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(54)	Benevnelse	**METHOD AND DEVICE FOR OPTICALLY MEASURING DISTANCES OVER WIDE DISTANCE RANGES**
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METHOD AND DEVICE FOR OPTICALLY MEASURING DISTANCES OVER WIDE DISTANCE RANGES

DESCRIPTION

The invention relates to a method with which the distance of objects (targets) can be measured based on the principle of pulse transit-time measurement, and to a suitable device, such as is known in generic form from WO 2008/009387.

From the prior art a multiplicity of distance-measuring devices (devices for optical distance measurement) are known, which are equipped with a pulsed laser diode and function according to the principle of pulse transit-time measurement. They are applied in such areas as military technology, logistics, industrial measurement technology and safety technology and are designed for specific distance ranges depending on the application.

To evaluate a reception signal generated from a transmitting pulse impinging on an object and a reception pulse reflected from the object, different evaluation methods are known, for example the threshold method and the sampling method.

In the threshold method, the electronic time measurement is started with the transmission of a single pulse and stopped with the reception of the reception pulse. The reception pulse is detected, and from this a so-called threshold signal is generated if the amplitude of an electric, analog reception signal generated therefrom exceeds a specified threshold. For the comparative detection with high temporal accuracy, the amplitude of the reception signal must be high enough to provide an adequate signal to noise ratio (SNR), the pulse shape of the reception signal must have a high slew rate and the threshold of the comparator must lie above the amplitudes of possible noise peaks. After the time measurement is stopped the transit time is known and the distance can be determined in the known manner by means of the speed of light. For example, in the case of transmission pulses with a pulse width of 5 ns, a pulse power of 20 W and a pulse frequency of 1 kHz, the distance measuring device is eye-safe and is suitable for ranges up to approx. 100 m (short range), wherein the measurement accuracy is about 5 cm and the measuring time for a single pulse transit time measurement is in the range of µs. In order to process the reception signal without losses in the pulse rise time, pulse amplitude and pulse width, the receiver bandwidth should correspond to the frequency spectrum of the transmitted pulse and be located at a frequency of 150 MHz.

In the sampling method, the analog reception signal is sampled and the digitized sample values are used to create a memory image, which constitutes a so-called sampling signal. The number of samples, starting with the emission of a laser pulse and ending with detection of the reception pulse, and the length of a sampling interval can be used to subsequently calculate the transit time and the distance. By accumulation, which means the repeated time-synchronous sampling and addition of associated sampling values of successive reception signals, the SNR of the accumulated memory image is considerably improved and therefore the range is considerably increased. The improvement in the SNR is proportional to the square root of the number of accumulated measurements. For example, in the case of transmission pulses with a pulse width of 50 ns, a pulse power of 2W and a pulse frequency of 1 kHz, the distance measuring device is eye-safe and is suitable for a range of up to 3000 m (long range), wherein the measurement accuracy is approximately 0.5 m and the measuring time until a viable signal to noise ratio is reached is approximately 1 s. The receiver bandwidth for processing the transmission pulses without distorting their shape is 15 MHz.

Distance measuring devices that work with laser pulses are considered as eye-safe if the laser energy that reaches the eye does not exceed the limits assigned to the emission times. This means that, assuming an equal number of transmission pulses between two pulse sequences over the same time period for an identical maximum amount of energy of an individual transmission pulse, eye safety is still provided.

With distance measuring devices in which the signal evaluation is performed with the threshold method, it is advantageous to generate a transmission pulse with a minimum possible pulse width and a maximum possible pulse power, while with distance measuring devices in which the signal evaluation is performed with the sampling method, it is advantageous to generate a transmission pulse with the longest possible pulse width, during which the analog reception signal can be sampled multiple times, and a low pulse power. If the pulse power and pulse width are specified, then by observing the criteria for eye safety a maximum pulse frequency is determined.

If the distance measuring devices are intended for applications either in the short range or in the long range, then the reception signals generated by the reception pulses are evaluated with either one or the other method. A laser pulse generator comprised by the distance measuring device is accordingly designed such that it generates transmission pulses that are advantageous for the specific method, and the bandwidth of the receiver is adjusted for the specific method.

Because no method exists which is equally suitable for evaluating the reception signals generated from pulses received from both the short range as well as the long range, the need arises to apply different measuring methods to evaluate the reception signal, namely the threshold method for the short range and the sampling method for the long range.

