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Description

This invention relates to an optical pickup apparatus and optical grating assembly for the same. More particularly, this invention relates to an optical pickup apparatus for reading information stored in a recording medium such as an information carrier disc by directing small read-out spots of light to the disc and detecting the light reflected therefrom by a photosensitive detector, and an optical grating assembly suitable for use in such pickup apparatus.

Information carrier discs are known in the art where data are stored and arranged along a spiral track comprising a succession of reflective elements. The reflective elements constituting the track generally take the form of hollows called "pits", which hold audio, video or other information in the digital form. The information carriers also dubbed as optical discs are finding their way rapidly into such industries as music, movie and computer.

In order to read out the information stored in the carrier disc, an optical read-out or pickup device is used. Fig. 1 schematically illustrates the arrangement of a typical prior-art optical pickup device where the three-beam method for tracking servo control and the astigmatic detection for focusing servo control are employed. Before having a detailed description of Fig. 1, the three-beam method and astigmatic detection are briefly explained with reference to Figs. 2 and 3.

Turning to Fig. 2, the three-beam method for tracking servo control uses three beams of light: a main beam to be concentrated into a main reading spot 18a and a pair of sub-beams to be focused into a pair of sub-reading spots 18b and 18c on the opposite sides of the main reading spot 18a. A tracking error signal is obtained by sensing the difference in amount between the pair of reflected sub-beams.

Turning next to Fig. 3, the astigmatic detection for focusing servo control makes use of a cylindrical lens which acts as a lens with respect to light in one direction but does not with respect to light in the opposite direction. A beam of light passing through the cylindrical lens forms a circular spot at the focal point, and distorted circular spots or elliptical spots on the far and near sides of the focal point. Any variation in shape of the reading spot of beam is electrically detected to thereby generate a focus error signal.

Now referring to Fig. 1, the optical pickup or read-out device includes a source of laser 1. A beam of laser 16 emitted by the laser source 1 is directed to a diffraction grating 12 where it is diffracted into a zero-order diffracted main beam 17a and a pair of first-order diffracted sub-beams 17b and 17c. The main beam 17a is for reading out the pit information recorded on the disc and for sensing focusing error, while the two sub-beams 17b and 17c are for sensing tracking error or failure of the main reading beam. The three diffracted beams 17a, 17b and 17c are directed to a planar beam splitter 13 provided with a half-silvered surface or mirror 13a where they are reflected toward a collimating lens 5. As the three beams pass out of the collimating lens 5, they are rendered parallel. The collimated beams continue to an objective lens 6 which focuses them into three spots 18a, 18b and 18c on the surface of the information carrying disc 7 in a pattern as shown in Fig. 2. The main reading spot 18a derives from the main beam 17a, whereas the sub-spots 18b and 18c from the sub-beams 17b and 17c. The spot forming beams 17a, 17b and 17c are modulated by the data carrying track on the disc and reflected back through the objective lens 6 and the collimating lens 5 toward the beam splitter 13, following substantially the identical path. The beam splitter being disposed obliquely or at an angle with respect to the optical path of the returning beams, the return beams impinge obliquely on the beam splitter 13 and pass therethrough. The length of optical paths, for example, 1 and m within the beam splitter for the light beams passing therethrough vary depending on the locations at which those beams strike the splitter. The net result of this is similar to going through a cylindrical lens, and, thus, astigmatism is developed. The returning beams transmitted through the beam splitter 13 proceed to a plane concave lens 14 by which the incident beams are axially or longitudinally magnified and focused into spots 19a, 19b and 19c onto a six-segment photosensitive detector 15. These beam spots 19a, 19b and 19c are projected on the photodetector 15 in various patterns as shown in Figs. 4A-4C depending on the positions of the disc 7 relative to the objective lens 6. It is noted that the spot 19a is derived from the main beam 17a, while the spots 19b and 19c are from the sub-beams 17b and 17c, respectively.

Turning to Figs. 4A-4C, the photodetector 15 comprises photosensitive segments A-D arranged in square configuration to receive the main spot of beam 19a, and a pair of similar photosensitive segments E and F disposed on both sides of the square array A-D for receiving the sub-spots 19b and 19c of the beam. When the surface of the information carrying disc 7 is situated right in the focal plane of the objective lens 6, thereby making it possible for the reading spots to be focused in the data track of the disc, the beam spots 19a-19c are projected on the photodetector in the shape of round circles and in the pattern as shown in Fig. 4B. If the disc surface is closer to the objective lens beyond its focal point i.e. if the disc surface is positioned on the near side of the focal point of the objective lens, then the projected beam spots take the form of ellipses or oval circles arranged as shown in Fig. 4A. On the other hand, when the disc surface is farther than the focal point of the objective lens i.e. when the disc surface is positioned on the far side of the focal point of the objective lens, the beam spots 19a-19c are projected on the photodetector 15 in the form of oval circles and in a pattern as shown in Fig. 4C.

A pit signal RF obtained by reading the pits in the data track of the disc with the read-out light spots is expressed by the following equation:

$$RF = a + b + c + d$$

where a, b, c and d represent electrical signals corresponding to the amounts of light received on the photosensitive segments A, B, C and D, respectively.

A tracking error signal TES provided by the three-beam method is expressed as follows:

$$TES = e - f$$

where e and f represent electrical signals proportional to the amounts of light projected and received on the photosensitive segments E and F, respectively.

A focus error signal FES generated by the astigmatic detection is expressed as follows:

$$FES = (a + d) - (b + c)$$

Whenever tracking error is sensed by a tracking error detector 41, a lens actuator or driver 44 operates in response to the output signal from the detector 41 to move the objective lens 6 in a direction and amount to correct the error. Likewise, when focusing error is sensed by a focusing error detector 42, a lens actuator or driver 43 operates responsive to the output signal from the detector 42 to move the objective lens 6 in a direction and amount to correct the focusing error. In this manner, the position of the objective lens 6 relative to the disc 7 is always adjusted so that the disc surface is kept in the focal plane of the objective lens and the reading beam spots are focused right on the data track of the disc, assuring accurate and reliable read-out of the pits in the data track.

In Fig. 5, there is schematically illustrated another prior-art optical pickup device which incorporates a holographic grating. The pickup device relies on the push-pull method for tracking servo control and on the wedge prism method for focusing servo control.

Before having a description of the optical pickup device of Fig. 5, the push-pull and wedge prism methods are explained in brief.

Turning to Fig. 7, the push-pull detection employs a single spot of beam for reading the information stored in the form of pit on the disc. When the reading spot illuminated on the information track is in perfect registration with the data pit as represented by the center spot in Fig. 7, two photosensitive segments of a photodetector 45 receive equal amounts of reflected light. However, any lateral deviation of the projected light spot with respect to the data pit causes a difference in the intensity of light impinging on the photosensitive segments. This difference sensed by the photodetector 45 produces a signal indicating the tracking error.

The wedge prism method for focusing servo control employs a wedge prism 46 shown in Fig. 8A. One face of the prism is contoured in the form of a V shaped valley. A beam of light incident on the wedge prism emanate therefrom in two beams of light as illustrated in Fig. 8B. At its focal point F, the transmitted beams are converged into tiny spots, while at positions X and Y on the near and far sides, respectively, of the focal point, the beams form semicircular spots of different size and orientation. The varying semicircular spots of light beams are sensed by a photodetector, which produces electric outputs indicating focusing errors.

Now turning to Fig. 5, the optical pickup device includes a source of laser 1. A laser beam 22 from the source of laser 1 is directed to the holographic grating 20. Fig. 6 illustrates the holographic grating 20 in an enlarged perspective view. The holographic grating 20 comprises a glass or plastic plate member formed with a number of fine curved grooves or slits for diffracting the light beam passing therethrough. In order for the diffraction grating 20 to function like a wedge prism, the grating is divided into two sections 20a and 20b.

Turning back to Fig. 5, the holographic grating 20 diffracts the laser beam 22 from the source into several diffraction orders. Among them, only zero-order diffraction beam continues to a collimating lens 5. The first-order diffraction beam wholly misses the collimating lens 5 because of its larger diffraction angle. The zero-order diffraction beam through the collimating lens 5 is turned into parallel beams. The collimated beams are oriented to an objective lens 6 which focuses them into a spot of light on the surface of the information carrier disc 7. The impinging beam is reflected by the disc 7 and is returned to the holographic grating 20 along substantially the same optical path. The return beam is diffracted into several orders by the diffraction grating 20. Zero-order diffraction beam proceeds toward the source of laser 1, while first-order diffraction beam is directed to a four-segment photodetector 21. As stated hereinabove in connection with Fig. 6, the holographic grating 20 is divided into grating sections 20a and 20b along a line oriented in a tangential direction of the disc 7 (while the dividing line is conspicuous in the drawing to show the boundary between the grating sections, no such line exists in an actual holographic grating). As can also be seen in Fig. 6, the sections 20a and 20b are formed with grating grooves of different design or pattern so that the first-order diffracted beams emanating from these sections are converged onto different points. More specifically, the two first-order diffracted beams 24a and 24b emanate from the holographic grating 20 due to its composite structure. The beams 24a and 24b impinge on a four-segment photodetector 21 to form spots of light 25a and 25b. The formations of light spots 25a and 25b on the photodetector 21 are shown in enlargement in Figs. 9A-9C where the alphabetical letters A, B, C and D denote photosensitive segments comprising the photodetector 21. In an erroneous read-out situation where the disc 7 lies closer to the objective lens 6 beyond its focal point, i.e. it is located within the focal length of the objective lens 6, semicircular spots 25a and 25b are formed on the outermost photosensitive segments A and D as shown in Fig. 9A. When the disc 7 lies in the focal plane of the objective lens 6, i.e. the disc is at the focus of the objective lens, tiny spots of light are projected on the photodetector 21 as shown in Fig. 9B. If the disc 7 lies farther away from the objective lens beyond its focal point, i.e. if it is positioned outside the focal length of the objective lens, semicircular spots 25a and 25b are illuminated on the innermost photosensitive segments B and C as shown in Fig. 9C.

A pit signal RF obtained by optically reading the disc 7 is expressed as follows:

$$RF = a + b + c + d$$

where a, b, c and d represent electrical signals corresponding to the amounts of light received by the photosensitive segments A, B, C and D, respectively.

A tracking error signal TES provided by the push-pull method is expressed as follows:

$$TES = (a + b) - (c + d)$$

The wedge prism method provides a focusing error signal FES expressed by the following equation:

$$FES = (a + d) - (b + c)$$

It should be noted that the composite holographic grating 20 acts optically like a wedge prism.

Referring again to Fig. 5, when a focusing error is sensed by a focusing error detector 42, a lens actuator 43 operates to drive the objective lens 6 in a direction and amount to correct the error. Likewise, as a tracking error detector 41 senses a tracking error, another actuator 44 operates to move the objective lens 6 in a direction and amount to offset the focusing error, thereby achieving an accurate and reliable reading of the pits on the disc.

The prior-art optical pickup devices of the type described above, while generally satisfactory in optical read-out operation, suffer some drawbacks.

The optical pickup device of Fig. 1 which employs the three-beam detection for the tracking servo control shows an excellent ability to detect tracking error. However, it requires both the diffraction grating 12 and the plane beam splitter 13 for the diffraction of the laser beam, compared with the one and single holographic grating for the optical pickup device of Fig. 5 based on the push-pull detection method. One additional component part means one additional step of operational adjustment as well as additional cost.

On the other hand, in the pickup device of Fig. 5 relying on the push-pull detection technique, a single holographic grating 20 is sufficient for the intended diffraction of the laser beam. One less component part and one less step for the operational adjustment in this pickup device than in the device based on the three-beam detection surely leads to a considerable cost reduction. However, the push-pull type of pickup device is disadvantageous in that the tracking error signal fluctuates with varying pit depths, making it impossible to obtain a stable and constant tracking error signal.

An optical pickup device which uses a separate beam splitter and diffraction grating, like the device shown in Fig. 1, is known from EP-A-0,226,403.

The use of holograms in optical pickup devices, to direct a light beam reflected from a record medium toward an optical sensor, is known from EP-A-0,123,048 and EP-A-0,195,657. From these two documents, it is also known to form an assembly in which two holograms are adhered to each other by an optical adhesive.

It is an object of this invention to provide an optical pickup apparatus for optically reading information stored in a flat information carrier.

It is another object of the invention to provide an optical pickup apparatus for optically reading a flat information carrier which uses a three-beam method for tracking servo control and which is simpler in construction than similar prior art apparatus.

It is still another object of the invention to provide a novel optical grating assembly suitable for use in the optical pickup apparatus.

According to one aspect, the invention provides an optical pickup apparatus for reading information recorded on a track or tracks on a recording medium by causing a focused light spot to scan along said track or tracks and by directing light reflected from said medium toward a photodetector, the apparatus comprising:

first grating means for deriving from a light beam emitted by a light source a main beam, which is focused to form said focused light spot, and a pair of sub-beams which are focused onto the recording medium for use in sensing tracking error of the main beam; characterised by:

second grating means for directing part of the light beam reflected from said recording medium toward said photodetector; and

an optical grating assembly which is made of a single part comprising a first surface portion receiving light from said light source and provided with said first grating means and a second surface portion receiving light reflected from said recording medium and provided with said second grating means.

In preferred embodiments, the first grating means is a diffraction grating and the second grating means is a holographic grating.

According to another aspect, the invention provides an optical grating assembly for use in an optical pick-up apparatus for reading information recorded on a recording medium in which apparatus said assembly is disposed between a light source and said recording medium, characterized in that said optical grating assembly is made of a single part comprising:

a first surface portion, arranged in use to receive light from said light source;

a second surface portion, arranged in use to receive light reflected from said recording medium;

first grating means provided on said first surface portion for deriving from a light beam emitted by said light source a zero-order beam and a pair of first order beams; and

second grating means provided on said second surface portion for directing part of the light beam reflected from said recording medium toward a photodetector of said apparatus.

The present invention will become more apparent from the following detailed description of preferred embodiments, taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic illustration showing an overall arrangement of a prior art optical pickup device;

Fig. 2 is a schematic illustration helpful in understanding some basic working principles of the three-beam detection method for tracking servo control;

Fig. 3 is a schematic illustration helpful in understanding some basic working principles of the astigmatic detection method for focusing servo control;

Figs. 4A-4C are schematic illustrations showing light spots formed in different shapes and patterns on a six-segment photodetector of a prior art optical pickup device which employs a diffraction grating;

Fig. 5 is a schematic illustration showing an overall arrangement of a prior-art optical pickup device which employs a holographic grating;

Fig. 6 is an enlarged perspective view of a holographic grating;

Fig. 7 is a schematic illustration helpful in understanding the basic working principle of a push-pull method;

Fig. 8A is an enlarged perspective view of a typical wedge prism employed in a wedge prism method;

Fig. 8B is a schematic illustration helpful in understanding some basic working principle of the wedge prism method;

Figs. 9A-9C are schematic illustrations showing light spots formed in different shapes and orientations on a four-segment photodetector of a prior-art optical pickup device which employs a holographic grating;

Fig. 10 is an enlarged perspective view of an optical grating assembly according to a preferred embodiment of this invention;

Figs. 11A-11F are schematic cross-sectional illustrations showing successive steps for manufacturing the optical grating assembly according to this invention;

Fig. 12 is an enlarged cross-sectional view showing the working of the optical grating assembly of Fig. 10;

Fig. 13 is a schematic illustration showing the overall arrangement of an optical pickup apparatus according to this invention;

Figs. 14A-14C are schematic illustrations showing light spots formed in different shapes and orientations on a six-segment photodetector of the optical pickup apparatus of Fig. 13 according to this invention;

Fig. 15A is an enlarged perspective view of an optical grating assembly according to another embodiment of this invention;

Fig. 15B is an enlarged perspective view of an optical grating assembly according to still another embodiment of this invention;

Fig. 16 is an enlarged cross-sectional view showing the working of the optical grating assemblies of Figs. 15A and 15B;

Fig. 17 is an enlarged perspective view of an optical grating assembly according to still another embodiment of this invention;

Fig. 18 is an enlarged perspective view showing the working of the optical grating assembly of Fig. 17;

Fig. 19 is a schematic illustration showing the overall arrangement of an optical pickup apparatus according to this invention which employs the optical grating assembly of Fig. 18;

Figs. 20A-20C are schematic illustrations showing light spots formed in different shapes and orientations on a six-segment photodetector of the optical pickup apparatus shown in Fig. 19;

Fig. 21 is an enlarged perspective view of an optical grating assembly according to still another embodiment of this invention;

Fig. 22 is an enlarged perspective view of an optical grating assembly according to still another embodiment of this invention;

Fig. 23 is an enlarged perspective view showing the working of the optical grating assembly of Fig. 22; and

Fig. 24 is a schematic illustration showing the overall arrangement of an optical pickup apparatus according to this invention which employs the optical grating assembly of Fig. 22.

