United States Patent [19]

Van Sant

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[54] **REPLACEABLE LASER AND LENS ASSEMBLY**

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[73] Assignee: **General Electric Company,** Moorestown, N.J.

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[51] **Int. Cl.**[4] **G02B 7/02**

[52] **U.S. Cl.** **350/253;** 369/122

[58] **Field of Search** 350/502, 571, 417, 252, 350/253; 369/122

[56] **References Cited**

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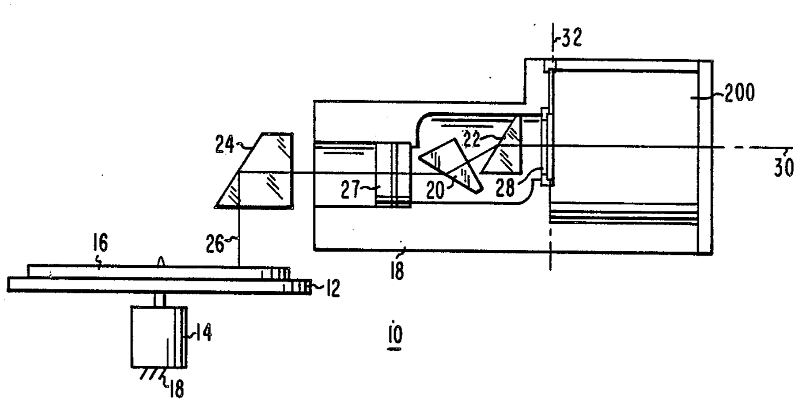
[57] **ABSTRACT**

An optical recorder such as a data recorder has an interchangeable, prealigned laser diode/lens module arrangement which can be readily replaced without complex realignment of the recorder. The module includes a cylindrical outer housing/heat-sink, and a tiltable yoke within the outer housing/heat-sink. A heat pump such as a thermoelectric element has a hot side coupled to the yoke, and also has a cold side. A combination mount is at least thermally cantilevered from the cold side of the thermoelectric element, and is thermally isolated from adjacent structures. A laser diode is bonded to a structure within the combination housing, and a lens is loosely mounted at the light-emitting end of the combination housing. The module is prealigned by operating for a period sufficient to achieve thermal stability in a fixture which is dimensionally identical to the optical recorder with which the module is to be used. When thermal stability has been achieved, the yoke is tilted, and the position of the lens is adjusted in order to achieve focus at a selected location relative to the reference plane. The lens is then secured in the selected position. That position will remain constant or substantially constant as the ambient temperature changes. This enables the optical recorder to be operated at any ambient temperature needing virtually no adjustment to the optical alignment.