For example, in ship docking manoeuvres in harbours, or in a battlefield monitoring scenario, the distance can range from a few metres up to several thousand metres. Such a distance range, which at least in part comprises the short-range and long-range, will be defined in the context of the invention as a large distance range.

The problem is exacerbated if the objects to be measured can be both cooperative targets as well as non-cooperative targets, since these differ in their reflectivity by orders of magnitude.

In comparison to cooperative targets (on which retro-reflectors are installed), non-cooperative targets (the surface of the target is used as a reflector) reflect a component of the incident laser energy which is approximately 1 thousand times smaller.

Therefore, for non-cooperative targets the transition between the short and long range is at a distance of approximately 100 m, while for cooperative targets it is about 1000 m away.

In applications for a large distance measuring range, two different distance measuring devices are often operated in practice, in each of which one of the two evaluation methods is used.

From WO 2008/009387 A1 a method for opto-electronic distance measurement and a distance measuring device are known, in which both of the described evaluation methods are applied in parallel and preferably at the same time, which enables the dynamic range of a distance sensor to be comparatively extended.

In the method disclosed here, laser light (hereinafter referred to as a transmission pulse) is emitted in the direction of a target object that detects the light signal (hereinafter referred to as a reception pulse) back-scattered by the target object, and the distance to the target object is derived. To derive the distance the principles of the threshold method and the sampling method are combined, so that a reception pulse can be detected and evaluated with an extended dynamic range of the distance sensor. For identifying and determining the temporal position of the reception pulse, in parallel with the evaluation of an electrical reception signal generated from this according to the threshold method, an evaluation is performed according to the sampling method. In this case the dynamic ranges of the threshold method - lower dynamic range - hereinafter referred to as the short range, and of the sampling method - upper dynamic range - hereinafter referred to as the long range, overlap, but they can also be adjacent to each other. Therefore when detecting a reception pulse, different evaluation methods for a received signal generated thereby are used for a lower and an upper dynamic range. In the overlap region both evaluation methods are applied in parallel, in particular simultaneously, which is intended to lead to an improvement in the signal evaluation.

A distance measuring device (apparatus) for implementing this method comprises a laser transmitter for emitting laser light (hereinafter transmission pulses), a receiver for detecting a light signal (hereinafter reception pulses) back-scattered by the target object, a signal processing unit, with which from at least one reception signal generated from a reception pulse, a reception time can be derived using different methods at the same time. For this purpose, the signal processing unit is designed in such a way that from an identical reception signal, it can derive the reception time over a first channel with the threshold method and over a second channel with the sampling method, and from this can deduce the distance to the target object.

The disadvantages of this method and the device are given below:

- So that the transmission pulse can be used for both evaluation methods, a compromise has to be made. As explained, in the threshold method a laser pulse with a high pulse power is used for a long range, and one with a short rise time for a high measurement accuracy, the pulse being as short as possible so that it only has a small energy content while still guaranteeing eye safety. In the sampling method, a laser pulse with a maximum possible duration is used to obtain as many sampling points as possible for a shape-preserving memory image. The pulse power in this case must be low enough that even for a large pulse width, the pulse nevertheless only has a small energy content to ensure eye safety. In order to emphasize a reception pulse over the noise, a plurality of reception signals is sampled cumulatively in a known manner.

  These requirements for method-specific optimized reception signals are incompatible with the method and apparatus described in accordance with WO 2008/009387 A1, since for both evaluation methods the transmission pulse is an identical form-stable laser pulse with the same parameters. Both methods cannot therefore be used optimally, which in both cases gives rise to a lower measurement accuracy, smaller range and longer measuring time. For a measuring device which is designed to be eye-safe, compared to individual devices that are specifically designed for the short range and work with the threshold method, the short range is therefore limited to a shorter distance, i.e. a higher measuring accuracy, which is obtained with the threshold method in comparison to the sampling method, is limited to a smaller short range.

- The receiver must be adapted to the short, high transmission pulses when applying the threshold method, or to the long, low transmission pulses when applying the sampling method. This means that the shape-preserving transmission of the analog reception signal requires a minimum electrical bandwidth. Increasing electrical bandwidth leads to increased electrical noise. This causes deterioration of the signal-to-noise ratio of the analog reception signal, which also leads to a reduction of the measurement accuracy and range.

