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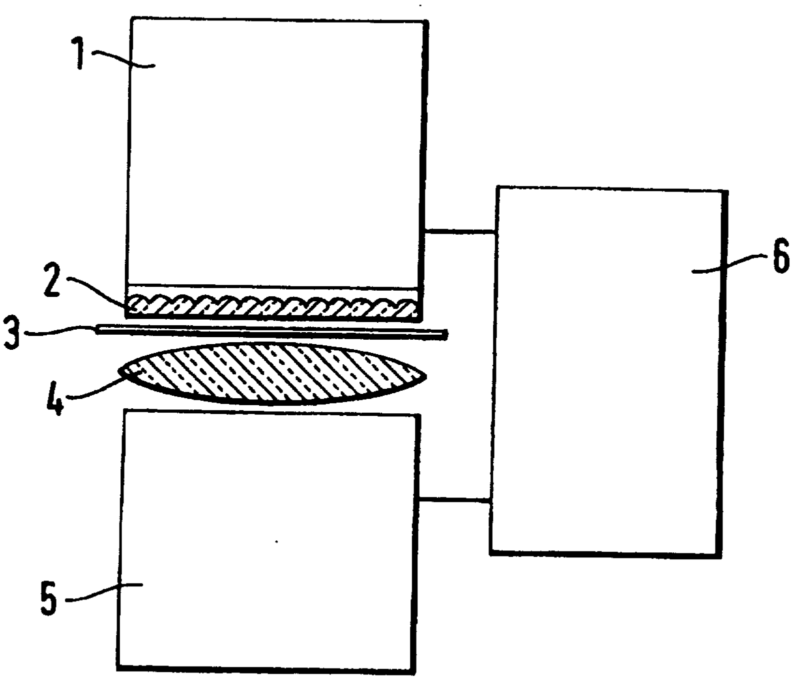
**(54) Title:** METHODS FOR OPTICAL DATA STORAGE AND APPARATUS FOR SAME

**(57) Abstract**

In a method for optical data storage a write/read device is employed with a first optical lens system consisting of an array of lenslets which are associated with one or more areas on a data-carrying medium which forms part of the optical data memory. During writing/reading of data in the data-carrying medium the optical data medium is positioned on one or more reference surfaces. When localizing or reading data which are stored in an optical data memory in this fashion, the data-carrying medium is brought in register with the first optical lens system in the write/read device, whereupon light from the write/read device passes through a set of angular coordinates, the optical response from the data-carrying medium being detected simultaneously and in parallel by means of the write/read device. A device for implementation of the method comprises a write/read device in which there is provided a first optical system (1) consisting of an array of lenslets, one or more light sources (2) for illumination of the lenslets, a second optical system (4) for imaging of the data-carrying medium and an electronic detector (5), the write/read device being further connected to an analysis unit (6).



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# Methods for optical data storage and apparatus for same

The invention concerns a method for optical data storage according to the introduction to claim 1, a method for positioning an optical data medium for optical data storage as stated in the introduction to claim 5, and a method for localization of data stored or written into an optical data memory as stated in the introduction to claim 14, together with a device for implementing the method during the optical data storage and a method for localization of data stored in or written into an optical data memory, wherein the device comprises a write/read device.

In general the present invention concerns methods and devices for optical storage and retrieval of data in planar data media or data carriers in the form of cards, disks or tapes. Similarly, the invention also concerns the mechanical construction and procedures for mechanical handling and control of the data-carrying medium during write and read operations.

Medium-high density optical data storage today is totally dominated by laser-based tracking systems, in which a sharply focused light beam follows a data track under servocontrol, e.g. in a spiral pattern covering the surface of the rotating disk. This method has a number of serious drawbacks. First of all a high precision optomechanical system is required with attendant cost and space constraints. Secondly, reading is performed serially, thus restricting the opportunities for sophisticated error correction by correlation and adaptation based on synoptic raw data acquisition from the data-carrying medium. Furthermore, very fast random access is impossible due to the mechanical tracking and finally it is difficult or impossible to increase the data density in the write/read speeds by multi-level data encoding at each individual datum location.

Recently a radically different concept has been proposed, based on incorporating a large number of microlenses in the actual data carrier and addressing a cluster of data spots under each microlens by illumination of the microlenses from a predefined set of incidence angles, as described in Norwegian patent application no. 90 0443 with the title "Data storage medium and methods for input and output of data". The data spots are located in a thin burn film inside the data-carrying medium, thus causing light which is incident on the microlenses from the write/read device to be focused to a series of small spots in the burn film, one spot being assigned to each microlens. The microlenses act as magnifying glasses, increasing the apparent size of each data spot in the burn film by one order of magnitude and more and making it possible for read-out to be performed by simultaneous imaging of large areas on the data-carrying medium, since the depth of field increases as the square of the resolution. The use of an electronic matrix detector, such as a CCD camera for the imaging enables the imaged data spot pattern to be subjected to logic operations which completely eliminate the need for mechanical alignment and tracking. In addition to this, the integration of microlenses and a data-carrying medium provides a number of other advantages. Unfortunately this is only in theory. For practical implementation in a commercial environment, there exists a number of technological as well as cost-related barriers: A major problem is that of mass production of data-carrying media with integrated microlenses, since in order to fully exploit the potential with regard to high data densities, each microlens must be very precisely controlled with respect to physical shape, positioning relative to the burn film and bulk optical properties. Each individual data-carrying medium, such as a card or disk, typically has to incorporate hundreds of thousands or millions of microlenses, arranged in precisely defined patterns parallel to the data-carrying surface.

