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(54) Title: CAMERA

(57) **Abstract:** The camera of the invention comprises an optical system, with which the radiation reflected from an object to be photographed is directed to a detector, and a detector with which picture coordinates are produced from the details of the object to be photographed on the basis of the radiation directed to the detector. The camera is mainly characterized in that the detector is a one-point radiation detector with which the image to be photographed can be scanned. Preferably, the detector is first connected to an optical system, whereby the area to be photographed can be scanned by turning the optical system. The optics is directed, in other words the image area is scanned, with a swing mechanism fastened to the optical system.



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CAMERA

TECHNICAL FIELD

- 5 The invention is concerned with a camera, especially an infrared camera.

BACKGROUND ART

10 A camera comprises in principle a telescope objective, an ocular and a camera objective. Parallel light beams from a remote object meet the telescope objective and the light goes through the telescope objective after having gone through the camera objective via the ocular. The light that has reflected from the object and thereafter gone through the objectives draws an image on a film plane where it is stored on a film or cell.

15

The lenses of the objective improve the image compared to an image formed through an opening.

20 When using lenses to collect an image on a film of a camera or cell, one is faced with the problem that the image is sharp only from a given distance. A lens works in such a way that an image from a point at infinity becomes sharp at the focal length from the lens plane and closer objects will be more behind.

25 Focusing means that the place of the lens system of the camera or the focal length is changed with respect to the film in such a way that the image is sharp on the film or cell from the desired distance. In principle, the right distances could be calculated, but in practice the focusing is performed by fine-adjusting the place of the object in such a way that the image appears to be sharp from the view finder. Earlier, the photographer had to do this manually – nowadays the
30 camera can focus automatically.

Several row ends of the cell can be used as focusing points. Either the camera itself decides which point is the most suitable or the user can select the focusing point wanted. However, in cells of today, only horizontal or vertical rows can be used, wherefore the method necessarily does not find a completely parallel or
5 completely vertical contrast.

Separate detectors are used in a camera, which have to get a visual image through the optics. Generally, this is performed in such a way that the mirror of the finder is partially transparent and behind this mirror there is another mirror,
10 which leads the light to the detectors in the lower part of the camera.

There is one detector for each focusing point, consisting of vertical or horizontal units, each having two comparing rows of pixels and small lenses directing light to those. Often, the most middle focusing point consists of both a vertical and
15 horizontal unit.

The position of the lenses in the optics has to be changed completely mechanically for the real focusing. An electric motor is used in the automatic focusing, which rotates the focusing lens in turns in order to move it forward and
20 backwards.

The motor can be placed in the optics or in the camera body and the motor is steered electrically or mechanically or electromechanically.

25 Usually, the cameras measure light radiation reflected from an object. There are also infrared cameras, which work with the same principle as the image cameras but which measure infrared radiation radiating from the object (thermal radiation).

Thermal imaging is suitable for investigation of apartments/rooms of individual
30 houses, rowhouses, apartment houses and business houses or for investigation of the whole building. In addition to the above mentioned uses, infrared

photographing (thermal imaging) can for example be used to investigate moist areas in constructions, moisture damages, positions of pipe systems, conditions of electrical devices (e.g. switch yards), the condition of different parts in a heating network, position and distribution of surface temperatures, the temperature distributions of machines and devices and the condition of insulations, geological and ecological phenomena as air photography and for product development and research. Defects in the thermal insulation of buildings and heating, plumbing, ventilation and electrical installation cause energy losses and damages. The problem sites can be localized with an infrared camera without discharging the constructions. By performing an infrared photographing before reparations, information can be collected from the building on the basis of which the reparations can be directed to the real defects. Infrared photography is also suitable for the quality control of the thermal functionality of buildings. Infrared photography is a fast investigation method, with which the properties and conditions of an object and devices can be analyzed without decomposing constructions. Typical objects for infrared photographing are e.g. real estates, district heating networks, electric networks and industry maintenance.