- The threshold method is a real-time method in which the measurement time is determined by the transit time of the laser pulse. In the sampling method, the memory image of one or even a plurality of reception signals is generated in real time, but subsequently to determine the transit time the sampled values are used to model the shape of the analog reception signal and compared with a software threshold, resulting in a much longer sampling time. If both evaluation methods are applied at the same time, the measurement time is determined by the much longer evaluation time of the sampling method.

WO 97/33182 A1 discloses an electronic distance measuring instrument, in which the distance of an object is measured first with a coarse measurement method and then with a fine measurement method. Both methods provide a rough distance value and a more accurate distance value in a range around the rough distance value.

The measurement interval for the coarse measurement method is chosen so that an emitted measuring pulse is received after reflection at an object being measured, before the next measurement pulse is sent. From the transit time a coarse estimate of the distance to the object is made. A series of fine measurements is then carried out. Since the approximate time interval for the arrival of the reflected measurement pulse is known after the coarse measurement, the fine measurement can be carried out with a much lower intensity and with 100 to 100,000 times the number of measuring pulses compared to the coarse measurement. The evaluation of the reception signals of the coarse measurement and the fine measurement can be performed with different methods.

The object of the invention is to find a method and a device with which an optical distance measurement is possible over large distance ranges with a higher accuracy, a greater range and a high degree of integration.

This object is achieved by a method for optical distance measurement over large distance ranges, in which a transmitter emits transmission pulses, which after reflection at a target are detected as reception pulses by a receiver, which generates electrical, analog signals from these, which are converted into at least one first digital reception signal, constituting a threshold signal, via a threshold method, and into at least one second digital reception signal, constituting a sampling signal, via a sampling method, and wherein reception times are derived for the threshold signals and the sampling signals are derived and used to calculate the distance of the target. The transmission pulses are first and second transmission pulses that are emitted one after the other in time. The first transmission pulses are emitted with a higher pulse power and shorter pulse width and the second transmission pulses are emitted with a lower pulse power and longer pulse width. The first transmission pulses give rise to the reception times of the threshold signals that are derived via the evaluation of the reception signals generated from reception pulses caused by these first transmission pulses, using the threshold method. The second transmission pulses give rise to the reception times of the sampling signals that are derived via the evaluation of the reception signals generated from reception pulses caused by these first transmission pulses, using the sampling method.

In order to keep the measurement and evaluation time as low as possible, the first transmission pulses emitted are those for the evaluation using the threshold method and the transmission pulses for the evaluation using the sampling method are only emitted secondly, if no reception time can be derived with the evaluation using the threshold method.

Alternatively, the second transmission pulses for the evaluation by means of the sampling method are emitted first and secondly the first transmission pulses for the evaluation using the threshold method are then sent out, if the distance determined with the evaluation method by means of the sampling method, by using a first transmission pulse in which eye safety is ensured, can be determined with the threshold method.

In order to obtain a large range and measurement accuracy, the pulse energies for the first and second transmission pulses are advantageously maximized while maintaining eye safety.

The object is achieved by a device for optical distance measurement over wide distance ranges, which is configured to carry out a method described above, said device comprising a transmitter for emitting optical transmission pulses, a receiver having a reception optics system, a photodiode, an amplifier for detecting a reception pulse which corresponds to a component of the transmission pulse reflected by a target, and generating an electric, analog reception signal, and means for converting the analog reception signal into a digital reception signal, as well as a computer and memory unit, by the fact that the means for converting the analog reception signal into a digital reception signal are formed by an ADC, which is configured such that it can be switched by means of a control signal from an ADC control unit such that it either converts the analog reception signal coming from the amplifier into a digital sampling signal by sampling at a predetermined sampling interval, when switched to sampling operation, or converts the signal into a digital threshold signal by passing the analog reception signal through a threshold value, when switched to comparator operation.

Advantageously, the transmitter is formed by a laser optics system, a pulse laser diode and a laser pulse generator, which is connected to a pulse control unit configured such that at least one of the first transmission pulses is emitted with the comparatively higher pulse power and shorter pulse width, when the ADC is switched to comparator operation and at least one of the second transmission pulses is emitted with the comparatively lower pulse power and longer pulse width, when the ADC is switched to sampling operation.

It is advantageous if the amplifier is designed in such a way that its electrical bandwidth is matched to the frequency range of the transmission pulses via an amplifier control unit.