At present a number of techniques are under development which are intended to be employed to create arrays of microlenses which are formed in situ by deposition, transformation, etching, etc. However, the current state of the art in this field is not such that quality, size and cost parameters can simultaneously satisfy the demands for mass-produced data-carrying media suitable for consumer applications.

As an alternative to in situ solutions the use has been proposed of transparent microspheres which are mounted in regular arrays on a surface. The only known, possible source of microspheres with technical specifications which could satisfy the requirements of data-carrying media with integrated microlenses is presently Dyno Particles AS of Lillestrøm, Norway, who employ a proprietary technique, known as the Ugelstad process for production of polymer microspheres in sizes restricted to 100 microns or less. In addition to the purely technical problems regarding the quality and uniformity of the microspheres themselves, the commercial viability of using microsphere-based, data-carrying media is dependent on resolving price and delivery issues stemming from the single-source situation, and these problems may well persist beyond the lifetimes of the patent protection of the method for manufacturing such microspheres according to the Ugelstad method. Even though perfectly smooth, round, clear and mono-sized polymer microspheres can be obtained in bulk at acceptable prices, a number of problems will still remain. These include the fact that the spheres have to be positioned on and integrated in the data-carrying medium at a commercially acceptable yield, acceptable speed and reasonable costs. This normally involves production lines which each supply a data carrier containing millions of microspheres every few seconds. Moreover, the spherical focusing surface creates maging errors which limit the attainable spot size, especially at large apertures where spherical aberration is a serious problem. In addition the Uglestad process or the so-called "Swollen Emulsion" process limits the choice of optical materials for the microspheres. Thus the refractive index is typically in the range N = 1.5 to N = 1.6, i.e. it is significantly less than for other polymer and glass optical materials which are currently in general use. A high microlens index of refraction is therefore a significant factor in achieving small focal spot sizes and thereby high data storage densities.

The object of the present invention is to provide remedies for the shortcomings and difficulties inherent in the state of the art as set forth above. This applies both to mainstream technologies based on tracking laser beams and relative to integrated microlens technology, and a particular object is to deal with isolated technical issues in connection with such technologies as well as potential barriers to their commercial exploitation.

This object is achieved according to the present invention with a method which is characterized by creating the first optical lens system from an array of lenslets, arranging the lenslets in a system of an array of lenslets, arranging the lenslets in a predetermined, free choice pattern, assigning each lenslet to one or more areas on one of the respective data-carrying media which form part of the optical data memory, and directing light from the light source or the light sources through the optical lens system, with the result that each lenslet directs the light to the respective area(s) associated with it on the data-carrying medium; a method which is characterized by positioning the data-carrying medium on at least one reference surface, the position of the data-carrying medium being maintained during at least one cycle which comprises writing and reading respectively or only reading of data in the data-carrying medium; and a method which is characterized in that in a first stage it comprises bringing the data-carrying medium in register with the first optical lens system in the write/read device by means of a translational and/or rotational movement generated by mechanical servos which are in engagement with the data-carrying medium and controlled by a deviation minimizing program, and in a second stage allowing light from the read/write device to pass through a discrete or continuous set of angle coordinates which are located near one or more sets of reference angle coordinates, the optical response from the data-carrying medium being detected simultaneously and in parallel by means of the write/read device as a predetermined set of x,y coordinates, with subsequent generation of angle correction data for all x,y coordinates; together with a device which is characterized in that in the write/read device there are provided a first optical system consisting of an array of lenslets, one or more light sources arranged to illuminate the lenslets individually or in parallel and with predetermined illumination parameters, thus directing light from the lenslets towards specific areas on a data-carrying medium inserted in the device, a second optical system arranged for imaging of the illuminated data-carrying medium and an electronic matrix detector with light-sensitive elements arranged in a one or two-dimensional pattern for recording of the illuminated data-carrying medium, and that the write/read device is further connected to an analysis unit arranged to analyse the recorded imaging emitted in the form of signals from the electronic matrix detector. Further features and advantages are presented in the attached dependent claims.

The invention will now be explained in more detail with reference to the accompanying drawing in which:

figure 1 is a general schematic illustration of a write and/or read device,
figure 2 illustrates optical addressing of a given bit location in a data-carrying medium,
figure 3 illustrates the mounting of a flexible data-carrying medium,
figure 4 illustrates the mounting of a rigid data-carrying medium, and

figure 5 illustrates a data-carrying medium with an optical contact coating in an autofocusing arrangement.