Referring now to Fig. 10, there is illustrated a grating assembly for use in an optical pickup apparatus according to this invention. As shown, the grating assembly 2 has a face 202 turning toward a source of radiant light and provided with a diffraction grating 4a as a first grating component. The diffraction grating 4a functions to distribute a light beam from the source into a main beam for reading a data pit formed on the information carrying disc, and a pair of sub-beams for sensing tracking error of the main reading beam. The other face 201 of the grating assembly 2 turning toward the information carrying disc is provided with a holographic grating 3 as a second grating component. The holographic grating 3 comprises a number of curved parallel grooves arranged to deflect a part of the light beam impinging upon it. Thus, when incorporated in the optical pickup apparatus of the invention to be described later, the holographic grating 3 works to turn a portion of the light beam reflected from the information carrying disc to a photodetector. It should be noted that the diffraction grating 4a and the holographic grating 3 are made of plastics or glass, and formed into the grating assembly 2 of unitary or integral structure. However, this invention is not limited to the uses of plastics and glass. Other suitable materials can also be used for the unitary grating assembly.

Fabrication of the unitary grating assembly 2 is now briefly described with reference to Figs. 11A-11G.

Fig. 11A illustrates the grating assembly 2 in schematic cross-section. The grating assembly 2 has the holographic grating 3 on one face and the diffraction grating 4a on the other face. It is fabricated by introducing (thermoplastic) synthetic resin material or glass into a mould 33 shown in Fig. 11B. The mould 33 comprises an upper moulding half 33a provided with a counterpart design of the desired holographic grating, and a lower moulding half 33b ruled with a complementary design of the desired diffraction grating. The mould 33 also has an inlet passage 33c formed therein, and glass or plastic material in the molten or fluid state is introduced into the mould through the inlet passage 33c. A pool of molten material within the mould 33 is left to set into a solid body which constitutes the unitary composite grating structure 2. Other grating structures according to the invention which will be described hereinbelow are all fabricated in substantially the same manner.

Now the forming of the mould half 33a is described with reference to Figs. 11C-11G. A glass pane or a sheet of glass 30 is prepared as shown in Fig. 11C. A coating 31 of photoresist is applied over one surface of the glass pane 30 (Fig. 11D).

As a next step, using photolithographic technique (and, when necessary, two-beam interference technique), the photoresist coating 31 is etched away to leave a pattern of fine thread-like projections 32 (Fig. 11E). The pattern of the fine projections 32 is covered with a coating of electroplated metal 33d having a desired thickness (Fig. 11f). When the electroplated metal coating 33d is stripped off the underlying glass sheet 30, it is incorporated into the upper mould half 33a as a grating-forming surface layer. A similarly grating-forming layer for the lower moulding half 33b can be fabricated following substantially the same process as described above.

The optical working of the grating assembly 2 of Fig. 10 is illustrated in Fig. 12 in a greatly enlarged cross-section taken along the line A-A of Fig. 10. Referring to Fig. 12 together with Fig. 13 which schematically shows an optical pickup apparatus according to the present embodiment and having the grating assembly 2 incorporated therein. The optical pickup apparatus includes a source of laser 1, typically a semiconductor laser device, and an objective lens 6 positioned close to an information carrier disc 7 for converging the laser light from the source 1 on the disc. A collimating lens 5 is disposed closer to the objective lens, while the optical grating assembly 2 closer to the source of laser 1. The pickup apparatus also includes a six-segment photosensor or photodetector 8 which produces electric outputs in response to and as a function of incident radiation of light.

Now to describe the operation of the illustrated pickup apparatus, a laser beam 9 emitted from the laser source 1 falls on the diffraction grating 4a provided on the face 202 of the grating assembly 2. The incident laser beam is diffracted by the diffraction grating into a zero-order diffracted beam 9a for reading the data pits on the disc 7, and a pair of first-order diffracted beams 10a and 11a for sensing tracking error of the main read-out beam 9a. These three diffracted beams 9a, 10a and 11a pass through the holographic grating 3 on the other face 201 of the grating assembly 2, which diffracts the passing beams into zero-order beams and first-order beams. Of these, only three zero-order beams continue to the collimating lens 5. The first-order beams miss the collimating lens 5 due to their greater diffraction angles. The three beams 9a, 10a and 11a impinging on the collimating lens 5 are rendered parallel as they pass therethrough and are directed to the objective lens 6, which focuses them into three spots 9b, 10b and 11b onto the disc 7 for reading out the information carried therein.

The spot 9b derives from the major laser beam 9a, whereas the spots 10b and 11b from the sub-beams 10a and 11a of the laser, respectively. The three beam spots are focused on the data carrying surface of the disc in a relative arrangement as shown in Fig. 2. Thus, the spots 10b and 11b are displaced tangentially or in a direction of the disc rotation with respect to the centre spot 9b.

The spot-forming laser beams are reflected by the disc 7 and return along substantially the same optical paths through the objective lens 6 and the collimating lens 5 to the grating assembly 2 where the return beams fall on the holographic grating 3. The incident beams are then diffracted into zero-order diffraction beams and first-order diffraction beams. While the zero-order beams continue straight back toward the laser source 1, the first-order diffracted beams 9c, 10c and 11c are deflected sideways. As a consequence, the first-order beams 9c, 10c and 11c pass out of the grating assembly 2 through a non-grated area 4b in the lower face 202, bypassing the diffraction grating 4a. It is pointed out that the first-order diffracted beams which pass obliquely through the grating assembly 2 inevitably undergo an astigmatic effect or distortion which is used to advantage to produce electrical signals indicating focusing errors as will be explained later. The first-order beams 9c, 10c and 11c passing out through the non-grated area 4b impinge on the six-segment photodetector 8 and form light spots 9d, 10d and 11d, respectively, in various shapes and orientations as shown in Figs. 14A-14C.

Formation of the light spots on the six-segment photodetector 8 in the pickup apparatus of the present embodiment of the invention, both as to their shapes or arrangements, is similar to that obtained in the prior art pickup device of Fig. 1 (see Figs. 4A-4C). Note that the prior art pickup device includes both the diffraction grating 12 and the plane beam splitter 13 as its essential optical components.

The pickup apparatus of this embodiment shown in Figs. 12 and 13 makes use of the three-beam detection for tracking servo control and the astigmatic detection for focusing servo control as does the prior-art device of Fig. 1. However, the pickup apparatus of the invention relies only on a single grating assembly 2 for the purpose of beam diffraction, compared to the two optical components in the prior-art device.

In an erroneous reading situation where the disc 7 is within the focal length of the objective lens 6 or is closer to the objective lens beyond its focal point, the three spots 9d-11d are formed on the six-segment photodetector in oblong shape and in orientation as shown in Fig. 14A. In a correct reading situation where the disc 7 is in the focal plane of the objective lens 6, three circular spots 9d-11d are projected on the six-segment photodetector 8 as shown in Fig. 14B. In another erroneous reading situation where the disc 7 is on the far side of the focal point of the objective lens 6 or outside its focal length, the three light spots 9d-11d projected on the photodetector 8 take on oblong shapes oriented as shown in Fig. 14C.

A pit signal RF obtained by optically reading the data pits in the disc 7 is expressed as follows:

$$RF = a + b + c + d$$

where a, b, c and d represent electrical outputs corresponding to the amounts of the light received by the photosensitive segments A, B, C and D.

A tracking error signal TES provided by the three-beam method is expressed as follows:

$$TES = e - f$$

where e and f represent electrical outputs in proportion to the quantities of light received by the photosensitive segments E and F, respectively.

A focusing error signal FES provided by the astigmatic detection method is expressed as follows:

$$FES = (a + d) - (b + c)$$

Referring again to Fig. 13, when a focus error detector 42 senses a focusing error through the photodetector 8, it operates a lens actuator 43 so that the actuator drives the objective lens 6 in a direction and amount to correct the error. Similarly, as a tracking error detector 41 senses a tracking error through the photodetector 8, it operates a lens actuator 44 such that the actuator moves the objective lens 6 in a direction and amount to correct the error. An accurate and reliable reading of the data pits on the disc is attained in this manner.

Referring to Figs. 15A and 15B, there are shown optical grating assemblies according to another embodiment of the invention. The grating assemblies of Figs. 15A and 15B are essentially identical in construction to the one shown Fig. 10 except for the structural feature to be described hereinbelow. Thus, like component parts are designated by like reference numerals without having any further description thereof.

The novel structural feature of the optical grating assemblies 2 shown in Figs. 15A and 15B is the provision of a lens structure 4c in its lower face 202 in the area through which the reflected laser beam deflected by the holographic grating 3 toward the photodetector passes. In the grating assembly of Fig. 15A, the lens structure 4c is provided in the form of a cylindrical lens, whereas in Fig. 15B, the lens structure 4c is in the form of a concave lens.

The optical working of the grating assembly 2 with the lens structure 4c is shown in Fig. 16. With the cylindrical lens structure of Fig. 15A, the beams passing through the lens structure undergo a greater astigmatic distortion, which, in turn, is effective to cause the photodetector to generate more distinct outputs. On the other hand, the concave lens structure 4c of Fig. 15B functions to magnify the transmitted beams in axial or longitudinal direction. The axially magnified beams are more readily picked up by the photodetector.

While the cylindrical lens structure 4c has been separately incorporated as means for enhancing the astigmatic development, the holographic grating 3 may suitably be designed to have a similar function instead of providing a separate structure 4c.

An optical grating assembly 2 according to still another embodiment of the invention is shown in Fig. 17. The grating assembly 2 is substantially identical in construction to that of Fig. 10. Thus, similar parts are indicated by similar reference numerals. However, the grating assembly 2 of Fig. 17 differs from that of Fig. 10 in that its holographic grating 3 is divided into two sections 3a and 3b along a line 30 which extends in the tangential or circumferential direction of the disc 7. The dividing line 30 is added in the drawing for the purpose of indicating the boundary between the two grating sections 3a and 3b. No such line is seen in an actual grating structure. The two-section holographic grating is fabricated following the procedure described hereinabove in connection to Figs. 11A-11F.

The operation of an optical pickup apparatus which incorporates the grating assembly 2 of Fig. 17 is now explained with reference to Fig. 19 together with Fig. 18 which illustrates the optical working of the grating assembly.

A laser beam 1 emitted from a source of laser 1 impinges on a diffraction grating 4a provided in one face 202 of a grating assembly 2 where it is diffracted into a zero-order main beam 9a for reading the data pits on a disc 7 as well as sensing focusing error, and a pair of first-order sub-beams 10a and 11a for sensing tracking error. The beams 9a, 10a and 11a pass through a holographic grating sections 3a and 3b which diffract these beams again into zero- and first-order beams. The first-order beams, being diffracted through a far greater angle, miss a collimator lens 5. Thus, only the zero-order diffracted beams of the incident beams 9a, 10a and 11a continue to the collimator lens 5 to be cast into parallel rays. The collimated beams are directed to an objective lens 6 which functions to focus the incoming beams into three spots 9b, 10b and 11b on the data recorded surface of an information disc 7. The three focused spots assume the arrangement as shown in Fig. 2 with the spots 10b and 11b being tangentially displaced away from the centre spot 9b.

The laser beams which form the spots 9b, 10b and 11b on the disc are reflected by the data surface of the disc 7 and return along substantially the identical paths through the objective lens 6 and the collimating lens 5 to the grating assembly 2. The returning beams fall on the grating sections 3a and 3b of the holographic grating 3 which function to independently and separately diffract the transmitted beams into zero- and first-order beams. As before, the zero-order diffracted beams are directed straight back to the laser source 1. On the other hand, the first-order beams 9c, 10c and 11c diffracted by the holographic grating section 3a, and the first-order beams 9d, 10d and 11d diffracted by the other holographic grating section 3b pass out of the grating assembly 2 through a non-grated region in the lower face 202. The holographic grating sections 3a and 3b are designed such that the outgoing first-order diffracted beams converge on different locations. Accordingly, the diffracted beams 9c, 10c and 11c through the grating section 3a fall on a six-segment photodetector 8 to form three spots 9e, 10e and 11e, while the diffracted beams 9d, 10d and 11d through the other grating section 3b impinge on the photodetector 8 to form three different spots 9f, 10f and 11f. It is noted here that the light spots 9e and 9f derive from the main laser beam 9a, and that the light spots 10e-10f and 11e-11f come from the sub-beams 10a and 11a, respectively. With the arrangement of the pickup apparatus shown in Figs. 18 and 19, a laser beam from the source is distributed into one main beam and a pair of sub-beams by the grating assembly, making possible the three-beam tracking error detection. At the same time, each returning beam reflected by the disc is divided into two separate beams by the grating assembly, making possible focusing error detection in a manner similar to that achieved by the wedge prism method.

Formation of the light spots on the photodetector 8 under some typical reading situations are shown in Figs. 20A-20C.

In an erroneous reading situation where the information disc 7 is located off the focal point of the objective lens 6 on the near side thereof, i.e. the disc is positioned within the focal length of the objective lens, light spots 9e-11e and 9f-11f are formed on the photodetector in semicircular shape and in an arrangement as shown in Fig. 20A. In a correct reading situation where the disc 7 is located on the focal point of the objective lens 6, pinpoint spots 9e-11e and 9f-11f are projected on the photodetector in a pattern as shown in Fig. 20B. In another erroneous reading situation where the disc 7 is located off the focal point of the objective lens on the far side thereof, i.e., the disc is positioned outside the focal length of the objective lens, semicircular light spots 9e-11e and 9f-11f are formed on the photodetector in an arrangement and orientation as shown in Fig. 20C.

A pit signal RF obtained by reading the pits in the data track of the disc 7 with the read-out light spots is expressed by the following equation:

$$RF = a + b + c + d$$

where a, b, c and d represent electrical signals corresponding to the amounts of light received on the photosensitive segments A, B, C and D, respectively.

A tracking error signal TES provided by the three-beam method is expressed as follows:

$$TES = e - f$$

where e and f represent electrical signals proportional to the amounts of light projected and received on the photosensitive segments E and F, respectively.

A focus error signal FES generated by the wedge prism type detection is expressed as follows:

$$FES = (a + d) - (b + c)$$

Whenever a tracking error is sensed by a tracking error detector 41, a lens actuator or driver 44 operates in response to the output signal from the detector 41 to move the objective lens 6 in a direction and amount to correct the error. Likewise, when a focusing error is sensed by a focusing error detector 42, a lens actuator or driver 43 operates in response to the output signal from the detector 42 to move the objective lens 6 in a direction and quantity to correct the focusing error. In this manner, the position of the objective lens 6 relative to the disc 7 is always adjusted so that the disc surface is kept in the focal plane of the objective lens and the reading beam spots are focused right on the data track of the disc, assuring accurate and reliable read-out of the pits in the data track.

In Fig. 21, there is illustrated a grating assembly according to still another embodiment of the invention and suitable for use in an optical pickup apparatus of the invention. The grating assembly of Fig. 21 is substantially identical in construction to that shown in Fig. 17, and like parts are designated by like reference numerals. A distinct feature of the grating assembly 2 of Fig. 21 not found in the grating assembly of Fig. 17 is that a holographic means for relieving influence of astigmatism is provided over the holographic grating sections 3a and 3b. The holographic grating may be made to have an additional function of relieving influence of the coma. In Fig. 21, the provision of the anti-astigmatism holographic means is represented by drawing the grating sections 3a and 3b to have grating configuration or pattern different from the one shown in Fig. 17. The particular holographic means may be fabricated by photolithographic technique which employs two-beam interference (Fig. 11E). As can be seen in Fig. 18, the returning light beams are transmitted obliquely through the grating assembly 2 toward the photodetector 8, which inevitably develops astigmatic distortion in the transmitted light beams. As a result, these beams form on the photodetector light spots of oblong circles or ellipses instead of regular circles. By providing the anti-astigmatism holographic means over the holographic grating sections 3a and 3b, the development of astigmatic effects on the light beams transmitted through the grating assembly 2 is prevented, resulting in the formation of fully round light spots on the photodetector.

