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Dunne

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(54) **CAMERA MODULE AND FOLDED OPTICAL SYSTEM FOR LASER-BASED SPEED GUN**

(2013.01); *G03B 17/48* (2013.01); *G08G 1/054* (2013.01); *H04N 5/2252* (2013.01); *H04N 5/2254* (2013.01)

(71) Applicants: **Laser Technology, Inc.**, Centennial, CO (US); **Kama-Tech (Hk) Limited**, Hong Kong (CN)

(58) **Field of Classification Search**
CPC G03B 13/08; G03B 13/36; G01S 17/023; G01S 17/58; G02B 17/008
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See application file for complete search history.

(72) Inventor: **Jeremy G. Dunne**, Parker, CO (US)

(73) Assignees: **Laser Technology, Inc.**, Centennial, CO (US); **Kama-Tech (HK) Limited**, Hong Kong (CN)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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Related U.S. Application Data

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Primary Examiner — Clayton E Laballe
Assistant Examiner — Linda B Smith
(74) *Attorney, Agent, or Firm* — William J. Kubida;
Hogan Lovells US LLP

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G03B 13/36 (2006.01)
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G03B 17/17 (2006.01)
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(57) **ABSTRACT**

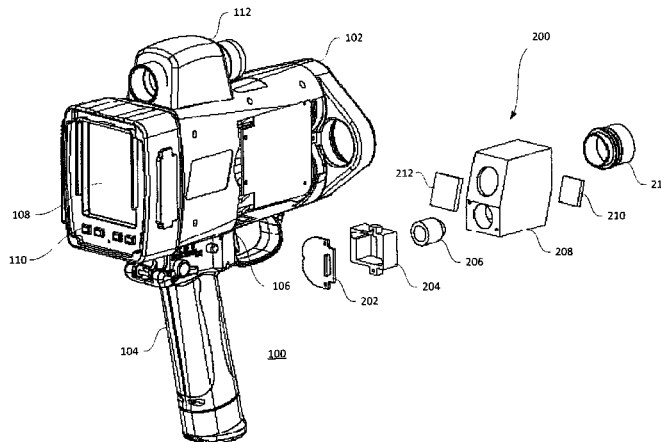
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A laser-based speed gun includes a camera module and a folded optical system including an objective lens and an eyepiece lens. The folded optical system includes first and second image redirecting elements for redirecting an image pathway from the objective lens to the eyepiece lens adjacent the camera module.

(52) **U.S. Cl.**

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2 Claims, 3 Drawing Sheets



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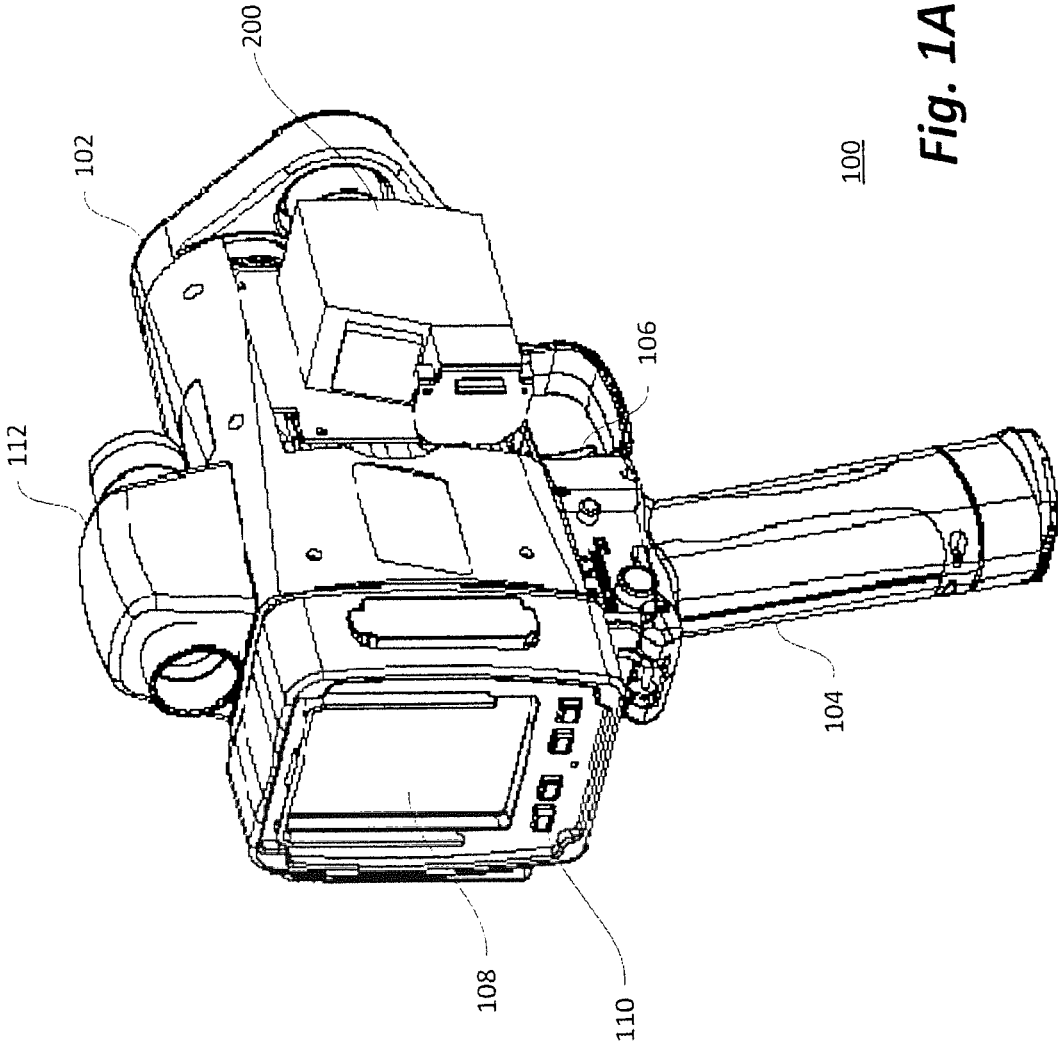