The invention will be explained in more detail below by means of a drawing and by reference to exemplary embodiments. Shown are:

Fig. 1 a block diagram of a device for distance measurement (distance measuring device).

A method according to the invention and a device according to the invention will be explained in more detail below for a first exemplary embodiment, by reference to a block diagram of a distance measuring device.

As with all contemporary generic methods, a transmission pulse directed by a transmitter 20 onto a target 10 is reflected by the target 10 and component of the transmission pulse, attenuated by a distance-dependent amount and impinging on a receiver 30, is detected as a reception pulse, from which the distance 11 to the target 10 is indirectly derived via the reception times of the reception signals generated.

In a first exemplary embodiment of the method, the distance 11 to a non-cooperative target 10 is to be determined, in which the distance 11 is determined firstly via the sampling method and subsequently, under certain conditions, via the threshold method. A distance measuring device is also disclosed within the context of this description.

The transmitter 20 comprises a laser pulse generator 23, a pulse laser diode 22 connected thereto, and a laser optics system 21 arranged upstream in the emission direction.

The receiver 30 comprises a receiver optics system 31, a photodiode 32 arranged downstream in the irradiation direction, and an amplifier 33 connected thereto. The amplifier output is connected to an ADC 34, whose input is connected to an ADC control unit 44 and whose output is connected to a computer and memory unit 43. One input of the amplifier 33 is connected to an amplifier control unit 45.

In addition to the amplifier control unit 45, the ADC control unit 44 and the computer and memory unit 43, a pulse control unit 42 and a laser trigger 41, which are connected to inputs of the laser pulse generator 23, are present in a controller 40.

For implementing the method the laser pulse generator 23 of the transmitter 20 is initialized by a pulse control signal, which is generated in the pulse control unit 42 of the controller 40. Consequently, the pulse laser diode 22 emits a laser beam via the laser optics system 21, which beam consists of a sequence of laser pulses, for example with a pulse width of 50 ns, a pulse power of 2W, and a pulse frequency of 1 kHz. With each triggering of the laser trigger 41 a laser pulse is emitted synchronously.

The amplifier 33 is also initialized by means of the amplifier control unit 45, so that a reception pulse absorbed by the photo diode 32 via the receiver optics system 31 is received with a best possible signal to noise ratio (SNR), by virtue of the bandwidth of the amplifier 33 being matched to the frequency spectrum of the transmission pulses, which in the specific example is, e.g., 15 MHz.

In addition, by means of a control signal of the ADC control unit 44, the ADC 34 is adjusted such that it samples the incoming analog reception signal from the amplifier 33 in sampling operation with a sampling interval of 10 ns in the example case, and converts said signal into a digital reception signal (hereinafter the sampling signal) with an amplitude resolution of 8 bits. The time of the triggering of the laser trigger 41 and the consecutive sampling values within a sampling signal are stored in the computer and memory unit 43 and in this way a digital image of the analog reception signal is generated. By a repeated time-synchronous addition of sampling signals, the SNR of the accumulated sampling signal is enhanced in comparison to the SNR of a single sampling signal by a factor proportional to the root of the number of accumulated sampling signals.

In each case, after a specified number of accumulations the accumulated sampling signal is examined, and once a sufficient SNR is obtained the accumulation is terminated. The sampling signals are stored in the computer and memory unit 43 and the result of the measurement value is calculated as a distance value and the SNR of a single reception signal.

Depending on the SNR obtained and the number of accumulated sampling signals, the pulse power can be derived with which a pulse would have to be emitted at a given distance in order to generate an analog signal with the resulting reception pulse, from which additionally the distance 11 can again be determined with the threshold method.

If eye safety for the distance measuring device is ensured for such a pulse obtained in this way, the distance 11 is determined once again by means of the threshold method, leading to a higher level of accuracy of the measurement result. To achieve this, the laser pulse generator 23 is initialized by means of a pulse control signal from the pulse control unit 42 such that the pulse laser diode 22 emits a laser beam, via the laser optics system 21, which contains a single laser pulse or a sequence of laser pulses with, for example, a pulse width of 5 ns, a pulse power of 20 W and a pulse frequency of 1 kHz. With each triggering of the laser trigger 41 a laser pulse is emitted synchronously. In principle, the distance 11 can be determined based on only a single emitted laser pulse. Through the analysis of a plurality of analog reception signals, the measurement result can be verified, averaged and represented more accurately. For the sake of a simpler description it will be assumed hereafter that a sequence of laser pulses with a specified pulse frequency is emitted.