It is also possible to design the holographic grating to have an image magnifying function for enlarging the light spots formed on the photodetector. With the enlarged light spots, the photodetector works to generate electrical outputs of greater intensity.

There is illustrated in Fig. 22 an optical grating assembly 2 according to still another embodiment of the invention, which is essentially identical in structure to that shown in Fig. 17. Thus, like component parts are designated by like reference numerals.

In contrast to the grating assembly of Fig. 17, the grating assembly 2 of Fig. 22 has been divided into two holographic grating sections 3a and 3b along a line 30 which extends parallel to the fine grooves in the diffraction grating 4a on the other face 202 of the assembly 2. When the dividing line 30 extends orthogonally with respect to the grating grooves, it gives rise to the following problems.

Turning back to Fig. 18, the wavelength of the laser beam 9 emitted by the semiconductor source 1 undergoes slightest change with a varying temperature. As the emanating laser beam changes its wavelength, so does the return beam reflected by the disc 7. The relation expressed by the following equation exists between the wavelength λ of the reflected beam and the diffraction angle Θ through which the reflected beam is diffracted into the first-order beam:

$$\mathrm{Sin}\,\Theta = \frac{\lambda}{d}$$

where d denotes the pitch spacing of the holographic grating.

As will be seen from the equation, any variation in the wavelength of the light beam causes a change in the diffraction angle Θ. If the diffraction angle with respect to the first-order diffracted beam undergoes fluctuation in response to the varying wavelength λ, the light spots 9e-11e and 9f-11f focused on the photodetector 8 are displaced laterally in the direction toward or away from the source 1 as seen in Fig. 18. As a result, the spots 9e-11e are positioned much closer to one another, making it difficult to obtain clear and distinct RF signals, tracking error signals as well as focusing error signals. This is true also of the light spots 9f-11f.

In order to make allowance for the possible fluctuation in the wavelength of the laser beam caused by varying temperature conditions or different semiconductor devices used as the laser source 1, it has been necessary to design the optical system of the pickup apparatus such that the light spots 10e and 10f are displaced on the photodetector 8, as much as possible, away from the light spots 11e and 11f, respectively. To this end, the beams 10b and 11b on the disc 7 must be made to lie farthest apart from each other, or alternatively additional optical component parts should be incorporated. These propositions are disadvantageous in that they impose stringent requirements on the mounting accuracy of the whole apparatus, and also involve higher manufacturing costs and lower operating stability.

The aforementioned problems relating to the fluctuating wavelength of the laser beam are effectively overcome by the novel grating assembly 2 of Fig. 22 in which the holographic grating 3 is divided into the grating sections 3a and 3b along the line 30 extending parallel to the fine grooves or slits of the diffraction grating 4a. Now to refer to Fig. 23 where the optical working of the grating assembly 2 of Fig. 22 is illustrated, together with Fig. 24 where an optical pickup apparatus employing the grating assembly of Fig. 22 is shown. As the wavelength of the laser beam 9 from the source 1 fluctuates, the light spots focused on the photodetector 8 are displaced laterally in a direction away or toward the laser source 1. However, the spacing between the light spot 10e and 11e is never diminished. Nor is the distance between the spots 10f and 11f. Hence, it is not necessary to set the spacing between the light spots 10e and 11e, and the spacing between the light spots 10f and 11f broader than usual in anticipation of possible shrinking.

Fluctuations of the spacing between the spots 10e and 10f, and the spacing between the spots 11e and 11f in the direction toward or away from the source of laser 1 are effectively compensated for by adjusting the pitch of the grating grooves in the grating sections 3a and 3b.

As has been described in detail hereinabove, the optical pickup apparatus of the preferred embodiments includes the diffraction grating which distributes a light beam from a source into a main beam for reading the data pits on the information carrier disc, and a pair of sub-beams for sensing tracking error of the main reading beam. The diffraction grating ensures a generation of stable tracking error signals. The pickup apparatus also includes a holographic grating for directing and converging part of the light beam reflected by the disc onto the photodetector. The holographic grating is integrally formed with the diffraction grating into a unitary grating assembly, which eliminates the need for two separate grating components. A reduction of the requisite grating components leads to a reduction in the number of delicate operational adjustments. The overall result is the provision of an inexpensive optical pickup apparatus which possesses an excellent ability to sense tracking error of the read-out beam.

Further, in the novel grating assembly of the preferred embodiments, the diffraction grating for diffracting the beam from the source into zero- and first-order beams, and the holographic grating for orienting part of the light beams reflected by the disc toward the photodetector are formed integral with each other. This unitary structure makes it possible to fabricate both the diffraction grating and the holographic grating simultaneously in an economical manner as shown in Fig. 11B. The unitary grating assembly also makes putting component parts together into a pickup apparatus easier and less troublesome.

Claims

1. An optical pick-up apparatus for reading information recorded on a track or tracks on a recording medium (7) by causing a focused light spot (9b) to scan along said track or tracks and by directing light reflected from said medium toward a photodetector (8), the apparatus comprising:

   first grating means (4a) for deriving from a light beam (9) emitted by a light source (1) a main beam (9a), which is focused to form said focused light spot (9b), and a pair of sub-beams (10a, 11a) which are focused onto the recording medium for use in sensing tracking error of the main beam, characterised by:

   second grating means (3) for directing part of the light beam reflected from said recording medium toward said photodetector; and

   an optical grating assembly (2) which is made of a single part comprising a first surface portion (202) receiving light from said light source (1) and provided with said first grating means (4a) and a second surface portion (201) receiving light reflected from said recording medium (7) and provided with said second grating means (3).

2. An optical pickup apparatus according to claim 1, wherein the light beam (9d) directed by said second grating means (3) is detected by said photodetector (8) using the astigmatic method to produce focusing error signals.

3. An optical pickup apparatus according to claim 1, wherein the light beam (9e, 9f) directed by said second grating means (3, 3a, 3b) is detected by said photodetector (8) through the wedge prism method to produce focusing error signals.

4. An optical pickup apparatus according to any one of claims 1 to 3, wherein said first grating means comprises a diffraction grating (4a).

5. An optical pickup apparatus according to any one of the preceding claims, wherein said second grating means comprises a holographic grating (3).

6. An optical pickup apparatus according to any one of the preceding claims, wherein said optical grating assembly (2) is made of glass.

7. An optical pickup apparatus according to any one of claims 1 to 5, wherein said optical grating assembly (2) is made of plastics.

8. An optical pickup apparatus according to any one of the preceding claims, wherein said optical grating assembly (2) is provided with lens means (4c) for enhancing astigmatism in its first surface portion (202) in an area (4b) where the light beam directed by said second grating means (3) to said photodetector (8) passes.

9. An optical pickup apparatus according to claim 8, wherein said lens means for enhancing astigmatism comprises a cylindrical lens surface (4c, Fig. 15A).

10. An optical pickup apparatus according to any one of claims 1 to 7, wherein said optical grating assembly (2) is provided with lens means (4c) for magnifying light spots in said first surface portion (202) in an area (4b) where the light beam directed by said second grating means (3) to said photodetector (8) passes.

11. An optical pickup apparatus according to claim 10, wherein said lens means comprises a concave lens surface (4c, Fig. 15B).

12. An optical pickup apparatus according to claim 5, wherein said holographic grating (3) is divided into two sections (3a, 3b) in order to obtain focusing error signals through the wedge prism method.

13. An optical pickup apparatus according to claim 5, wherein said holographic grating (3) has an additional function of relieving influence of astigmatism or coma in the light beam (9c-11c) reflected by said recording medium and transmitted through said grating assembly (2).

14. An optical pickup apparatus according to claim 5, wherein said holographic grating (3) has an additional function of magnifying the light spots (9d - 11d) formed on said photodetector.

15. An optical pickup apparatus according to claim 5, wherein said holographic grating (3) has an additional function of enhancing astigmatism in the light beam (9c-11c) reflected by said recording medium and transmitted through said grating assembly (2).

16. An optical pickup apparatus according to claim 12, as appendent to claim 4, wherein said holographic grating (3) is divided into said two sections (3a, 3b) along a line (30, Fig. 22) which extends parallel to the grating lines of said diffraction grating (4a).

17. An optical pickup apparatus according to any one of the preceding claims, wherein said first and second grating means (4a, 3) are arranged such that the light beam (9c-11c) directed by said second grating means (3) to said photodetector (8) passes out of the grating assembly (2) through a non-grated area (4b) of said first surface portion (202).

18. An optical grating assembly (2) for use in an optical pick-up apparatus for reading information recorded on a recording medium in which apparatus said assembly is disposed between a light source and said recording medium, characterized in that said optical grating assembly is made of a single part comprising:

a first surface portion (202), arranged in use to receive light from said light source;

a second surface portion (201), arranged in use to receive light reflected from said recording medium;

first grating means (4a) provided on said first surface portion for deriving from a light beam (9) emitted by said light source a zero-order beam (9a) and a pair of first order beams (10a, 11a); and

second grating means (3) provided on said second surface portion for directing part of the light beam (9c-11c) reflected from said recording medium toward a photodetector of said apparatus.

19. An optical grating assembly according to claim 18, wherein said first grating means comprises a diffraction grating (4a).

20. An optical grating assembly according to claim 18 or claim 19, wherein said second grating means comprises a holographic grating (3).

21. An optical grating assembly according to any one of claims 18 to 20, which is made of glass.

22. An optical grating assembly according to any one of claims 18 to 20, which is made of plastics.

23. An optical grating assembly according to any one of claims 18 to 22, further comprising lens means (4c) for enhancing astigmatism and provided in said first surface portion (202) in an area (4b) where the light beam directed by said second grating means (3) to said photodetector passes.

24. An optical grating assembly according to claim 23, wherein said lens means for enhancing astigmatism comprises a cylindrical lens surface (4c, Fig. 15A).

25. An optical grating assembly according to any one of claims 18 to 22, further comprising lens means (4c) for magnifying the light spots formed on said photodetector and provided in said first surface portion (202) in an area (4b) where the light beam directed by said second grating means (3) to said photodetector passes.

26. An optical grating assembly according to claim 25, wherein said lens means comprises a concave lens surface (4c, Fig. 15B).

27. An optical grating assembly according to claim 20, wherein said holographic grating (3) is divided into two sections (3a, 3b) in order to divide the light beam reflected by said recording medium and impinging on said holographic grating into two first-order diffracted beams (9c-11c, 9d-11d).

28. An optical grating assembly according to claim 20, wherein said holographic grating (3) has an additional function of relieving influence of astigmatism or coma in the light beam (9c-11c) reflected by said recording medium and transmitted through the grating assembly.

29. An optical grating assembly according to claim 20, wherein said holographic grating (3) has an additional function of magnifying the light spots formed on said photodetector.

30. An optical grating assembly according to claim 20, wherein said holographic grating (3) has an additional function of enhancing astigmatism in the light beam (9c-11c) reflected by said recording medium and transmitted through the grating assembly.

31. An optical grating assembly according to claim 27, as appendent to claim 19, wherein said holographic grating (3) is divided into said two sections (3a, 3b) along a line (30, Fig. 22) which extends parallel to the grating lines of said diffraction grating (4a).

32. An optical grating assembly according to any one of claims 18 to 31, wherein said first and second grating means (4a, 3) are arranged such that, in said optical pickup apparatus, the light beam (9c-11c) directed by said second grating means (3) to said photodetector passes out of the grating assembly through a non-grated area (4b) of said first surface portion (202).

Patentansprüche

1. Optische Abtastvorrichtung zum Lesen von Information,
die in einer Spur oder Spuren auf einem Aufzeichnungsträger (7) aufgezeichnet ist, durch Abtastung der Spur oder der Spuren mittels eines fokussierten Lichtstrahls (9b), wobei das vom Träger reflektierte Licht auf einen Photodetektor (8) gelenkt wird, welche Vorrichtung folgendes aufweist:
   - eine erste Gitteranordnung (4a) zum Erzeugen eines Hauptstrahls (9a) aus einem von einer Lichtquelle (1) emittierten Lichtstrahl (9), wobei der Hauptstrahl (9a) so fokussiert wird, daß er den fokussierten Lichtstrahl (9b) bildet, und eines Paars von Nebenstrahlen (10a, 11a), die auf den Aufzeichnungsträger fokussiert werden und zum Erfassen einer Spurabweichung des Hauptstrahls dienen, **gekennzeichnet durch:**
   - eine zweite Gitteranordnung (3), die einen Teil des vom Aufzeichnungsträger reflektierten Lichtstrahls auf den Photodetektor lenkt; und
   - eine optische Gitteranordnung (2), die aus einem einzigen Teil besteht, das einen ersten Oberflächenbereich (202), der Licht von der Lichtquelle (1) empfängt und mit der ersten Gitteranordnung (4a) versehen ist, und einen zweiten Oberflächenbereich (201) aufweist, um das vom Aufzeichnungsträger (7) reflektierte Licht zu empfangen, und der mit der zweiten Gitteranordnung (3) versehen ist.

2. Optische Abtastvorrichtung nach Anspruch 1, bei welcher der von der zweiten Gitteranordnung (3) gelenkte Lichtstrahl (9d) vom Photodetektor (8) unter Anwendung eines Astimagismusverfahrens erfaßt wird, um Fokussierabweichungssignale zu erzeugen.

3. Optische Abtastvorrichtung nach Anspruch 1, bei der der von der zweiten Gitteranordnung (3, 3a, 3b) ausgerichtete Lichtstrahl (9e, 9f) vom Photodetektor (8) durch das Keilprismaverfahren erfaßt wird, um Fokussierabweichungssignale zu erzeugen.

4. Optische Abtastvorrichtung nach einem der Ansprüche 1 bis 3, bei der die erste Gitteranordnung ein Beugungsgitter (4a) aufweist.

5. Optische Abtastvorrichtung nach einem der vorstehenden Ansprüche, bei der die zweite Gitteranordnung ein holographisches Gitter (3) aufweist.

6. Optische Abtastvorrichtung nach einem der vorstehenden Ansprüche, bei der die optische Gitteranordnung (2) aus Glas besteht.

7. Optische Abtastvorrichtung nach einem der Ansprüche 1 bis 5, bei der die optische Gitteranordnung (2) aus Kunststoff besteht.

8. Optische Abtastvorrichtung nach einem der vorstehenden Ansprüche, bei der die optische Gitteranordnung (2) in ihrem ersten Oberflächenbereich (202) in einer Fläche (4b), die der durch die zweite Gitteranordnung (3) zum Photodetektor (8) gerichtete Lichtstrahl durchläuft, mit dem Astigmatismus einer vergrößernden Linseneinrichtung (4c) versehen ist.

9. Optische Abtastvorrichtung nach Anspruch 8, bei der die den Astigmatismus vergrößernde Linseneinrichtung eine Zylinderlinsenfläche (4c, Fig. 15A) aufweist.

10. Optische Abtastvorrichtung nach einem der Ansprüche 1 bis 7, bei der die optische Gitteranordnung (2) in ihrem ersten Oberflächenbereich (202) in einer Fläche (4b), die der durch die zweite Gitteranordnung (3) zum Photodetektor (8) gerichtete Lichtstrahl durchläuft, mit einer Linseneinrichtung (4c) zum Vergrößern der Lichtflecke versehen ist.

11. Optische Abtastvorrichtung nach Anspruch 10, bei der die Linseneinrichtung eine konkave Linsenfläche (4c, Fig. 15B) aufweist.

12. Optische Abtastvorrichtung nach Anspruch 5, bei der das holographische Gitter (3) in zwei Abschnitte (3a, 3b) unterteilt ist, um Fokussierabweichungssignale durch das Keilprismaverfahren zu erhalten.

13. Optische Abtastvorrichtung nach Anspruch 5, bei der das holographische Gitter (3) zusätzlich den Einfluß von Astigmatismus oder Koma in dem vom Aufzeichnungsträger reflektierten und durch die Beugungsanordnung (2) durch gehenden Lichtstrahl (9c - 11c) vermindert.

14. Optische Abtastvorrichtung nach Anspruch 5, bei der das holographische Gitter (3) zusätzlich die auf dem Photodetektor ausgebildeten Lichtflecke (9d - 11d) vergrößert.

15. Optische Abtastvorrichtung nach Anspruch 5, bei der das holographische Gitter (3) zusätzlich den Astigmatismus in dem vom Aufzeich-

nungsträger reflektierten und die Gitteranordnung durchstrahlenden Lichtstrahl (9c - 11c) vergrößert.