Production stops and fires in industry cause damages of millions of dollars each year. Leakages in the pipes of real estates, moisture and mold problems are a subject of discussion every day. The comfort of living is reduced by the thermal and air leakages in constructions and they increase the energy consumption. The problems can be cleared out by means of proper infrared photography.

In infrared photography, the surface temperatures of the object to be investigated are measured with an infrared camera. The measuring results are presented as an infrared image in which the temperature distribution is shown by using different colors.

Each body sends out electromagnetic infrared radiation not seen by a human eye. An infrared camera is a "receiver" of the infrared radiation in which the

image formed by the matrix detector is coded into temperature areas. The photography results can be analyzed in many ways with a computer and the results can be reported in digital form or on paper.

- 5 The infrared cameras for sale today are very expensive, which partly prevents a common use of those as a usable means for e.g. estimation of the condition of real estates.

10 A conventional and typical infrared camera is in principle a video camera working within the infrared radiation range. However, in several applications, it would be more advantageous to get "a photograph" from the infrared radiation rather than a "video image" because of the potentially better sharpness and smaller noise of a photograph. Such very common objects are for example the investigation of heat leakages of buildings or the temperature distribution of devices and
15 electronics. In addition, a big image detector sensible for infrared radiation must be used in an infrared camera of video camera type and a special optic designed for this, both being very expensive. It is either not possible to get a very wide-angled thermal optics with any costs.

20 Furthermore, in both infrared cameras and other conventional cameras, the image has to come in the right way onto the two-dimensional plane, which has detectors beside each other. The system becomes complicated because of different wave lengths from the object, which are refracted in different ways through the lenses and therefore there have to be several lenses. Because of the
25 long wave length, the use of glass or plastic lenses (of a reasonable price) can not be used in infrared photography and therefore, especially the infrared camera has to have germanium lenses which are very expensive.

Therefore there is a need for a cheaper and simpler camera, especially an
30 infrared camera, already of cost reasons.

SUMMARY OF THE INVENTION

The camera of the invention comprises an optical system, with which the radiation reflected from an object to be photographed is collected and directed to a detector, and a detector, with which image coordinates are produced from the details of the object to be photographed on the basis of the radiation directed to the detector. The camera is mainly characterized in that the detector is a one-point radiation detector with which the area to be photographed can be scanned point by point.

The preferable embodiments of the invention have the characteristics of the sub-claims.

The detector is fastened to the optical system, whereby the area to be photographed can be scanned by turning the optical system. The optics is directed, in other words the area of the image is scanned, with a swing mechanism fastened to the optical system. The focusing required by the distance between the object to be photographed and the camera is performed by changing the distance between the detector and the optics before starting the real scanning. During the scanning, the mirror and the detector stay still with respect to each other.

In the preferable embodiment of the invention, a mirror is used as an optical system. When infrared radiation is photographed, there is almost nothing required for the quality of the surface of the mirror, because of the long wave length and the coarse focal point (10 μ m and 1mm) compared to the optic of visible light (0,5 μ m and 0,01 mm). Compared to the lens optics, the swing mechanism also enables viewing angles of completely random width/height, for example 360°.

The most important idea in the invention is the use of a one-point detector instead of a conventional matrix cell and when a mirror is used as a lens in the camera, the mirror only has to photograph one-point at a time to the one-point detector. After each point, the camera system is turned for the following point,
5 whereby the detector/mirror combination still looks at the object from the same direction angle but at a different place of it.

Because the light radiation always is reflected in the same way when meeting the mirror, independently of the wave length, the accuracy required by different wave
10 lengths in this embodiment is not a problem and the detector can be correctly read.

The dynamic resolution and the dynamic area can also be freely varied. With a good dynamic resolution, more tones appear in the picture and the difference
15 between dark and light areas is better seen. The dynamic range determines the contrasts received on the picture. The size of the mirror and the reading electronics of the measuring device, when implemented in a suitable way, enable a multiplied dynamic resolution compared to existing camera devices because the reading electronics of the matrix cell can not be freely chosen.

