



Translated into English from the German original

Procedures and arrangement for photographing a vehicle

5 The invention involves a method and arrangement for photographing a vehicle, with which an image document (front photo) is produced, which is suitable for clearly identifying both the driver and the license plate and is protected against manipulation.

10 In order to obtain a legally valid document with traffic photography in accordance with German law, the driver and the license plate must be clearly recognizable on the front photo apart from clear assignment of the recorded data such as speed, driving direction, location, date and time to the front photo which is free of manipulation. Assignment of the driver to the license plate beyond any legal doubt is given whenever the front photo is produced with only one shot. However, this
15 involves photometric problems, both in the case of wet film technology, but even more so when employing digital technology as the photographic medium, which results in a high proportion of front photos which are incapable of being used.

20 In order to make it possible to obtain an image of the driver at all, the passenger interior and thus the driver must be sufficiently illuminated. As a rule, this is only possible with an additional flashlight independent of the amount of daylight if the distance between the vehicle and the camera is between 30 m and 12 m and at a vehicle speed of up to 250 km/h. In addition, matters are made more difficult through the frequent optical coloration of the windshields, which additionally
25 reduce the intensity of the radiation which is already only minimally reflected by the driver.

However, the retro-reflecting license plate reflects the radiation up to almost 100%. That is, on the one hand, one endeavors to photograph the vehicle at an angle that is as small as possible, i.e. to point the camera in a frontal direction toward the
30 windshield in order to record as much of the radiation reflected by the driver with the camera as possible; on the other hand, an angle which is as large as possible



would be advantageous so that only a small share of radiation reflected from the license plate is recorded.

Additional factors which affect the respective photographic situation include the constantly changing lighting conditions, photos of vehicles on different traffic lanes
5 and the changing meteorological influences.

The photometric extremes that develop under realistic conditions, as a function of the location in the case of a vehicle which is to be photographed (poorly illuminated vehicle interior and irradiated license plate) and their respective
10 change when objects are to be successively photographed (change in the amount of daylight, change of the driving lane, etc.) place very high demands on the dynamics to be met by the photographic medium.

Due to the substantially higher resolution and the clearly greater dynamics (2^{14}
15 gray levels per pixel) wet film continues to be preferentially employed in traffic photography. Pixels with extremely different illumination can be processed within certain limits by means of complex re-working when developing the film so that the image data becomes visible.

20 This succeeds with digital recording technology far more insufficiently as a result of the still poorer resolution which continues to prevail at the present and the clearly lesser dynamics (2^{10} gray levels per pixel). While imaging of the driver in the poorly illuminated passenger interior requires a high sensitivity and resolution, the irradiated license plate requires very high dynamics and resistance to over-
25 regulation.

Apart from the constant effort to improve the physics of the photographic media, the attempt is made to solve the indicated problems when it comes to traffic photography either through improved evaluation of the image data, which
30 represents an electronic solution for digital technology, or the attempt is made to affect the imaging of the object by means of optical solutions.

In DE 35 35 588 A1 a procedure and a device are disclosed for the photographing very luminous or reflecting parts of a visual field which is to be photographed. For example, in order to be able photograph a retro-reflecting license plate of a vehicle together with the remaining, normally illuminated parts of the visual field, a filter which diminishes the light in the image plane of the camera is attached which extends crosswise over the image plane. The brightness of the image is diminished within the range covered by the filter. In order to obtain a photograph where precisely the radiation that is reflected by the license plate is damped by the filter, the image of the license plate must develop within the range of the filter, i.e. the camera must be aimed at the vehicle in a very precise manner.

DE 198 02 811 A1 speaks of improved identification of the driver and the license plate by means of a larger number of pictures as well as employment of a contrast procedure. However, no more precise information is provided.

In DE 297 18 274 U1 a camcorder for speed indicators is disclosed which is characterized by a graduated filter positioned in front of the lens. This filter which is colored on one half with a smooth transition from the dark to the light part is used in such a way that the darker part in particular diminishes the reflex luminosity of the license plate. However, this locally differentiated diminishment can only be completely inadequate, even to the point that it does not work at all if the filter is located near or in the entrance pupil of the lens.