The photodiode 32 receives the reception pulse via the receiver optics system 31. For amplification with an optimal SNR, in accordance with the frequency spectrum of the now substantially shorter transmission pulses, the electrical bandwidth of the amplifier 33 is increased via the amplifier control unit 45, in the example case to 150 MHz. By means of the ADC control unit 44, the ADC 34 is switched over to comparator operation, and the sampling clock required in the sampling method with/without accumulation is switched off, so that the ADC 34 constitutes a comparator, which generates a single digital reception signal (threshold signal) by passing the analog reception signal through a threshold value. The time difference between the triggering of the laser trigger 41 and the rising edge of the threshold signal is measured by means of an electronic time measurement with a time resolution of, for example, 667 ps (distance resolution 1 cm) and the distance 11 is determined from this.

After the implementation of the sampling method, the evaluation of the content of the computer and memory unit 43 can also be used to derive further information about the measurement path (e.g. rain, fog, snowfall), which can be used for parameterizing the transmission pulse for the threshold method. Thus, for example, to allow discrimination of so-called soft targets such as fog patches, the sensitivity of the receiver 30 can be changed in real time.

If the SNR achieved using the sampling method with accumulation is not suitable for the application of the threshold method, in other words if the analog signal is located deep within the noise and for the purpose of detection would require a transmission pulse that could no longer guarantee eye safety, then the distance 11 can be determined using the sampling method alone.

In a second exemplary embodiment, the distance 11 to a non-cooperative target 10 is to be determined, in which the distance 11 is first determined via the threshold method and subsequently, under certain conditions, via the sampling method. The determination of the distance 11 via one or the other method takes place in the same way as described in the first exemplary embodiment. The advantage of the method according to the second exemplary embodiment is that if a distance 11 can be measured with the threshold method, the measuring procedure is completed more quickly. Only when no distance 11 can be determined using the threshold method is the sampling method applied. It is understood that the application of one or the other method comprises the parameterization of the transmission pulse and the adaptation of the distance measuring device as described. While the adaptation of the distance measuring device is clear from the description of the exemplary embodiments, information on the parameterization of the transmission pulse can also be obtained from the introduction to the description, where for both methods the preparation of their respective optimum transmission pulses has been described.

It will be clear to the person skilled in the art in the field of this invention that the invention is not limited to the specifics of the embodiments cited above, but rather that the present invention can be embodied in other specific forms without deviating from the scope of the invention which is specified by the enclosed patent claims.

For a distance measuring device according to the invention it is of significant advantage that a distance 11 can be determined with it using the threshold method and the sampling method in sequence, wherein the laser pulse generator 23 can be activated in such a way that it can generate optimum transmission pulses, or optimal sequences of transmission pulses, for both the one method and for the other method, the amplifier 33 is adapted in terms of its bandwidth to the frequency spectrum of the respective laser pulse, and the ADC 34 is configured in such a way that it converts an analog signal into a digital reception signal, which constitutes either a threshold signal or a sampling signal.

REFERENCE LIST

10	Target
11	Distance
20	Transmitter
21	Optics system
22	Pulsed laser diode
23	Laser pulse generator
30	Receiver
31	Receiver optics system
32	Photodiode
33	Amplifier
34	ADC = analog/digital converter
40	Controller
41	Laser trigger
42	Pulse control unit
43	Computer and memory unit
44	ADC control unit
45	Amplifier control unit

Patentkrav

1. Fremgangsmåte for optisk avstandsmåling over store avstandsområder, hvor en sender (20) sender ut sendeimpulser som, etter refleksjon fra et mål (10), detekteres som mottaksimpulser av en mottaker (30), som genererer elektriske, analoge mottakssignaler fra disse, som omdannes til minst ett første digitalt mottakssignal som danner et terskelsignal, ved hjelp av en terskelmetode, og til minst ett andre digitalt mottakssignal som danner et samplingssignal, ved hjelp av en samplingsmetode, og hvor mottakstidspunkter avledes for terskelsignalene og sampingssignalene og anvendes for å beregne avstanden til målet (10),

karakterisert ved at

sendeimpulsene er første og andre sendeimpulser, som sendes ut etter hverandre i tid, hvor de første sendeimpulsene sendes ut med en høyere impulseffekt og en kortere impulsbredde og anvendes for å avlede mottakstidspunktene for terskelsignalene, og de andre sendeimpulsene sendes ut med en lavere impulseffekt og en lengre impulsbredde og anvendes for å avlede mottakstidspunktene for samplingssignalene, hvor, for å holde måle- og evalueringstiden nede, de første sendeimpulsene sendes ut først for evaluering ved hjelp av terskelmetoden og de andre sendeimpulsene deretter sendes ut for evaluering ved hjelp av samplingsmetoden, men bare dersom et mottakstidspunkt ikke kan avledes fra evalueringen ved hjelp av terskelmetoden.