20 When a mirror is used as an optical system for the infrared radiation measurement according to the preferable embodiment of the invention, the long wave length is very forgiving for the surface quality, wherefore almost any metal or metallized plastics can be used. One advantage with the mirror – also with one
25 reflecting visible light – is of course that the focusing distance is possible to check by eye by watching the reflected detector from a desired focusing distance.

The limited response time of the thermal detector restricts the scanning speed of the image area. Depending on desired resolution and size of image area, the
30 photographing takes minutes or even tens of minutes. Of this reason, the method presented is suitable only for photographing static objects.

The camera does not contain a single valuable component and it can be implemented with only a minor part of the costs compared to conventional infrared cameras.

5

The resolution and dynamic of the invention enable a very high quality infrared photography by a very cost effective electronic and mechanical solution.

10 In the following, the invention is presented by means of the figure by referring to an advantageous example, which is not intended to restrict the invention, only to illustrate it.

FIGURES

15

Figure 1 is a principle view of the camera of the invention

DETAILED DESCRIPTION

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The object to be photographed is in this example assumed to be a thermal leakage possibly from a building emitting infrared radiation (marked with a dotted line in figure 1 by reference number 1). Thus, thermal radiation emits from the object to be photographed to the mirror 6 of a camera. A detail of the object is
25 imaged via the mirror 6 to a one-point detector 4. The detector 4 is at such a distance from the mirror that the beam from the detail of the object reflected from the mirror is directed to the detector 4. The mirror optics shows the detail of the object 1 on the detector and a complete photograph of the object is obtained by scanning the desired image area by moving the mirror, as in the device of the
30 invention, there is a one-point detector 4 fastened to the turnable mirror 6 instead of a normal matrix photograph cell of a camera.

Such a mechanical solution is needed for the adjustment of the focal distance between the detector 4 and the mirror 6, which enables a change of the detector distance with respect to the mirror 6.

5

The mirror 6 is moved by means of a swing mechanism which in this example consists of turning axles 3a, 3b fastened to the mirror and which are perpendicular to each other. The photographing can thus take place for example in horizontal stripes, whereby measuring data from the detector is always collected during the movement extending from edge to edge of a horizontal image. After one horizontal stripe, the following stripe is selected with a vertical movement and so on. Also an other kind of turning axle geometrics is possible, but then it is the application running in the PC or the steering units which alone are responsible for realizing the right-angled picture.

15

When the light radiation of the object meets the detector, one of the parts of the thermal pair of the detector 4 is warmed up and the detector therefore gives a voltage which is proportional to the difference between the detail of the object and the characteristic temperature of the detector. This voltage is measured with an Analog/Digital Converter (ADC) 7 and the measuring result is shown on the screen of the computer 5.

20

The steering unit 2 takes care of the electromechanical movement of the turning platform 3 of the mirror 6 and the forwarding of the A/D result of the ADC 7 of the detector 4. The computer 5 has an application containing the intelligence needed which also works as the user interface of the device.

25

The apparatus (the camera of the invention) contains a processor system in the steering unit 2.

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An absolute accuracy is not required for the movement of the mirror but the movements should preferably be reasonably repeatable and for example quit even for the part of the horizontal movement. Both step and gear DC motors are suitable, both because of the costs and properties, to carry out a good movement. The latter alternative however requires some feedback of the position (for example an incremental encoder).

The extensions of the movement areas are also dependent on application. As the method does not restrict the viewing angle so much, this feature should be made use of.

The steering unit 2 is needed in the apparatus for reading the thermal detector and for steering of the mechanical turning of the mirror. The requirement for the performance of the steering unit almost only depend on how the user interface of the apparatus is realized. The lightest integrated implementation can be achieved by transferring all intelligence and user interface elements of the apparatus to the other side of the cable (for example rs232-cable or USB etc) to the personal computer of the user. Then the only thing the steering device have to do is to forward the A/D converting results and the steering of the motors according to the instructions from the computer. In this way, the steering unit can be constructed around a very light and cheap 8-bit microprogram.

