

Description

The invention relates to a grating objective comprising a first and a second diffraction grating which are arranged one behind the other in the radiation path extending from the object side to the image side, the gratings being adapted and arranged in such a way that a beam ray which is an axial ray or a border ray for one grating is a border ray or an axial ray, respectively, for the other grating. The invention also relates to an optical scanning device comprising said grating objective.

A grating objective of the type described above is known from the article "Wavelength independent grating lens system" in "Applied Optics", Vol. 28, no. 4, 1989, pages 682-686. As compared with conventional objective lenses, objectives in the form of gratings or holograms have the advantage that they are smaller and lighter and can be more easily mass-produced by means of known replica techniques. The drawback of a grating used as a lens is that it has a greater wavelength dependence than a conventional lens. At a small variation of the wavelength of the beam, the angle at which the beam portions are diffracted changes, which results in image aberrations.

To reduce the wavelength dependence, said article in "Applied Optics", 1989, pages 682-6 proposes to compose a grating lens from two gratings which are arranged one behind the other. The gratings are adapted in such a way that each ray of the beam is diffracted by the second grating at a second angle which is opposed to a first angle at which this ray is diffracted by the first grating. Consequently, the deviation of the first diffraction angle, caused by a wavelength variation, is compensated by an opposite deviation of the second diffraction angle.

The grating lens described in said article in "Applied Optics", 1989, pages 682-6 is sufficiently achromatic, or wavelength-invariant, but this grating has a very small image field, for example, with a diameter of the order of 1 μm . Consequently, this lens is not suitable for certain applications. One of these applications is its use as an objective in a device for scanning an information plane in an optical record carrier. This objective must focus a radiation beam from a radiation source, for example a diode laser such as an AlGaAs laser, to a diffraction-limited radiation spot on an information track in the information plane. This objective must have a relatively large diffraction-limited image field, with a diameter of the order of 100 μm , or a field angle of the order of 1°. The larger image field is necessary so that the scanning device can be adjusted during its assembly, i.e. to enable the various components to be positioned satisfactorily with respect to each other and to enable the scanning beam to be tilted with respect to the objective during use of the device so that the scanning spot position can be corrected with respect to a track pattern to be scanned in the information plane. As already noted in said article in "Applied Optics", 1989, pages 682-6, the objective described in this article produces a beam having a non-uniform, i.e.

a Gaussian intensity distribution.

The present invention provides a grating objective which is sufficiently achromatic, has a sufficiently large image field and produces a beam with a satisfactorily uniform intensity distribution. This grating objective is characterized by at least a third grating arranged in the radiation path formed by the first and the second grating, so that the axial ray and border ray of a beam traversing the grating objective are interchanged at least two times, and in that for each ray the sum of the sines of the angles at which said ray is diffracted by the successive gratings is substantially equal to zero.

With the third grating, and possibly subsequent gratings, optical aberrations such as spherical aberrations and coma occurring in the case of larger image fields in a grating objective with two gratings can be compensated, thus obtaining a relatively large diffraction-limited image field. Moreover, the three or more gratings are adapted in such a way that for each ray of the beam the sum of the angles at which said ray is diffracted by the successive gratings is substantially equal to zero so that also a variation of this sum caused by a wavelength variation is negligible. Due to the fact that the border ray and the axial ray are interchanged at least two times, it is achieved that the intensity distribution is sufficiently uniform.

In principle, the grating objective need only comprise one additional grating, or only a third grating, to comply with the above-mentioned requirements: sufficiently corrected, sufficiently large image field and uniform intensity distribution. A fourth grating can be added to such a grating objective so as to correct for residual errors of the three other gratings. If the specifications which the objective must satisfy are such that more stringent requirements must be imposed on the gratings, with the result that these are more difficult to realise in practice, a fifth grating and possibly further gratings can be used to facilitate the manufacture of all the gratings.

It is to be noted that European Patent Application 0268357 discloses a number of read units for an optical record carrier in which a third grating is used in addition to a grating pair constituting a grating objective for forming a scanning spot on a record carrier. In all these embodiments the grating objective comprises only two gratings and the third grating performs an other function, like concentrating radiation reflected by the record carrier on an annular photodiode arranged around the radiation source, or splitting the beam reflected by the record carrier into two subbeams which are directed towards separate detectors, or collimating the scanning beam.

The grating objective according to the invention may be further characterized in that all gratings are transmission gratings.

