的装置，包括三个邻近光接收面放置的光源。

23. 如权利要求 22 所述的装置，其特征在于第一透镜和第二透镜是一个整体透镜。

24. 如权利要求 23 所述的装置，其特征在于观察面是凸面。

25. 如权利要求 20 所述的装置，其特征在于第一透镜和第二透镜是一个整体透镜。

26. 如权利要求 25 所述的装置，其特征在于成象面是平面，观察面是凸面。

27. 一种用于对图形化物体形成高对比度图象的装置，包括：

三角棱镜，它包括：

成象面，待成象的图形化物体靠着其放置；

至少一个光接收面，邻近于成象面，光从其穿过进入三角棱镜；和

观察面，邻近于光接收面，图形化物体的图象经其投影；

至少一个透镜，与观察面相邻并用于接收和聚焦经观察面投影的图形化物体的图象；和

至少一个光源，用于把入射光投射到三角棱镜上，与光入射面相邻，在观察面和成象面之间投射入射光，其中，至少入射光的一部分在成象面和观察面之间发生全内反射，不透过观察面，使得基本上由

成象面的所有散射光产生图形化物体的图象。

28. 如权利要求 27 所述的装置，其特征在于：
光接收面包括三角棱镜的第一矩形面；
成象面包括三角棱镜的第二矩形面；和
观察面包括三角棱镜的第三矩形面。

29. 如权利要求 28 所述的装置，其特征在于三角棱镜包括等腰棱镜。

30. 如权利要求 27 所述的装置，其特征在于第一光源邻近三角棱镜的第一三角形面放置，第二光源邻近三角棱镜的第二三角形面放置。

31. 如权利要求 30 所述的装置，其特征在于第一光源与第一三角形面共同延伸，第二光源与第二三角形面共同延伸。

32. 如权利要求 31 所述的装置，其特征在于至少一个邻近观察面的透镜至少与观察面一样宽。

33. 如权利要求 30 所述的装置，其特征在于第一光源较窄并且在邻近成象面和第一三角形面之间的三角棱镜的第一边放置，第二光源较窄并且在邻近成象面和第二三角形面之间的三角棱镜的第二边放置。

34. 如权利要求 33 所述的装置，其特征在于至少一个邻近观察面的透镜至少与观察面一样宽。

35. 一种对图形化物体成象的方法，包括：
提供一个具有成象面、光接收面和观察面的光折射器；

对着光折射器的成象面放置图形化物体；

把来自光源的入射光经光折射器的光接收面投射；

在入射光照射到成象面之前反射离开光折射器的成象面之外的至少一个面；和

使入射光散射离开成象面和图形化的物体并穿过观察面。

36. 如权利要求35所述的方法，还包括步骤：

邻近观察面设置一个透镜；

把观察面的散射光投射到透镜上，形成图形化物体的图象。

37. 如权利要求36所述的方法，其特征在于提供光折射器包括提供一个等腰三角棱镜，该棱镜具有大于45度的底角。

38. 如权利要求37所述的方法，其特征在于使入射光反射离开三角棱镜的至少一个面包括使入射光散射离开三角棱镜的该至少一个面。

39. 如权利要求38所述的方法，其特征在于提供透镜的步骤包括相对于观察面平面倾斜透镜的透镜平面，以减小图形化物体的图象中的梯形失真。

40. 一种对图形化物体成象的方法，包括：

提供一个具有成象面、光接收面和观察面以及第一和第二三角形端面的三角棱镜；

对着三角棱镜的成象面放置图形化物体；

把来自第一光源的入射光经第一三角形端面投射；

使入射光散射离开成象面和图形化物体并穿过观察面；

邻近观察面提供一透镜；

把来自观察面的散射光投影到透镜上，形成图形化物体的图象。

41. 如权利要求 40 所述的方法，还包括经第二三角形端面投射第二光源的入射光。

42. 一种把图象捕获系统容装其中的计算机输入装置，该图象捕获系统用于形成图形化物体的高对比度图象且包括：

用于反射和折射光线的光折射器，该光折射器包括：

成象面，待成象的图形化物体对着其放置；

至少一个光入射面，邻近于成象面，光从其穿过进入折射器；和

观察面，邻近于成象面，光从其穿过对待成象物体的图象投影；

至少一个聚焦透镜，该透镜邻近观察面，用于接收并聚焦经观察面投影的图形化物体的图象；和

至少一个光源，邻近光接收面并发射入射到折射器的入射光，在观察面产生图形化物体的图象，图象由至少一个聚焦透镜聚焦，光源放置在使从其发射并进入光折射器的光在照射到成象面之前照射到光折射器的至少一个其它面的位置，使得基本上由成象面的所有散射光产生来自成象面并经观察面投影的图形化物体的图象。

43. 如权利要求 42 所述的装置，其特征在于计算机输入装置包括一个鼠标，所述图象捕获系统装在鼠标内。

44. 如权利要求 43 所述的装置，其特征在于所述折射器包括等腰三角棱镜。

说　明　书

用于图象捕获的高对比度、低失真的光学捕获系统

技术领域

本发明涉及一种与图象捕获和识别系统一起使用的光学捕获装置。尤其是，本发明包括一种用于获得高对比度、低失真的图形化物体的图象的光学捕获装置。

相关技术说明

图形化物体识别系统在工业和商业设施中变得越来越常用并有多种用途。例如，这种系统可以用在扫描文本文件、图和照片的扫描器中。近来，制造商正在试图降低图形识别系统的成本，以使它们更可为消费者所接受。一个消费者对图形识别系统的应用包括指纹捕获和识别。例如，此系统可用于通过读取可能用户的指纹与已授权使用计算机或存取某种文件或计算机的功能的指纹相比来提高计算机的安全性。这种系统例如可以取代那种利用注册名和密码的安全系统。

这种指纹识别系统、或任何图形识别系统必须能够做的第一件事情是精确地获得指纹或其它图形以用于分析。有大量设备用于这种图形数据的捕获。例如，美国专利 US3,975,711；US4,681,435；US5,051,576；US5,177,435 和 US5,233,404 都公开了用于捕获图形化物体的图象的装置。

图 1 是一种现有指纹捕获和识别系统的简图。在图 1 中，光学识别系统 108 包括一个光源 112，一个光学三角棱镜 110，一个透镜组 114，一个图形传感器 116 和一个存储与处理单元 125。棱镜 110 包括一个成象面 118，一个光接收面 120 和一个观察面 122。成象面 118 是一个靠着其放置待成象的图形化物体、如指纹的面。光源 112 例如可以是一个发光二极管（LED），邻近光接收面 120 放置并产生传到

光学棱镜 110 的入射光 124。光学棱镜 110 是一个等腰直角三角形，与成象面 118 对着的角约为 90 度，其它两个“底角”（即等腰棱镜的两个等角）各约为 45 度。

通常入射光 124 以与入射面法线 115 夹角 126 入射到成象面 118 上。角 126 大于临界角 128。一般地，在入射光线和面的法线之间测量临界角。超过临界角，入射光将产生全内反射离开该面，低于临界角，入射光将穿过该面。因此，临界角 128 是与成象面 118 的法线的夹角，超过此角度，入射光将从成象面 118 全内反射，并作为反射光 130 经观察面 122 穿出棱镜 110。反射光 130 通过邻近观察面 122 的透镜组 114。透镜组 114 可包括一个或多个光学透镜。之后，从透镜组 114 出来的光被图象传感器 116 捕获。图象传感器 116 例如可以是一个电荷耦合器件（CCD）或是一个互补金属氧化物半导体（CMOS）器件，它捕获光线图象并将其转换成电信号。这种图象传感器对于本领域的技术人员是公知的。然后电信号被传递到存储和处理单元 125。

存储和处理单元 125 可以包括一个存储器单元、一个处理器和一个模拟-数字转换器（未示出）。模拟-数字转换器把来自图象传感器 116 的模拟电信号转换成数字数据。存储器用于存储数字数据和算法，将捕获的指纹图象与存储的指纹图象进行比较。处理器根据用于比较此数据的算法来比较捕获的数字数据与先前存储在存储器中的数据。处理器还可分析捕获的数字数据以用于不同与存储的数据进行比较的其他目的。这种存储和处理单元对于本领域的技术人员是公知的，并且可以包括配置有合适软件的标准个人电脑。例如在美国专利 US4,135,147 和 US4,688,995 中公开了用于处理和比较图象数据的算法，这两份专利分别在此引为参考。

当把指纹放在光学棱镜的成象面 118 上时，指纹的波峰 111 接触到成象面 118，指纹的波谷 109 保持与成象面 118 不接触。所以，在指纹波谷 109 中，如果入射光的入射角超过光学棱镜 110 的临界角，

则从光源 112 进入光学棱镜 110 的入射光 124 在成象面 118 发生全内反射。但是，在指纹的波峰 111 处，有一些入射光 124 被吸收并散射离开指纹波峰。这里的“散射”一词表示在射到不规则面上之后光线从多个方向辐射或不规则地反射离开不规则面。

这种散射和/或吸收的结果是，在指纹波峰 111 处具有的入射光 124 少于其全内反射。所以，从指纹的波谷 109 离开棱镜 110 的反射光 130 的强度大于从指纹的波峰 111 离开棱镜 110 的反射光 130 的强度。从波峰 111 反射的较低强度的反射光 130 传到较暗的区域，表示物体在光束和指纹面之间入射点处的存在。相反，较高强度的反射光 130，如经过全内反射的光，传较亮的区域，表示物体在入射光 124 和成象面 118 之间入射点处不存在。这使得能够区分较暗的指纹波峰 111 和较亮的指纹波谷 109。因为入射光在指纹波峰 111 处的吸收主要对产生一个指纹图象起作用，所以系统 108 被称作“吸收”成象系统。

上述系统能够捕获光学指纹图象并处理光学指纹图象的电学表示。但是，在指纹波峰 111 的区域中，入射光 124 仍发生一些全内反射和一些在平行于反射光 130 方向上的散射。所以，从指纹波谷 109 和指纹波峰 111 反射的光 130 之间的强度差可能较小。即指纹图象中指纹波峰 111 和波谷 109 之间的对比度可能较低。这使得图象捕获、处理和比较较为困难。

另外，由于光学棱镜 110 和透镜组 114 之间有较大的距离，所以光学识别系统 108 易于较大。光学棱镜 110 和透镜组 114 之间较大的距离由这样的事实导致：成象面 118 中的指纹很可能大于透镜组 114 中的第一透镜。所以，如果把透镜组 114 靠近观察面 122 放置，则透镜组 114 将很可能捕获不到在接近指纹边缘的点处的指纹图象。因此，希望在系统 108 中光学棱镜 110 和透镜组 114 之间有较大的距离，这是因为这样可在靠近指纹边缘处更好地成象。所以，使图象捕获系统 108 较为紧凑成为问题。另外，由于光干涉，观察面 122 和透镜组 114