Fig. 1A

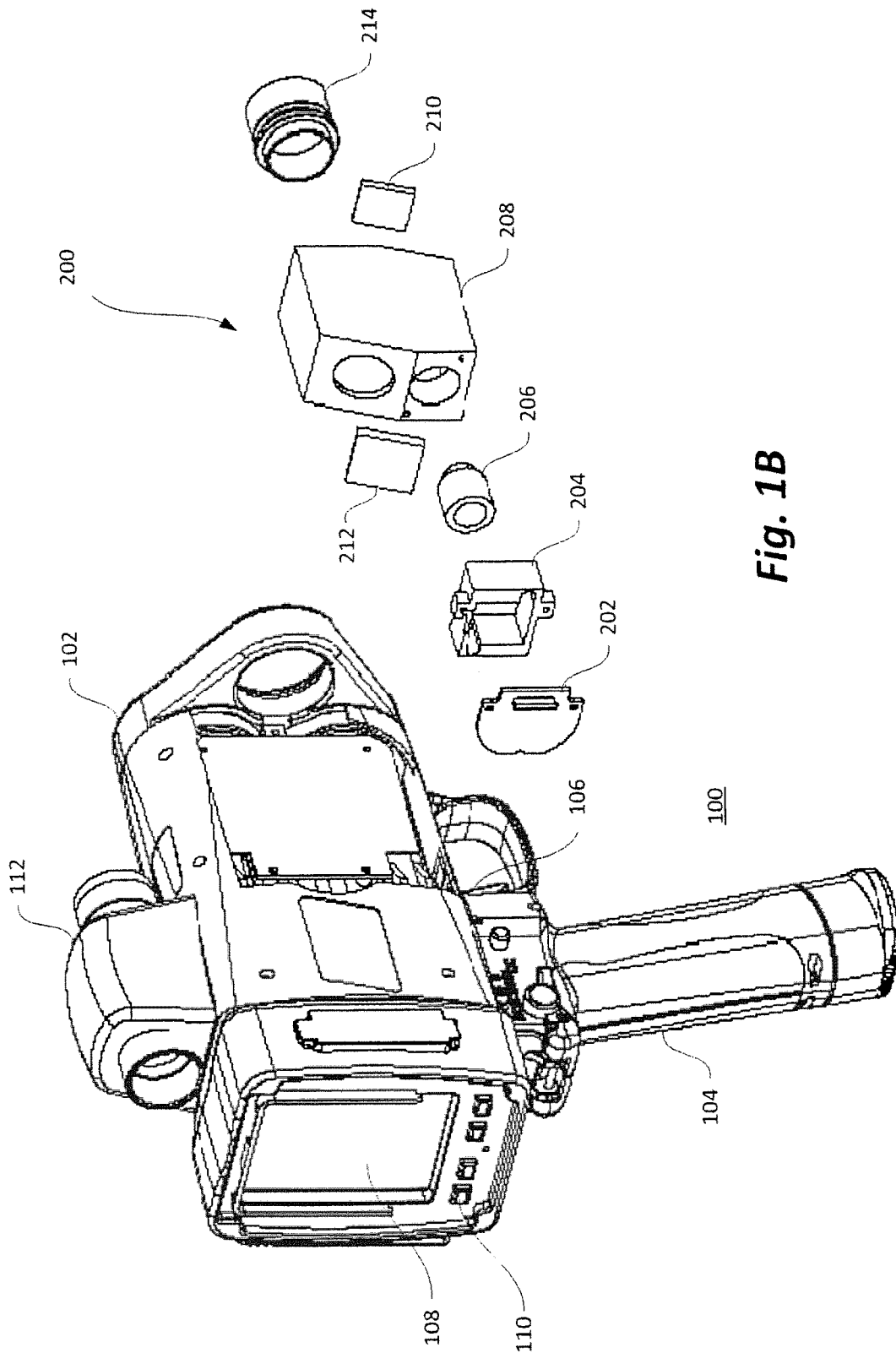


Fig. 1B

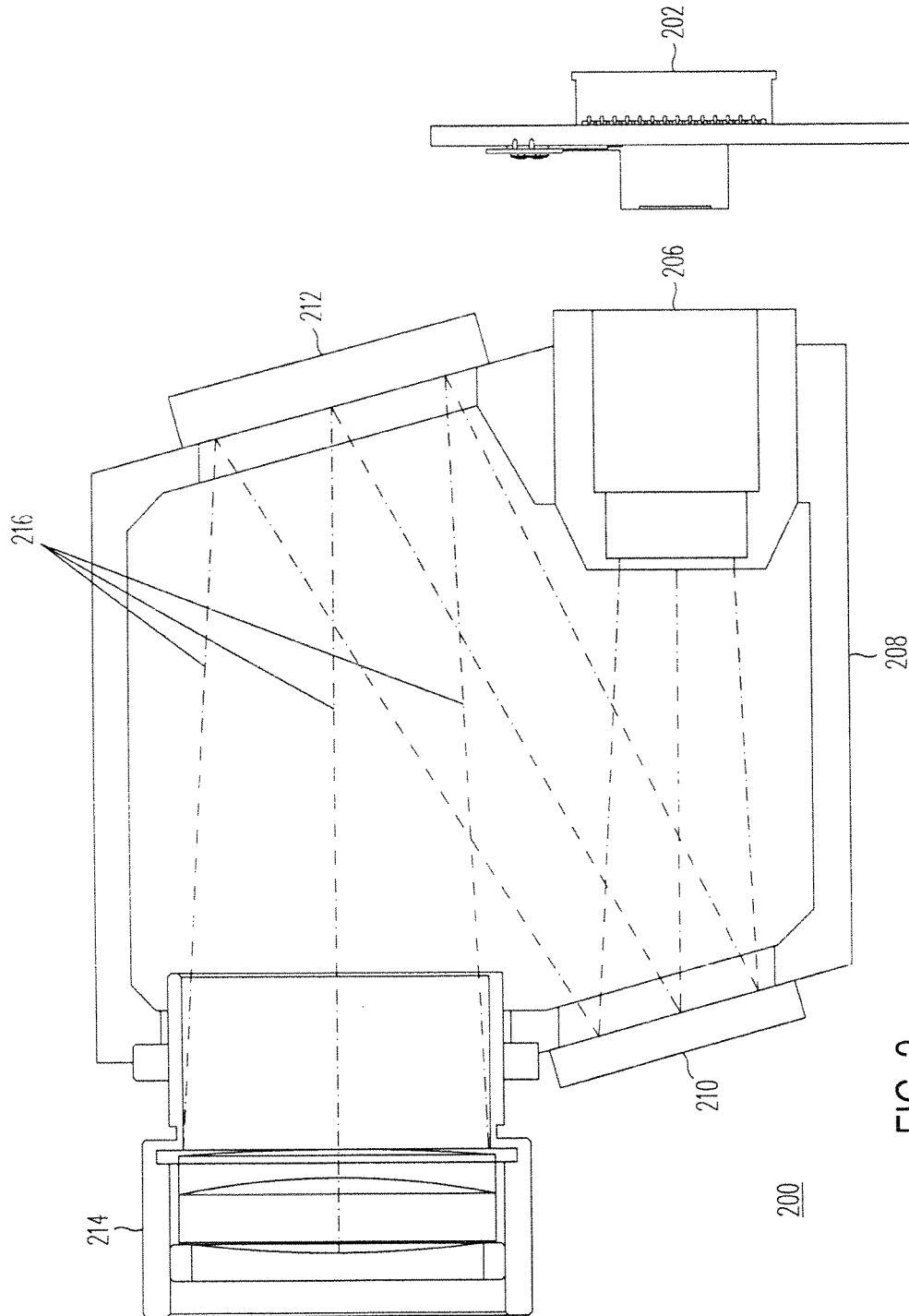


FIG. 2

CAMERA MODULE AND FOLDED OPTICAL SYSTEM FOR LASER-BASED SPEED GUN

RELATED APPLICATIONS

The present application relates to and claims priority of U.S. provisional patent application Ser. No. 62/316,319, filed on Mar. 31, 2016. The disclosure of the Provisional application is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