However, a grating objective according to the invention, comprising a transparent plane-parallel plate having a first surface at the object side and a second surface at the image side and an optical axis perpendicular to the first and second surfaces, is preferably characterized

in that the first surface has a radiation window surrounding the optical axis, in that a first grating is reflecting and is arranged on the second surface around the optical axis, in that a second grating is reflecting and is arranged around the radiation window on the first surface and in that a third grating is radiation-transmissive and is arranged on the second surface around the first grating.

This grating objective is extremely compact and very suitable for use in small and light-weight devices for playing optical record carriers.

In the current optical scanning devices a semiconductor laser is generally used as a radiation source, which laser has a rectangular exit aperture and emits a beam whose aperture angle in a plane through the beam axis and perpendicular to the transition layer. The laser beam then has an elliptical cross-section instead of a circular-symmetrical cross-section. To be able to focus such a beam to a scanning spot having the desired circular shape, a first, or capturing lens, for example, a collimator lens may be used in the optical system, which lens has such a small numerical aperture that it is exactly filled by the beam in the direction of the minor axis of the ellips of the beam cross-section. In the other direction this lens only accepts a small portion of the radiation energy. It is true that the beam emerging from the capturing lens has a circular-symmetrical beam cross-section, but a much lower intensity than the beam emitted by the diode laser. This radiation loss is particularly objectionable if the scanning device is intended for writing information for which a higher radiation intensity is required than for reading information. The same problem may occur in, for example, optical printers in which one or more diode lasers are used as a radiation source.

It is known to use a beam shaper in the form of a system of prisms, instead of a limiting aperture so as to reshape a beam having an elliptic cross-section to a beam having a circular cross-section. Due to the stringent requirements which must be imposed on a prism of such a system, such a prism is expensive. Moreover, a plurality of prisms in succession are used in practice, which makes the system large and heavy.

In accordance with the present invention the grating objective and a beam shaper may be combined so that a grating objective with a built-in beam shaper is obtained. Such a grating objective is characterized in that it comprises two-dimensional gratings each having grating periods which are different in two mutually perpendicular directions.

Another object of the invention is to provide a scanning device for optically scanning an information plane, which device comprises a radiation source supplying a scanning beam and an objective system for focusing the scanning beam to a scanning spot in the information plane, which device is small and light and has a relatively large image field and is largely independent of wavelength variations. This device is characterized in that the objective system is constituted by a grating objective as described hereinbefore.

Scanning an information plane is understood to mean both scanning for reading a prerecorded information plane and scanning for writing information in this plane by means of a radiation beam whose intensity is modulated in accordance with the information to be written. In the case of writing a magneto-optical record carrier, the radiation beam may also have a constant intensity and the magnetic field may be modulated in accordance with this information to be written. The information plane may be a plane of an optical record carrier, but also a surface or a face of an object to be tested, the scanning device then forming part of, for example, a microscope.

Finally, the invention has for its object to provide a scanning device comprising a radiation source which produces a scanning beam with an elliptical cross-section, a beam shaper for reshaping the elliptical beam cross-section into a circular beam cross-section and an objective system for focusing the scanning beam to a scanning spot in the information plane, which device produces a scanning spot with a relatively large intensity. This device may be characterized by a grating objective comprising a built-in beam shaper as described hereinbefore.

Embodiments of the invention will now be described in greater detail, by way of example, with reference to the accompanying drawings in which

Figs. 1 and 2 show two embodiments of an optical scanning device according to the invention,

Fig. 3 shows an embodiment of such a device with a grating objective composed of transmission gratings,

Fig. 4 shows a diode laser which emits a beam having an asymmetrical cross-section,

Fig. 5 shows a beam shaper for reshaping this beam into a beam having a circular-symmetrical cross-section,

Fig. 6 is a cross-sectional view of an integrated optical read unit comprising a diode laser, a grating objective and a photo diode.

Fig. 1 shows in a cross-sectional view, a part of an optical record carrier 10 having a reflecting information plane 11. A scanning device comprising a grating objective 30 and a radiation source 40 is arranged proximate to the record carrier. The radiation source 40 emits a scanning beam 20 which is focused to a scanning spot 41 in the information plane 11 by the grating objective 30. The entire information plane can be covered by the scanning spot because the scanning device and the record carrier can be moved with respect to each other, for example, because the record carrier can rotate about a shaft (not shown) perpendicularly to the plane of the record carrier, while the scanning device can be moved radially with respect to the same shaft.

The grating objective 30 is formed by a transparent plane-parallel plate 31 having a first surface 32 facing the radiation source 40 and a second surface 33 at the

side of the record carrier. The first surface has a radiation window 34 located centrally around the optical axis AA', through which window the beam 20 enters. The Figure only shows half this beam, limited by an axial ray 22 and a border ray 21.