Apart from the optical solutions indicated thus far, with which the reflected radiation of the license plate is entirely damped, EP 0621 572 A1 offers a procedure and a device with which two different image areas of a traffic scene are photographed at the same time with two digital cameras at a different angle. The electronic image data of both photographs are stored together for securing evidence. Although the problem of the very different reflection of different object areas indicated at the outset is not explicitly represented as the task which is to be solved, it is nevertheless obvious that the license plate, if it is photographed at an angle greater than the angle of the retro-reflection, no longer irradiates, while the faint scenery is photographed at a rather very small angle. Through the necessity

of two cameras (camera) alone such a solution requires great technical expenditure and great expenditure for on-site installation.

5 While the optical solutions have an impact on the imaging of the object, the electronic solutions, two of which are to be designated in the following, involve evaluation of the digital image data.

10 In DE 199 60 888 A1 a procedure and a device are described with which at least two pictures of different brightness are produced from the image data of one photograph. To this end the first 8 bits of the CCD sensor, which contain more useful information about the bright portion, are read out as a dark frame which allows for easier identification of the very brightly radiating license plate. The last 8 bits of the sensor produce the flat field which contains more useful information about the dark portion of the image and thus the driver. Preferably these two
15 digital images are to be combined with one another in such a way that an image develops where both the license plate and the driver can at least be recognized better. Whether or not recognizability is given in any case, in particular with regard to the license plate, appears doubtful.

20 A second interesting electronic solution is disclosed in DE 100 29 578 A1. With the procedure described here exposure of the license plate and exposure of the passenger interior can be handled separately with specification of a target value (desired exposure of the object). Thus photographs can be produced optimized in terms of the brightness of the passenger interior and photographs
25 optimized in terms of the brightness of the license plate, which naturally requires at least two photographs.

The state of the art can be summarized as follows. None of the indicated solutions sufficiently secures both the recognizability of the driver and the license plate with
30 only a single photograph of a vehicle independently of the photographic medium.

It is the task of the invention to set forth a procedure and a device which create an image document with only a single photograph, on which independently of the

objective lighting conditions and of photographic medium both the driver and the license plate are represented in a visually recognizable manner beyond all doubt.

The device according to the invention shall be capable of being usefully created for traffic photography by retrofitting cameras available on the market.

- 5 Preferably such retrofitting should be possible without tampering with the hardware of the camera and without any necessary adjustment of the camera by the user. The operating mode of the camera (e.g. triggering the photograph and the flashlight, flashlight performance, reading out, storage and evaluation of the image data) is not to be affected by the retrofitting of the camera. Nothing should change
10 in the handling for the user.

- The task of the invention shall be solved for a procedure in accordance with the generic term of Claim 1 in that the image-creating imaging radiation beam reflected by the vehicle is split into two partial radiation beams, whereby the first
15 partial radiation beam, with only an imperceptibly smaller light intensity than that of the entire imaging radiation beam, produces a first image on which the driver is easily recognizable, while the second partial radiation beam with a light intensity of less than 5% produces a second image on which the license plate is easily recognizable and that the two geometrically identical images are produced [with
20 local offset] and stored on the photographic medium at the same time relative to each other.

- For an arrangement in accordance with the generic term of Claim 2 the task shall be solved by the fact that in the optical path of the imaging radiation beam means
25 are present for division of the imaging radiation beam into two partial radiation beams of different intensity offset relative to each other which cause two geometrically identical images of different intensity on the photographic medium locally offset to each other, whereby the first image recognizably illuminates the driver and the second image the license plate.

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Advantageous embodiments for an arrangement according to the invention are specified in dependent claims 3 to 8.

The essence of the procedure according to the invention consists in the fact that with a single photograph of an object field two geometrically identical images of the object field are produced offset to each other on the same photographic medium. It is essential for the invention that the second image is generated with
5 very low light intensity, less than 5%, preferably less than 1%, while for the first image the remaining light intensity, which can be up to more than 99% of the radiation incident to the lens, is employed as far as possible.

The first image, only imperceptibly less in terms of the light intensity vis-à-vis the image with full light intensity images the full object field, whereby good
10 recognizability is provided as in the case of conventional photographs of drivers in the passenger compartment through the flashlight and the highly reflecting license plate frequently appears only as a [saturated] light spot. A low-contrast area develops on the first image underneath the vehicle, which is practically always on an, as it were, homogeneous low-contrast road surface.