As illustrated in figure 1, a write/read device contains an optical element in the form of a transparent plate 2 with a matrix of lenslets 2', a large number of identical lenslets being arranged in a predetermined pattern, typically in rows and columns in a square or rectangular grid or in a close-packed, e.g. hexagonal pattern. The lenslet matrix plate 2 is illuminated from above by a light source, the light being focused at one or more spots in the data-carrying medium 3 below. Light which is transferred or re-emitted from the data-carrying medium 3 is imaged by a second optical lens system 4 on to the electronic matrix detector 5 and the signals from the latter are analysed by a logic unit 6 which also controls the various sub-assemblies in the write/read device.

The data-carrying medium 3 is typically planar, containing a data-carrying layer which may be of the read-only-memory (ROM) type or the "Write Once Read Many Times" (WORM) type or of the multiple write and erase type ("ERASABLE" type).

Data are stored in the data-carrying medium 3 as precisely defined optical properties in a data-carrying layer provided in the medium, at specific microscopic areas, which are termed "spot locations" below, each of which has associated with it a unique address which may be written x, y, θ, φ. Figure 2 illustrates the optical addressing of a given spot location on the data-carrying medium 3 and shows the centre beams for light beams which strike a lenslet 2' from five directions. The lenslets 2' naturally form a part of the lenslet matrix plate 2. As illustrated in figure 2, each lenslet 2' has associated with it a cluster of spot locations which are optically accessed through the lenslet by illumination at angles θ, φ. Thus θ, φ can be defined as spot location coordinates relative to the associated lenslet, whereas the x, y part of the address denotes the coordinates for the relevant spot location cluster, relative to the coordinate system on the surface of the data-carrying medium. In the case of data-carrying media which remain immobile in the write/read device during writing and/or reading (no mechanical motion), the x,y coordinate can also denote the centre coordinates for the different lenslets 2' in the write/read device which are in a one-to-one correspondence with the spot location clusters.

Upon insertion into the write/read device, the data-carrying medium 3 is held in position relative to the lenslet matrix plate 2, thereby enabling light which is focused through the latter to come into focus in the data-carrying layer in the data-carrying medium. In order to obtain small focal spots and hence high data density, the distance between the lenslets and the data-carrying layer must be controlled with great precision, typically within a tolerance range of ± 0.5 μm ≤ δ (distance) ≤ ± 50 μm.

Figure 3 illustrates examples of the mounting of a thin, flexible data-carrying medium which is positioned against two flat reference surfaces 7,8 as illustrated in figure 3a, which shows how a close contact between the reference surfaces 7,8 for example, can be achieved by means of mechanical securing or clamping between two flat surfaces, or against a flat reference surface 7, as illustrated in figure 3b. A second alternative which is well known from its use in holding recording paper in x,y recorders and the like, is the use of electrostatic attraction towards a supporting surface. This kind of situation corresponds to that which is schematically illustrated in figure 3b, where electrostatic or pneumatic forces are employed against the supporting or reference surface 7 on the same side as the light source, while figure 3c illustrates the use of electrostatic or pneumatic forces against the supporting or reference surface 8 on the detector side. In the latter case the supporting surface 8 is covered by a bearing surface in the form of an optically transparent electrode 9, e.g. of indium tin oxide. A further alternative which is well known from, e.g., lithographic contact printing, is the application of a gas pressure differential in order to push the data-carrying medium 3 against the supporting surfaces 7 or 8 (not shown).

In the case of a rigid, self-supporting data-carrying medium, this does not need any reference surface in order to achieve the desired flatness or shape, but still has to be positioned with high precision relative to the lenslet matrix plate 2. Figure 4 illustrates how this is achieved by pressing the data-carrying medium against mechanical reference points 10 in the write/read device.

The various schemes for mounting and securing the data-carrying medium as illustrated in figures 3 and 4, where light sources and detection systems are omitted for the sake of clarity, become increasingly vulnerable to dust, contamination and mechanical imprecision as the tolerance δ (the distance) becomes less. In very high data density media a particle with dimensions of only a few microns, lodged between the data-carrying medium and one of the supporting surfaces 7,8 in figure 3, could bring the data-carrying layer out of focus. Strategies for avoiding this may include avoiding contamination of the data-carrying medium or the supporting surfaces. In the case of removable data-carrying media, where mechanical sealing is impossible, a combination of methods may be employed, including the application of a filtered airstream, keeping the data-carrying medium in a sealed envelope which is opened automatically as soon as it is inserted in the write/read device and by employing automatic cleaning procedures.

If a rigid data-carrying medium 3 is used as illustrated in figure 4, with mechanical positioning against a few, for example 3 or more, pointed surfaces 10 on the supporting surface, particles at the contact points will be brushed aside when the data-carrying medium is inserted. Outside these small contact areas the spacing between the data-carrying medium and other parts of the write/read device will be sufficient to accommodate contaminating particles without dislocation of the data-carrying medium.