The beam traverses the plate 31 and is incident on a first reflecting diffraction grating 35 having a circular-symmetrical pattern of grating grooves. The parameters of this grating, such as the grating period, the ratio between the width of the grating strips and those of the intermediate strips, the depth and the shape of the grating grooves, may be chosen to be such that the radiation is predominantly reflected in one diffraction order, for example, the -1 order. The grating 35 and the subsequent gratings 36 and 37 may have varying grating periods.

Due to the different angles at which the border ray 21 and the axial ray 22 are incident on the grating 35 and due to the possibly varying grating period, these rays are diffracted by the grating 35 at different angles and directed as rays 21₁ and 22₁ to a second grating 36 which is also reflecting and surrounds the window 34. The ray 21₁ is incident on the inner edge of the grating 36 so that this ray is, as it were, an axial ray for the annular grating 36. The ray 22₁ is incident on the outer edge of the grating 36 and is a border ray for this grating. The grating 36 is also formed in such a way that it reflects the radiation mainly in one order, for example, the +1 order. The rays 21₂ and 22₂ reflected by the grating 36 are incident on a third transmissive grating 37 which is annular and surrounds the first grating 35. The ray 21₂ is incident on the outer edge of the grating 37 and the ray 22₂ is incident on the inner edge of this grating so that, passing from the grating 36 to the grating 37, the axial ray and the border ray are interchanged again. The grating 37 diffracts the radiation for the greater part in one order, for example, the -1 order again, so that the rays 21₃ and 22₃ and the intermediate rays are directed towards the optical axis AA' where they meet one another at 41.

The beam half which is not shown traverses an analogous path through the grating objective and its rays also meet at 41.

The grating system 35, 36 and 37 in Fig. 1 is formed in such a way that for each ray of a beam traversing the system the sum of the sines of the diffraction angles, taking the sign of these angles into account, is approximately zero. Then the sum of the deviations of these diffraction angles due to a wavelength variation will also be substantially zero, thus rendering the total grating system independent of the wavelength.

Aberrations which occur in the case of a larger image field in the two-grating system can be corrected by extending a two-grating system to a three-grating system as is shown in Fig. 1. In this case the Abbe sine condition known from the optical handbooks is also satisfied, so that the image field is sufficiently large. This sine condition implies that for a satisfactory image at some distance y' from the axis of an optical imaging system it must hold that: $y \sin \alpha = y' \sin \alpha'$, in which α and α' are the aperture

angles of the imaging beam at the object side and the image side, respectively, and y is the distance between a point to be imaged and the optical axis.

When using a grating objective, the effect occurs that the central beam portion is spread by the first grating over a relatively large annular region on the second grating, while the border portion of the beam is concentrated in a small circular region on the second grating. In a two-grating system the second grating does not interchange the central beam portion and the border beam portion so that the emerging beam does not have a uniform intensity distribution. In the grating system according to Fig. 1, using three gratings, said effect is eliminated, due to the extra interchange of the central beam portion and the border beam portion, so that a satisfactorily uniform intensity distribution is obtained.

The grating objective according to Fig. 1 can be extended with further gratings if it might appear under circumstances that the gratings are difficult to realise due to the stringent requirements which must be imposed on them. When using a plurality of gratings, the requirements imposed on the separate gratings may be less stringent, which will simplify the manufacture of these gratings. For example, a fourth grating may be arranged behind the grating objective of Fig. 1. It is alternatively possible to replace the grating 37 by a reflecting grating and to arrange a fourth reflecting and annular grating around the grating 36. The fourth grating then reflects the radiation issuing from the grating 37 to the point 41. A fifth grating which is radiation-transmissive and annular may then also be arranged around the grating 37. Under certain circumstances it may be desirable that the border ray and the axial ray are interchanged five times or a larger odd number of times. Since the extra added fourth, fifth, etc. gratings are considerably weaker than the first three gratings, the number of interchanges may often be an even number in practice.

The gratings are preferably phase gratings because they have a higher efficiency than amplitude gratings. The phase gratings may be profile gratings comprising grating grooves alternating with intermediate strips. It is alternatively possible for the phase gratings to be so-called volume gratings which are formed by a layer composed of strips alternately having a first and a second refractive index.

The gratings may also be formed in such a way that the radiation is mainly diffracted in the second orders or even higher orders instead of in the first orders as described with reference to Fig. 1. With the grating period remaining the same, the diffraction angles can be enlarged then or, with the diffraction angles remaining the same, the grating periods can be increased then.