16. Optische Abtastvorrichtung nach Anspruch 12 in Abhängigkeit von Anspruch 4, bei der das holographische Gitter (3) in die besagten zwei Abschnitte (3a, 3b) entlang einer Linie (30, Fig. 22) unterteilt ist, die sich parallel zu den Gitterlinien des Beugungsgitters (4a) erstreckt.

17. Optische Abtastvorrichtung nach einem der vorstehenden Ansprüche, bei der die erste und zweite Gitteranordnung (4a, 3) so angeordnet sind, daß der durch die zweite Gitteranordnung (3) auf den Photodetektor (8) ausgerichtete Lichtstrahl (9c - 11c) durch eine nicht mit einem Gitter versehene Fläche (4b) des ersten Oberflächenbereichs (202) aus der Gitteranordnung (2) austritt.

18. Optische Gitteranordnung (2) zur Verwendung in einer optischen Abtastvorrichtung zum Lesen von auf einem Aufzeichnungsträger aufgezeichneter Information, in welcher Vorrichtung die Anordnung zwischen einer Lichtquelle und dem Aufzeichnungsträger angeordnet ist, **dadurch gekennzeichnet,** daß die optische Gitteranordnung aus einem einzigen Teil besteht, mit:

- einem ersten Oberflächenbereich (202), der bei Benutzung so angeordnet ist, daß er Licht von der Lichtquelle empfängt;
- einem zweiten Oberflächenbereich (201), der bei Benutzung so angeordnet ist, daß er vom Aufzeichnungsträger reflektiertes Licht empfängt;
- einer ersten Gittereinrichtung (4a), die im ersten Oberflächenbereich ausgebildet ist, um aus einem von der Lichtquelle abgestrahlten Lichtstrahl (9) einen Strahl (9a) nullter Ordnung und ein Paar Strahlen (10a, 11a) erster Ordnung zu erzeugen; und
- einer zweiten Gittereinrichtung (3), die im zweiten Oberflächenbereich ausgebildet ist, um einen Teil des vom Aufzeichnungsträger reflektierten Lichtstrahls (9c - 11c) zum Photodetektor der Vorrichtung zu lenken.

19. Optische Abtastvorrichtung nach Anspruch 18, bei der die erste Gitteranordnung ein Beugungsgitter (4a) aufweist.

20. Optische Gitteranordnung nach Anspruch 18 oder Anspruch 19, bei der die zweite Gittereinrichtung ein holographisches Gitter (3) aufweist.

21. Optische Gitteranordnung nach einem der Ansprüche 18 bis 20, die aus Glas besteht.

22. Optische Gitteranordnung nach einem der Ansprüche 18 bis 20, die aus Plastik besteht.

23. Optische Gitteranordnung nach einem der Ansprüche 18 bis 22, die ferner eine Linseneinrichtung (4c) zum Fördern von Astigmatismus aufweist und die im ersten Oberflächenbereich (202) in einer Fläche (4b) angeordnet ist, durch die der durch die zweite Gittereinrichtung (3) ausgerichtete Lichtstrahl zum Photodetektor läuft.

24. Optische Gitteranordnung nach Anspruch 23, bei der die Linseneinrichtung zum Fördern von Astigmatismus eine Zylinderlinsenfläche (4c, Fig. 15A) aufweist.

25. Optische Gitteranordnung nach einem der Ansprüche 18 bis 22, die ferner eine Linseneinrichtung (4c) zum Vergrößern der auf dem Photodetektor ausgebildeten Lichtflecke aufweist, die im ersten Oberflächenbereich (202) in einer Fläche (4b) angeordnet ist, durch die der durch die zweite Gittereinrichtung (3) ausgerichtete Lichtstrahl zum Photodetektor läuft.

26. Optische Gitteranordnung nach Anspruch 25, bei der die Linseneinrichtung eine konkave Linsenfläche (4c, Fig. 15B) aufweist.

27. Optische Gitteranordnung nach Anspruch 20, bei der das holographische Gitter (3) in zwei Abschnitte (3a, 3b) unterteilt ist, um den vom Aufzeichnungsträger reflektierten, auf das holographische Gitter fallenden Lichtstrahl in zwei Beugungsstrahlen erster Ordnung (9c - 11c, 9d - 11d) aufzuteilen.

28. Optische Gitteranordnung nach Anspruch 20, bei der das holographische Gitter (3) die zusätzliche Funktion des Linderns des Einflusses von Astigmatismus oder Koma in dem vom Aufzeichnungsmedium reflektierten und durch die Gitteranordnung durchgestrahlten Lichtstrahl (9c - 11c) aufweist.

29. Optische Gitteranordnung nach Anspruch 20, bei der das holographische Gitter (3) die zusätzliche Funktion des Vergrößern der auf dem Photodetektor ausgebildeten Lichtflecke aufweist.

30. Optische Gitteranordnung nach Anspruch 20, bei der das holographische Gitter (3) die zusätzliche Funktion des Förderns des Astigmatismus in dem vom Aufzeichnungsträger reflektierten und durch die Gitteranordnung hindurchgestrahlten Lichtstrahl (9c - 11c) aufweist.

31. Optische Gitteranordnung nach Anspruch 27 in Abhängigkeit von Anspruch 19, bei der das holographische Gitter (3) in die besagten zwei Abschnitte (3a, 3b) entlang einer Linie (30, Fig. 22) unterteilt ist, die sich parallel zu den Gitterlinien des Beugungsgitters (4a) erstreckt.

32. Optische Gitteranordnung nach einem der Ansprüche 18 - 31, bei der die erste und zweite Gittereinrichtung (4a, 3) so ausgebildet sind, daß in der optischen Abtastvorrichtung der durch die zweite Gittereinrichtung (3) auf den Photodetektor (8) ausgerichtete Lichtstrahl (9c - 11c) durch eine nicht mit einem Gitter versehene Fläche (4b) des ersten Oberflächenbereichs (202) aus der Gitteranordnung (2) austritt.

Revendications

1. Appareil de lecture optique pour lire des informations enregistrées sur une ou des pistes définies sur un support d'enregistrement (7) en obligeant un point lumineux focalisé (9b) à effectuer un balayage le long de ladite ou desdites pistes et en dirigeant une lumière réfléchie à partir dudit support vers un photodétecteur (8), l'appareil comprenant :

des premiers moyens formant réseau (4a) destinés à dériver d'un faisceau de lumière (9) émis par une source de lumière (1) un faisceau principal (9a) qui est focalisé pour former ledit point lumineux focalisé (9b), et deux faisceaux secondaires (10a, 11a) qui sont focalisés sur le support d'enregistrement pour servir à détecter une erreur de piste du faisceau principal, caractérisé par :

des seconds moyens formant réseau (3) destinés à diriger une partie du faisceau de lumière réfléchi à partir dudit support d'enregistrement vers ledit photodétecteur; et

un ensemble de réseaux optiques (2) formé d'une seule pièce comprenant une première partie de surface (202) qui reçoit une lumière provenant de ladite source de lumière (1) et comporte lesdits premiers moyens formant réseau (4a), et une seconde partie de surface (201) qui reçoit une lumière réfléchie à partir dudit support d'enregistrement (7) et comporte lesdits seconds moyens formant réseau (3).

2. Appareil de lecture optique selon la revendication 1, dans lequel le faisceau de lumière (9d) dirigé par lesdits seconds moyens formant réseau (3) est détecté par ledit photodétecteur (8) à l'aide de la méthode d'astigmatisme pour produire des signaux d'erreur de focalisation.

3. Appareil de lecture optique selon la revendication 1, dans lequel le faisceau de lumière (9e, 9f) dirigé par lesdits seconds moyens formant réseau (3, 3a, 3b) est détecté par ledit photodétecteur (8) grâce à la méthode du prisme en coin pour produire des signaux d'erreur de focalisation.

4. Appareil de lecture optique selon l'une quelconque des revendications 1 à 3, dans lequel lesdits premiers moyens formant réseau comportent un réseau de diffraction (4a).

5. Appareil de lecture optique selon l'une quelconque des revendications précédentes, dans lequel lesdits seconds moyens formant réseau comportent un réseau holographique (3).

6. Appareil de lecture optique selon l'une quelconque des revendications précédentes, dans lequel ledit ensemble de réseaux optiques (2) est fait de verre.

7. Appareil de lecture optique selon l'une quelconque des revendications 1 à 5, dans lequel ledit ensemble de réseaux optiques (2) est fait de matières plastiques.

8. Appareil de lecture optique selon l'une quelconque des revendications précédentes, dans lequel ledit ensemble de réseaux optiques (2) comporte des moyens formant lentille (4c) destinés à augmenter un astigmatisme dans sa première partie de surface (202) au niveau d'une zone (4b) dans laquelle passe le faisceau de lumière dirigé par lesdits seconds moyens formant réseau (3) vers ledit photodétecteur (8).

9. Appareil de lecture optique selon la revendication 8, dans lequel lesdits moyens formant lentille destinés à augmenter un astigmatisme comportent une surface de lentille cylindrique (4c, Fig. 15A).

10. Appareil de lecture optique selon l'une quelconque des revendications 1 à 7, dans lequel ledit ensemble de réseaux optiques (2) comporte des moyens formant lentille (4c) destinés à grossir des points lumineux dans ladite première partie de surface (202) au niveau d'une

zone (4b) dans laquelle passe le faisceau de lumière dirigé par lesdits seconds moyens formant réseau (3) vers ledit photodétecteur (8).

11. Appareil de lecture optique selon la revendication 10, dans lequel lesdits moyens formant lentille comportent une surface de lentille concave (4c, Fig. 15B).

12. Appareil de lecture optique selon la revendication 5, dans lequel ledit réseau holographique (3) est divisé en deux sections (3a, 3b) afin d'obtenir des signaux d'erreur de focalisation grâce à la méthode du prisme en coin.

13. Appareil de lecture optique selon la revendication 5, dans lequel ledit réseau holographique (3) a une fonction supplémentaire qui consiste à atténuer l'influence d'un astigmatisme ou d'une coma du faisceau de lumière (9c-11c) réfléchi par ledit support d'enregistrement et transmis par l'intermédiaire dudit ensemble de réseaux (2).

14. Appareil de lecture optique selon la revendication 5, dans lequel ledit réseau holographique (3) a une fonction supplémentaire qui consiste à grossir les points lumineux (9d-11d) formés sur ledit photodétecteur.

15. Appareil de lecture optique selon la revendication 5, dans lequel ledit réseau holographique (3) a une fonction supplémentaire qui consiste à augmenter un astigmatisme du faisceau de lumière (9c-11c) réfléchi par ledit support d'enregistrement et transmis par l'intermédiaire dudit ensemble de réseaux (2).

16. Appareil de lecture optique selon la revendication 12, lorsqu'elle est dépendante de la revendication 4, dans lequel ledit réseau holographique (3) est divisé pour définir lesdites deux sections (3a, 3b) le long d'une ligne (30, Fig. 22) qui s'étend parallèlement aux lignes de réseau dudit réseau de diffraction (4a).

17. Appareil de lecture optique selon l'une quelconque des revendications précédentes, dans lequel lesdits premiers et seconds moyens formant réseau (4a, 3) sont disposés de telle façon que le faisceau de lumière (9c-11c) dirigé par lesdits seconds moyens formant réseau (3) vers ledit photodétecteur (8) sort dudit ensemble de réseaux (2) en passant à travers une zone sans réseau (4b) de ladite première partie de surface (202).

18. Ensemble de réseaux optiques (2) destiné à être utilisé dans un appareil de lecture optique pour lire des informations enregistrées sur un support d'enregistrement, appareil dans lequel ledit ensemble est disposé entre une source de lumière et ledit support d'enregistrement, caractérisé en ce que ledit ensemble de réseaux optiques est formé d'une seule pièce comprenant :

une première partie de surface (202) disposée pour, en service, recevoir une lumière provenant de ladite source de lumière;

une seconde partie de surface (201) disposée pour, en service, recevoir une lumière réfléchie à partir dudit support d'enregistrement;

des premiers moyens formant réseau (4a) prévus sur ladite première partie de surface pour dériver d'un faisceau de lumière (9) émis par ladite source de lumière un faisceau d'ordre zéro (9a) et deux faisceaux (10a, 11a) du premier ordre; et

des seconds moyens formant réseau (3) prévus sur ladite seconde partie de surface pour diriger une partie du faisceau de lumière (9c-11c) réfléchi à partir dudit support d'enregistrement vers un photodétecteur dudit appareil.

19. Ensemble de réseaux optiques selon la revendication 18, dans lequel lesdits premiers moyens formant réseau comportent un réseau de diffraction (4a).

20. Ensemble de réseaux optiques selon la revendication 18 ou la revendication 19, dans lequel lesdits seconds moyens formant réseau comportent un réseau holographique (3).

21. Ensemble de réseaux optiques selon l'une quelconque des revendications 18 à 20, qui est fait de verre.

22. Ensemble de réseaux optiques selon l'une quelconque des revendications 18 à 20, qui est fait de matières plastiques.

23. Ensemble de réseaux optiques selon l'une quelconque des revendications 18 à 22, comportant également des moyens formant lentille (4c) destinés à augmenter un astigmatisme et prévus dans ladite première partie de surface (202) au niveau d'une zone (4b) dans laquelle passe le faisceau de lumière dirigé par lesdits seconds moyens formant réseau (3) vers ledit photodétecteur.

24. Ensemble de réseaux optiques selon la revendication 23, dans lequel lesdits moyens formant lentille destinés à augmenter un astigmatisme comportent une surface de lentille cylindrique (4c, Fig. 15A).

25. Ensemble de réseaux optiques selon l'une quelconque des revendications 18 à 22, comportant également des moyens formant lentille (4c) destinés à grossir les points lumineux formés sur ledit photodétecteur et prévus dans ladite première partie de surface (202) au niveau d'une zone (4b) dans laquelle passe le faisceau de lumière dirigé par lesdits seconds moyens formant réseau (3) vers ledit photodétecteur.

26. Ensemble de réseaux optiques selon la revendication 25, dans lequel lesdits moyens formant lentille comportent une surface de lentille concave (4c, Fig. 15B).

27. Ensemble de réseaux optiques selon la revendication 20, dans lequel ledit réseau holographique (3) est divisé en deux sections (3a, 3b) afin de diviser le faisceau de lumière réfléchi par ledit support d'enregistrement et incident sur ledit réseau holographique en deux faisceaux diffractés (9c-11c, 9d-11d) du premier ordre.

28. Ensemble de réseaux optiques selon la revendication 20, dans lequel ledit réseau holographique (3) a une fonction supplémentaire qui consiste à atténuer l'influence d'un astigmatisme ou d'une coma du faisceau de lumière (9c-11c) réfléchi par ledit support d'enregistrement et transmis par l'intermédiaire de l'ensemble de réseaux.

29. Ensemble de réseaux optiques selon la revendication 20, dans lequel ledit réseau holographique (3) a une fonction supplémentaire qui consiste à grossir les points lumineux formés sur ledit photodétecteur.

30. Ensemble de réseaux optiques selon la revendication 20, dans lequel ledit réseau holographique (3) a une fonction supplémentaire qui consiste à augmenter un astigmatisme du faisceau de lumière (9c-11c) réfléchi par ledit support d'enregistrement et transmis par l'intermédiaire de l'ensemble de réseaux.

31. Ensemble de réseaux optiques selon la revendication 27, lorsqu'elle est dépendante de la revendication 19, dans lequel ledit réseau holographique (3) est divisé pour définir lesdites deux sections (3a, 3b) le long d'une ligne (30, Fig. 22) qui s'étend parallèlement aux lignes de réseau dudit réseau de diffraction (4a).

32. Ensemble de réseaux optiques selon l'une quelconque des revendications 18 à 31, dans lequel lesdits premiers et seconds moyens formant réseau (4a, 3) sont disposés de telle façon que, dans ledit appareil de lecture optique, le faisceau de lumière (9c-11c) dirigé par lesdits seconds moyens formant réseau (3) vers ledit photodétecteur sort de l'ensemble de réseaux en passant à travers une zone sans réseau (4b) de ladite première partie de surface (202).