之间较大的距离可能导致指纹图象对比度的降低。

另外，在图形捕获系统 108 中会发生公知的梯形失真现象。成象系统中的梯形失真具有使系统产生的方形图象显示成梯形的效果。图 2 是解释图象捕获系统 108 中产生梯形失真的原因的示意图。从光源 112 发出的入射光 124 进入棱镜 110 并反射离开成象面 118，对物体 AB 成象。然后反射光 130 透出观察面 122 并到达透镜组 114 的 A'和 B'点，形成物体 A'B'。通过观察面 122 观察物体 AB，物体 AB 将显现成位于"表观图象"的物体 ab。具体地说，点 A 显视为点 a，距离观察面 122 aa'的距离，点 B 显现为点 b，距离观察面 122 bb'的距离。显现的物体表观图象距离观察面 122 的距离由物体距离观察面 122 的实际距离除以棱镜 110 的折射率给出。具体地说，距离 aa'由下式给出：

aa'＝Aa'/n

这里"n" 是棱镜 110 的折射率。类似地，

bb'＝Bb'/n

当物体的表观图象到透镜组 114 的透镜平面的光路长度对于成象物体的不同部分不同时，出现梯形失真。具体地说，因为距离 aA'大于距离 bB'，所以在系统 108 中出现梯形失真。上述方程清楚地表明，只有当光通过折射率不为 1（假设物体处于折射率 n=1 的空气中）的物体时才出现梯形失真。

为了校正这种失真，现有的制造商把透镜组 114 的透镜平面 107 和图象传感器 116 放成倾斜，以增大距离 bB'和减小距离 aA'，达到两个距离近似相等的程度。但是，这是等腰直角棱镜（即底角约为 45 度、而非底角或顶角约为 90 度的三角棱镜）的特点，反射光 130 基本上垂直于观察面 122 射出棱镜 110。即当射出观察面 122 时反射光 130 不发生折射。另外，一般地，入射到透明物体面上的角度越大，入射光从面反射的部分越大。所以，虽然倾斜的透镜组 114 可以减少

梯形失真，但因为反射光 130 以更大的入射角入射到透镜组 114，所以它也导致反射光 130 更多地反射离开透镜组 114 的面和图象传感器 116 的面。这样降低入射到图象传感器 116 的光的强度，使得图象处理和比较更困难。

此外，光源 112 和透镜组 114 的相对位置关系使得光源 112 发出的漫射光 113 能够入射进入透镜组 114。这会产生额外的背景“噪声”光，会进一步降低捕获的图象的质量，并使得图象处理更为困难。

为了克服与上述吸收型图象捕获系统有关的一些困难，设计了一些主要基于散射机制而非吸收机制的捕获系统。在授权给 J.Lougheed 等人的 1993 年 8 月 3 日的美国专利 US5,233,404 中公开了这样一种捕获系统。图 3 是 Lougheed 等人提出的装置的图象捕获部分示意图。如图 3 中所示，现有的图象捕获系统 208 包括一个梯形棱镜 210，一个光源 212，一个透镜组 214 和一个图象传感器 216。梯形棱镜 210 包括至少一个成象面 218，一个光接收面 220 和一个观察面 222。

成象面 218 是一个待成象物体如指纹靠着其放置的面。光源 212 邻近并面对基本上平行于成象面 218 的光接收面 220 放置。所以，从光源 212 发出的入射光 224 经棱镜 210 以一般小于成象面 210 临界角 228 的角度投影到成象面 218 上。因此，在指纹的波谷 209 中，指纹不与成象面接触的放置在成象面 218 上，不发生全内反射并且入射光 224 穿过成象面 218。在指纹波峰 211 与成象面 218 的接触点，入射光 224 入射到指纹波峰上，产生散射（或等价于不规则地反射）光 230。散射光 230 从包括邻近观察面 222 放置的透镜组 214 方向的几乎所有方向上传播回到棱镜 210。散射光通过观察面 222 并进入到由图象传感器 216 探测的透镜组 214 中，传感器 216 例如可以是一个 CCD、CMOS 或其它类型的探测器。

在指纹的波谷 209 区域中，入射光 224 穿过成象面 218。并且，

在指纹的波峰 211 区域中，入射光 224 散射离开成象面 218 被透镜组 214 和图象传感器 216 拾取。因此，指纹的图象在指纹的波峰 211 处较亮，在指纹的波谷 209 处较暗。因为散射光 230 被图象传感器 216 拾取，所以这种类型的系统被称作“散射”系统。

由此散射系统产生的指纹图象中波峰和波谷之间的强度差会比图 1 中所示的吸收系统中产生的指纹图象中波峰和波谷之间的强度差大。结果，由此散射系统产生的指纹图象可以显示出比吸收系统产生的图象指纹波峰和波谷之间的对比度高。所以，由图象传感器 216 捕获的图象会更精确。这可以减小该系统进行的后序指纹比较的误差。但是，棱镜 210 这样的梯形棱镜会比图 1 所示棱镜 10 那样的三角棱镜有更高的制造成本。这是因为在其它的原因当中还有一个额外的面要抛光。这会提高成象系统 208 这样的成象系统的价格，使得很少有消费者使用。另外，诸如大到足以用于指纹成象的棱镜 210 这样的梯形棱镜会比类似地适当的三角棱镜大。所以诸如棱镜 110 这样的梯形棱镜的使用会导致成象系统不够小巧。

另外，图象捕获系统 208 可导致类似于图象捕获系统 108 的方式的指纹图象梯形失真。这在成象面 218 和观察面 222 彼此成大约 45 度角时尤其如此。如果是这样，图象捕获系统 208 将出于与上述图象捕获系统 108 相同的原因造成梯形失真。例如，在美国专利 US5,210,588 中公开了一种利用梯形棱镜的图象捕获系统，梯形棱镜的成象面和观察面之间有 45°的夹角。

从上面的讨论中清楚地看到，需要有一种改进的图象捕获装置与图形化的物体识别系统一起使用。具体地说，希望有一种能够产生高对比度、低失真图象的图象捕获装置。另外，装置应相对较小巧。另外，装置的制造成本应较低，使得用户可以负担。

技术方案

本发明包括一个产生高对比度、低失真图象的袖珍图象捕获装置，它能够以较低的成本制造。该装置包括一个光折射器，光折射器具有图形化物体可靠着其放置的成象面，一个光入射面和一个观察面。光入射面邻近成象面并使得光能够进入到折射器。观察面也邻近成象面并且经观察面投射图形化物体的象。该装置还包括一个邻近观察面的用于接收并聚焦图形化物体的象的聚焦透镜。光源邻近光接收面并发射入射到折射器的入射光，在观察面产生图形化物体的图象。然后聚焦透镜聚焦图象。光源放置在使从其发射的光在照射到成象面之前至少照射到其它一个面的位置。通过这种方式，基本上由所有的散射光产生来自成象面并经观察面投影的图象。这种散射光的图象具有较高的对比度并且被均匀地照明。

在本发明的第二方面，折射器是一个底角大于 45 度的等腰三角棱镜。另外，聚焦透镜的透镜平面相对于观察面确定的平面倾斜。通过这种方式可以有利地减小图形化物体的图象中的梯形失真。

在本发明的第三方面，用于图形化物体成象的装置包括一个第一透镜，一个物镜或透镜组，和一个光源。第一透镜包括一个图形化物体靠着其放置的成象面和一个与光入射面相对的观察面，物体的图象经该观察面投影。第一透镜还包括一个邻近成象面的光接收面。装置还包括一个把入射光投射到透镜的光源。光源邻近光入射面放置，在成象面和观察面之间投射入射光。入射光能在成象面和观察面之间发生全内反射，不通过观察面。通过这种方式，基本上由所有的散射光产生经观察面投影的图形化物体的图象。装置还包括一个邻近观察面的物镜或透镜组，聚焦经观察面投影的图形化物体的象。

第一透镜的成象面可以是凹面，以便更好地适合放置在成象面上的指纹的轮廓。另外，第一透镜和物镜可以形成一个整体。这样易于组装、降低制造成本，并能够使得图象捕获装置更小巧。

在本发明的第四方面，用于图形化物体成象的装置包括一个三角棱镜，一个聚焦透镜和一个光源。三角棱镜包括一个成象面、一个邻近于成象面的光接收面和一个邻近于光接收面的观察面。透镜邻近于观察面并用于接收和聚焦图形化物体的图象。光源把入射光投影到三角棱镜上并邻近于光接收面放置，以便在成象面和观察面之间投射光线。大部分入射光在成象面和观察面之间进行全内反射，不透过观察面。通过这种方式，基本上由成象面的全部散射光产生经观察面投影到物镜的图形化物体的图象。

在本发明的第四方面，第一光源可以放置在棱镜的第一三角形端面上，第二光源可以放置在棱镜的与第一三角形端面相对的第二三角形端面上。这种结构有利地提供成象面均匀地照明，从而产生较为均匀的图形化物体的图象。

根据本发明产生图形化物体的图象的方法包括提供一个具有成象面、光接收面和观察面的光折射器。对着成象面放置图形化物体。来自光源的入射光经光折射器的光接收面投射，并在入射光照射到成象面之前反射离开折射器的成象面之外的至少一个另外的面。入射光散射离开成象面和图形化物体并穿过观察面。邻近观察面设置一个透镜，并且散射光投射到把散射光聚焦成图形化物体的图象的透镜上。

附图简介

图 1 是利用吸收图象捕获技术的现有图象捕获装置的示意图；

图 2 是图 1 所示图象捕获装置的梯形失真的示意图；

图 3 是利用散射图象捕获技术的第二现有图象捕获装置的示意图；

图 4 是根据本发明的图象捕获系统的示意图，该系统包括一个棱镜、光源、透镜组和图象传感器，其中棱镜的观察面包括光接收面；

图 5 是图 4 所示棱镜和光源的透视图；

图 6A 是表示图 4 所示图象捕获系统如何减小梯形失真的示意图；

图 6B 是表示可与图 4 中所示图象捕获系统一起使用的透镜组的示意图；

图 7 是根据本发明的图象捕获系统第二实施例的示意图，该系统包括一个棱镜、光源、透镜组和图象传感器，其中棱镜的观察面邻近光接收面；

图 8 是根据本发明的图象捕获系统第三实施例的示意图，该系统包括一个棱镜、光源，其中光源邻近棱镜的每个三角形端面；

图 9 是图 8 所示棱镜和光源的透视图；

图 10A 是图 8 所示棱镜和光源的前视图；

图 10B 是图 8 所示棱镜和光源的局部透视图。

图 11 是根据本发明的图象捕获系统第四实施例的局部示意图，该系统包括几个光源和一个棱镜，其中每个光源包括一个邻近于棱镜的三角形端面的带光源；

图 12 是图 11 所示棱镜和光源的端视图；

图 13 是根据本发明的图象捕获系统第五实施例的示意图，该系统包括一个棱镜、光源、透镜组和图象传感器，其中入射光发生全内反射；

图 14 是图 13 所示棱镜和光源的透视图；

图 15 是根据本发明的光捕获系统第六实施例的示意图，该系统包括一个第一棱镜、光源、透镜组和图象传感器；

图 16 是图 15 所示第一透镜和光源的顶视图；

图 17 是根据本发明的图象捕获系统第七实施例的示意图，该系统包括一个透镜组、光源和图象传感器；

图 18 是根据本发明的图 17 中所示透镜的另一实施例简图；

图 19 是计算机鼠标和计算机连接电缆的顶视图，鼠标中包含根据本发明的图象捕获系统；

图 20 是图 19 所示计算机鼠标的透视图；

图 21 是图 19 所示计算机鼠标的侧视图；

图 22 是图 19 中所示计算机鼠标的局部顶视图，其中鼠标中包含根据本发明的图象捕获系统。

详细说明

图 4 和图 5 表示根据本发明的图形化物体的图象捕获系统 308。捕获系统 308 最好包括一个三角形棱镜 310，一个光源 312，一个透镜组 314 和一个图象传感器 316。棱镜 310 是一种五个面的等腰三角棱镜，其长度延伸到图 4 的平面中。棱镜 310 包括一个矩形成象面 318，对着它放置待成象的物体，如指纹 335。棱镜 310 还包括一个矩形观察面 320，靠着放置在成象面 318 上的指纹 335 的图象经观察面 320 透出棱镜 310。在图 4 和 5 的实施例中，观察面 320 还用作一个使光能够透到棱镜 310 上的光接收面。棱镜的光散射面 322 包括棱镜 310 的一个第三矩形面。为了下面的详细描述，光散射面 322 最好是一个漫射面。