In order to avoid spurious signals due to particles or blemishes on the surfaces between the lenslet matrix plate 2 and the top surface of the data-carrying medium 3, the data-carrying layer may be located some distance inside the data-carrying medium. This prevents such contamination and any blemishes from coming into focus, in analogy with the scratch protection strategy in CD disks.

Depending on cost and performance specifications it may be desirable to place an antireflection coating on the surface of the reference surfaces or the supporting surfaces 7,8, where they face the lenslet matrix plate 2 and the data carrier 3 respectively in order to avoid Fabry-Pérot resonances, spurious reflections and light loss.

Partial protection against reflection and other benefits can be obtained by employing a data-carrying medium 3 on which is provided a thin, transparent, soft layer 11, as illustrated in figure 5. The material 11, termed "optical contact coating" below, is elastic, e.g. in the form of a transparent silicon polymer, and when it is pressed against the reference surface 7 on the lenslet plate 2 it closes the air gap between the reference surface 7 and the top of the data-carrying medium. In order to prevent air bubble entrapment, the optical contact coating 11 should have a microtextured surface and/or a slightly convex shape and/or the data-carrying medium may be aligned from one edge upon insertion. In addition to the antireflection feature a thin optical contact coating may be beneficial in moderating the effect of contaminating particles in simple mounting and securing arrangements as illustrated for example in figure 3a.

As illustrated in figure 5, an optical contact coating 11 with a thickness and elasticity which provide adequate freedom of movement can be employed in conjunction with mechanical actuators 12 under feedback control to optimize the focal distance. This permits a relaxation of the mechanical precision requirements (cf. the discussion above relating to distance tolerance $\delta$), and the sensitivity to particle contamination is reduced. Of course, active distance control will also be possible without the use of an elastic optical contact coating, in which case the mechanical mounting becomes slightly more complex. E.g.: mechanical translation of the lower support or reference plate 8 in the device in fig. 3c or fig. 4, where in the latter case the mechanical stops would be positioned outside the range of travel.

As described thus far the data-carrying medium 3 has been described as mechanically clamped relative to the write/read device during the writing and reading operations. In certain cases where it is desired to read large amounts of data from a data carrier without employing a large and costly electronic matrix detector, it is desirable to displace the data-carrying medium 3, so as to introduce new portions of the latter into the write/read region. This can be achieved in steps by a sequence of securing or clamping operations of the type which is described above. In the case of a rigid, self-supporting data-carrying medium continuous motion can also be achieved by employing appropriate mechanical guides of a type which is well known in the art and therefore does not need to be described here.

The writing of data on the data-carrying medium will now be described in more detail. Data can be written by directing light incident at the relevant angles $\theta,\varphi$ on the relevant lenslet which addresses spot location clusters at the coordinates x,y, in a short pulse of sufficient intensity to create a change in the optical properties of the data-carrying layer at the addresses $x,y,\theta,\varphi$. Depending on the application, a single lenslet 2' may thus be illuminated at a time or several lenslets may be illuminated in parallel. Furthermore, the intensity, duration, spectral content and coherence properties of the light from the light source may vary within very wide limits, depending on the type of information or data-carrying layer, etc. The design of light sources for writing are outside the scope of the present invention, and therefore no explicit description of these is included here, since it is presumed that the design of such light sources will be well known to a person skilled in the art. It should be noted, however, that the light source 1 may consist of a number of small light-emitting elements with a typical diameter of circa 50 μm which can illuminate the individual lenslets 2' in parallel. If a light source 1 is used consisting of a single large light-emitting element, the strip of light is collimated and directed towards the lenslet matrix plate 2 at a desired angle.

A lenslet matrix 2' is not the only optical system which can be used for writing data on the data-carrying medium 3. Since the data-carrying medium 3 is a separate physical entity, separated from the lenslet plate 2, a single, pulsed laser beam can be scanned across the data-carrying medium in a different setting from those which are given by the context of a write/read device, e.g. at the production location. The basic criterion is that the data should be written into the correct spot locations on the data-carrying medium 3. Alternatively, other physical or chemical processes (stamping or moulding of pits, exposure of photo-sensitive film through an encoding mask) could be used to encode the desired optical response at the spot locations.

Writing of data to a data-carrying medium containing previously written data requires alignment of new spot locations relative to already existing ones. Alignment techniques are discussed below.

Reading may be performed by means of an angle-selective illumination of a single lenslet at a time, in which case a matrix detector is not explicitly required. Of greater practical interest, however, are techniques where the whole lenslet matrix plate 2 and the corresponding part of the data-carrying medium 3 are illuminated simultaneously and the optical responses from all illuminated spots on the data carrier are imaged in parallel onto a matrix detector 5, as illustrated in fig. 1. Several illumination modes of this type are possible.