FIG.1

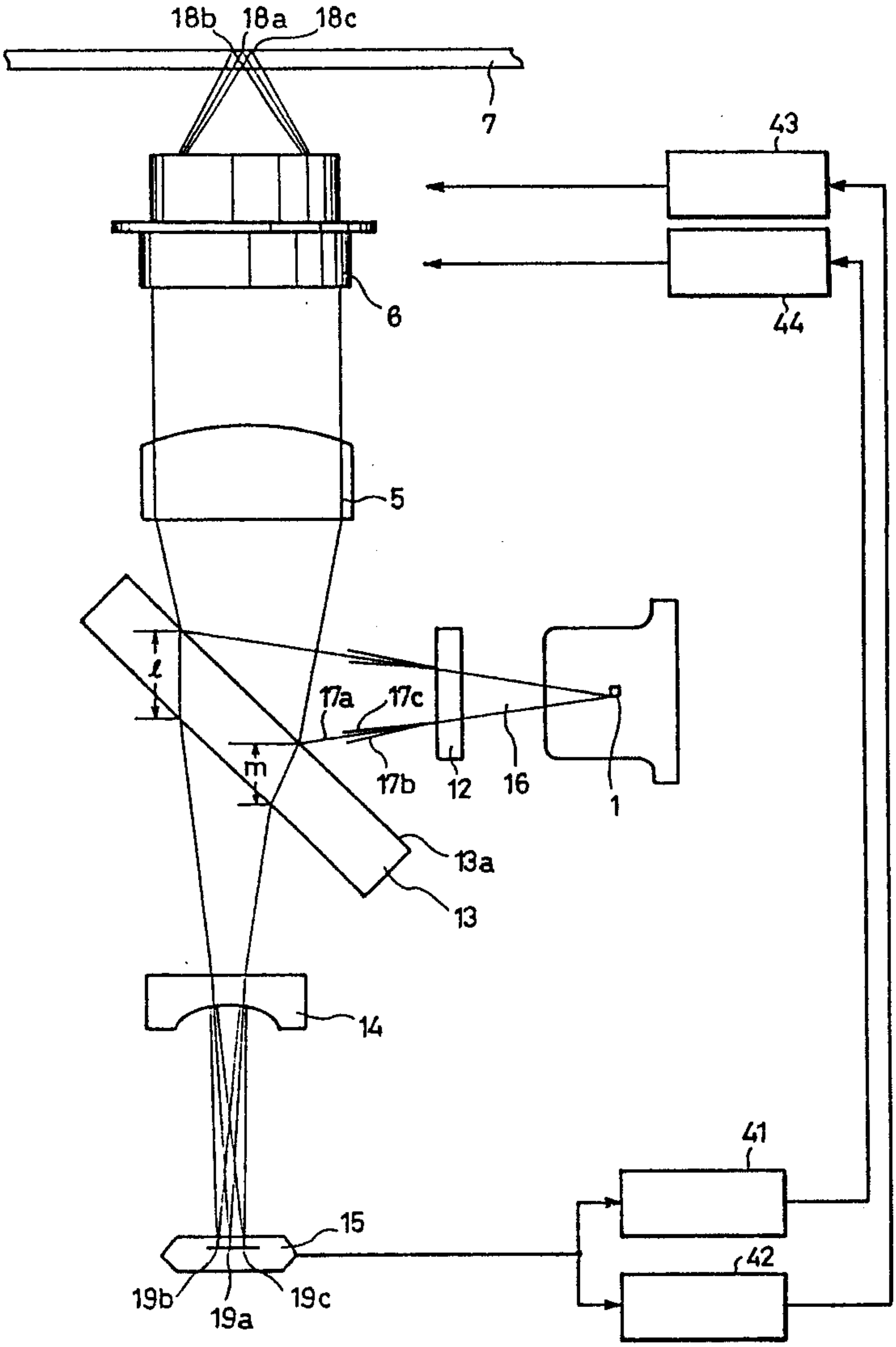

18b
18a
18c
7
43
44
6
5
1
12
16
17a
17c
17b
13a
13
14
41
42
15
19b
19a
19c

FIG. 2

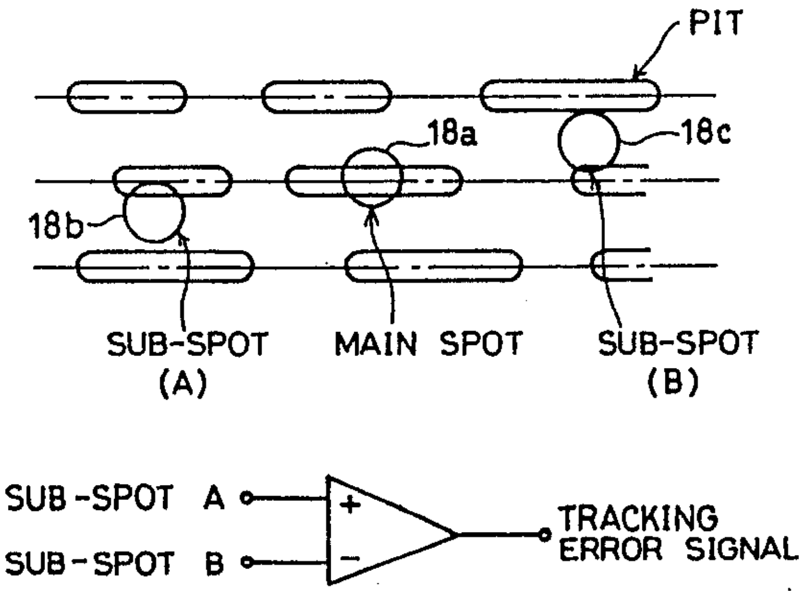

PIT
18a
18c
18b
SUB-SPOT
(A)
MAIN SPOT
SUB-SPOT
(B)
SUB-SPOT A
SUB-SPOT B
+
−
TRACKING
ERROR SIGNAL

FIG. 3

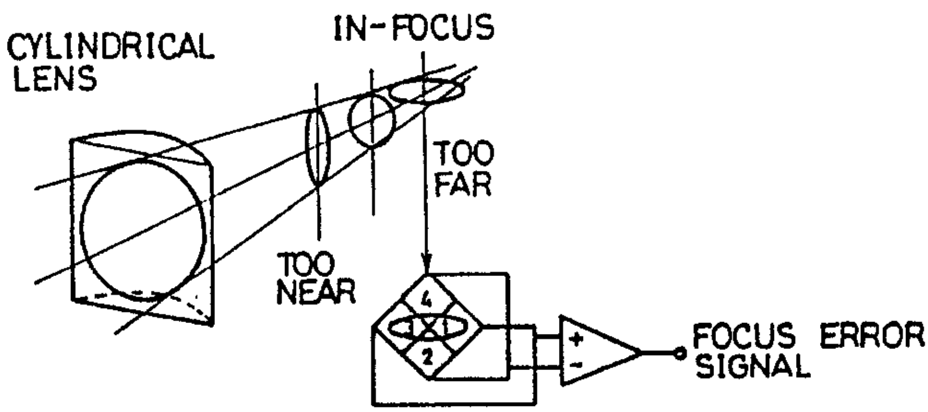

CYLINDRICAL
LENS
IN-FOCUS
TOO
FAR
TOO
NEAR
4
1
2
+
-
FOCUS ERROR
SIGNAL

FIG.4A

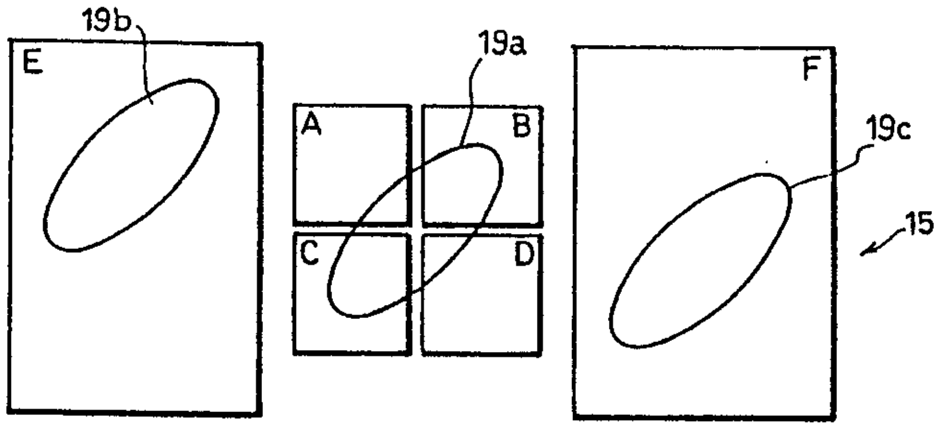


FIG.4B

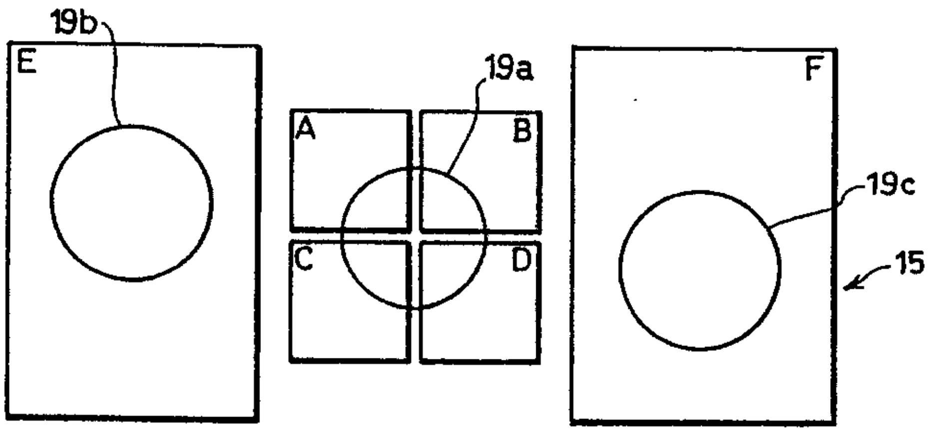


FIG.4C

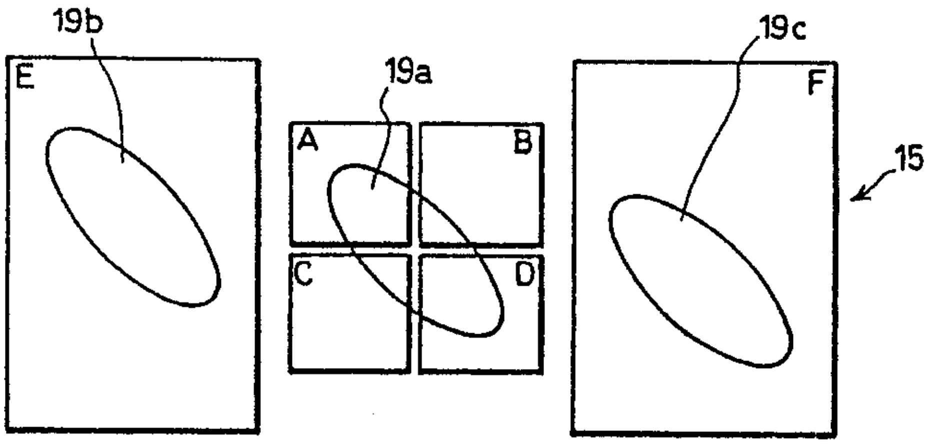


FIG.5

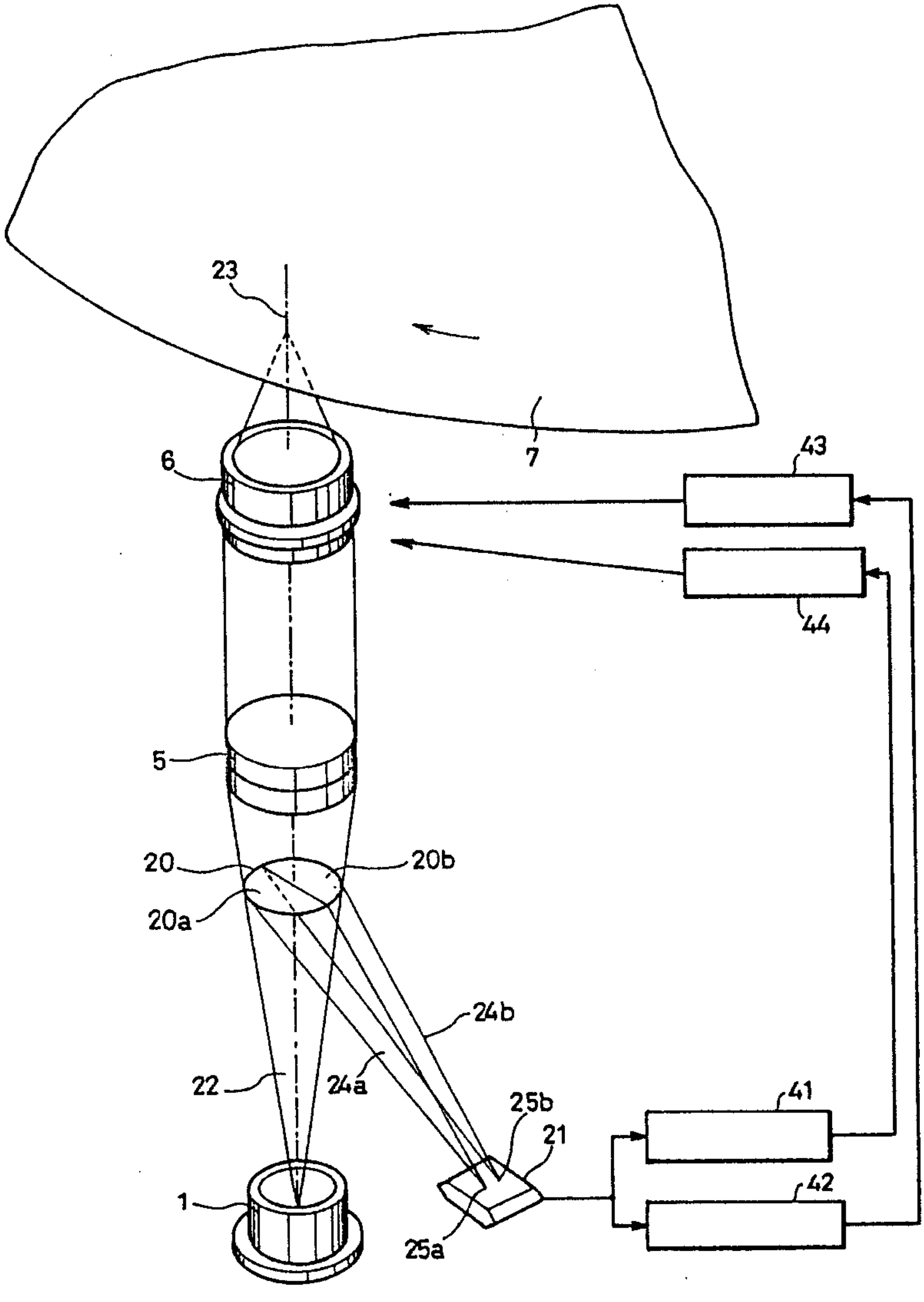


FIG.6