光源 312 最好是一个细长的 LED 阵列，由在棱镜 310 的长度上延伸（延伸成图 4 的平面）的单行发光二极管（LED）组成。如果这种 LED 用作光源 312，则可以在 LED 和观察面 320 之间放置一个漫射罩以提供成象面 318 更均匀的照明。但是，在本发明的范围之内，光源 312 可以是任何一种其它的把入射光提供给棱镜 310 的光源。光源 312 最好沿棱镜 310 的一个与成象面 318 相对的边缘 338 放置。

透镜组 314 用于接收来自指纹 335 的散射光 330 并把散射光 330 聚焦到图象传感器 316 上。透镜组 314 可以是一个单透镜，或最好是由多个透镜组成。尤其透镜组 314 最好具有大约 13.48mm 的焦距并在距离观察面 320 大约 13.5mm 的位置放置。另外，如图 6B 所示，该图是透镜组 314 的一个实施例简图，透镜组最好由三个透镜组 904、906 和 908 组成，透镜的各自光轴与公共光轴 902 对齐。透镜 904 最好具有大约 17.8mm 的直径，透镜 906 和 908 最好具有大约 6mm 的直径。一般认为透镜组 314 中可以包括任何数量的透镜组。

图象传感器 316 捕获来自透镜组 314 的光学图象并把它们转换成

电信号。图象传感器 316 可以是一种电荷耦合器件（“CCD”）或任何其它的把光信号转换成模拟或数字电信号的装置。图象传感器 316 最好是一种互补金属氧化物半导体器件。CCD 和 CMOS 图象传感器是本领域的技术人员所公知的。图象传感器 316 产生的电信号可以利用公知的装置处理并用于与输入的图形如指纹比较。如背景技术的描述中所述，这种信号处理装置例如是美国专利 US4,135,147 和 US4,688,995 中所描述的那种，这两份美国专利在此引为参考。

为了在图象传感器 316 上产生指纹 335 的光学图象，把指纹 335 靠着成象面 318 放置。光源 312 发出的入射光 334 穿过观察面 320 并入射到棱镜 310 上。因为光源 312 邻近边缘 338 放置，所以入射光 324 入射到散射面 322 上。如上所述，散射面 322 最好是漫射面。这样的话，照射到散射面 322 的入射光 334 的较大部分在棱镜 310 中内散射。然后散射光照射到成象面 318 上。即使光散射面 322 不是漫射面，基本上所有的入射光 324 也将以大于散射面 322 的临界角的角度 323 入射散射面 322。然后入射光反射离开散射面 322 并入射到成象面 318。为了增强散射面 322 对入射光的反射，可朝着散射面 322 放置一个反射面 381 的镜面。

因为入射光 324 散射或直接反射离开散射面 322，所以较大比例的入射光 324 将以小于成象面 318 的临界角 328 的角度 327 入射到成象面 318 上。因此，入射到成象面 318 的一个具有指纹波谷 309 的区域中的入射光 324 将不发生全内反射并将基本上透过成象面 318，使得照射到有一个指纹波谷 309 的成象面 318 区域的光基本上没有直接导向穿过成象面 322。但是，照射到成象面 318 上有与成象面 318 接触到的指纹波峰 311 的入射光 324 基本上散射，产生散射光 330。散射光 330 的一部分经观察面 320 射出棱镜 310。一经出射棱镜 310，散射光 330 将折射到透镜组 314 中。透镜组将散射光 330 聚焦到图象传感器 316 中。

因为入射光 324 可以由散射面 322 散射，所以入射光 324 提供成象面 318 上较为均匀的照明，产生一个较为均匀的图象。这一均匀的图象是很理想的，因为它易于处理和与其它存储的指纹数据比较。为了进一步提高成象面 318 上的照明均匀度，观察面 320 面对光源 312 的部分可以通过观察面 320 中的蚀刻线 370 加线条，如图 5 所示。线条 370 沿棱镜 310 的长度方向并平行于顶边 338。线条 370 用于散射从光源 312 发出的穿过观察面 320 的光。如上所述，此散射增强了成象面 318 上照明的均匀性。

除了上述元件以外，图象捕获系统 308 最好还包括一个邻近光源 312 的光接收面部分上的挡光屏蔽 350。挡光屏蔽沿棱镜 310 的整个长度方向延伸（到图 4 的平面中）。挡光屏蔽 350 减少光源 312 发出的可能入射到透镜组 314 中并与指纹图象干涉的漫射光的量。还认为挡光屏蔽 350 面对棱镜 310 内部的面是镜面。此镜面可用于理想地提高入射到成象面 318 上的散射光强度。另外，代替挡光屏蔽 350，可以把第二挡光面 352 放置在光源 312 和透镜组 314 之间。挡光屏蔽 352 最好从观察面 320 以一定的角度延伸，以阻挡光源 312 发出的漫射光进入透镜组 314。

因为光源 312 较狭窄并且邻近与成象面 318 相对的边缘 338 放置，所以基本上所有到达成象面 318 的入射光都被反射或散射离开散射面 322。即几乎没有入射光 324 从光源 312 直接入射到成象面 318。为了进一步减小入射光 324 直接入射到成象面 318 上的可能性，最好把光源 312 构造成不延伸超过线条 360，如图 5 所示，沿棱镜 310 的长度延伸并由正交于观察面 320 的平面的与边缘 365 相交交线限定，邻近成象面 318。如果光源 312 与顶边 338 保持在此线条的同一侧，则基本上没有从光源 312 垂直发出的入射光 324 直接照射到成象面 318 上。

通过减少从光源 312 直接入射到成象面上的入射光 324，在成象

面 318 上有指纹波谷 309 的区域中基本上没有全内反射。这意味着这些波谷区域的少量光通过观察面 320 并入射到透镜组 314 上。然而基本上所有从成象面 318 通入到透镜组 314 中的光都从指纹波峰 311 散射到成象面 318 上。这样提供的指纹图象在指纹波峰 311 和指纹波谷 309 之间具有较高的对比度。如此高对比度的指纹图象比较易于处理以及与其它指纹图象对比，并因此能有利地提高处理精确度。

与背景部分讨论的 Lougheed 中公开的梯形棱镜相反，利用一个三角棱镜实现用于图象捕获的散射技术。因为三角棱镜可以比梯形棱镜更有效地制造，所以图象捕获系统 308 可以以较低的成本制造。

而且，与基本上在一个方向的散射相反，散射光一般在多个方向上从物体散射。所以，从物体散射的光可以通过一个透镜在很宽的距离范围内收集并聚焦，在接近图象边缘处的图象没有任何显著的质量衰减。因此，透镜组 314 可以放置得比较接近观察面 320，图象质量没有显著地损失。这样能使图象捕获系统 308 较为小巧。

另外，本发明的图象捕获系统可以减小梯形失真。如背景部分所述，图象中的梯形失真被证明具有关于被成象的实际物体的尺度失真。梯形失真由成象物体的一部分与另一部分从物体的表观图象到透镜组 314 的光程的变化所致。但是，如图 6A 所示，在图象捕获系统 308 中，散射光 330 从指纹 335 的表观图象 335'上的不同点到透镜组 314 的路径长度基本上相同。具体地说，路径 AA'基本上等于路径 BB'和路径 CC'。所以，梯形失真可以有利地减小。如图 6A 所示，路径 AA'、BB'和 CC'的基本等同化通过相对于观察面 320 倾斜透镜组 314 方便地实现。但是，与图 1 所示的图象捕获系统 108 不同，这种透镜组 314 的倾斜不降低到达图象传感器 316 的图象的强度。如背景部分关于图象捕获系统 108 的描述，倾斜透镜组 114 致使反射光 130 以与法线一定的角度照射到透镜组 314 的第一元件上。这导致反射光 130 从透镜组 114 的面更多地反射，由此不理想地降低图象传感器 116 处

的图象强度。

但是，如上所述，棱镜 310 是一个等腰棱镜，并且最好具有 45 度以上的底角 340 和 341。底角 340 是边 365 处成象面 318 和散射面 322 之间的角，底角 341 是边 338 处与成象面 318 相对的角。另外，棱镜 310 最好具有不等于 1 的折射率。因此，当照射到观察面 320 的散射光 330 出射棱镜 310 时折射离开观察面 320 的法线。这样，通过倾斜透镜组 314 的透镜平面 307，散射光 330 基本上以 90 度的角度照射到透镜组 314 上。所以，由于在透镜组 314 的面不发生散射光的反射，图象强度没有损耗，可以不损失图象传感器 316 处图象强度地减小梯形失真。棱镜 310 在边 365 和 338 的底角在 50～65 度范围内较好，最好为 62 度或 63 度。如果棱镜 310 具有大约 62 度的底角，则棱镜 310 的折射率在 1.71~1.72 之间较好，最好为 1.713。如果棱镜 310 具有大约 63 度的底角，则棱镜 310 具有 1.68~1.70 的折射率较好，最好为 1.6935 或 1.6968。但是，预期棱镜 310 具有大于 1 的任何折射率。

棱镜 310 可以由玻璃、丙烯酸或其它折射率不同于 1（空气的折射率）的透明材料构成。具有优选折射率和角度的棱镜可以从韩国汉城的 Shinkwang Ltd.获得，并且由 LaK-7 或 Lak-8 型号的玻璃制成。

诸如透镜组 314 的透镜组可以从韩国汉城的 Shinkwang Ltd.获得，并且由 BaK-7 型号的玻璃制成。如果在透镜组 314 中使用不止一个元件，如图 6A 所示，则可以通过把它们放置在塑料模具或其它现有的制造装置制造的框架中而将各个元件对齐并间隔放置。

光源 312 最好由四个放置在电路板上成直线阵列的标准 LED 组成。LED 的供电对于本领域的技术人员是公知的。图象传感器 316 最好是 CMOS 型传感器，可以从韩国汉城的 Hyudai Electronics、加利福尼亚 San Jose 的 VLSI Vision, Ltd.或加利福尼亚 Sunnyvale 的 Omnivision Technologies Inc.获得。

为了如图 4 所示地固定图象捕获装置各个元件的相对位置，可以塑料模制或其它方法制造一个对于各个元件都有固位槽的框架。光源 312 既可以放置在邻近观察面 320 的固位槽中，也可以利用现有的半透明粘合剂直接连接到观察面 320。

在图 4-6 所示的本发明实施例中，光源 312 位于邻近也是光接收面的观察面 320。但是，在本发明的范围之内，还可以把光源 312 移到三角棱镜的其它面。这样的一个实施例中，光源邻近的面不是观察面，如图 7 所示。图中可以看到，捕获系统 408 包括一个等腰三角棱镜 410，一个光源 412，一个透镜组 414，和一个图象传感器 416。与图象捕获系统 308 的棱镜 310 一样，棱镜 410 包括一个靠着其放置指纹 435 的成象面 418 和一个观察面 420，指纹 435 的图象透过观察面 420 投影到透镜组 414 上。