15 However, except for the license plate, which is shown here optimally exposed, the second image is nearly completely dark due to the low light intensity.

The two images (double images) are offset relative to each other such that the license plate which is recognizable in the second image is shown there on the photographic medium, whereas low-contrast areas without useful image data are
20 shown from the first image. Preferably the area underneath the vehicle is used here.

Practical tests have shown that no ghost images develop when using electronic photographic media (CCD sensor) in particular due to the low dynamics. The usable image data of the second image (only the license plate) is projected onto
25 an area of the first image in which no usable image data (only the road surface) is present.

The image data of both images is at the same time stored and processed as a single image. Likewise a wet film, used as a photographic medium, is subjected to one-time exposure just as described for a CCD sensor.

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The driver and license plate are photographed with identical imaging optics and stored in an overall view and/or a data record in a manner that is unambiguous in legal terms and protected against manipulation. Using the knowledge involving the

offset images, defined by the device arrangement, scenic realization of the overall view into the first and second image is at least possible and thus clearly assignable for the electronic photographic medium.

What is decisive for the relationship of the light intensity for the two images, which is to be implemented in accordance with the device, is the quantity of light with which the license plate is optimally imaged. Since this relationship can be arbitrarily realized in accordance with the device and thus the second quantity of light selected for determining the image can be very small, even less than 1%, it is – regardless of the technical traffic possibilities – possible in principle to direct the camera at the vehicle from a frontal position.

In contrast to the solutions indicated in accordance with the state of the art which try to solve the problem of the irradiated license plate with optical damping and with only moderate success, the entire quantity of light incidental to the lens is used here in order to produce the image (here consisting of two superimposed images).

A device which is suitable for execution of the procedure must exhibit means that fulfill the following sub-functions:

1. Generation of an imaging radiation beam.
2. Separation of the imaging radiation beam into two partial radiation beams under a certain light intensity ratio (for the production of two geometrically identical images of different intensity).
3. Creation of an optical offset between the images.
4. Imaging of the two images and storage of the image data.

It is clear to expect that the individual sub-functions can be fulfilled in practical terms by different but also the same technical means. Likewise individual sub-functions can be fulfilled by the interaction of several technical means.

Numerous arrangement variants can be generated from the numerous practicable technical means and their arrangement to each other.

All of the arrangement variants consist in principle of a lens (means for the production of an imaging radiation beam), a photographic medium, such as a wet

film (chemical storage) or an electronic sensor arrangement (electronic storage) arranged in the image plane of the lens (means for imaging the two images and storage of the image data) as well as means for dividing the imaging radiation beam and offsetting the resultant partial radiation beam.

- 5 The means for division of the imaging radiation beam and for offsetting the partial radiation beam essentially differ for the individual embodiment variants through the physical principle effected by them, the resulting concrete technical realization and their arrangement within the scope of the respective arrangement variant.

- 10 In principle, these means can be arranged in front of the lens, within the lens or between the lens and the photographic medium.

Assuming that the object (vehicle) which is to be imaged is always located at an infinite distance to the lens, as it were, the imaging radiation beam between the object and the lens is a parallel beam.

- 15 Thus introduction of these means, which provide for optical handling of the ray beam, is a possibility in particular before the lens when it comes to retrofitting cameras that are already available on the market. Additional introduction of optically effective means within the lens or between the lens and the photographic medium is in principle possible only through reconstruction of a camera as these
20 additional optical means must be taken into consideration in calculating the optical system of the camera, determined by the photographic lens and the photographic medium. With the present description the expert will be in a position to make equivalent use of such solutions for any reconstructions.

- 25 Independently of their arrangement the means for separating the ray beam both can be based on physical beam splitting, e.g. with a divisor cube, a prism, a coated separating plate or a separating plate or on geometrical beam splitting through pupil division with a firm or variable division ratio.

- Offsetting of the partial radiation beams can be caused by an image angle offset
30 e.g. with a wedge, a pair of rotating wedges, a prism or a corner reflector (fixed or variable) and/or a parallel beam offset, e.g. with a parallel plate (fixed or variable). All of the concrete technical means indicated as well as others that are suitable instead are well-known to the expert.