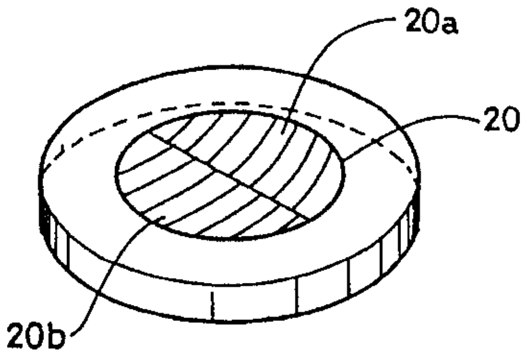

20a
20
20b

FIG.7

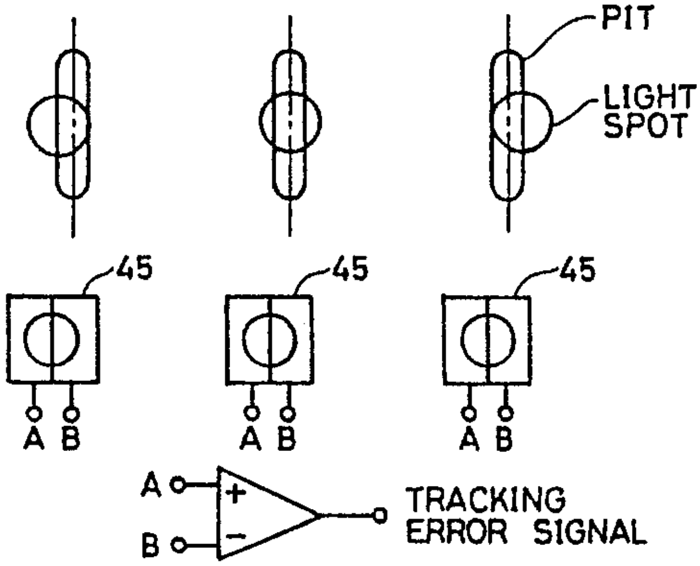

PIT
LIGHT SPOT
45
45
45
A B
A B
A B
A
B
+
−
TRACKING ERROR SIGNAL

FIG.8A

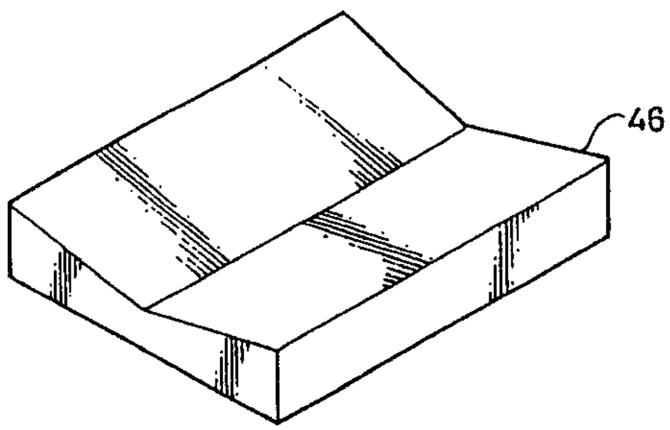


FIG.8B

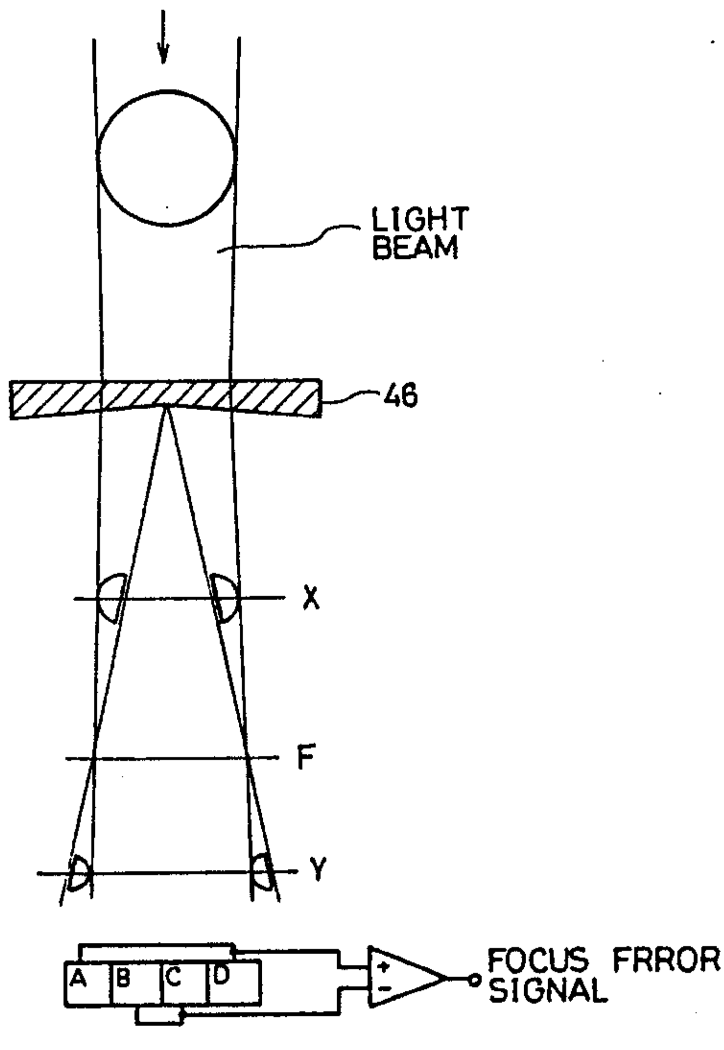


FIG.9A

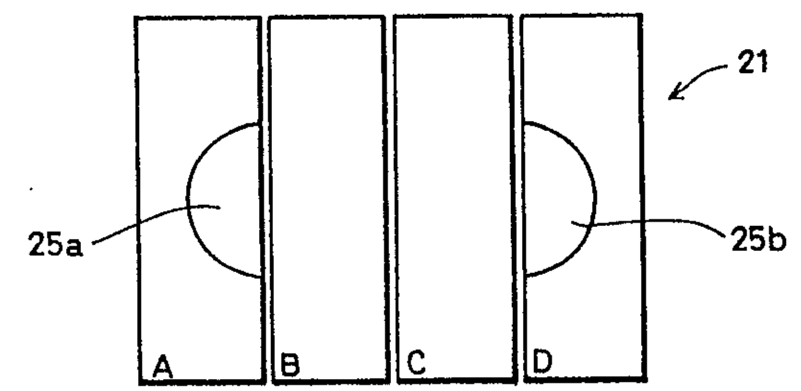


FIG.9B

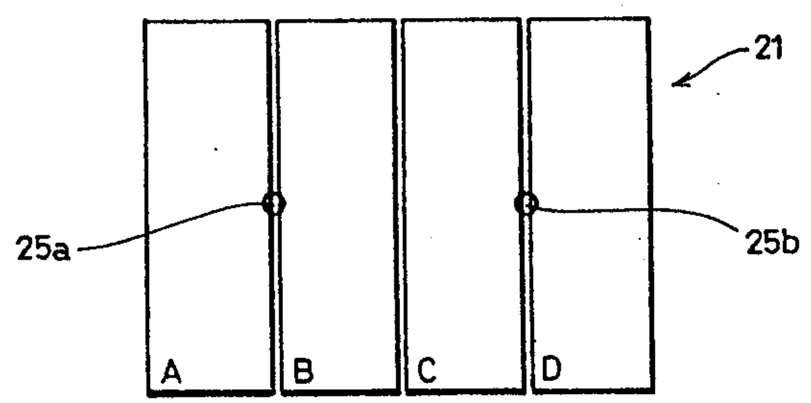


FIG.9C

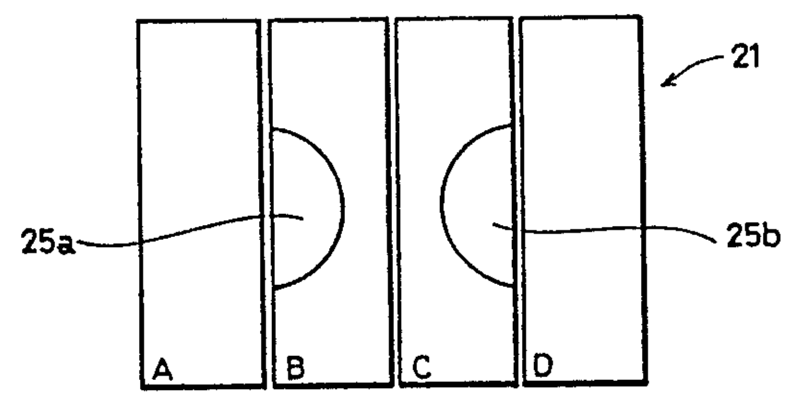


FIG.10

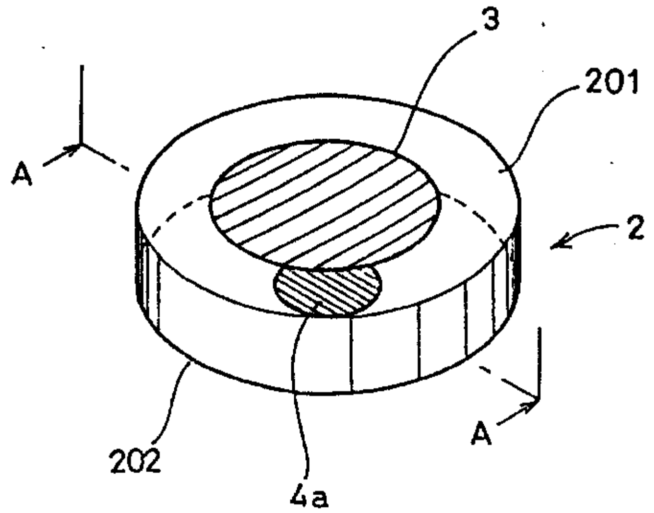


FIG.11A

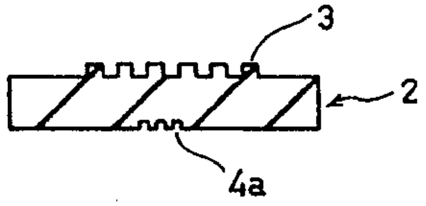


FIG.11B

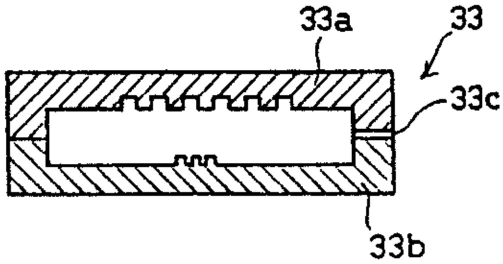


FIG.11C

FIG.11D

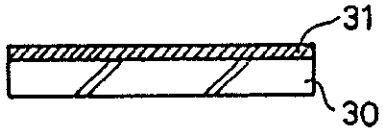