但是，如图所示，光源 412 邻近于光接收面 422 放置，光接收面 422 不同于观察面 420。光源 412 是一个较狭窄的光源，例如可以是一个单行的 LED。光源 412 最好直接邻近边 448 放置，边 448 与观察面 418 相对并在棱镜 418 的长度方向延伸（到图 7 的平面）。如图象捕获系统 308 的光源 312，最好光源 412 没有一部分跨过光接收面 422 中的某一线条，而该线条由光接收面 422 和正交于光接收面 422 并与光接收面 422 对面的边 465 相交的平面交线确定。

从光源 412 发出的入射光 424 穿过光接收面 422 并照射到观察面 420。因为观察面 420 上大部分入射光 424 的入射角大于面 420 的临界角，所以入射光 424 将反射或散射离开面 420 并照射到成象面 418。在这一点上，图象捕获系统 408 的操作基本上与图象捕获系统 308 的相同。入射光 418 以小于成象面 418 的临界角的角度照射到成象面，把指纹 435 的图象经观察面 420 投影到透镜组 414 上。然后透镜组 414 把此图象聚焦到图象传感器 416 上。

如上所述，入射光 424 在照射到成象面 418 上之前散射或反射离开观察面 420。这样有利地为成象面 418 提供较为均匀地照明。另外，基本上所有的入射光 424 以小于成象面 418 临界角的角度入射到成象面 418。所以，如同上面关于图象捕获系统 308 的描述，基本上由所有散射光 430 产生投射过观察面 420 的指纹 435 的图象。这样有利地使得透镜组 414 可以放置得比较接近观察面 420，基本上没有图象衰减，并且能够提供较高的指纹图象对比度。

与图象捕获系统 308 一样，图象捕获系统 408 也可以包括一个位于观察面 420 上沿其长度延伸（到图 7 的平面上）并邻近顶边 438 的挡光屏蔽 450。面朝观察面 420 的挡光屏蔽 424 的面可以为不透明、漫射或反射面。另外，图象捕获系统 408 也可以包括一个沿观察面 420 的长度延伸并以一定的角度延伸的第二挡光屏蔽 452。两个挡光屏蔽 450 和 452 通过减少光源 412 发出的可能入射到透镜组 414 的漫射光的量而防止指纹 435 的图象衰减。

另外，与图象捕获系统 308 一样，在光源 412 面对光接收面 422 的区域中光接收面 422 的面可以加以沿面 422 的长度方向延伸并平行于顶边 438 的线条。这些线条用于使得入射光 424 更多的漫射。如上所述，这样对成象面 418 提供更均匀地照明。

另外，等腰棱镜 410 最好包括大于 45 度的底角 440 和 441。底角 440 和 441 在 50～65 度范围内较好，包括 50 和 65 度最好为 62 度或 63 度。另外，棱镜 410 的折射率最好大于 1.5。这样，当散射光 430 透过观察面 420 时，散射光 430 将折射离开观察面 420 的法线。所以，如图 7 所示，透镜组 414 的透镜平面可以相对于观察面 420 倾斜以便有利地减小梯形失真，并且散射光 430 将仍然基本上正交于透镜平面地进入透镜组 420。所以，与图象捕获系统 308 一样，可以保持较高的指纹 435 图象的强度。

包括棱镜 410、光源 412、透镜组 414 和图象传感器 416 的图象捕获系统 408 的元件可以全部与图象捕获系统 308 的相同。另外，图象系统 408 可以基本上按照与图象捕获系统 308 相同的方式制造。特别是，为了如图 7 所示地固定图象捕获装置各个元件的相对位置，可以塑料模制或其它方法制造一个对于各个元件都有固位槽的框架。光源 412 既可以放置在邻近光接收面 422 的固位槽中，也可以利用现有的半透明粘合剂直接连接到光接收面 422。

设想上述的框架和固位槽可以是标准计算机输入装置的一部分，例如是键盘、跟踪球或鼠标的一部分。这使得本发明的光学捕获系统可以容装在这一装置中。图 19-22 表示本发明的一个实施例，其中光学捕获系统如 308 或 408 装在传统的计算机鼠标中。

图 19 是装有光学捕获系统如捕获系统 408 的计算机鼠标 910 的顶视图。连接到鼠标 910 的是一个并行端口连结器 920 和一个常规的计算机鼠标连结器 930。还认为鼠标 910 包括代替并行端口连结器的串行端口连结器。图 20 和 21 分别表示鼠标 910 的透视图和侧视图，可以看出，棱镜 410 的成象面 418 可以暴露在鼠标 910 的一边缘上。这使得用户可以在使用鼠标 910 时把拇指或手指放在成象面 418 上，通过鼠标 910 连接的计算机捕获一个指纹图象。图 22 是表示装有图象捕获系统 408 的鼠标 910 的局部顶视图。如图所示，图象捕获系统 408 通过框架 917 保持在鼠标 910 的适当位置上，框架 917 中包含棱镜 410、透镜组 414 和图象传感器 416。另外，信号管路 406 可以是一个电线，从图象传感器 416 延伸到探测电子设备（未示出）。

如上所述，图象捕获系统 308 可以有利地被做得很小巧。这样便于图象捕获系统 308 在鼠标 910 中的放置。在本优选实施例中，计算机鼠标 910 同时包括相对于成象面 318 的水平导向器 911 和垂直导向器 912，分别用于确保将被摄取图象的手指在水平和垂直方向正确地

对齐。在计算机鼠标的一些实施例中，可以只用一个水平或垂直导向器就足以对齐手指和光学棱镜。在图 21 中，垂直导向器 912 表现为接近计算机鼠标 910 的底部。在另一个实施例中，垂直导向器 912 可以放置在接近计算机鼠标 910 的顶部（或成象面 418）而不是图 21 中所示的底部。

如上所述，鼠标 910 耦接到一个并行连结器 920 和常规的计算机鼠标连结器 930。并行连结器 920 把指纹捕获数据从光学结构传递到耦接到定点装置的计算机。常规的鼠标端口连结器在计算机鼠标 910 和耦接计算机鼠标 910 的计算机（未示出）之间传输功率和其它与常规鼠标操作有关的信号。常规的鼠标端口连结器 930 可以是一个 PS/2 端口连结器。还预计不用鼠标端口连结器 930，只用一个万能串行总线连结器代替并行连结器 920。

虽然以上对计算机鼠标做了描述，但注意到本发明的光学结构可以与多种其它装置连用。具体地说，光学结构可以组合到电话、电视、汽车、门或其它物件中。指纹图象可以用作前述物件的安全密钥，并且可以在引导计算机或重新从屏幕服务器进入计算机系统时用作访问计算机系统的安全密钥或密码。

在图 8-10 中示出了本发明在不同位置具有光源的另一实施例。图 8 是图象捕获系统 508 的侧视图，该系统与图象捕获系统 308 和 408 一样，包括一个等腰三角棱镜 510，一个透镜组 514 和一个图象传感器 516。与图象捕获系统 308 的棱镜 310 一样，棱镜 510 包括一个放置指纹 535 的成象面 518 和一个指纹 535 的图象经其投影到透镜组许 14 的观察面 520。但是，从图 9 和 10A 可以很好地看到，该图分别是棱镜 510 的透视图和前视图，图象捕获系统 508 包括至少两个单独的光源 521a 和 512b，每个光源分别放置在棱镜 510 三角形端面 519 和 521（图 9 所示）。光源 512a 和 512b 最好分别是一个 LED 阵列。但是，光源 512a 和 512b 可以是给棱镜 510 照明的任意光源。还预计图

象捕获系统 508 仅包括一个或不止两个光源。

光捕获系统 508 的操作如图 10A 和 10B 所示。如图所示，从接近成象面 518 的光源 512a 区域发出的入射光 524 以大于成象面 518 临界角的角度入射到成象面 518。因而，在有指纹波谷 509 的成象面 518 的区域中，入射光 524 发生全内反射，并且反射光 530 将照射到棱镜 510 的三角形面 521。然后，反射光或者透过面 521，或者散射离开面 521。另一方面，照射到指纹波峰 511 的入射光 524 将主要发生散射，而此入射光 524 的小部分将被吸收。散射光 530b 将在观察面 520 的方向上辐射并从中通过到达透镜组 514。如图 10B 所示，该图是棱镜 510 和光源 512a、512b 的局部透视图，由成象面 518 和观察面 520 之间接近棱镜边缘 557 的光源 512a、512b 发出的入射光 524 将首先全内反射离开成象面 518。然后，因为观察面 520 接近成象面 518 的近边缘 557，所以将全内反射离开观察面 520 并且不进入透镜组 514。所以，近边缘 557、棱镜 510 用作光导向器，并且出射接近边缘 557 的观察面 520 的光基本上全部从成象面 518 散射。

另外，再参见图 10A，从远离成象面 518 的光源 512a 区域发出的入射光 524'很可能以小于成象面 518 临界角的角度照射到成象面 518。因此，入射光 524'将以与图象捕获系统 308 和 408 的入射光 324 和 424 相同的方式形成指纹 535 的图象。入射光 524'在与光源 512a、512b 和入射光 524 等距离的成象面 518 区域提供照明，并且入射光 524 在接近邻近三角形端面 519 和 521 的成象面 518 的边缘的区域提供照明。通过这种方式，光源 512a 和 512b 在整个成象面 518 上提供较为均匀地照明。所以图象捕获系统 508 可以有利地产生较为均匀的指纹 535 的图象。

如上所述，图象捕获系统基本上由所有的散射光产生指纹 535 的图象。所以，与图象捕获系统 308 和 408 一样，由图象捕获系统 508 产生的图象对比度较高。另外，如图 10A 所示，透镜组 514 最好宽到

足以从三角形面 519 延伸到三角形面 521。因此，透镜组 514 可以放置得比较接近观察面 520。这样有利地使得捕获系统 508 更为小巧。

另外，棱镜 510 具有底角 540 和 541，优选底角 540 和 541 在 50 度以上，在 50～65 度范围内较好，最好为 62 度或 63 度。因此，与图象捕获系统 308 和 408 一样，当散射光 530a 和 530b 出射观察面 520 时发生折射。这使得透镜组能够关于观察面 520 倾斜，从而减少梯形失真，而基本上没有图象强度损失。

虽然如图 8～10 所示，光源 514a 和 514b 实质上可以分别与三角形端面 519 和 521 共同延伸，但也可以设想位于棱镜 510 的三角形端面 519 和 521 上的光源只覆盖面 519 和 521 每个的一部分。例如，如图 11 和 12 所示，光源可以是较狭窄的带光源。图 11 和 12 表示具有分别连接到三角形面 519 和 521 的带光源 572a 和 572b 的棱镜 510。带光源 572a 和 572b 分别沿边 518 和 518b 延伸，三角形端面 519 和 521 分别与成象面 518 相符。光源 572a 和 572b 最好每个都是一个单行的 LED。但是，可以使用任何照明棱镜 510 内部的较窄的带光源。