When scanning a reflecting information surface provided, for example, on the optically readable digital audio discs known under the name of "Compact Disc", the beam reflected in the spot 41 is captured by the grating objective and traverses the reverse path therein towards the radiation window 34. The reflected beam may enter

the radiation source and when using a semiconductor laser as a radiation source, it may be detected by this laser. This so-called feedback read-out is described, for example in British Patent Specification no. 1,584,664. However, the common radiation path of the emitted and reflected radiation beams preferably accommodates a beam-separating element, for example, a splitting cube 50 by which a portion of the reflected radiation is separated from the scanning beam 20 and is projected on a radiation-sensitive detection system 60. Since the radiation reflected in the information plane 11 is modulated with the information stored in said information plane and scanned by the radiation spot, the system 60 converts the information flux into an electric signal which is suitable for further processing.

The beam separation may not only be effected by means of a separate element but also by the objective itself, if a coupling-out diffraction grating 38, as shown in Fig. 2 is arranged on the entrance and exit window 34.

This diffraction grating is, for example, a diffraction grating having straight grating strips. This grating splits a beam incident thereon into a non-diffracted zero-order sub-beam and into two diffracted sub-beams of the plus first order and the minus first order and a plurality of sub-beams diffracted in higher orders. The grating parameters, such as the ratio between the width of the grating strips and that of the intermediate grating strips, and in the case of a phase grating, the shape and the depth of the grating grooves may be chosen to be such that the intensity product of the zero-order sub-beam formed upon the first passage through the grating 38 and a first-order sub-beam formed upon the second passage through the grating is maximum. It may be ensured that the first-order sub-beams formed upon the first passage through the grating 38 are diffracted through such an angle that the radiation of these beams, after reflection by the information plane 11, does not reach the detection system 60.

The coupling-out grating 38 may consist of two grating portions which are distinguished from each other in that they have different grating periods, or different directions of the grating lines, as described in US Patent 4,665,310. The beam returning through the grating objective is then split into two sub-beams. If these sub-beams are incident on two detector pairs, a focus-error signal and possibly a tracking error signal can be generated. It is alternatively possible for the coupling-out grating 38 to be formed in such a way that it renders the returning beam astigmatic. With such a beam, in combination with a detector in the form of a four-quadrant cell, a focus-error signal can also be generated as described in US Patent 4,023,033.

Although the reflection-grating objective according to Figs. 1 and 2 is preferred because of its compactness, the grating objective may also be formed with transmission gratings, for example, with three transmission gratings, as is shown in Fig. 3.

In this objective the axial ray 22 is diffracted out-

wards by the grating 35 so as to reach the grating 36 as border ray 22₁. This border ray is diffracted inwards by the grating 36 so as to reach the grating 37 as axial ray 22₂. The grating 37 diffracts the ray once more so that it continues as ray 22₃ along the optical axis to the point 41. The border ray 21 is diffracted inwards by the grating 35, subsequently diffracted outwards by the grating 36 and finally diffracted inwards again by the grating 37 towards the point 41.

In modern scanning devices for optical record carriers, but also in, for example, laser printers, a diode laser, for example an AlGaAs diode laser is preferably used as a radiation source. Fig. 4 shows such a laser 40 in a perspective view. This laser comprises a plurality of p and n-type semiconductor layers, inter alia, a so-called active layer 43, in which laser radiation is generated if an electric current I of sufficient power is passed through the diode laser in a direction transverse to the layers. The laser radiation emerges from the active layer at the front side, or front facet, 44, while the principal axis 23 of the laser beam is parallel to this layer. The radiation-emitting surface 45 of the diode laser is rectangular, with the dimension in the direction parallel to the active layer, the so-called lateral direction, being larger than the dimension in the direction transverse to the active layer, the so-called transversal direction. Furthermore, the aperture angle α of the laser beam in the lateral plane is smaller than the aperture angle β in the transversal plane. This beam therefore has an elliptic cross-section.

In view of the desired high information density in optical record carriers, the scanning spot formed in the information plane must be circular, must have a minimum diameter and must be diffraction-limited. Such a spot can only be obtained if the beam entering the objective has a circular cross-section with such a diameter that the pupil of the objective is filled satisfactorily. Also for a laser printer it is desirable that the radiation spot formed on the recording medium is circular. For obtaining a diode laser beam with a circular cross-section a so-called beam shaper must be arranged in the path of this beam.