In the following several embodiments are to be described in more detail on the basis of a drawing. The following shall be shown to this end:

- 5 Fig. 1a: Side view of first embodiment as a sectional representation
- Fig. 1b: Top view of embodiment in accordance with Fig. 1a
- Fig. 2: Side view of lens adapter for a second embodiment as a sectional representation
- Fig. 3: Side view of lens adapter for a third embodiment as a sectional representation
- 10 Fig. 4a: Side view of lens adapter for a fourth embodiment as a sectional representation
- Fig. 4b: Lens adapter in accordance with Fig. 4a in sectional representation (IVb-IVb) in the angle of rotation $\varphi = 0^\circ$ to the lens
- 15 Fig. 4c: Lens adapter in accordance with Fig. 4a in sectional representation (IVb-IVb) in the angle of rotation $\varphi = 45^\circ$ to the lens
- Fig. 4d: Lens adapter in accordance with Fig. 4a in sectional representation (IVb-IVb) in the angle of rotation $\varphi = 90^\circ$ to the lens
- 20 Fig. 5: Side view of lens adapter for a fifth embodiment as a sectional representation

Since, as already in described detail, optical processing is effected in a particularly favorable fashion in the parallel beam path before the lens 1, all of the following embodiments describe arrangements consisting of a camera 4 with a lens 1, a photographic medium 2 in the image plane of the lens 1 which can be both a wet film and a CCD sensor and a lens adapter 3. The lens adapter 3 is arranged differently for the individual embodiments; in particular, the individual embodiments include different concrete technical means for processing the ray beam integrated in the lens adapter 3.

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A first embodiment is represented in Fig. 1a and 1b.

A camera 4 is shown from which, apart from the stylized represented housing elements, only the assemblies required for understanding the invention, i.e. the lens 1 and the photographic medium 2, are represented. The lens adapter 3 is screwed on by means of a lens filter accessory thread 5 on the camera 4 via an
5 outer ring 6. A segmented optical wedge 8 is fixed at an angle α in a retaining ring 7 fitted into outer ring 6. It is clear to the expert that the outer ring 6 represented here consists of at least a two-piece assembly, alone so that retaining ring 7 can be inserted. Once again, it is thus stressed that the representations in the drawings were reduced to the absolute essence in order to clearly represent
10 the solutions with regard to the principle.

Through the wedge 8 the pupil opening 9 is divided geometrically into two partial surfaces, whereby the division ratio and the resulting distribution of intensity for the two ensuing partial radiation beams is determined by the dimensioning of the wedge surface 10. Retaining ring 7 is capable of rotation in outer ring 6 and can be
15 adjusted by the operator by means of a bored key engaging in holes 12 so that a precisely vertical offset of the second image, which is formed by the partial radiation beam running through the wedge 8, is effected vis-à-vis the first image, which develops via the uninfluenced partial radiation beam. The offset is determined by the wedge angle of deflection $\sigma_1 = \alpha(n-1)$, where α is the angle of
20 the wedge 8 and n is the refractive index of the wedge 8.

The locus of the image 13 of the first partial radiation beam which enters unchanged through the remaining free surface 11 of the pupil opening 9, develops as usual on optical axis of the lens 1 at the level of the photographic medium 2.
25 The second partial radiation beam that passes through the wedge 8 meets the lens 1 below the wedge angle of deflection σ_1 and is thus imaged on the photographic medium 2 offset to the optical axis (locus of the image 14 of the second partial radiation beam). The lens adapter 3 has a thread of the same dimensioning as the lens filter thread 5 on its front side turned away from the
30 lens 1. Thus any available conventional filter adapters can continue to be used. For stationary systems it makes sense to stipulate and firmly set both the position of the wedge 8 and the wedge surfaces 10. An extension of the arrangement

according to the invention would be a mechanical moving unit which arranges the wedge 8 in an adjustable radial direction. Thus particularly in the case of mobile and mobile-stationary facilities the brightness of the second image could be optimized in accordance with the current lighting situation.

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Fig. 2 shows a lens adapter 3 for a second embodiment. This lens adapter 3 is mounted on the camera 4 in similar fashion for the first embodiment.