The present invention relates, in general, to the field of speed measurement devices capable enabling the identification of particular vehicles in recorded images. More particularly, the present invention relates to a camera module and folded optical system for laser-based speed guns.

Laser Technology, Inc. assignee of the present invention, has introduced the TruCAM® (a registered trademark of Laser Technology, Inc.) video laser device which is the industry's first all-in-one laser-based video camera. In operation it collects and stores a complete chain of video evidence for both speeding and tailgating violations along with a high-resolution image that identifies the vehicle make, model and license plate number.

Representative of the technology embodied in the TruCAM devices is disclosed, for example, in U.S. Pat. No. 7,920,251 issuing Apr. 5, 2011 for: "Integrated Still Image, Motion Video and Speed Measurement System" and U.S. Pat. No. 8,311,343 issuing Nov. 13, 2013 for: "Vehicle Classification by Image Processing with Laser Range Finder" the disclosures of which are herein specifically incorporated by this reference in their entirety.

SUMMARY OF THE INVENTION

Disclosed herein is a camera module and folded optical system for a laser-based speed gun which may be conveniently implemented with a commercially available cell phone camera module. Such camera modules exhibit good image quality with built-in autofocus mechanisms at relatively low cost. However, they also have a very short focal length which would preclude them from use in zooming in on a vehicle license plate at a distance of 100 meters or so when implemented in a laser-based or other speed measurement instrument.

In order to fit within the dimensions of a handheld laser-based speed gun, a folded optical system is disclosed herein in conjunction with the camera module that effectively extends the focal length of the camera module by a factor of 12.5 thereby enabling it to discern a vehicle license plate out to a range of 100 meters or more.

Particularly disclosed herein is a laser-based speed gun which comprises a camera module and a folded optical system comprising an objective lens and an eyepiece lens. The folded optical system includes first and second image redirecting elements for redirecting an image pathway from the objective lens to the eyepiece lens adjacent the camera module.

BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned and other features and objects of the present invention and the manner of attaining them will become more apparent and the invention itself will be best

understood by reference to the following description of a preferred embodiment taken in conjunction with the accompanying drawings, wherein:

FIG. 1A is an isometric view of a representative laser-based speed gun incorporating the camera module and folded optical system of the present invention;

FIG. 1B is a comparable isometric view of the representative laser-based speed gun of the preceding figure illustrating an exploded view of the camera module and folded optical system; and

FIG. 2 is a cross-sectional, side elevational view of the representative embodiment of the camera module and folded optical system of the preceding figures illustrative of the image pathway between the objective lens and eyepiece lens adjacent the camera module.

DESCRIPTION OF A REPRESENTATIVE EMBODIMENT

With reference now to FIG. 1A, an isometric view of a representative laser-based speed gun **100** is shown incorporating the camera module and folded optical system **200** of the present invention. The laser-based speed gun **100** comprises a housing **102** and associated handle **104** for handheld operation. A trigger **106** is provided to initiate the transmission and reception of laser pulses toward a moving object, such as a vehicle, as well as initiate the recording of video of the object in conjunction with the camera module and folded optical system **200**. The laser-based speed gun **100**, as illustrated, includes a display **108**, user input and selection elements **110** as well as target vehicle sighting optics **112**.

With reference additionally now to FIG. 1B, a comparable isometric view of the representative laser-based speed gun **100** of the preceding figure is shown further illustrating an exploded view of the camera module and folded optical system **200**. With respect to this figure, like structure to that previously described with respect to the foregoing figure is like numbered and foregoing description thereof shall suffice herefor.

The exemplary camera module and folded optical system **200** of the present invention comprises an autofocus camera module **202** such as might be employed in cellular telephones. As an example the camera module **202** may advantageously be provided as an e-CAM52A_MI5640_MOD 5 mega pixel MIPI camera module available from e-con Systems, St. Louis, Mo. The camera module **202** is affixed to a spacer block **204** to set the proper spacing between the camera module **202** and the eyepiece lens **206**. A housing **208** secures the eyepiece lens **206**, first and second image redirection elements in the form of mirrors **210**, **212** and objective lens **214**.