Such a beam shaper may comprise diffraction gratings whereby, for example, three one-dimensional gratings are used. The operation of the beam shaper is substantially not influenced by wavelength variations of the laser beam 20. Fig. 5a shows a cross-section of such a beam shaper 70 in a plane perpendicular to the grating lines, while Fig. 5b shows the same beam shaper in a plan view. The grating lines extend in the Z-direction, i.e. perpendicularly to the plane of the drawing in Fig. 5a, and parallel to the plane of the drawing in Fig. 5b and parallel to the lateral plane of the diode laser of Fig. 4.

As is shown in Fig. 5a, the desired widening is obtained in that the axial rays 26 of the beam halves of the incident beam 20 are diffracted away from the axis by the first grating 71. The second grating 72 diffracts these rays towards the optical axis while the third grating 73 gives them the desired direction. The border rays 24 and 25 are firstly diffracted by the grating 71 towards the op-

tical axis and subsequently diffracted away from the optical axis by the grating 72 so as to be finally diffracted in the desired direction by the grating 73.

When the beam traverses the beam shaper, the width of the beam is enlarged in the lateral, or X-Y plane (Fig. 5a) so that this width becomes equal to the width in the transversal, or Y-Z plane (Fig. 5b), which latter width does not change when the beam traverses the beam shaper.

A scanning device comprising a diode laser may be further miniaturised if according to the invention the beam shaper is built in the grating objective. This can be realised by rendering the optical power of the gratings, represented by the diffraction angles, to be different in the mutually perpendicular directions X and Y. These gratings are then no longer rotationally symmetrical but have different grating periods in the X and Y directions, resulting in different diffraction angles in these directions. The gratings of the grating objective with a built-in beam shaper can be considered as superpositions of the gratings 35, 36 and 37 of the grating objective 30 according to Figs. 1 and 2 on the gratings 71, 72 and 73 of Figs. 5a and 5b. In general it is also possible to superpose other gratings on the gratings 35, 36 and 37 of Figs. 1 and 2, such as coupling-out grating, a beam-splitting grating, a grating introducing astigmatism, etc.

Furthermore, the diffraction elements of the grating objective may alternatively be constituted by hologram gratings instead of by gratings in the narrower sense of the word. These hologram gratings are gratings made by means of holographic methods or gratings generated by means of a computer. The concept of grating should thus be understood in a wide sense and comprises all these variants.

Due to the compactness of notably the reflection grating objective of Figs. 1 and 2 it is possible to integrate this objective 30 together with the diode laser 40 and the radiation-sensitive detection system 60 in one housing. Fig. 6 shows such an integrated optical read unit in a cross-section. The grating objective 30 with the gratings 35, 36 and 37 and the coupling-out and beam-splitting grating 38 are arranged in a holder 80 which also forms part of the housing. This housing is closed at its lower side by a base plate 81. A cooling block 82 is arranged on this base plate, to which block both the diode laser 40 and the radiation-sensitive detection system in the form of a composite photodiode 60 are secured. The elements 83 are some of the input and output pins for supplying the energising current to the diode laser and for deriving the signals from the photodiode.

Claims

1. A grating objective (30) comprising a first and a second diffraction grating (35, 36) which are arranged one behind the other in the radiation path extending from the object side to the image side, the gratings

being adapted and arranged in such a way that a beam ray (21, 22) which is an axial ray or a border ray for one grating is a border ray or an axial ray, respectively, for the other grating, characterized by at least a third grating (37) arranged in the radiation path formed by the first and the second grating (35, 36), so that the axial ray (22) and the border (21) of a beam traversing the grating objective (30) are interchanged at least two times, and in that for each ray the sum of the sines of the angles at which said ray is diffracted by the successive gratings is substantially equal to zero.

2. A grating objective as claimed in Claim 1, characterized in that all gratings (35, 36, 37) are transmission gratings.
3. A grating objective as claimed in Claim 1, comprising a transparent plane-parallel plate (31) having a first surface (32) at the object side and a second surface (33) at the image side and an optical axis (AA') perpendicular to the first and second surfaces, characterized in that the first surface (32) has a radiation window (34) surrounding the optical axis, in that a first grating (35) is reflecting and is arranged on the second surface (33) around the optical axis (AA'), in that a second grating (36) is reflecting and is arranged around the radiation window (34) on the first surface (32) and in that a third grating (37) is radiation-transmissive and is arranged on the second surface (33) around the first grating (35).
4. A grating objective as claimed in Claim 1, 2 or 3, comprising a built-in beam shaper, characterized in that it comprises two-dimensional gratings (35, 36, 37) each having grating periods which are different in two mutually perpendicular directions.
5. A device for optically scanning an information plane, which device comprises a radiation source (40) supplying a scanning beam (20) and an objective system (30) for focusing the scanning beam to a radiation spot (41) in the information plane (11), characterized in that the objective system is constituted by a grating objective (30) as claimed in Claim 1, 2 or 3.
6. A device for optically scanning an information plane, which device comprises a radiation source (40) supplying a scanning beam (20) having an elliptic cross-section, a beam shaper for reshaping the elliptic beam cross-section to a circular cross-section and an objective system for focusing the scanning beam to a scanning spot in the information plane, characterized by a grating objective (30) comprising a built-in beam shaper as claimed in Claim 4.
7. A device as claimed in Claim 5 or 6, characterized in that an entrance window (34) of the grating objec-