光源 572a 和 572b 分别按与光源 512a 和 512b 类似的方式工作，照明成象面 518。但是，因为在离成象面 518 较远的三角形端面区域没有光源 572a 和 572b 部分，所以光源 572a 和 572b 的照明不能象光源 512a 和 512b 那样均匀。但是光源 572a 和 572b 基本上与光源 512a 和 512b 一样均匀地照明成象面 518，因而得到图象捕获系统 508 的其它优点。另外，因为光源 572a 和 572b 分别小于光源 512a 和 512b，所以光源 572a 和 572b 的制造成本可以较低，并且可以耗电较低。图象捕获系统 508 可以基本上以与图象捕获系统 308 和 408 相同的方式制造，并基本上具有相同的元件。

图 13 和 14 表示本发明的另一实施例，与图象捕获装置 508 一样，全内反射产生指纹的散射光图象。图 13 是图象捕获装置 608 的侧视

图，该装置包括一个等腰三角棱镜 610，一个光源 612，一个透镜组 614 和一个图象传感器 616。与棱镜 310、410 和 510 一样，棱镜 610 包括一个放置指纹 635 的成象面 618，一个指纹 635 的图象经其投影的观察面 620 和一个光经其照明棱镜 608 内部的光接收面 622。光源 612 邻近光接收面 622 放置，并如图 14 所示，可以实质上共同延伸，图 14 是包括一个光源 612 的棱镜 610 的透视图。透镜组 614 拾取指纹 635 的图象并把图象聚焦到图象传感器 616 上。

与图象捕获装置 508 的方式类似，从光源 612 发出的入射光 624 既可以照射到有指纹波峰 611 的成象面 618 的区域，也可以照到有指纹波谷 609 的区域。棱镜 610 与光接收面 622 相对的顶角 642 最好小到足以使成象面 618 接近观察面 620 以在棱镜 610 中产生光导向器的效果。即如果成象面 518 足够接近观察面 620，则照射到成象面 618 的有指纹波谷 609 的区域中的入射光 624 将将以大于临界角的角度照射成象面 618，并发生全内反射。然后，全内反射的光 630a 将照射观察面 620 但不透过观察面 620 和到达透镜组 614，而是再一次发生全内反射。一直这样直到全内反射的光 630a 或者全部耗尽或者经面对光接收面 622 的顶边 665 射出棱镜 610。但是，照射到成象面 618 有指纹波峰 611 的区域中的入射光 624 将大部分散射离开指纹波峰 611。此散射光 630b 的一部分将经观察面 620 出射棱镜 610，并被透镜组 614 拾取，透镜组 614 将散射光 630b 聚焦到图象传感器 616。所以，指纹 635 的图象在指纹波峰 611 处将较亮，在指纹波谷 609 处将较暗。

在上述方式中，棱镜 610 实际上用作一个光导向器，它包含不被指纹波峰 611 散射的入射光 624 并主要利用散射光产生指纹 635 的图象。因此，由图象捕获系统 608 产生的图象将有较高的对比度，并通过把透镜组 614 放置得较为紧密地接近观察面 620 而使得图象捕获系统 608 较为小巧。

而且，等腰棱镜 610 最好包括大于 50 度的底角 640 和 641。棱

镜 410 的折射率最好大于 1。这样，当散射光 630 通过观察面 620 时散射光 630 将折射离开观察面 620 的法线。所以，如图 13 所示，透镜组 614 的透镜平面能够关于观察面 620 倾斜，从而减少梯形失真，并且散射光 630 仍可以基本上垂直透镜平面地进入透镜组 620。因而，如图象捕获系统 308、408 和 508 一样，指纹 635 图象的强度仍保持较高。

使用光导型折射器如棱镜 510 或棱镜 610 的图象捕获系统不必局限于使用三角棱镜。在图象捕获系统中也可以使用用作光导向器的光折射器。例如，图 15 和 16 分别表示图象捕获系统 708 的侧视图和顶视图，该系统包括一个圆凹透镜 710；光源 712a、712b 和 712c；透镜组 714；和图象传感器 716。凹透镜 710 包括一个凹的成象面 718，一个平观察面 720，和一个圆形光接收面 722。光源 712a、712b 和 712c 最好关于光接收面 722 的圆周等距离地间隔。图象捕获装置也可以包括仅仅一个、两个或多于三个的光源。

与棱镜 610 的方式类似，凹透镜 710 用作一个光导向器。具体地说，从光源 712a、712b 和 712c 发出的入射光 724 以大于成象面 718 临界角的角度照射到成象面 718。因而，在有指纹波谷 709 的成象面 718 的区域中，入射光 724 发生全内反射。然后，反射光 730 不透过观察面 722 地传播过凹透镜 710 以进入透镜组 714。当入射光 724 照射到成象面 718 有指纹波峰 711 的区域时，入射光 724 将主要发生散射，散射光 730 的一部分将透过观察面 718 并被透镜组 714 聚焦到图象传感器 716 上。通过这种方式，图象捕获系统 708 产生一个指纹 735 的图象，其中指纹波峰 711 较亮，指纹波谷 709 较暗。

当使用具有平成象面的图象捕获面时，可以把指纹的二维图象而不是实际指纹放置在成象面上。通过这种方式，可以把连接到图象捕获系统的处理和比较装置“假冒（trick）”成登记指纹的二维复制件与真实指纹之间的假匹配。但是，透镜 710 的成象面 718 是凹形。所

以，更难于把指纹的二维图象放置到成象面 718 上并从而“假冒”连接到图象捕获系统 708 的处理和比较装置。另外，凹形成象面 718 将更加与待成象的拇指或手指的弯曲轮廓匹配。这意味着指纹面的较高部分将与成象面 718 接触，由此使得指纹的较大面积被成象。这可以有利地减小指纹处理和比较中的误差。

虽然图象捕获系统 708 的物镜组 714 与凹透镜 710 分离，但在本发明的范围内透镜组 714 中的第一物镜和凹透镜如透镜 710 可以形成一体。此图象捕获系统示于图 17 中。图象捕获系统 808 包括一个透镜 810，该透镜有一个凹状成象面 818 和一个凸状观察面 822。图象捕获系统 808 还包括基本上与光源 712a、712b 相同的光源 812a、812b，并且可以包括一个基本上与光源 712c 相同的第三光源。图象捕获系统 808 还包括一个图象传感器 816 和一个可包括或不包括物镜的透镜组 814。图象捕获系统 808 也可不包括与透镜 810 分离的透镜组。相反，在本发明的范围之内可把透镜组 814 组合到透镜 810 中成为一体。

图象捕获系统 808 的功能基本上与图象捕获系统 708 的相同，因而包含它的所有优点。还可设想透镜 810 的成象面 818 是平面的而不是图 18 所示的凹状。

在不脱离本发明范围的前提下可以构建多种不同的实施例。应该理解，本发明不局限于说明书中描述的特定实施例。例如，虽然本发明的上述实施例以指纹成象为例进行描述，但本发明可以对其它类型的图形化物体成象。