FIG.11E

FIG.11F

FIG.11G

FIG.12

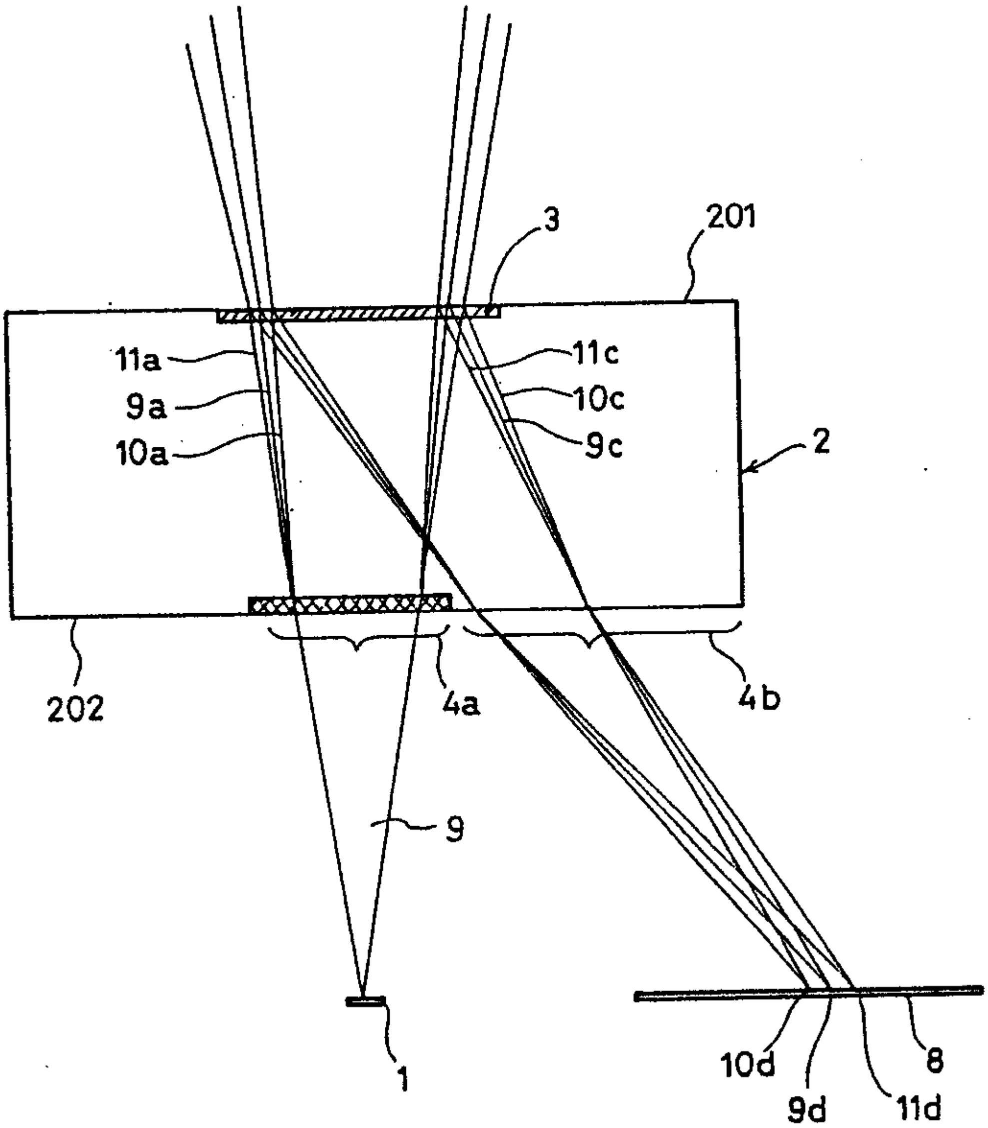


FIG. 13

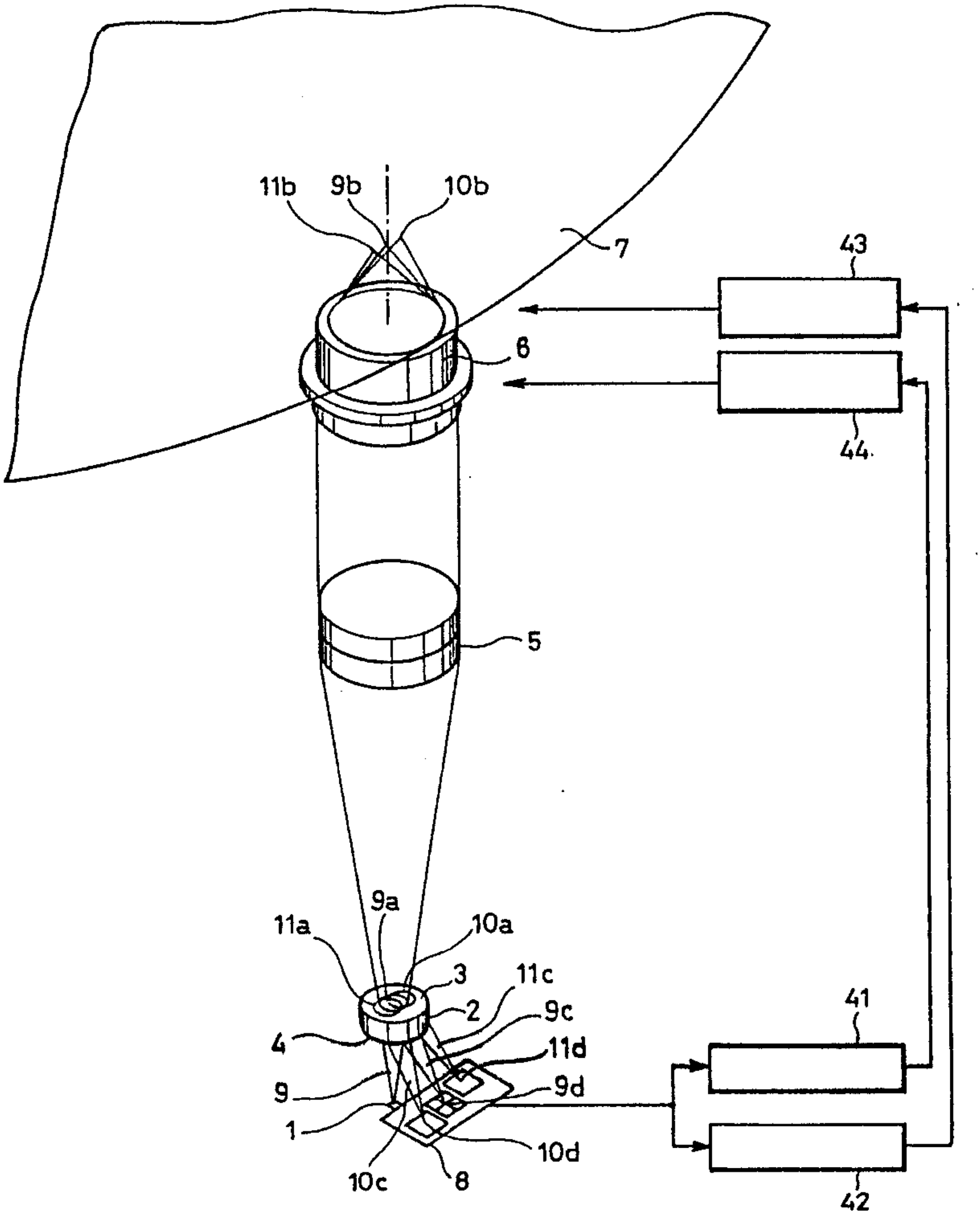


FIG.14A

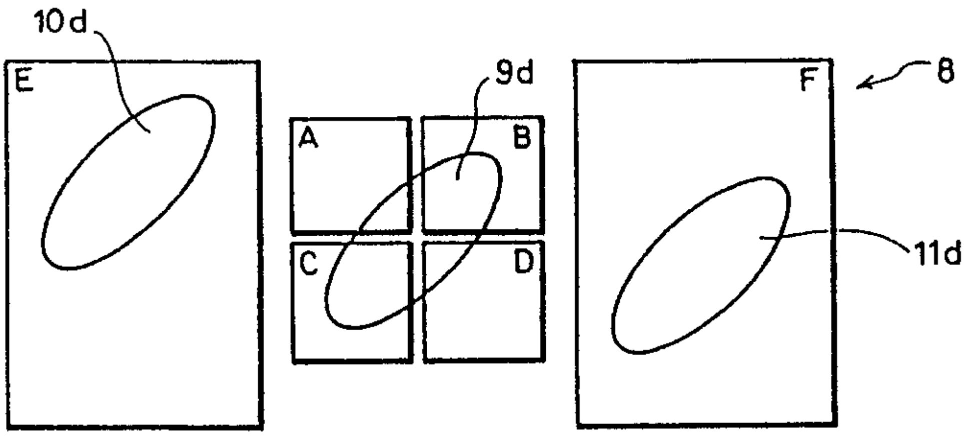


FIG.14B

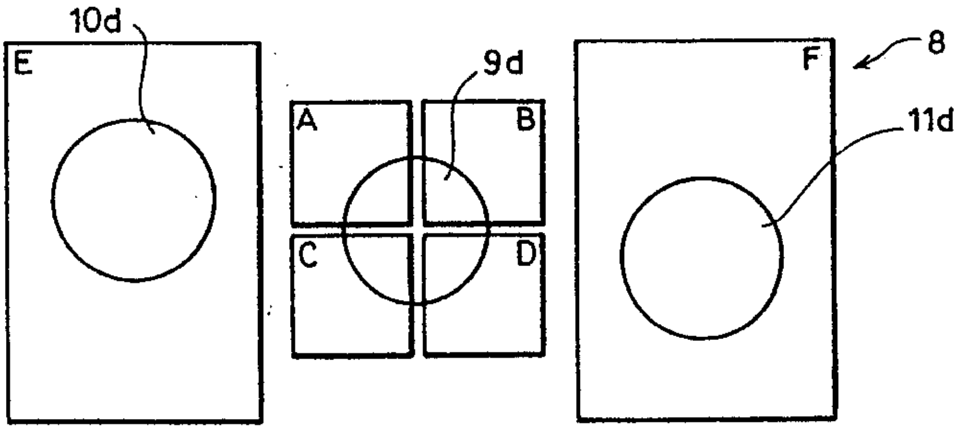


FIG.14C

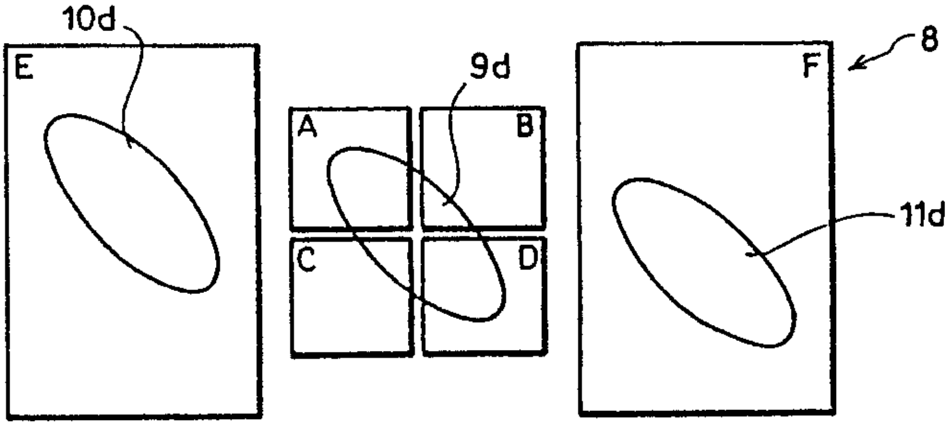


FIG.15A

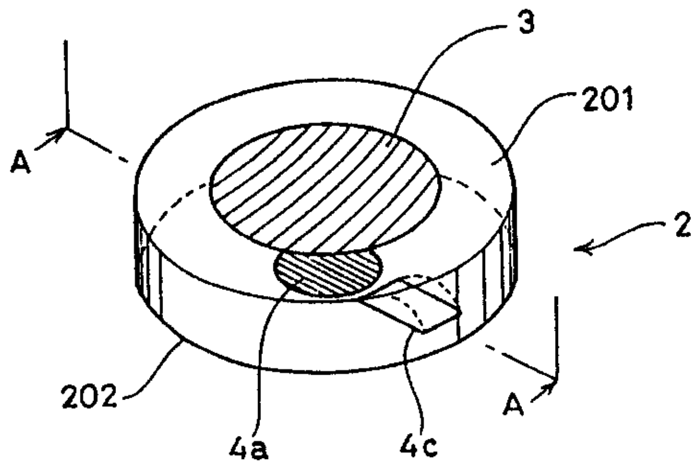


FIG.15B

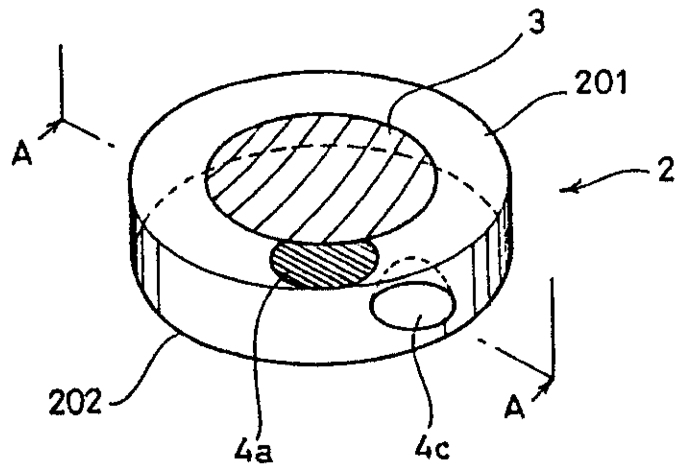


FIG.16

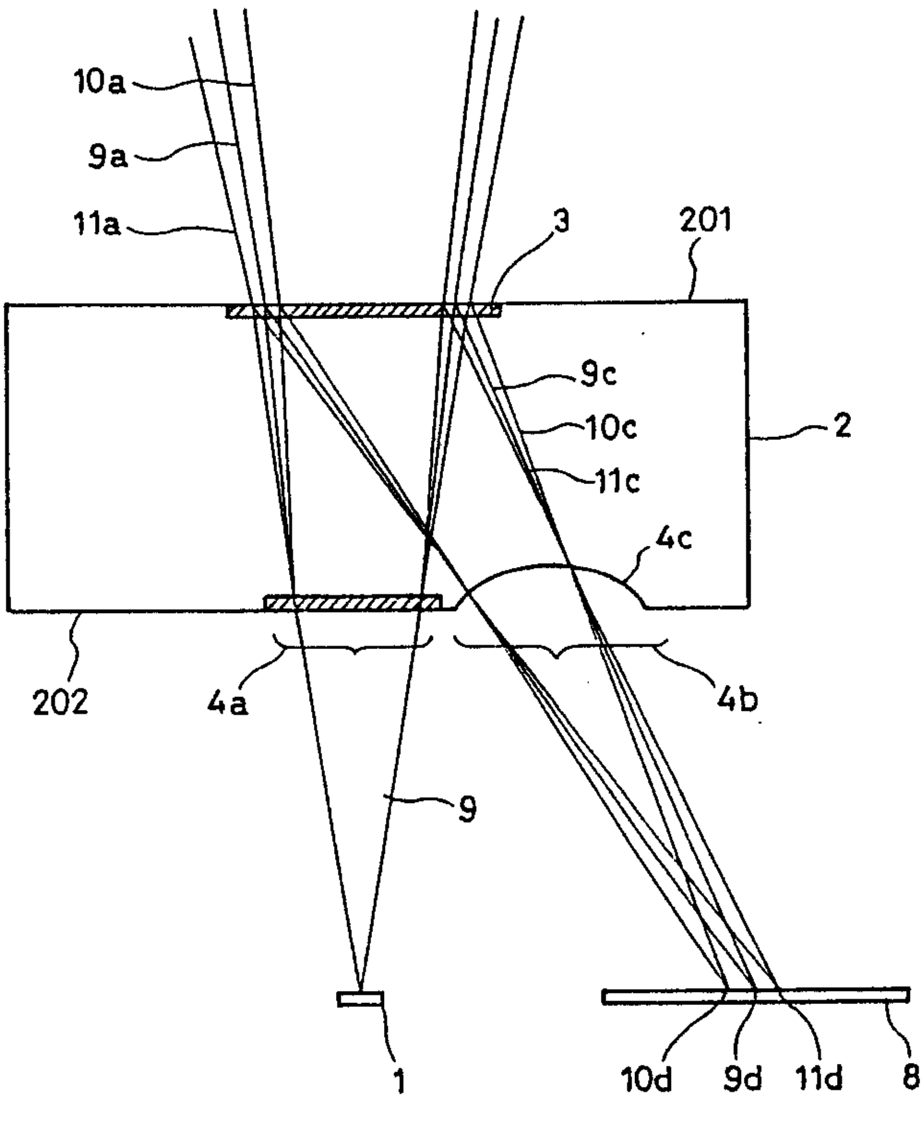


FIG.17

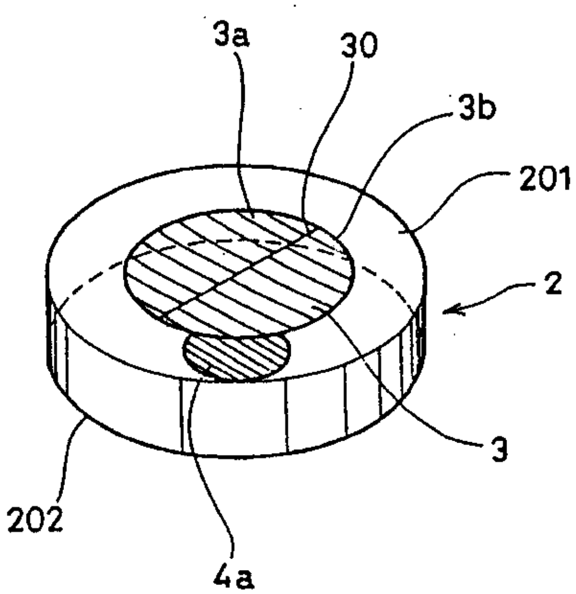


FIG.18

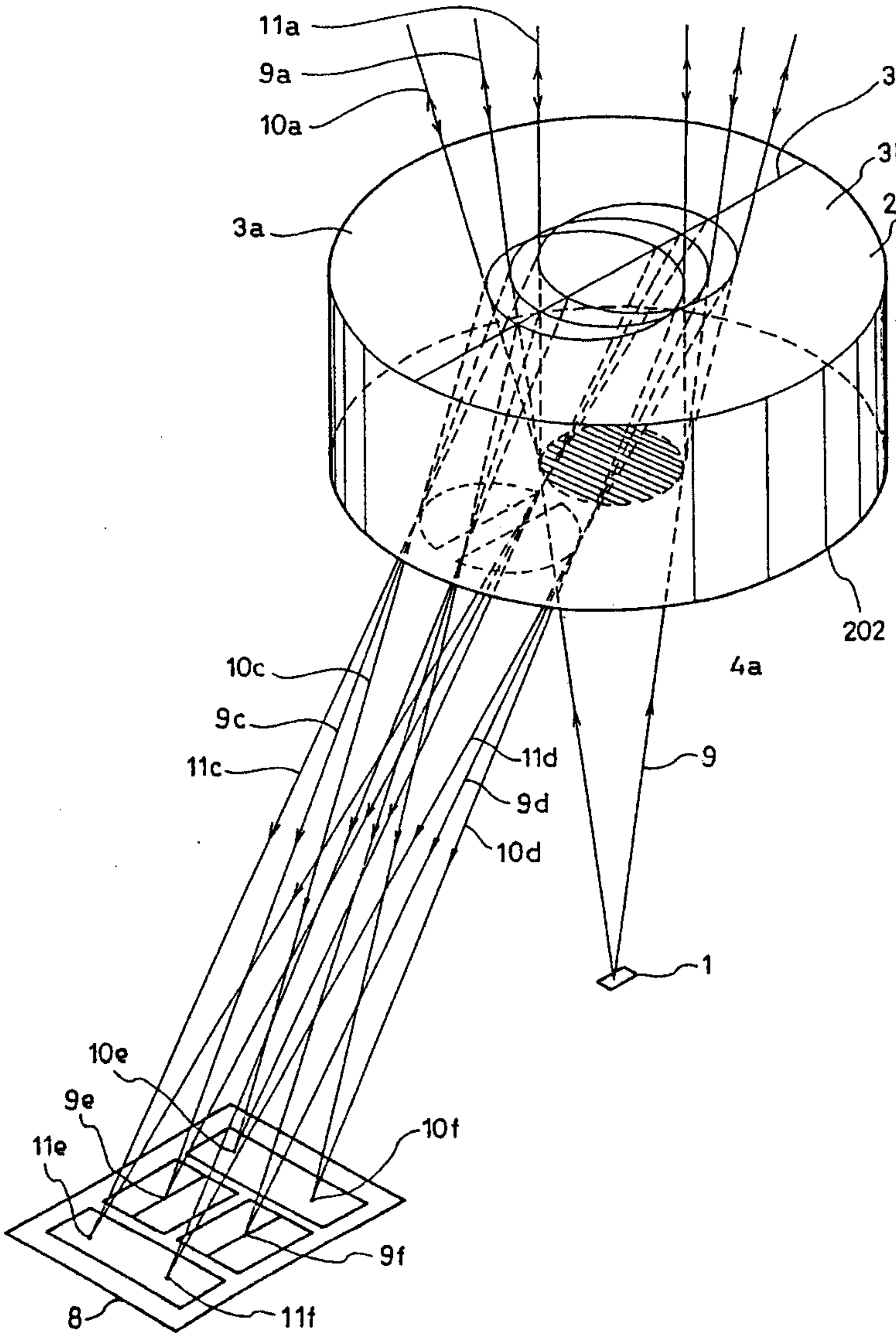

11a
9a
10a
30
3b
201
3a
2
202
4a
10c
9c
11c
11d
9
9d
10d
1
10e
9e
10f
11e
9f
8
11f