tical axis and subsequently diffracted away from the optical axis by the grating 72 so as to be finally diffracted in the desired direction by the grating 73.

When the beam traverses the beam shaper, the width of the beam is enlarged in the lateral, or X-Y plane (Fig. 5a) so that this width becomes equal to the width in the transversal, or Y-Z plane (Fig. 5b), which latter width does not change when the beam traverses the beam shaper.

A scanning device comprising a diode laser may be further miniaturised if according to the invention the beam shaper is built in the grating objective. This can be realised by rendering the optical power of the gratings, represented by the diffraction angles, to be different in the mutually perpendicular directions X and Y. These gratings are then no longer rotationally symmetrical but have different grating periods in the X and Y directions, resulting in different diffraction angles in these directions. The gratings of the grating objective with a built-in beam shaper can be considered as superpositions of the gratings 35, 36 and 37 of the grating objective 30 according to Figs. 1 and 2 on the gratings 71, 72 and 73 of Figs. 5a and 5b. In general it is also possible to superpose other gratings on the gratings 35, 36 and 37 of Figs. 1 and 2, such as coupling-out grating, a beam-splitting grating, a grating introducing astigmatism, etc.

Furthermore, the diffraction elements of the grating objective may alternatively be constituted by hologram gratings instead of by gratings in the narrower sense of the word. These hologram gratings are gratings made by means of holographic methods or gratings generated by means of a computer. The concept of grating should thus be understood in a wide sense and comprises all these variants.

Due to the compactness of notably the reflection grating objective of Figs. 1 and 2 it is possible to integrate this objective 30 together with the diode laser 40 and the radiation-sensitive detection system 60 in one housing. Fig. 6 shows such an integrated optical read unit in a cross-section. The grating objective 30 with the gratings 35, 36 and 37 and the coupling-out and beam-splitting grating 38 are arranged in a holder 80 which also forms part of the housing. This housing is closed at its lower side by a base plate 81. A cooling block 82 is arranged on this base plate, to which block both the diode laser 40 and the radiation-sensitive detection system in the form of a composite photodiode 60 are secured. The elements 83 are some of the input and output pins for supplying the energising current to the diode laser and for deriving the signals from the photodiode.

Claims

1. A grating objective (30) comprising a first and a second diffraction grating (35, 36) which are arranged one behind the other in the radiation path extending from the object side to the image side, the gratings

being adapted and arranged in such a way that a beam ray (21, 22) which is an axial ray or a border ray for one grating is a border ray or an axial ray, respectively, for the other grating, characterized by at least a third grating (37) arranged in the radiation path formed by the first and the second grating (35, 36), so that the axial ray (22) and the border (21) of a beam traversing the grating objective (30) are interchanged at least two times, and in that for each ray the sum of the sines of the angles at which said ray is diffracted by the successive gratings is substantially equal to zero.

2. A grating objective as claimed in Claim 1, characterized in that all gratings (35, 36, 37) are transmission gratings.
3. A grating objective as claimed in Claim 1, comprising a transparent plane-parallel plate (31) having a first surface (32) at the object side and a second surface (33) at the image side and an optical axis (AA') perpendicular to the first and second surfaces, characterized in that the first surface (32) has a radiation window (34) surrounding the optical axis, in that a first grating (35) is reflecting and is arranged on the second surface (33) around the optical axis (AA'), in that a second grating (36) is reflecting and is arranged around the radiation window (34) on the first surface (32) and in that a third grating (37) is radiation-transmissive and is arranged on the second surface (33) around the first grating (35).
4. A grating objective as claimed in Claim 1, 2 or 3, comprising a built-in beam shaper, characterized in that it comprises two-dimensional gratings (35, 36, 37) each having grating periods which are different in two mutually perpendicular directions.
5. A device for optically scanning an information plane, which device comprises a radiation source (40) supplying a scanning beam (20) and an objective system (30) for focusing the scanning beam to a radiation spot (41) in the information plane (11), characterized in that the objective system is constituted by a grating objective (30) as claimed in Claim 1, 2 or 3.
6. A device for optically scanning an information plane, which device comprises a radiation source (40) supplying a scanning beam (20) having an elliptic cross-section, a beam shaper for reshaping the elliptic beam cross-section to a circular cross-section and an objective system for focusing the scanning beam to a scanning spot in the information plane, characterized by a grating objective (30) comprising a built-in beam shaper as claimed in Claim 4.
7. A device as claimed in Claim 5 or 6, characterized in that an entrance window (34) of the grating objec-