说 明 书 附 图

图1 现有技术

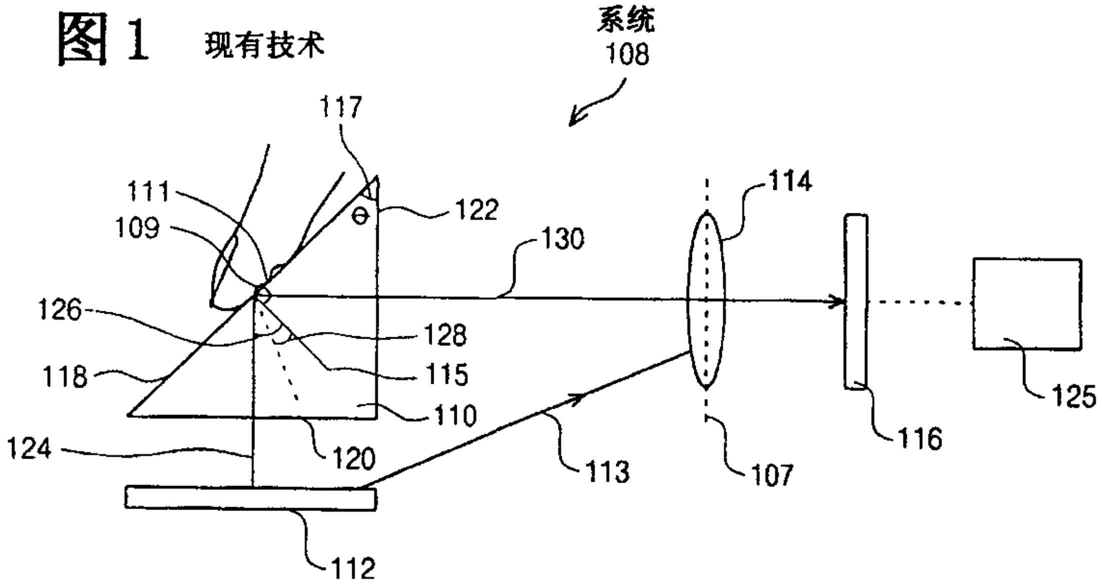


图2 现有技术

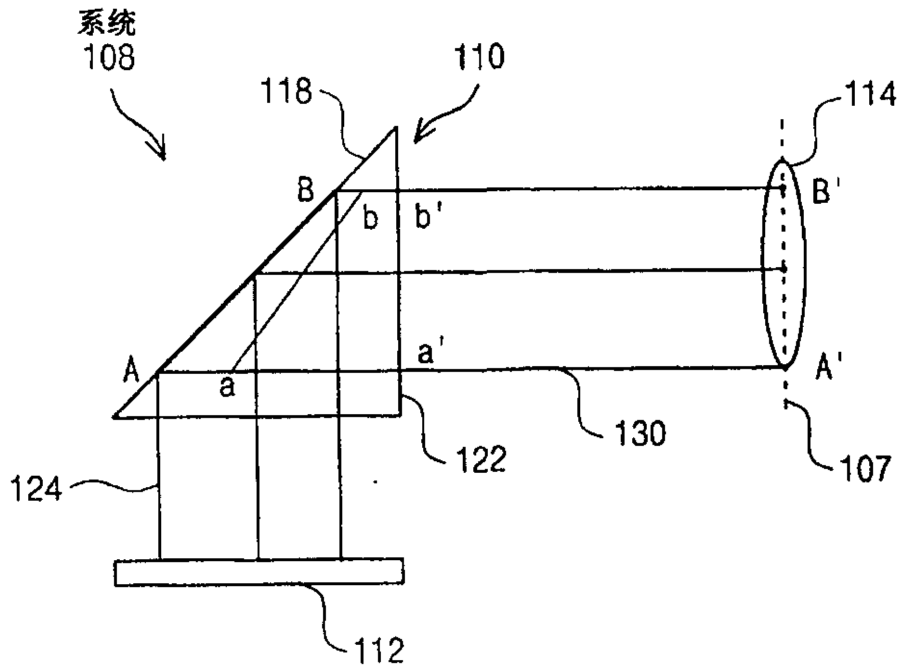


图 3 现有技术

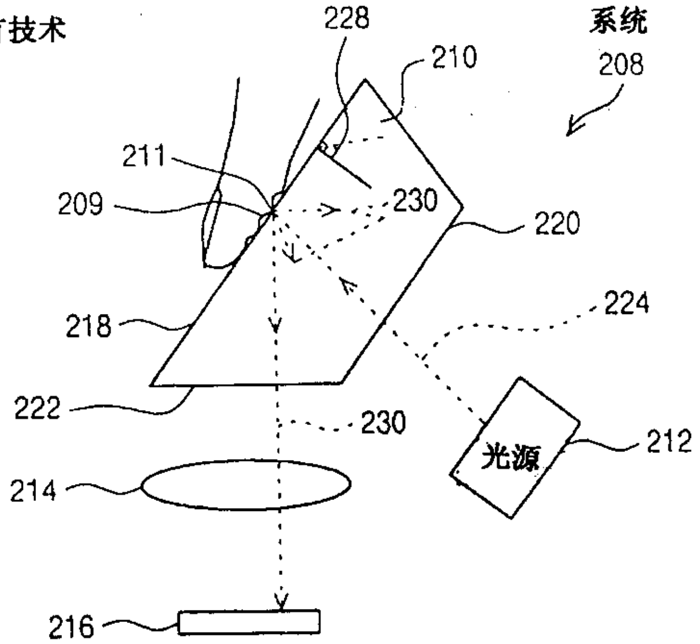


图 4 第一实施例

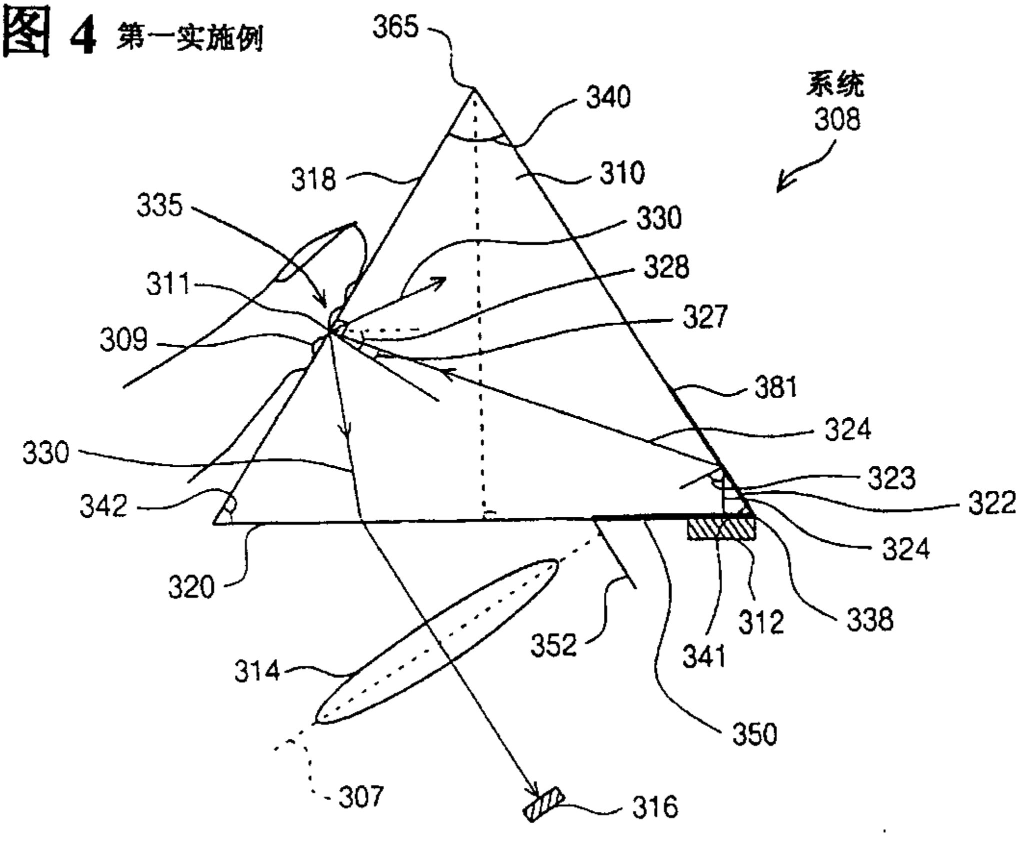
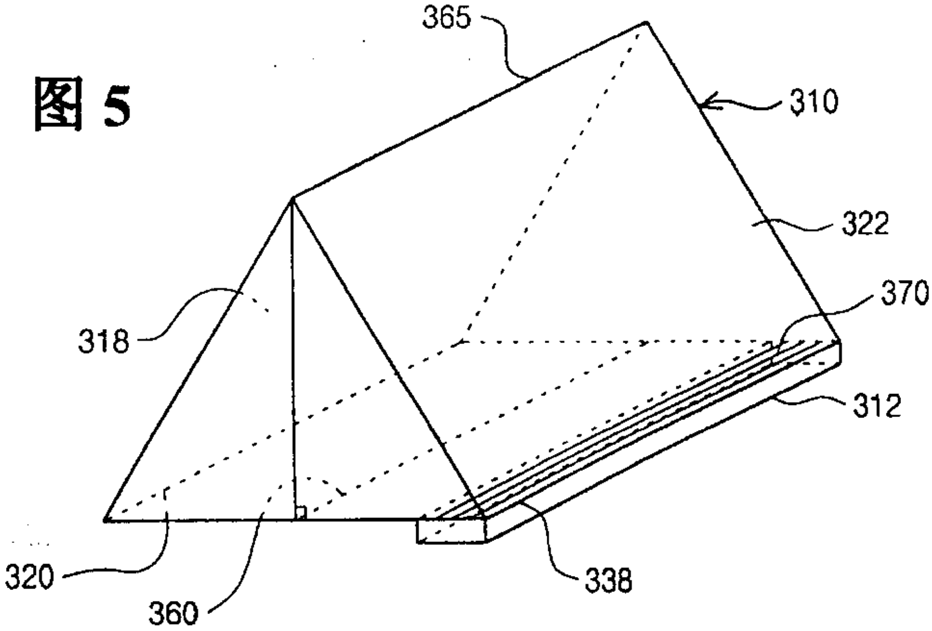