2. Fremgangsmåte for optisk avstandsmåling over store avstandsområder, hvor en sender (20) sender ut sendeimpulser som, etter refleksjon fra et mål (10), detekteres som mottaksimpulser av en mottaker (30), som genererer elektriske, analoge mottakssignaler fra disse, som omdannes til minst ett første digitalt mottakssignal som danner et terskelsignal, ved hjelp av en terskelmetode, og til minst ett andre digitalt mottakssignal som danner et samplingssignal, ved hjelp av en samplingsmetode, og hvor mottakstidspunkter avledes for terskelsignalene og samplingssignalene og anvendes for å beregne avstanden til målet (10),

karakterisert ved at

sendeimpulsene er første og andre sendeimpulser, som sendes ut etter hverandre i tid, hvor de første sendeimpulsene sendes ut med en høyere impulseffekt og en kortere impulsbredde og anvendes for å avlede mottakstidspunktene for terskelsignalene, og de andre sendeimpulsene sendes ut med en lavere impulseffekt og en lengre impulsbredde og anvendes for å avlede mottakstidspunktene for samplingssignalene, hvor de andre sendeimpulsene sendes ut først for evaluering ved hjelp av samplingsmetoden og de første sendeimpulsene deretter sendes ut for evaluering ved hjelp av terskelmetoden, men bare dersom avstanden bestemt med bruk av evalueringen ved hjelp av samplingsmetoden kan bestemmes ved hjelp av terskelmetoden med bruk av en første sendeimpuls for hvilken øyebeskyttelse av anordningen er sikret.

3. Fremgangsmåte ifølge krav 1 eller 2, **karakterisert ved at** impulsenergiene for de første og andre sendeimpulsene maksimeres, dersom øyebeskyttelse er sikret, for å oppnå lang rekkevidde og høy målenøyaktighet når henholdsvis terskelmetoden og samplingsmetoden anvendes.

4. Anordning for optisk avstandsmåling over store avstandsområder, som er innrettet for å utføre en fremgangsmåte ifølge krav 1 eller 2, hvor anordningen omfatter en sender (20), en mottaker (30) omfattende et mottakeroptikksystem (31), en fotodiode (32), en forsterker (33) for å detektere en mottaksimpuls som svarer til en andel av sendeimpulsen reflektert av et mål (10), og generere et elektrisk, analogt mottakssignal, og midler for å omdanne det analoge mottakssignalet til et digitalt mottakssignal, samt en datamaskin- og hukommelsesenhet (43), hvor senderen (20) er innrettet for å sende ut første og andre sendeimpulser etter hverandre i tid, hvor de første sendeimpulsene har en relativt høyere impulseffekt og kortere impulsbredde og de andre sendeimpulsene har en relativt lavere impulseffekt og lengre impulsbredde, og hvor midlene for å omdanne det analoge mottakssignalet til et digitalt mottakssignal er dannet av en ADC (34) som er innrettet slik at den kan omstilles ved hjelp av et styresignal fra en ADC-styring (44) slik at den enten omdanner det analoge mottakssignalet som kommer fra forsterkeren (33) til et digitalt samplingssignal ved å sample med et forbestemt samlingsintervall, når den er satt i samplingsmodus, eller omdanner

signalet til et digitalt terskelsignal ved å sende det analoge mottakssignalet gjennom en terskelverdi, når den er satt i komparatormodus.

5. Anordning ifølge krav 4, **karakterisert ved at** senderen (20) er dannet av et laseroptikksystem (21), en impulslaserdiode (22) og en laserimpulsgenerator (23), som er forbundet med en impulsstyring (42) innrettet slik at minst én av de første sendeimpulsene blir utsendt med den relativt høyere impulseffekten og kortere impulsbredden, når ADC (34) er satt i komparatormodus, og minst én av de andre sendeimpulsene blir utsendt med den relativt lavere impulseffekten og lengre impulsbredden, når ADC (34) er satt i samplingsmodus.