tive (30) is provided with a coupling-out grating (38) for diverting radiation (20) returning through the objective from the path of the source radiation beam (20).

8. A device as claimed in Claim 5, 6 or 7, characterized in that the grating objective (30) and the radiation sensitive detection system (60) are arranged in the housing (80) of the radiation source (40).

Patentansprüche

1. Gitterobjektiv (30) mit einem ersten und einem zweiten Beugungsgitter (35, 36), die hintereinander im von der Objektseite zur Bildseite verlaufenden Strahlungsweg angeordnet sind, wobei die Gitter so eingerichtet und angeordnet sind, daß ein Strahl (21, 22) eines Strahlenbündels, der ein Axialstrahl oder ein Randstrahl für eines der Gitter ist, für das andere Gitter ein Randstrahl bzw. ein Axialstrahl ist, gekennzeichnet durch mindestens ein in dem von dem ersten und dem zweiten Gitter (35, 36) gebildeten Strahlungsweg so angeordnetes drittes Gitter (37), daß der Axialstrahl (22) und der Randstrahl (21) eines das Gitterobjektiv (30) durchlaufenden Strahlenbündels mindestens zweimal ausgetauscht werden, und daß für jeden Strahl die Summe der Sinusse der Winkel, bei denen der genannte Strahl von den aufeinanderfolgenden Gittern gebeugt wird, nahezu gleich null ist.
2. Gitterobjektiv nach Anspruch 1, dadurch gekennzeichnet, daß alle Gitter (35, 36, 37) Transmissionsgitter sind.
3. Gitterobjektiv nach Anspruch 1, mit einer durchsichtigen planparallelen Platte (31), die eine erste Oberfläche (32) an der Objektseite und eine zweite Oberfläche (33) an der Bildseite und eine optische Achse (AA') senkrecht zu der ersten und der zweiten Oberfläche hat, dadurch gekennzeichnet, daß die erste Oberfläche (32) ein die optische Achse umgebendes Strahlungsfenster (34) hat, daß ein erstes Gitter (35) reflektierend ist und auf der zweiten Oberfläche (33) um die optische Achse (AA') herum angeordnet ist, daß ein zweites Gitter (36) reflektierend ist und auf der ersten Oberfläche (32) um das Strahlungsfenster (34) herum angeordnet ist und daß ein drittes Gitter (37) strahlungsdurchlässig und auf der zweiten Oberfläche (33) um das erste Gitter (35) herum angeordnet ist.
4. Gitterobjektiv nach Anspruch 1, 2 oder 3, mit einem eingebauten Bündelformer, dadurch gekennzeichnet, daß es zweidimensionale Gitter (35, 36, 37) umfaßt, die jeweils in zwei zueinander senkrechten Richtungen unterschiedliche Gitterperioden haben.

5. Einrichtung zum optischen Abtasten einer Informationsebene, welche Einrichtung eine ein Abtaststrahlenbündel (20) liefernde Strahlungsquelle (40) und ein Objektivsystem (30) zum Fokussieren des Abtaststrahlenbündels in einen Strahlungsfleck (41) in der Informationsebene umfaßt, dadurch gekennzeichnet, daß das Objektivsystem von einem Gitterobjektiv nach Anspruch 1, 2 oder 3 gebildet wird.