图 5


365
310
322
370
312
318
320
360
338

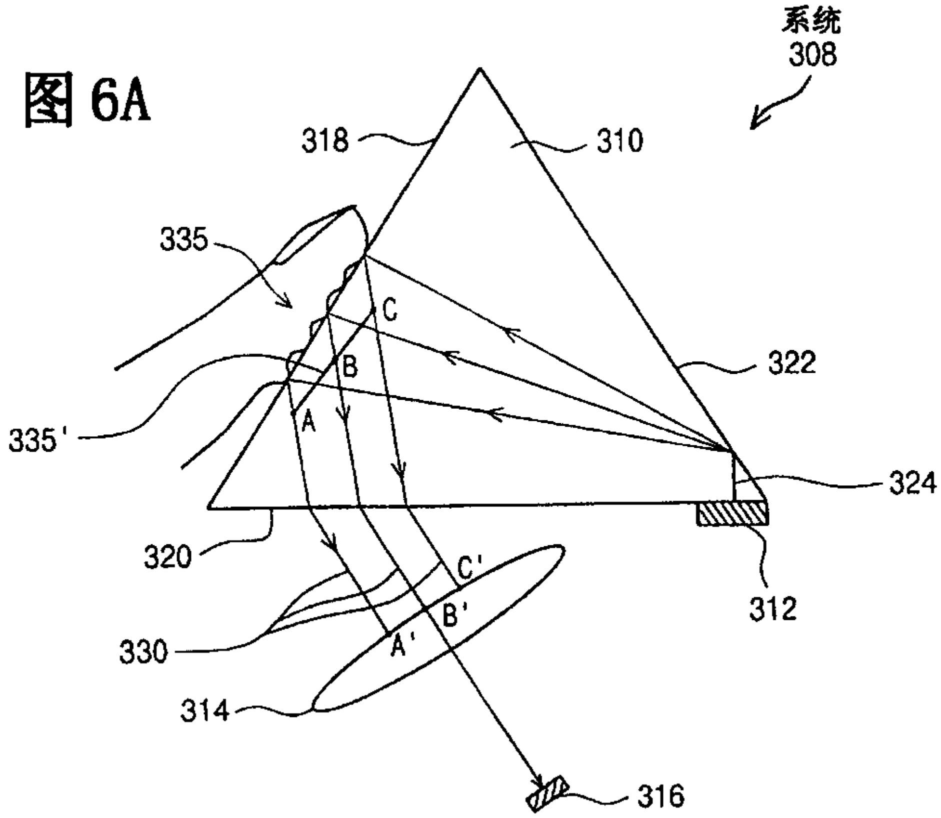

系统
308
318
310
335
C
B
A
335'
322
324
320
312
C'
B'
A'
330
314
316

图 6A

图 6B

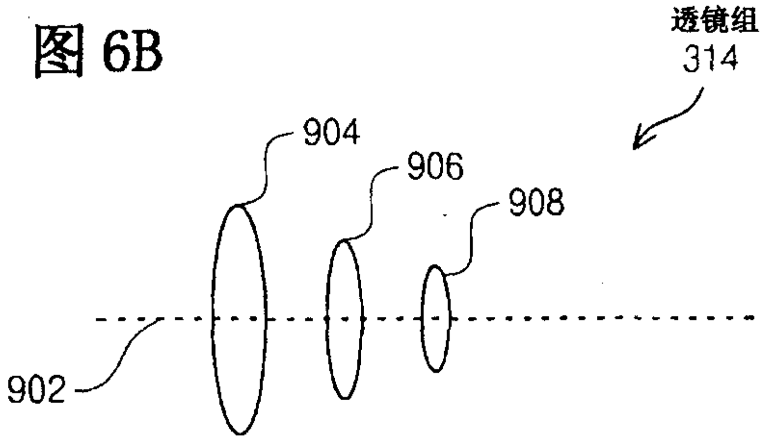

透镜组
314
904
906
908
902

图 7 第二实施例

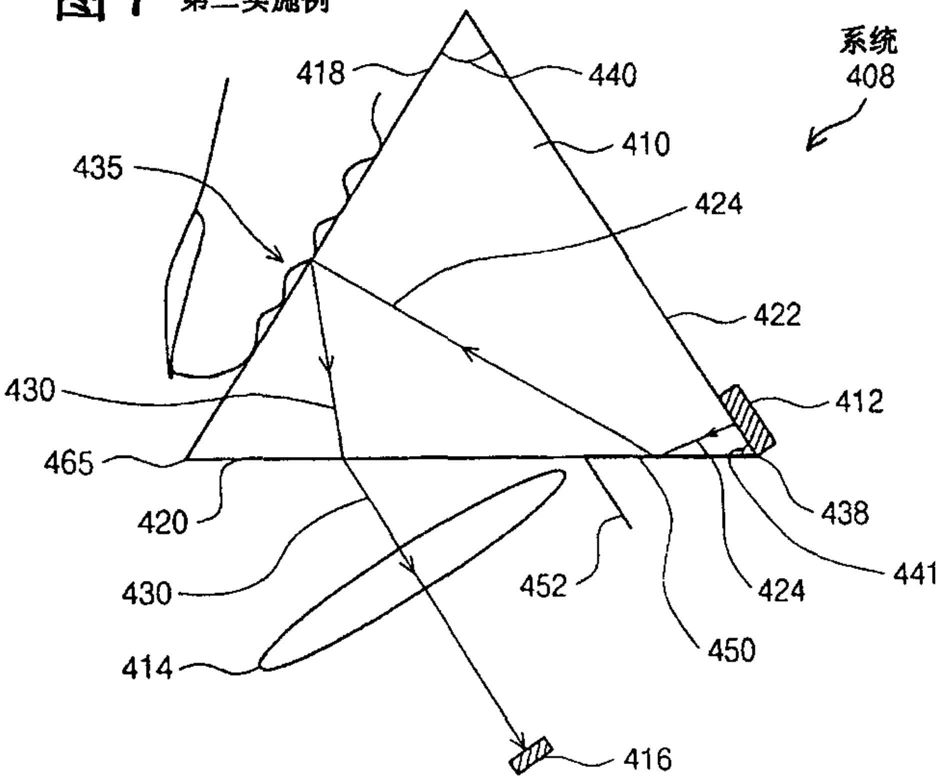

系统
408
418
440
410
435
424
422
430
412
465
420
438
441
430
452
424
450
414
416

图 8 第三实施例

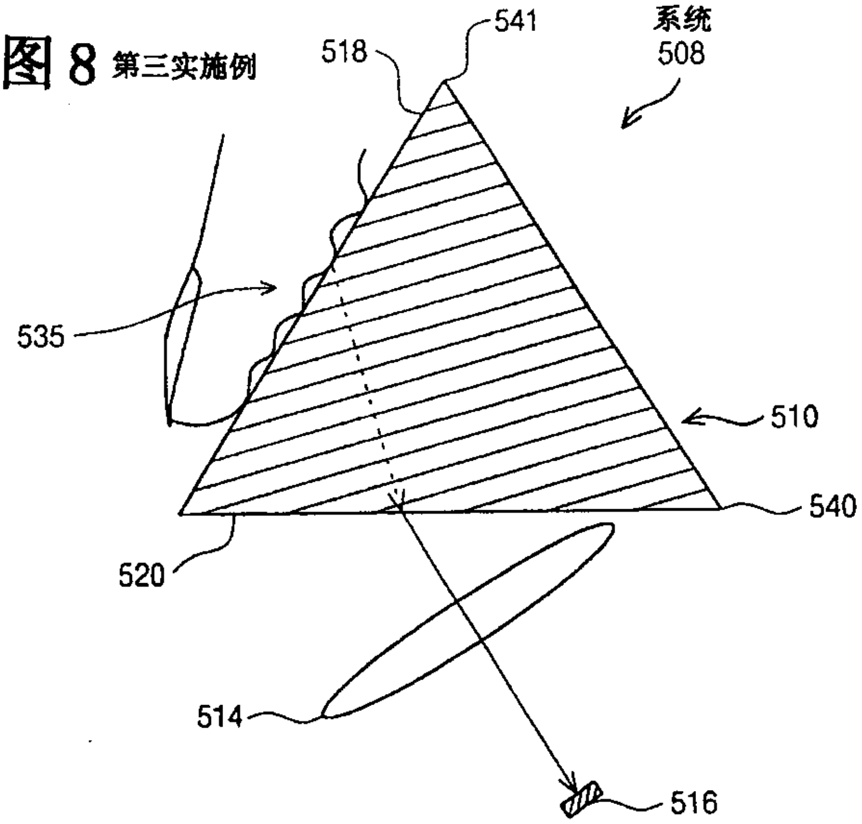


图 9

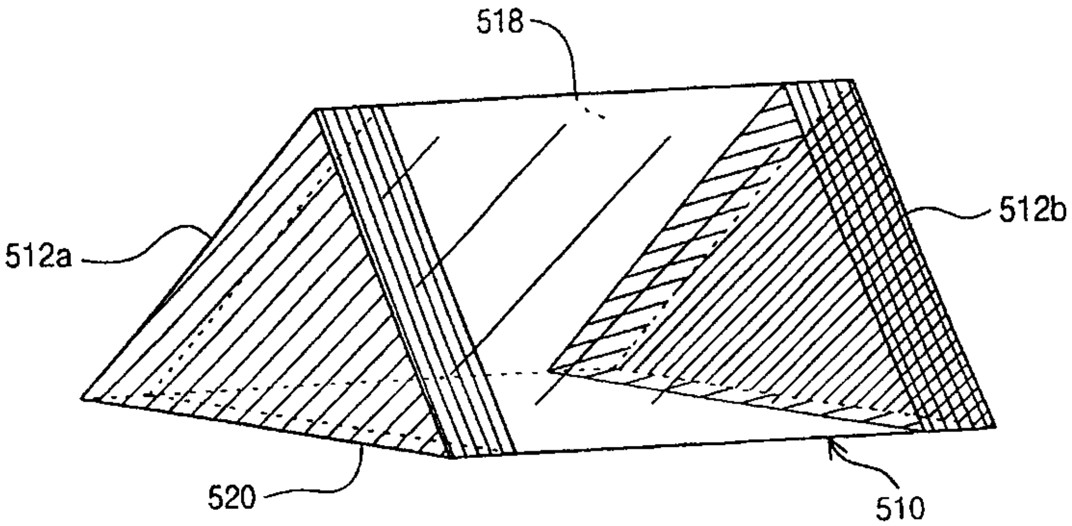
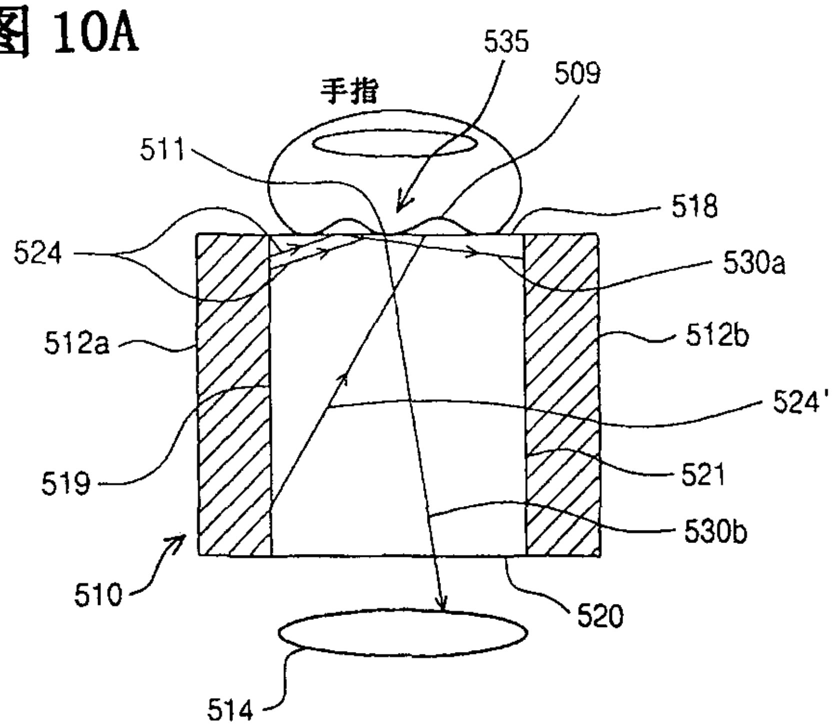
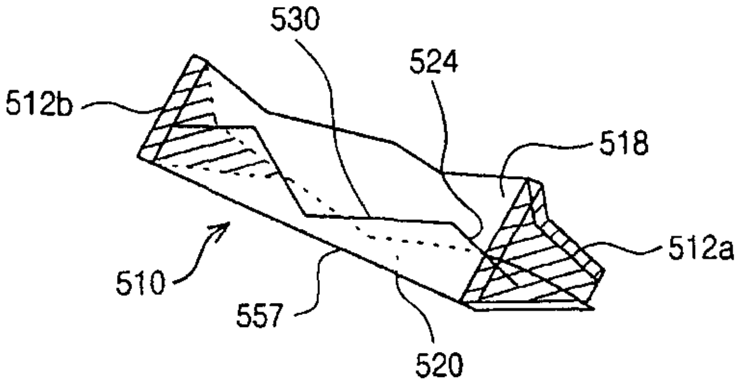