In contrast to the first embodiment a pair of parallel plates 15 represents the intended optical means in this case which fixes a firm angle α including in the retaining ring 7. The pair of parallel plates 15 represents a corner reflector with a fixed angle. In accordance with the Fresnel laws the ray beam entering the pupil is divided into a penetrating and a reflected partial radiation beam on the respective surface of the parallel plates which each represent an optical boundary surface (glass – air and/or air – glass). The penetrating partial radiation beam is within the meaning of the invention the first partial radiation beam, which is used for the visible imaging of the driver, while the reflected partial radiation beam is the second partial radiation beam which, in the description of the invention, is exclusively intended for the visible imaging of the license plate.

If these boundary surfaces are not provided with optical antireflection coating, then approximately 4% of the beam intensity is reflected on each surface (with perpendicular penetration). Thus the directly penetrating, first partial radiation beam has an intensity of approximately 85% of the ray beam entering the pupil. The beam portion twice reflected on the surfaces toward the parallel plates forms the second partial radiation beam with an intensity of approximately 1.5% and leaves the pair of parallel plates 15 at an angle offset equal to the mirror angle deflection $\sigma_2 = 2\alpha$ to the optical axis. The rest of the radiation is lost essentially through reflection on the first boundary surface. The division ratio can be arbitrarily influence through targeted optical correction of the boundary surfaces.

The direction in which the second image is offset can be specified by turning the retaining ring 7 in this second embodiment as well.

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The third embodiment, which is represented in Fig. 3, also functions in accordance with the same principle as the second embodiment.

In contrast to the second embodiment the angle offset equal to the mirror angle deflection σ_2 is variably adjustable in that the angle α between the thin glass plates forming a pair of parallel plates 15 can be varied by an angle range α .

By means of an adjusting screw 16 arranged inside of the retaining ring 7 one of the two parallel plates can be variably tilted against the other one by the angle range $\Delta\alpha$. The adjusted angle α can be read off on the cylinder of the adjusting screw 16.

The possibility of the changing the angle offset can prove to be useful in the case of mobile stations in order to be able to adapt the image offset of the license plate image to the vehicle size shown in the case of various shooting distances (approximately 10 to 25 m).

The fourth embodiment is characterized by the fact that it permits variation of the intensity ratio in a simple constructional manner without changing the vertical image offset. Such a solution would be particularly favorable for mobile facilities which are to be quickly and easily adjusted to different lanes. As already described, the incidence of the radiation reflected by the license plate very much depends on the angle of view at which the vehicle is imaged.

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In Fig. 4a to 4c a fourth embodiment is represented.

The retaining ring 7 is capable of rotation in relation to the outer ring 6 and thus to the camera 4. In the retaining ring 7 a self-aligning ball bearing 17 is radially aligned to the optical axis. On the inner ring of the self-aligning ball bearing 17 a gravity-type pendulum 18 is hung, on which a wedge 8 is attached in such a way that the angle α is always in a perpendicular direction, so that the beam deflection is always in a vertical direction.

If the retaining ring 7 is twisted to the right or left from the zero position represented in Fig. 4a and 4b, then the gravity-type pendulum 18 and thus the wedge 8 continuously turn out of the beam path of the lens 1. Thus the relationship between the part of the wedge surface 10 in the beam path and the free surface 11 changes. Without affecting the offset of the second image to first,

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the intensity of the second image can be infinitely reduced up to zero and, of course, increased again as well. Fig. 4c and 4d show the position of the gravity-type pendulum 18 with the retaining ring 7 twisted by 45° and/or 90° in relation to the zero position.

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A fifth embodiment particularly suited for mass production is shown in Fig. 5. Compared with the embodiments elucidated thus far this fifth embodiment is particularly inexpensive to produce due to its simplest design with the least amount of means and assembly expenditure.

- 10 The lens adapter 3 is reduced here to the outer ring 6 and the wedge 8 and is attached to the lens 1. The wedge 8 extends over the entire pupil opening 9, whereby in contrast to the previously considered embodiments with wedge 8 the entire imaging radiation beam passes through the wedge 8. The two partial radiation beams are formed, on the one hand, through the refraction upon exiting
- 15 the wedge 8 and through the double reflection in the wedge 8. Here both partial radiation beams are deflected by an angle offset to the optical axis. The first partial radiation beam is deflected by refraction by the wedge deflection angle $\sigma_1 = \alpha (n-1)$ and the second partial radiation beam through retraction by the mirror angle deflection $\sigma_2 = 2\alpha$. The angle α is equal to the wedges 8 of the embodiments an
- 20 angle in relation to a perpendicular to the optical axis, i.e. the input surface of the wedge 8 stands perpendicularly on the optical axis, while the output surface is inclined vis-à-vis these perpendicular by angle α .