FIG.19

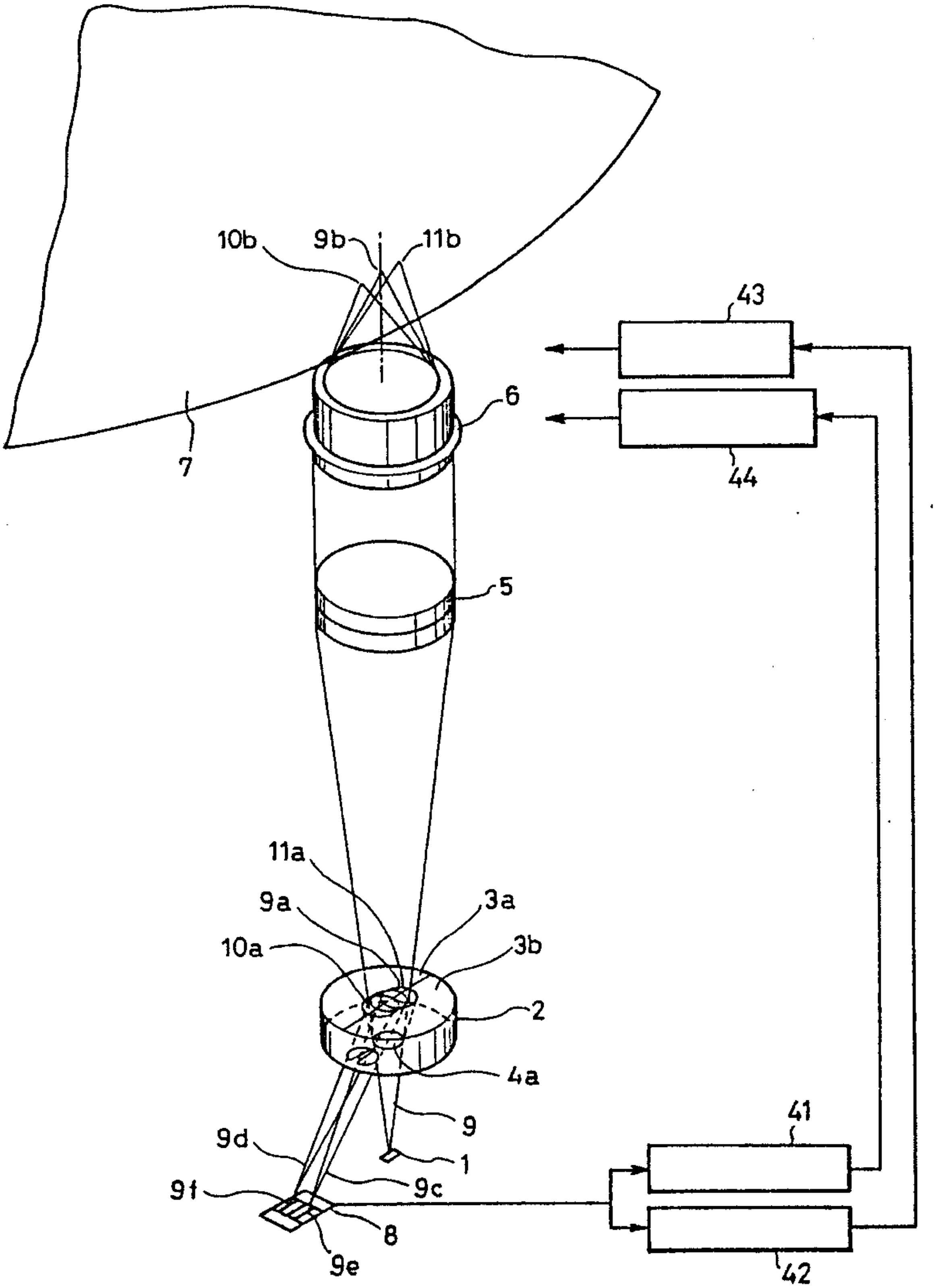


FIG.20A

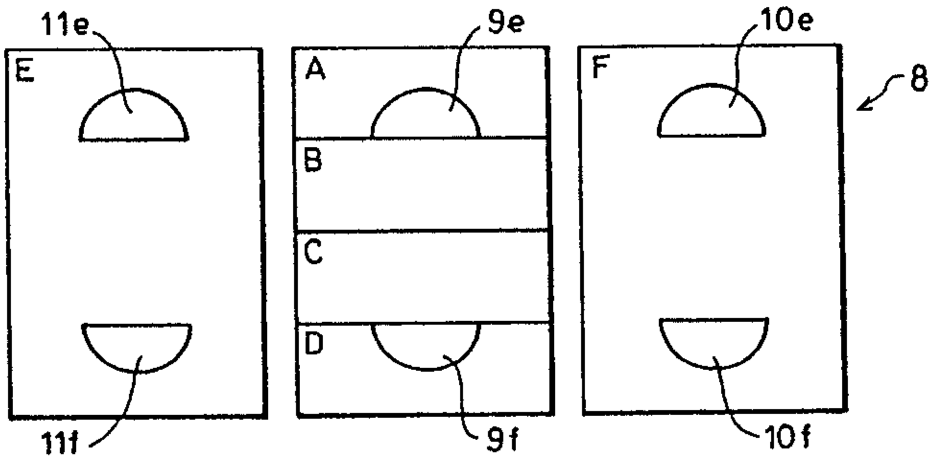


FIG.20B

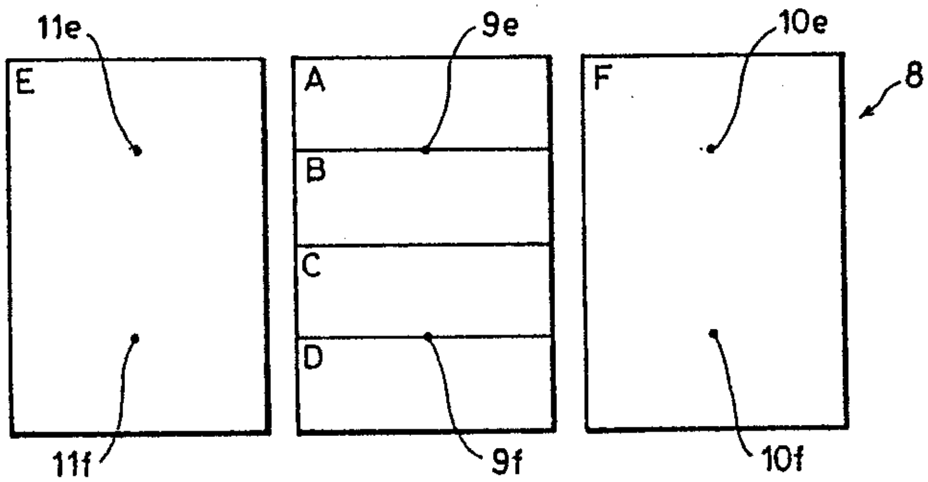


FIG.20C

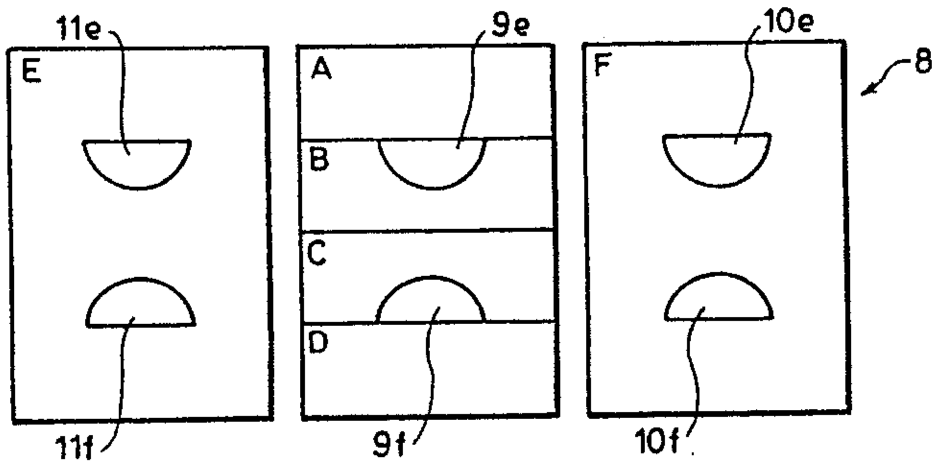


FIG.21

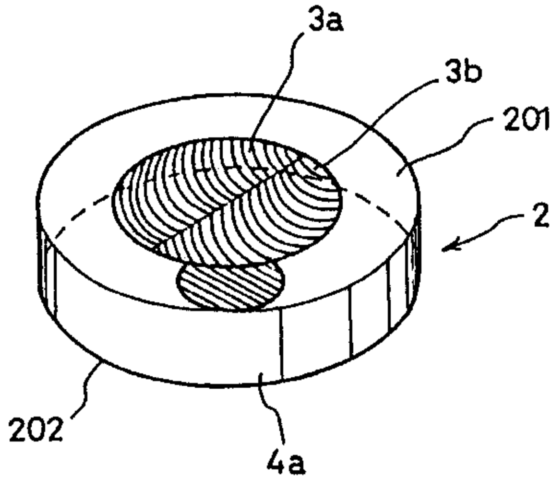


FIG.22

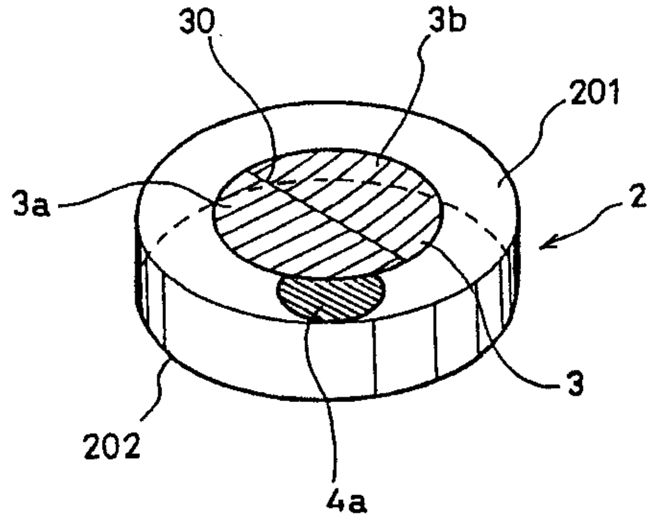


FIG. 23

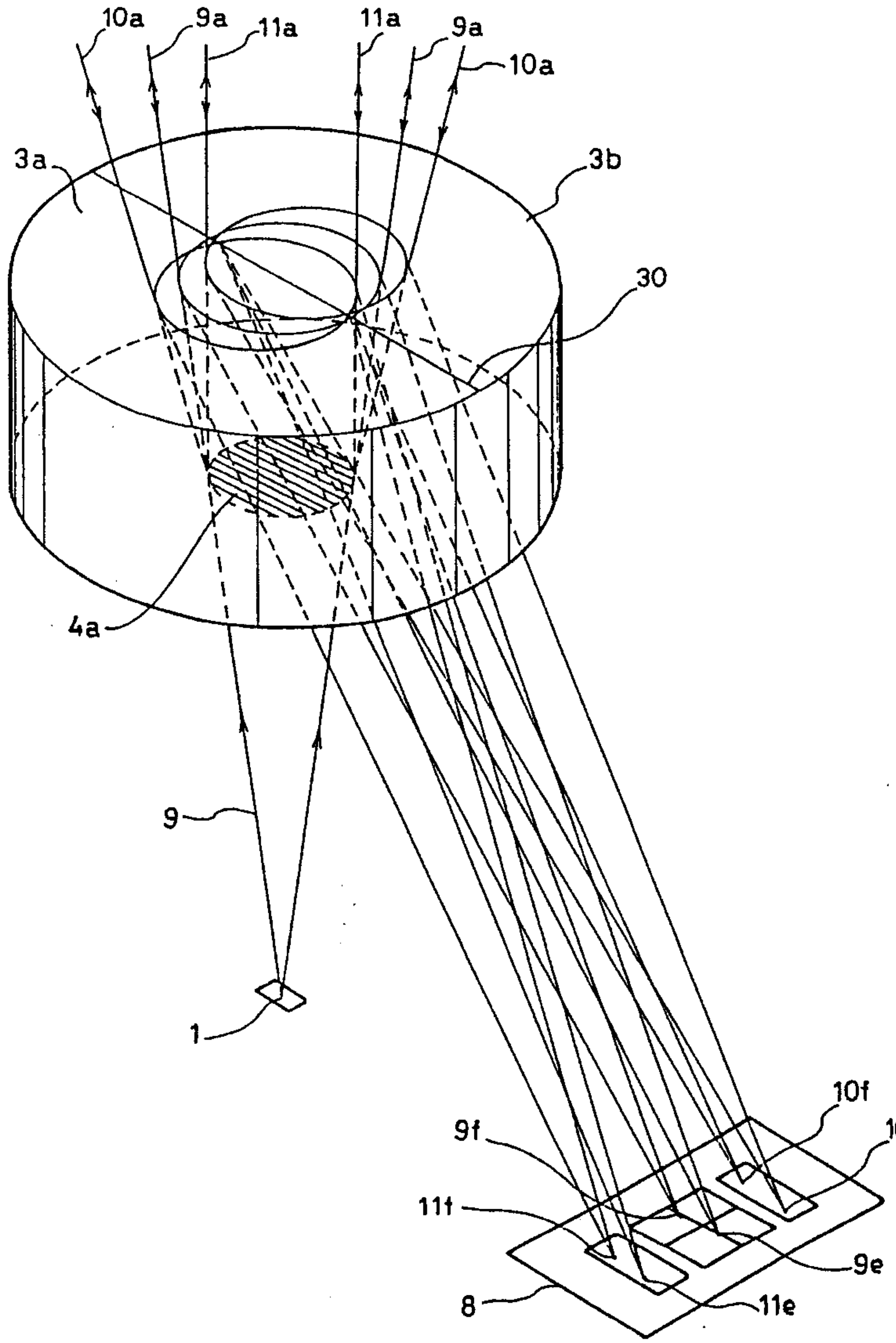
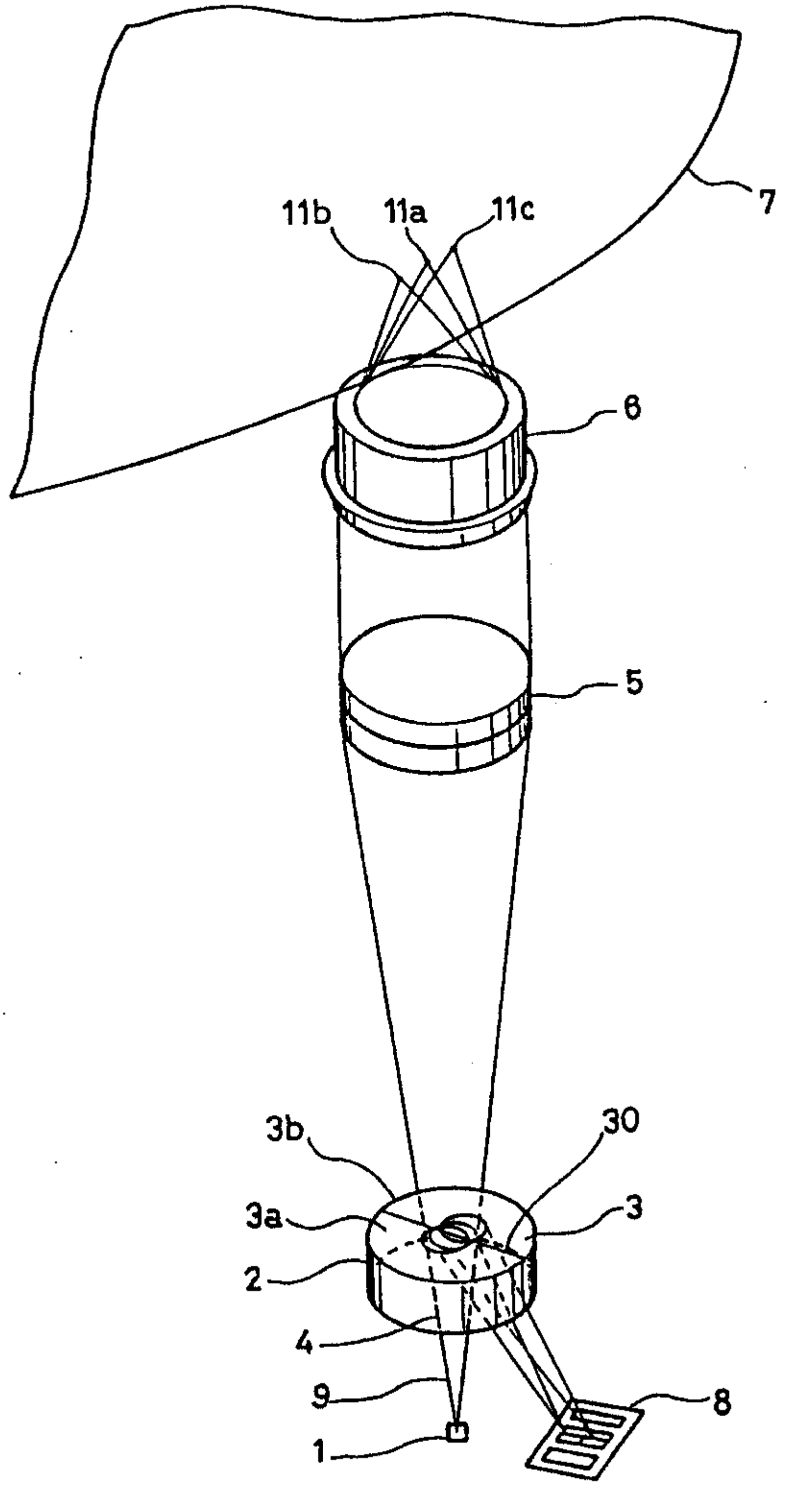


FIG. 24



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26.08.1987 in Japan - doc: 62212604
26.08.1987 in Japan - doc: 62212605
26.08.1987 in Japan - doc: 62212606

Divisional EP93200032.6

Designated States DE GB

Title OPTICAL PICKUP APPARATUS AND OPTICAL GRATING ASSEMBLY THEREFOR.

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