For illustrative purposes, it should be assumed here that a broad, collimated light beam from the light source 1 is sequentially directed onto the whole lenslet matrix plate 2 in a set of discrete directions $\theta_i,\varphi_i$, ($1\leq i\leq N$, where N is the total number of available illumination directions). At each given illumination direction $\theta_i,\varphi_i$, this causes each lenslet to focus a light beam on to the spot location $\theta_i,\varphi_i$ in its associated complement of spot locations, thus interrogating the logic state at this point. The logic state is thereby revealed at all spot locations $x_j,y_j,\theta_i,\varphi_i$, ($1\leq j\leq M$, where M is the number of illuminated lenslets), in a single imaging operation on to the matrix detector 5. By extension the logic state at all spot locations in the data-carrying medium 3 can be determined by performing one imaging operation for each of the N illumination directions.

Since the logic unit 6 controls the illumination direction, the $\theta_i,\varphi_i$ coordinate is known during each read-out cycle from the matrix detector 5, and the resolving power of the optical system 4 imaging the data on to the matrix detector, as illustrated in fig. 1, needs only to be high enough to distinguish between the spot location clusters associated with the different lenslets 2'. Thus a low-resolution optical system 4 can be used, with a correspondingly wide image field and resolution depth. The possibility of accessing a large data field on the data-carrying medium with a fixed-focus imaging system has profound practical implications, especially since it becomes possible to achieve very high speed data accessing and write/read devices with no mechanical motion.

In applications where the data-carrying medium 3 is initially blank when it is introduced into the write/read device and acts as a temporary storage unit or data recipient only, the data-carrying medium can be clamped in a fixed position relative to the lenslet matrix plate 2, all spatial references being derived from the write/read device without the need for pre-formatting or pre-alignment.

The appropriate data carriers will either be of the WORM or ERASABLE type. The data-carrying medium with the data thus stored may subsequently be removed from the write/read device for later re-insertion into the same or into another write/read device or it can be discarded and replaced with another, blank data-carrying medium. Reinsertion implies another dimension of complexity, however, cf. the discussion of the alignments below.

Even in the case where writing and reading are performed on a data-carrying medium which remains immobile in the write/read device, precautions must be taken in order to avoid misalignment between the lenslet matrix and the spot locations on the data-carrying medium. Misalignment may arise due to dimensional changes (swelling or shrinking on account of ageing, absorption of air moisture or ambient chemicals or due to differential thermal expansion, different thermal expansion rates for structural elements in the lenslet matrix plate on the one hand and the data carrier on the other hand). The former can be controlled by sealing and the choice of chemically stable materials. The latter imposes compatibility restrictions on the choice of materials for the lenslet matrix plate and the data-carrying medium. These restrictions become progressively more severe as the lateral extent of the illuminated region on the data-carrying medium increases, since the maximum misalignment due to differential thermal expansion scales linearly with the length across which recording has to be maintained.

On the other hand the materials in the lenslet matrix plate 2 and the data-carrying medium 3 can be deliberately chosen with heat expansion compatibility in mind and a relative differential thermal expansion $\leq 10^{-4}$ can easily be achieved within a reasonable working temperature range of for example ± 30°C, even for plastic materials. For lenslets with a diameter of less than 50 microns, this implies a misalignment between a 50 mm wide string of lenslets and their associated spot location clusters of not more than 5 microns, i.e. 10% of the lenslet diameter. This is the worst case scenario; otherwise the recording will be correct.

As stated above, different methods will now be described for aligning an already described data-carrying medium which has been inserted into a read device. In this case the read device has to perform a number of operations in order to ensure correct assignment of addresses $x_j,y_j$, $\theta_i,\varphi_i$ for all spot locations on the data-carrying medium. This applies to read-only storage applications as well as cases where data files stored in media of the WORM type and the ERASABLE type have to be supplemented or re-read.

In principle it is a simple matter to insert the data-carrying medium 3 and cause the lenslet matrix 2 to record with the corresponding cluster of spot locations, e.g. by means of servo-driven alignment with cursors in the data-carrying medium. In practice this becomes increasingly difficult at high data densities, i.e. when the distances between the spot locations in the data-carrying medium are small. At high data densities, therefore, the spot locations can be separated by 1 micron or less, and even a very small misalignment between the lenslet matrix plate and the data-carrying medium which is easily created by differential thermal expansion, distortion, shrinking, etc. will interfere with the addressing process.

This problem can be solved by a combination of addressing which involves "static" alignment on a coarse scale and "dynamic" alignment on a fine scale. The static alignment involves mechanical translation and rotation of the data-carrying medium 3 relative to the lenslet matrix plate 2 in order to minimize spatial misalignment between the individual lenslets 2' in the lenslet matrix plate 2 and their associated spot location clusters. This procedure is based on static dimension tolerances which are built into the lenslet matrix plate 2, and the data-carrying medium 3 and the lenslets 2' must be sufficiently large to keep a misalignment during the recording within given values under all working conditions (e.g. temperatures). This is achieved by a suitable choice of materials, cf. the above description.