List of the reference numbers used

	1	Lens
	2	Photographic medium
5	3	Lens adapter
	4	Camera
	5	Lens filter accessory thread
	6	Outer ring
	7	Retaining ring
10	8	Wedge
	9	Pupil opening
	10	Wedge surface
	11	Free surface
	12	Hole
15	13	Locus of the image of the first partial radiation beam
	14	Locus of the image of the second partial radiation beam
	15	Parallel plate pair
	16	Adjusting screw
	17	Self-aligning ball bearing
20	18	Gravity-type pendulum

	Angle of rotation	φ
	Angle	α
	Refractive index	n
25	Wedge deflection angle	σ_1
	Mirror angle deflection	σ_2

Patent claims

1. Procedure for photographing a vehicle, with which the vehicle is subjected to
5 a flashlight during its imaging on a photographic medium (2), characterized by,
the fact that the imaging radiation beam reflected from the vehicle causing
the image is split up into two partial radiation beams, whereby the first partial
radiation beam, with only an imperceptibly smaller light intensity than that of
10 the entire imaging radiation beam, produces a first image on which the driver
is easily recognizable, while the second partial radiation beam with a light
intensity of less than 5% produces a second image on which the license
plate is easily recognizable and that the two geometrically identical images
are produced simultaneously and offset relative to each other and stored on
15 the photographic medium (2).
2. Arrangement for photographing a vehicle with a camera (4), consisting of a
lens (1) for producing an imaging radiation beam and a photographic
medium (2) in the image plane of the lens (1) characterized by,
20 means are present in the beam path of the imaging radiation beam for
division of the imaging radiation beam into two partial radiation beams of
different intensity offset relative to each other which cause two geometrically
identical images of different intensity on the photographic medium (2) offset
to each other, whereby the first image recognizably illuminates the driver and
25 the second image the license plate.
3. Arrangement in accordance with Claim 2, characterized by,
the fact that the means are arranged in the imaging direction before the lens
(1) as a component of a lens adapter (3) in the beam path of the imaging
30 radiation beam.
4. Arrangement in accordance with Claim 2 or 3, characterized by,

the fact that the means are a pair of parallel plates (15) together including an angle (α), so that through physical beam splitting the radiation portion borne by reflection on the surfaces of the parallel plates forms the first partial radiation beam and the penetrating radiation portion the second partial radiation beam and the first partial radiation beam is deflected by an angle offset equal to the mirror angle deflection $\sigma_2 = 2\alpha$ vis-à-vis the optical axis.

5. Arrangement in accordance with Claim 3 or 4, characterized by, the fact that as the means a wedge (8) with the refractive index (n) and an angle (α) is used which projects into the imaging beam path and which via geometrical beam splitting deflects the incident radiation portion on the wedge surface (10) projecting into the image beam path as the second partial radiation beam by an angle offset equal to the wedge deflection angle $\sigma_1 = \alpha (n-1)$ and which leaves the radiation portion which does not run through the wedge surface (10) uninfluenced as the first partial radiation beam.
6. Arrangement in accordance with Claim 5, characterized by, the fact that the wedge surface (10) is capable of being moved into and out of the imaging beam path, whereby the optically effective surface of the wedge surface (10) is varied, which entails a change of the intensity of the second partial radiation beam in particular.
7. Arrangement in accordance with Claim 3 or 4, characterized by, the fact that as the means a wedge (8) with the refractive index (n) and an angle (α) is used which via physical beam splitting deflects the first partial radiation beam through refraction by an angle offset equal to the wedge deflection angle $\sigma_1 = \alpha (n-1)$ vis-à-vis the optical axis and the second partial radiation beam through reflection by an angle offset equal to the mirror angle deflection $\sigma_2 = 2\alpha$ vis-à-vis the optical axis.

8. Arrangement in accordance with Claim 2, characterized by,
the fact that an external thread is present on the side of the lens adapter (3)
toward the lens (1) by means of which the lens adapter (3) is connected with
the lens filter accessory thread (5) on the lens (1) and that on the side away
5 from the lens (1) an internal thread equal to the lens filter thread (5) is
located which provides for additional assembly of a filter.