With reference additionally now to FIG. 2, a cross-sectional, side elevational view of the representative embodiment of the camera module and folded optical system **200** of the preceding figures is shown illustrative of the image pathway **216** between the objective lens **214** and eyepiece lens **206** adjacent the camera module **202**. As can be seen the image pathway **216** viewed through the objective lens **214** is redirected by the mirrors **212** and **210** toward the eyepiece lens **206** to be focused at its exit pupil upon the front lens of the camera module **202**. The spacer block **204** is not shown in this figure. In operation, the camera module **202** itself can be appropriately positioned or the image electronically reversed as may be required.

Conventional cell phone camera modules provide good image quality with a built-in autofocus mechanism but

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exhibit a very short focal length. This short focal length means it is itself incapable of being able to zoom in on a license plate up to on the order of 100 meters or so away. In a representative embodiment of the camera module and folded optical system 200 of the present invention, the objective lens 214 may be substantially 150 mm while the eyepiece lens 206 is substantially 12 mm. This configuration provides an extension of the focal length by a factor of 150 mm/12 mm=12.5 thereby enabling the camera module 202 to identify a license plate out to 100 meters or more.

While there have been described above the principles of the present invention in conjunction with specific apparatus, it is to be clearly understood that the foregoing description is made only by way of example and not as a limitation to the scope of the invention. Particularly, it is recognized that the teachings of the foregoing disclosure will suggest other modifications to those persons skilled in the relevant art. Such modifications may involve other features which are already known per se and which may be used instead of or in addition to features already described herein. Although combinations of features, it should be understood that the scope of the disclosure herein also includes any novel feature or any novel combination of features disclosed either explicitly or implicitly or any generalization or modification thereof which would be apparent to persons skilled in the relevant art, whether or not such relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as confronted by the present invention. The applicants hereby reserve the right to formulate new claims to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

As used herein, the terms "comprises", "comprising", or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a recitation of certain elements does not necessarily include only those elements but may include other elements not expressly recited or inherent to such process, method, article or apparatus. None of the description in the present application should be read as implying that any particular element, step, or function is an essential element which must be included in the claim scope and THE SCOPE OF THE PATENTED SUBJECT MATTER IS DEFINED ONLY BY THE CLAIMS AS ALLOWED. Moreover, none of the appended claims are intended to invoke paragraph six of 35 U.S.C. Sect. 112 unless the exact phrase "means for" is employed and is followed by a participle.

The invention claimed is:

1. A laser-based speed gun system comprising:

- a hand holdable housing comprising sighting optics for viewing a target vehicle;
- a processor coupled to laser signal transmission and reception circuitry within said housing for directing

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- laser ranging signals toward, and receiving reflected signals from said target vehicle, said processor operative for storing a sequence of ranges to said target vehicle in a range data queue;
 - a speed determiner module coupled to said processor and said range data queue for determining a speed of said target vehicle at selected ones of said sequence of ranges;
 - a camera module associated with said housing and coupled to said processor for recording a sequence of images of said target vehicle over said sequence of ranges and operative for storing said sequence of images in an image data queue;
 - an image processing module coupled to said processor and said image data queue, said laser speed-gun system operative for storing an image record of said target vehicle speed associated with a corresponding one of at least a subset of said sequence of images; and
 - a folded optical system comprising an objective lens and an eyepiece lens, having first and second image redirecting elements for redirecting an image pathway from said objective lens to said eyepiece lens adjacent said camera module, wherein said objective lens has a focal length of substantially 150 mm and said eyepiece lens has a focal length of substantially 12 mm.
2. A laser-based speed gun system comprising:
- a hand holdable housing comprising sighting optics for viewing a target vehicle;
 - a processor coupled to laser signal transmission and reception circuitry within said housing for directing laser ranging signals toward, and receiving reflected signals from said target vehicle, said processor operative for storing a sequence of ranges to said target vehicle in a range data queue;
 - a speed determiner module coupled to said processor and said range data queue for determining a speed of said target vehicle at selected ones of said sequence of ranges;
 - a camera module associated with said housing and coupled to said processor for recording a sequence of images of said target vehicle over said sequence of ranges and operative for storing said sequence of images in an image data queue;
 - an image processing module coupled to said processor and said image data queue, said laser speed-gun system operative for storing an image record of said target vehicle speed associated with a corresponding one of at least a subset of said sequence of images; and
 - a folded optical system comprising an objective lens and an eyepiece lens, having first and second image redirecting elements for redirecting an image pathway from said objective lens to said eyepiece lens adjacent said camera module, said speed gun system further comprising a spacer block interposed between said eyepiece lens and said camera module.

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