One possibility is an implementation that has a display, a memory card, for example a Compact Flash (CF) or corresponding card place in the photographing device (camera itself) for storing the photographs and necessary tangents and regulators to take the picture. The display, the memory card place and the other accessories would then be contained in a component drawn to be the steering unit in figure 1. Thus, the camera does not have to have any display if the apparatus is realized in accordance with the cheapest schedule. Then the user does not need a computer to use the apparatus.

This way of implementation increases the usability of the apparatus in some cases but increases the production costs (but only little compared to a conventional infrared camera).

- 5 The detector is a thermal radiation detector of thermal pair type for example Melexis MLX90247D. The detector gives a voltage as its output which is dependent on the temperature difference of the own output of the detector and the space seen by the detector.
- 10 It is thus clever to measure both the voltage of the thermal pair and the temperature of the detector. It is probably clever to use for example 24-bit converters for the A/D-conversion of the voltages to be measured. It is possible to achieve a very good dynamics by dimensioning the amplification level between the detector and the A/D converter in a suitable way, without however the need to
- 15 arrange a special electric zero-point regulation.

The time constant of the detector is of the order of milliseconds, so there is only needed some kilosamples/seconds for the sampling frequency. Thus, the A/D converters can be freely chosen and they can be made in a cost efficient way.

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CLAIMS

1. Camera for photographing an object, the camera comprising an optical system (6) with which the radiation (1) reflected from the object to be photographed is collected and directed to a detector (4), and a detector (4) with which image coordinates are produced from the details of the object to be photographed on the basis of the radiation directed to the detector (4), characterized in that the detector (4) is a one-point radiation detector (4) with which the area to be photographed can be scanned point by point.

2. Camera of claim 1, characterized in that the detector (4) is connected to an optical system (6), whereby the area to be photographed can be scanned by turning the optical system (6).

3. Camera of claim 2, characterized in that the optical system has a swing mechanism (3a, 3b) with which the optical system (6) can be turned.

4. Camera of any of claims 1 – 3, characterized in that a computer (5) is connected to the camera, in the memory of which the image coordinates given by the detector (4) are stored to form a picture.

5. Camera of any of claims 1 – 3, characterized in that the image coordinates produced by the detector (4) are transferred during the photographing (scanning) directly to in the memory of the computer (5) working as a user interface and steering device.

6. Camera of any of claims 1 – 5, characterized in that the optical system (6) has turning axels (3a, 3b) working as a swing mechanism, which axles are perpendicular to each other, whereby the photographing can be performed horizontally point by point and vertically point by point.

7. Camera of any of claims 1 – 6, characterized in that the optical system (6) can be electromechanically turned.

8. Camera of any of claims 1 – 7, characterized in that the
5 optical system (6) comprises a mirror.

9. Camera of any of claims 1 – 8, characterized in that the
detector (4) is a thermal radiation detector having a thermal pair, which measures
the infrared radiation reflected to that from the mirror (6) by giving a voltage that
10 is proportional to the temperature difference of the detail of the object and the
detector (4).

10. Camera of claim 9, characterized in that a voltmeter (7) is
connected to the camera, the measuring results of which is shown on the screen
15 of the computer (5) as an A/D converter result.

11. Camera of any of claims 1 – 10, characterized in that a
steering unit (2) is connected to the camera taking care of the electro-mechanical
steering of the turning platform (8) of the optical system (6) and the forwarding of
20 the A/D converter result to the computer (5) measured with an Analog/Digital
Converter (ADC) in the detector (4).

12. Camera of any of claims 1 – 11, characterized in that the
camera itself has a display, a memory card and a corresponding card place for
25 storing pictures and necessary tangents and regulators for taking a picture.