The static alignment ensures that light from each lenslet 2' is focused on the nominal spot locations associated with this lenslet. A typical displacement in the data-carrying layer should not exceed 5-10% of the lenslet diameter, corresponding to 1-10 spot location separations, depending on the data density. The remaining displacement is corrected by a dynamic alignment, a correction depending on the position of the lenslet being introduced into the set of addressing angles θ,φ, as follows:

a) after completion of the static alignment a set of selected lenslets 2' are illuminated which cover the active write/read area in the data-carrying medium 3 at a number of angles of incidence, a search being made for reference signals from predetermined spot locations. For example the relevant lenslets 2 can be connected to reference marks in the data-carrying medium 3 only at nominal angular positions θ=0,φ=0. The search starts at these angular coordinates and will now find that the correct angle will be slightly different, since the correction angles are dependent on the lenslet position x,y.

b) The correction angles are entered in a logic memory in the logic unit 6 together with the x,y address for each reference lenslet.

c) A reference table or interpolation procedure is generated in the read-out logic in the logic unit 6, providing correct addressing angles for all lenslets 2'.

In this case read-out is generally not possible with a single imaging operation for simultaneously illuminated lenslets 2' in all x,y positions since the illumination can pass through a set of correction angles or a correction angle area stepwise or in a sweep mode. For each correction angle the logic unit 6 will identify the correct block of x,y coordinates and assign the data content recorded at these specific spot locations. The dynamic alignment procedures can be implemented with different degrees of technical refinement, since the number of reference lenslets and reference angles can be varied, and verification tests can be employed on the angular correction results. In this context, therefore, it will principally be a case of a compromise between the data density in the data-carrying medium 3 on the one hand and the speed and complexity and thereby the cost on the other.

It will be seen from the above description of the present invention that the use of a matrix with an array of lenslets integrated in the write/read device in order to perform optical addressing of data in a planar data-carrying medium combined with electronic imaging on a large scale provides a number of advantages which have not been capable of implementation with the hitherto known methods in the prior art. Thus the present invention permits the use of a combination of high data accessing and transfer speeds with high data densities, while at the same time the hardware used for writing/reading of the data-carrying media is both inexpensive and robust.

PATENT CLAIMS

1. A method for optical data storage in an optical data memory which comprises data-carrying media in the form of sheets, foils, tapes, cards and disks, either separately or in combination, wherein data are stored in one or more data-carrying layers or volumes in the data-carrying medium/media and written and/or read by means of light, and wherein there is employed in the method a write/read device with a first optical lens system associated with one or more light sources,
characterized by forming the first optical lens system from an array of lenslets, arranging the lenslets in a system of an array of lenslets, arranging the lenslets in a predetermined, freely chosen pattern, assigning each lenslet in one or more areas on one of the respective data-carrying media which form part of the optical data memory, and directing light from the light source or light sources through the optical lens system, with the result that each lenslet directs the light to the respective area(s) associated with it on the data-carrying medium.

2. A method according to claim 1,
characterized in that the light is directed towards each lenslet, each lenslet at a given time thereby forming one focal point at a time in a light-sensitive layer or volume in the data-carrying medium.

3. A method according to claim 2,
characterized in that the directions of the light are selected within a predetermined set of directions, with the result that the focal spot formed by each lenslet in the light-sensitive layer or volume is located in a position which is uniquely associated with the chosen direction.

4. A method according to claim 1,
characterized in that an optical response from the light-sensitive layer(s) or volumes in the data carrier is changed reversibly or irreversibly under the influence of the light directed through first lens systems, whereby data are written on the data-carrying medium.

5. A method for positioning of an optical data medium during optical data storage in an optical data memory which comprises data-carrying media in the form of sheets, foils, tapes, cards and disks, either separately or in

combination, wherein data are stored in one or more light-sensitive data-carrying layers or volumes in the data-carrying medium/media and written and/or read by means of light, and wherein there is employed in the method a write/read device with a first optical lens system associated with one or more light sources,
characterized by positioning the data-carrying medium on at least one reference surface, the position of the data-carrying medium being maintained during at least one cycle which comprises writing and reading respectively or only reading of data in the data-carrying medium.

6. A method according to claim 5,
characterized in that one side of a disk is employed as reference surface, the first optical lens system being provided on the opposite side of the disk.

7. A method according to claim 5,
characterized in that the position is maintained by holding the data-carrying medium between two reference surfaces.

8. A method according to claim 5,
characterized in that the position is maintained by conveying and holding the data-carrying medium against a reference surface by means of electrostatic forces.

9. A method according to claim 5,
characterized in that the position is maintained by conveying and holding the data-carrying medium against a reference surface by means of pneumatic forces.

10. A method according to claim 5, wherein a rigid data-carrying medium is employed,
characterized in that the position is maintained by conveying and holding the data carrier against pointed or extended surfaces on at least one reference surface.