6. Anordning ifølge krav 5, **karakterisert ved at** forsterkeren (33) er innrettet slik at dens elektriske båndbredde tilpasses til sendeimpulsenes frekvensspekter av forsterkerstyringen (45).

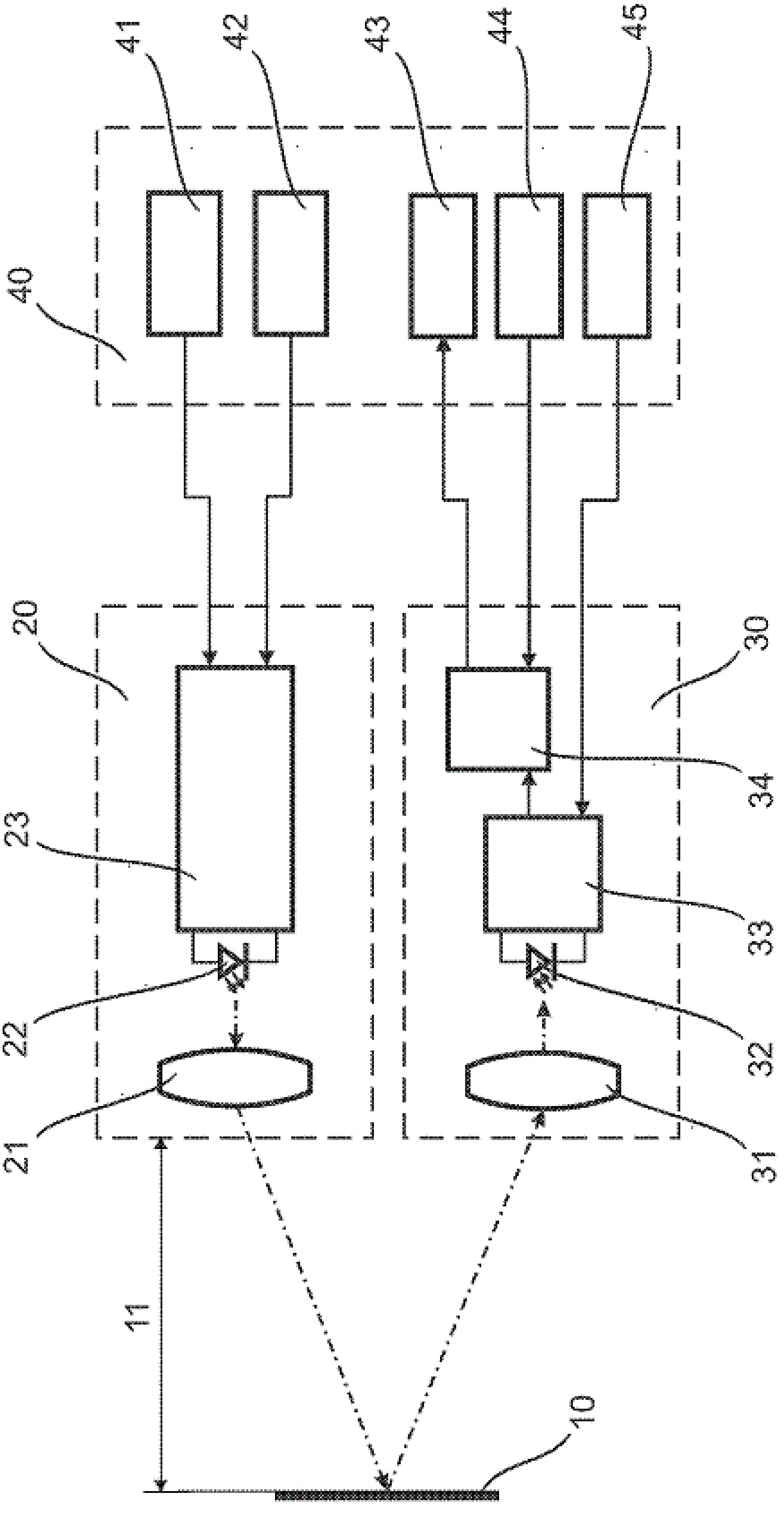

Fig. 1