图 10A



535
509
手指
511
518
524
530a
512a
512b
524'
519
521
530b
510
520
514

图 10B



530
524
512b
518
512a
510
557
520

图 11 第四实施例

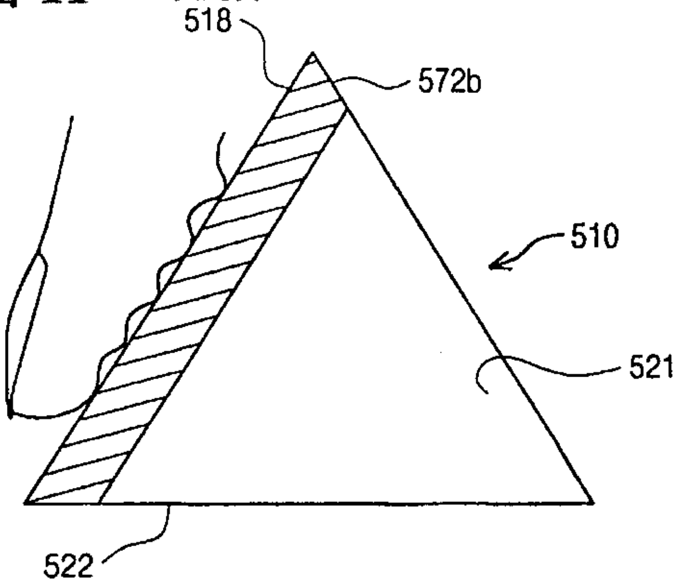


图 12

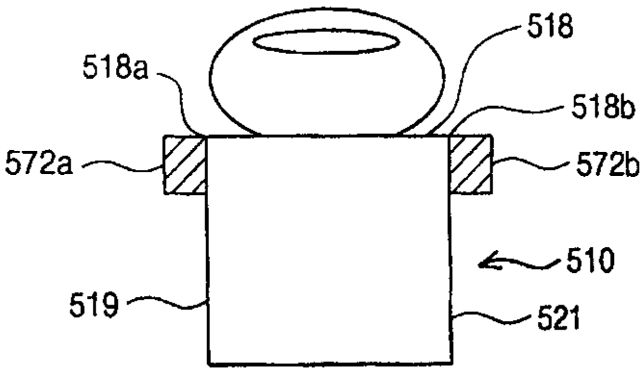


图 13 第五实施例

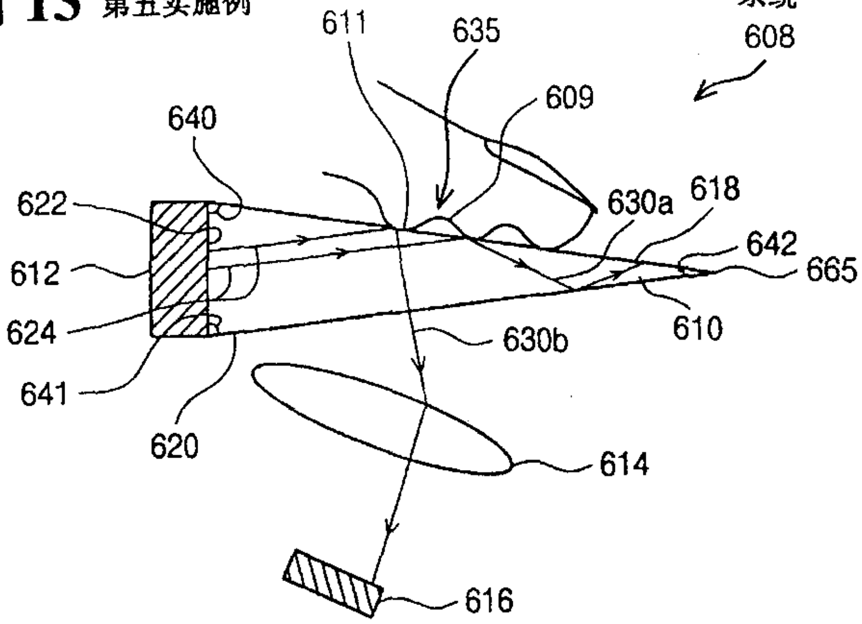


图 14

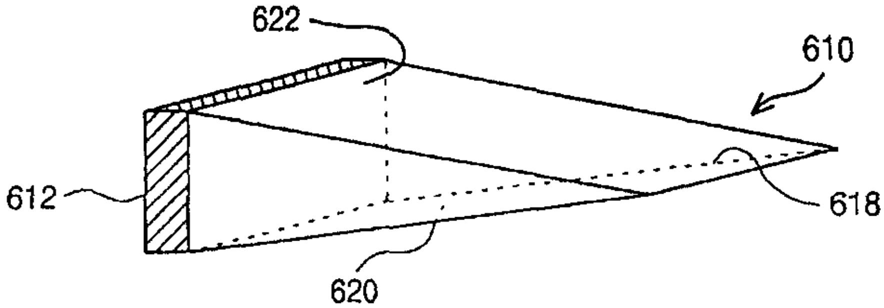


图 15 第六实施例

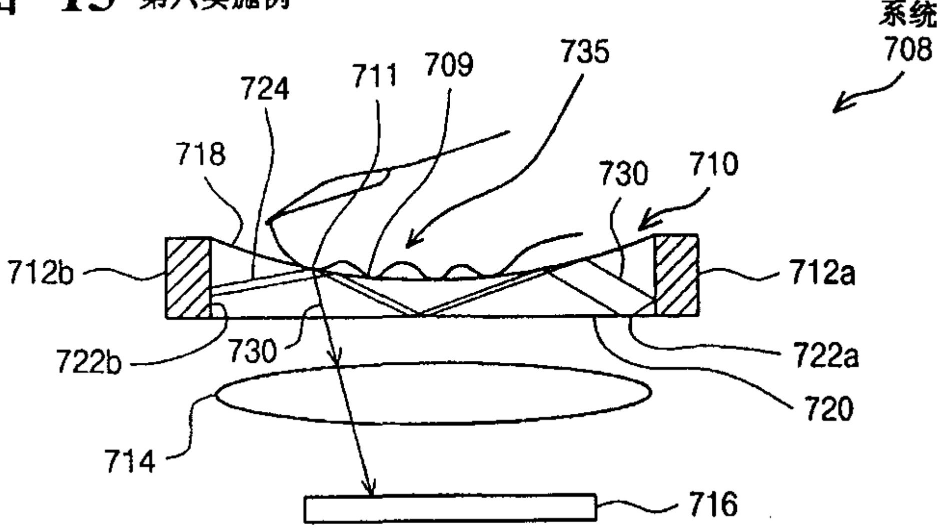


图 16

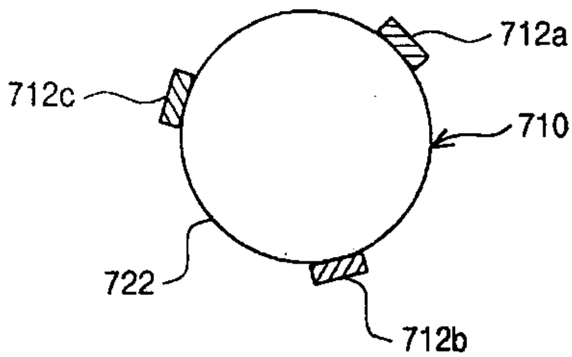


图 17

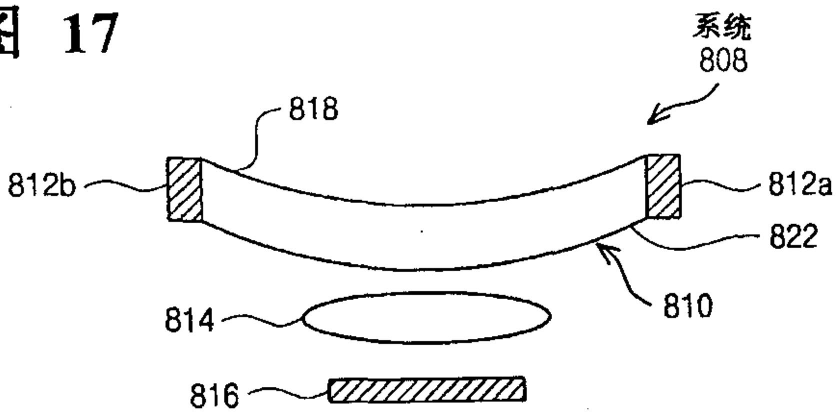


图 18

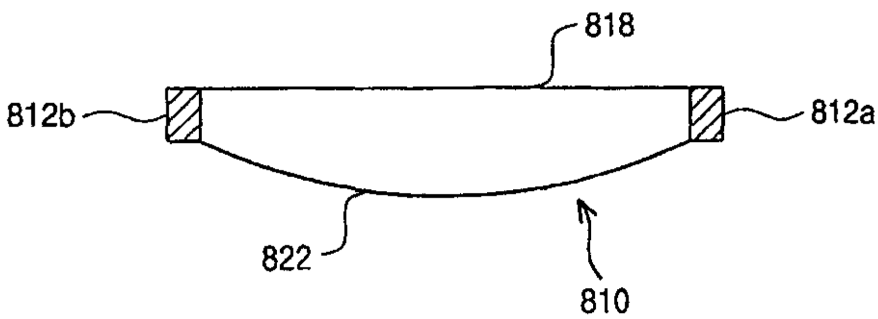


图 19

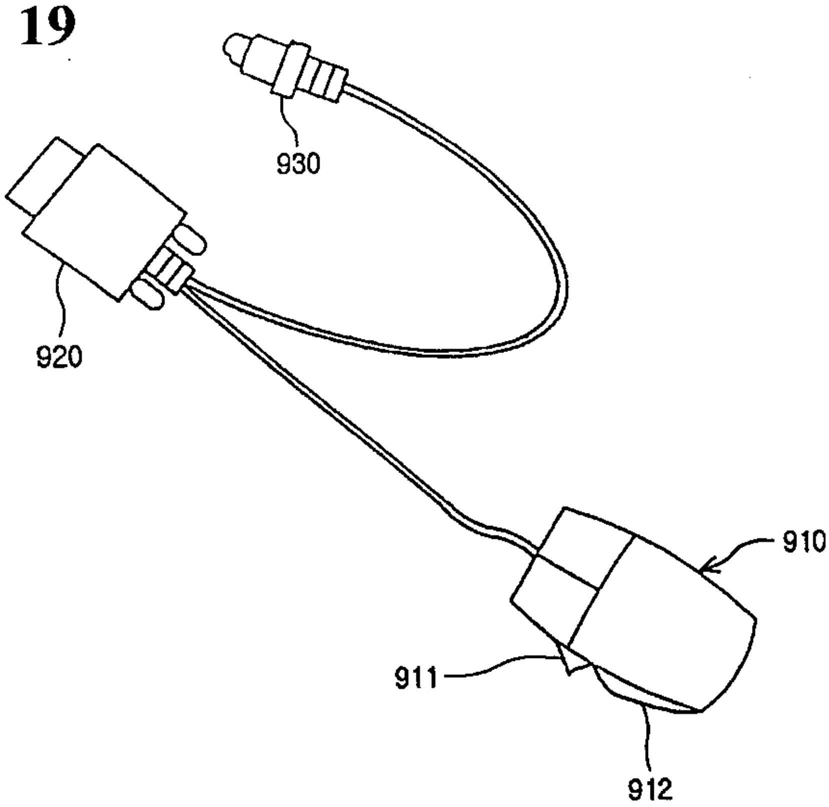


图 20

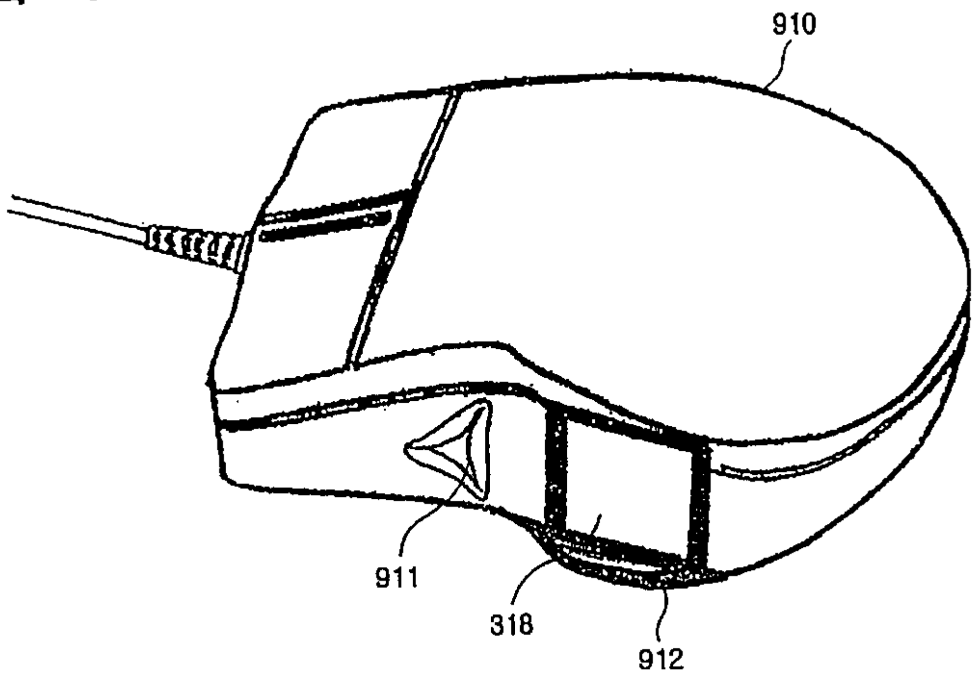


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图 21

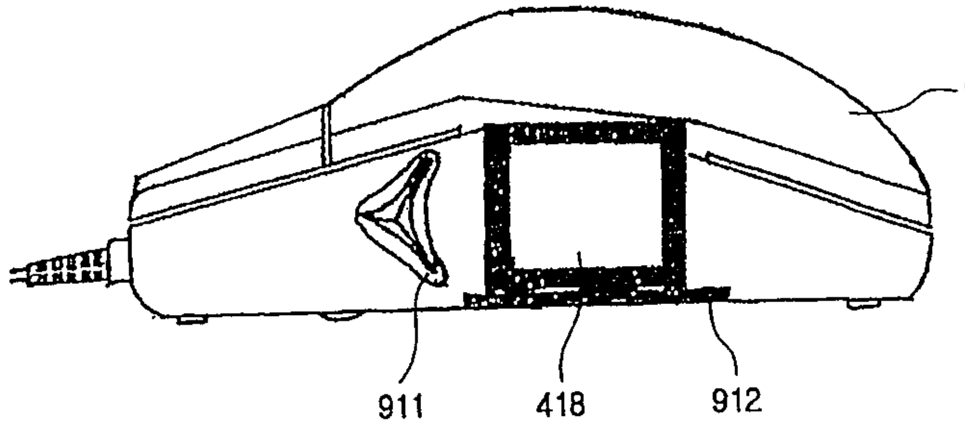

图 22