6. Einrichtung zum optischen Abtasten einer Informationsebene, welche Einrichtung eine ein Abtaststrahlenbündel (20) mit elliptischem Querschnitt liefernde Strahlungsquelle (40) umfaßt sowie einen Bündelformer zum Umformen des elliptischen Bündelquerschnitts in einen kreisförmigen Querschnitt und ein Objektivsystem zum Fokussieren des Abtaststrahlenbündels in einen Abtastfleck in der Informationsebene, gekennzeichnet durch ein Gitterobjektiv (30) mit einem eingebauten Bündelformer nach Anspruch 4.
7. Einrichtung nach Anspruch 5 oder 6, dadurch gekennzeichnet, daß ein Eintrittsfenster (34) des Gitterobjektivs (30) mit einem Auskoppelgitter (38) versehen ist zum Umleiten von Strahlung (20), die durch das Objektiv aus dem Weg des Quellenstrahlenbündels (20) zurückkehrt.
8. Einrichtung nach Anspruch 5, 6 oder 7, dadurch gekennzeichnet, daß das Gitterobjektiv (30) und das strahlungsempfindliche Detektionssystem (60) in dem Gehäuse (80) der Strahlungsquelle (40) angeordnet sind.

Revendications

1. Objectif de réseau (30) comportant un premier et un deuxième réseau de diffraction (35, 36) disposés l'un derrière l'autre dans le trajet de rayonnement s'étendant du côté d'objet vers le côté d'image, les réseaux étant adaptés et disposés de façon qu'un rayon de faisceau (21, 22), qui est un rayon axial ou un rayon périphérique pour un réseau, soit un rayon périphérique respectivement un rayon axial pour l'autre réseau, caractérisé par au moins un troisième réseau (37) disposé dans le trajet de rayonnement formé par les premier et deuxième réseaux (35, 36), de sorte que le rayon axial (22) et le rayon périphérique (21) d'un faisceau traversant l'objectif de réseau (30) sont échangés au moins deux fois, et en ce que pour chaque rayon la somme des sinus des angles sous lesquels ledit rayon est diffracté par les réseaux successifs est sensiblement égale à zéro.
2. Objectif de réseau selon la revendication 1, caractérisé en ce que tous les réseaux (35, 36, 37) sont



des réseaux de transmission.

3. Objectif de réseau selon la revendication 1, comportant une plaque planparallèle transparente (31) présentant une première surface (32) située du côté d'objet et une deuxième surface (33) située du côté d'image, et un axe optique (AA') perpendiculaire aux première et deuxième surfaces, caractérisé en ce que la première surface (32) présente une fenêtre de rayonnement (34) entourant l'axe optique, en ce qu'un premier réseau (35) est réfléchissant et qu'il est disposé sur la deuxième surface (33) entourant l'axe optique (AA'), en ce qu'un deuxième réseau (36) est réfléchissant et qu'il est disposé autour de la fenêtre de rayonnement (34) située sur la première surface (32), et en ce qu'un troisième réseau (37) est transmissible au rayonnement et qu'il est disposé sur la deuxième surface (33) entourant le premier réseau (35). 5
10
15
20
4. Objectif de réseau selon la revendication 1, 2 ou 3, comportant un convertisseur de faisceau incorporé, caractérisé en ce qu'il comporte des réseaux bidimensionnels (35, 36, 37) chacun présentant des périodes de réseau étant différentes dans deux directions mutuellement perpendiculaires. 25
5. Dispositif pour le balayage optique d'une surface d'information, ledit dispositif comporte une source de rayonnement (40) fournissant un faisceau de balayage (20) et un système d'objectif (30) pour focaliser le faisceau de balayage sur un spot de rayonnement (41) situé dans le plan d'information (11), caractérisé en ce que le système d'objectif est constitué d'un objectif de réseau (30) comme revendiqué dans les revendications 1, 2 ou 3. 30
35
6. Dispositif pour le balayage optique d'une surface d'information, ledit dispositif comporte une source de rayonnement (40) fournissant un faisceau de balayage (20) présentant une coupe transversale elliptique, un convertisseur de faisceau pour reconverter la coupe transversale de faisceau elliptique en une coupe transversale circulaire et un système d'objectif pour focaliser le faisceau de balayage sur un spot de balayage situé dans le plan d'information, caractérisé par un objectif de réseau (30) comportant un convertisseur de faisceau incorporé comme revendiqué dans la revendication 4. 40
45
50
7. Dispositif selon la revendication 5 ou 6, caractérisé en ce qu'une fenêtre d'entrée (34) de l'objectif de réseau (30) est prévue d'un réseau de sortie (38) pour dériver le rayonnement (20) retournant à travers l'objectif du trajet du faisceau de rayonnement de source (20). 55
8. Dispositif selon la revendication 5, 6 ou 7, caracté-

risé en ce que l'objectif de réseau (30) et le système de détection sensible au rayonnement (60) sont disposés dans le boîtier (80) de la source de rayonnement (40).