11. A method according to claim 5, wherein a data-carrying medium is employed which on at least one side is coated with an elastic, transparent layer,
characterized in that the position is maintained by a partial compression of

the elastic layer(s) when the data-carrying medium is conveyed towards the reference surface or reference surfaces.

12. A method according to claim 5,
characterized in that the data-carrying medium for a write/read cycle is actively positioned in the correct position in relation to the first optical line system by means of two or more focus-seeking servos provided on the read/write device.

13. A method according to claim 11 or 12,
characterized in that the data-carrying medium is actively positioned by means of translation and/or rotation of the data-carrying medium, the translation and/or rotation being effected by one of the servos exerting varying pressure against different sections of the data-carrying medium, thus causing the elastic layer(s) to be pressed together to varying degrees.

14. A method for localizing data stored or written into an optical data memory which comprises data-carrying media in the form of sheets, foils, tapes, cards and disks, either separately or in combination, wherein data are written and/or read by means of light, wherein there is employed in the method a write/read device with a first optical lens system associated with one or more light sources, and wherein for storage or writing a method is employed as specified in one of the claims 1-4 and a method as specified in one of the claims 5-13,
characterized in that in a first stage the method comprises bringing the data-carrying medium in register with the first optical lens system in the write/read device by means of a translational and/or rotational movement generated by servos which are in engagement with the data-carrying medium and controlled by a deviation minimizing program, and in a second stage allowing light from the read/write device to pass through a discrete or continuous set of angular coordinates which are located near one or more sets of reference angle coordinates, the optical response from the data-carrying medium being detected simultaneously and in parallel by means of the write/read device as a predetermined set of x,y coordinates, with subsequent generation of angle correction data for all x,y coordinates.

15. A device for implementation of the method according to claims 1-4 and the method according to claim 14, wherein the device comprises a

write/read device,
characterized in that there is provided in the write/read device a first optical system consisting of an array of lenslets 2', one or more light sources (1) arranged for illumination of the lenslets individually or in parallel and with predetermined illumination parameters, with the result that light from the lenslets is directed towards specific areas on a data-carrying medium (3) inserted in the device, a second optical system (4) arranged for imaging of the illuminated data-carrying medium (3), and an electronic matrix detector (5) with light-sensitive elements arranged in a one or two-dimensional pattern for recording the illuminated data-carrying medium (3), and that the write/read device is further connected to a logic unit (6) arranged for analysis of the recorded imaging emitted in the form of signals from the electronic matrix detector (5).

16. A device according to claim 15,
characterized in that the predetermined illumination parameters comprise parameters for illumination direction, illumination duration, illumination intensity and the spectral characteristics of the illumination.

17. A device according to claim 15,
characterized in that the electronic matrix detector (5) is an electronic camera.

18. A device according to claim 16,
characterized in that the logic unit (6) is arranged for control and checking of the write/read device's functions.

19. A device according to claim 15,
characterized in that it comprises a holder (9) for the data-carrying medium (3).

20. A device according to claim 19,
characterized in that it comprises focus-seeking servos (12), the focus-seeking servos being connected to the holder (9).

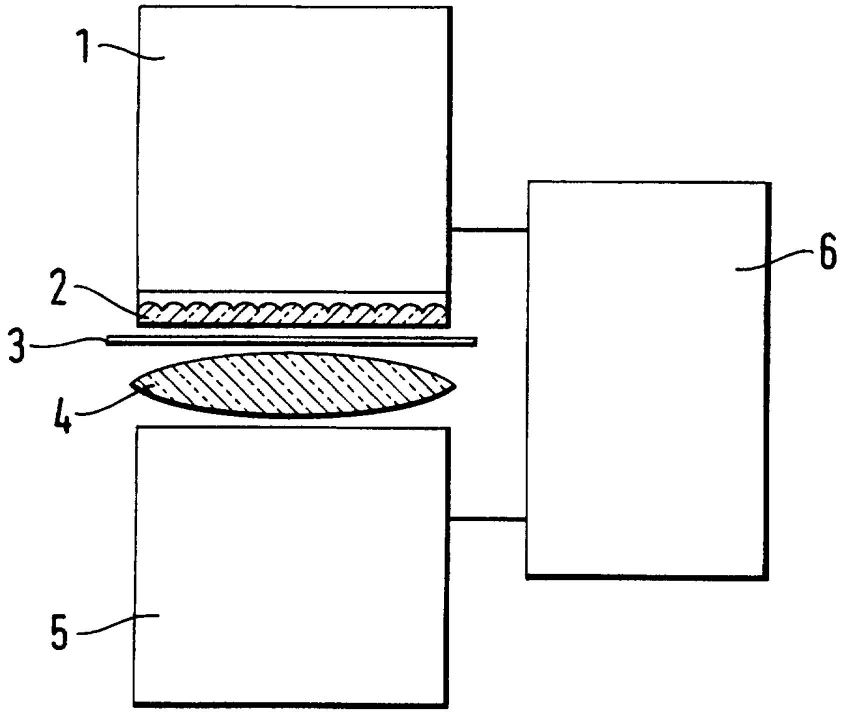

Fig.1

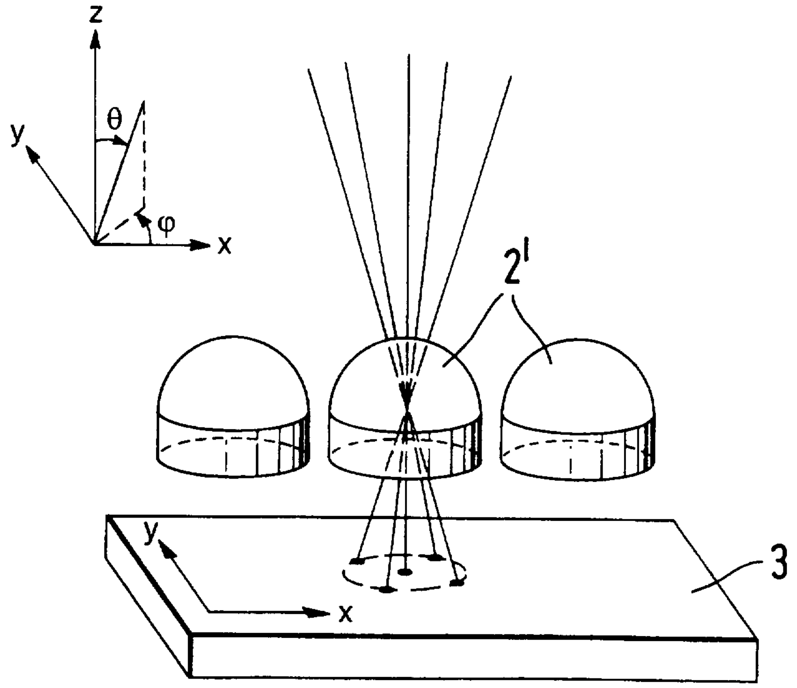

Fig.2

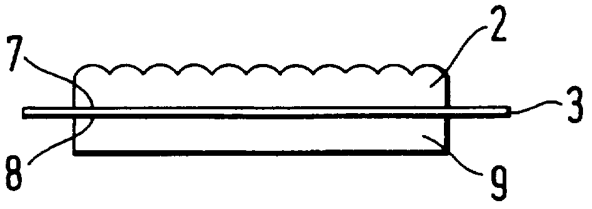

Fig.3a

Fig.3b

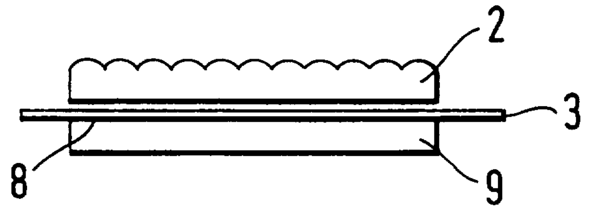

Fig.3c

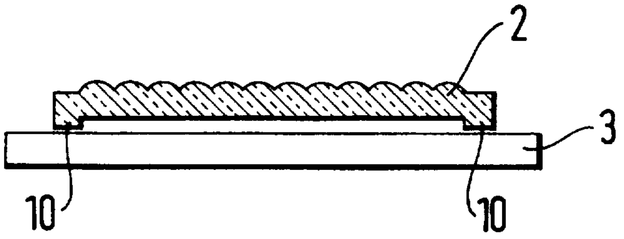

Fig.4

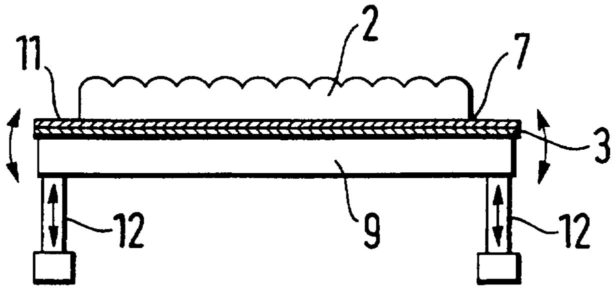

Fig.5

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 97/00067

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G11B 7/00, G11C 13/04
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G11B, G11C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| A | | 11,13,14 |
| | -- | |
| X | US 4633445 A (R.A. SPRAGUE), 30 December 1986 (30.12.86), column 3, line 55 - column 6, line 44, figures 1-3 | 1-4,15,16,18 |
| | -- | |

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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| | |
|---|---|
| Date of the actual completion of the international search<br>14 August 1997 | Date of mailing of the international search report<br>14 -08- 1997 |
| Name and mailing address of the ISA/<br>Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. +46 8 666 02 86 | Authorized officer<br>Bo Gustavsson<br>Telephone No. +46 8 782 25 00 |

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 97/00067

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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06/08/97

International application No.
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