20 Claims, 6 Drawing Sheets



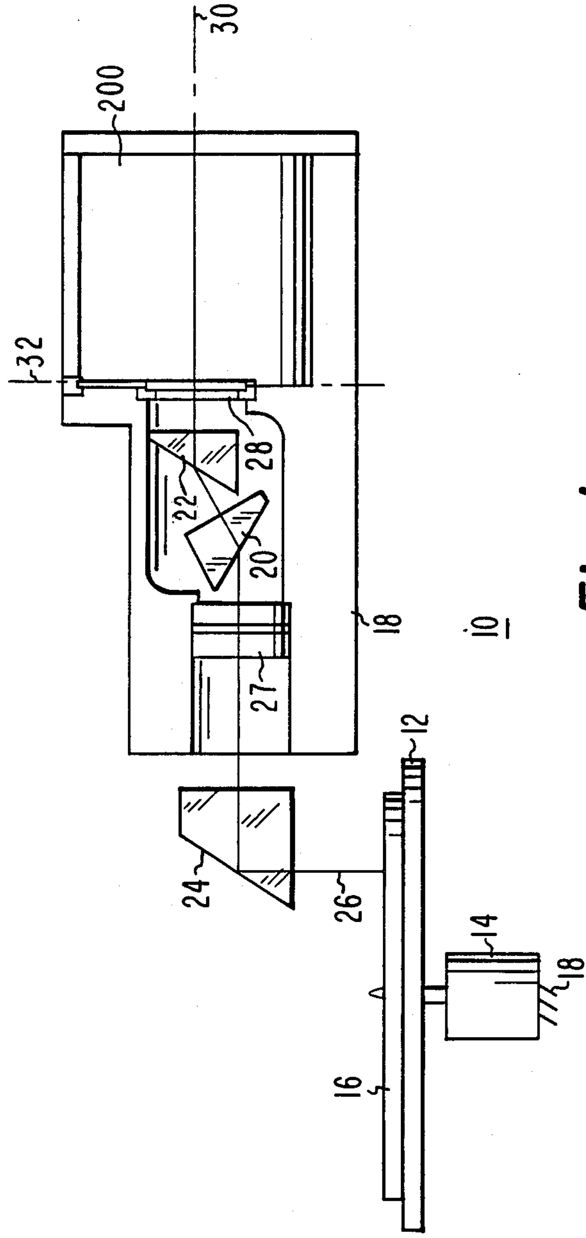


Fig. 1

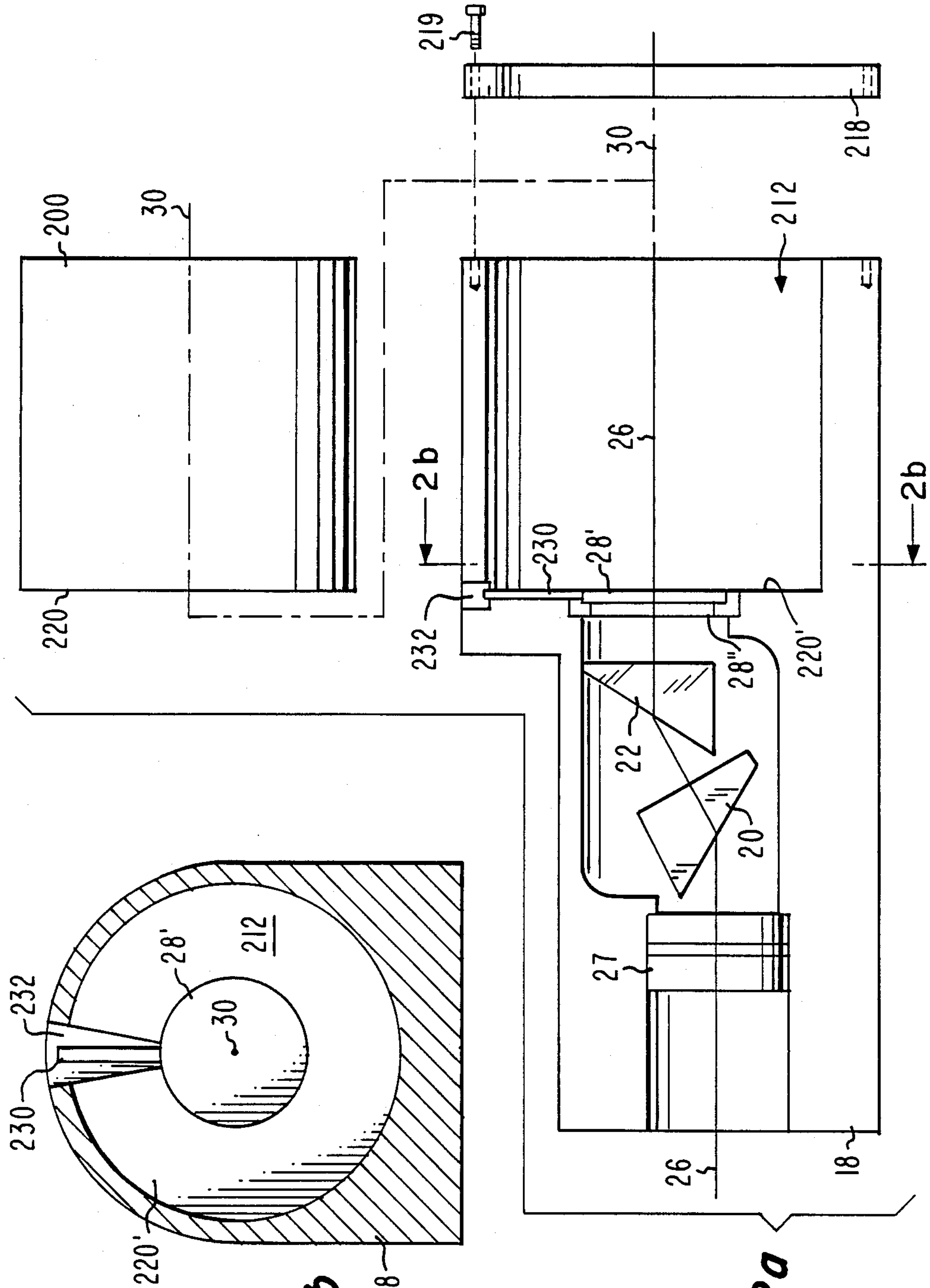

219
218
30
212
200
30
26
2b
2b
230
28'
232
220
220'
28"
22
20
27
26
18
232
28'
212
30
230
220'
18

Fig. 2a

Fig. 2b

REPLACEABLE LASER AND LENS ASSEMBLY

This invention was made with Government support under Contract No. F30602-85-C-0193 awarded by the Air Force. The Government has certain rights in this invention.

This invention relates to an assembly of a light-emitting device such as a laser diode with a focussing lens, which is arranged as a modular unit which focusses the light emitted at a predetermined distance from a reference plane.

Modern data techniques may require the handling and storage of large amounts of high-rate data. For example, data processing and storage at rates in excess of tens of megabits per second may be required. Optical disc recorders have been devised for recording and reproducing data at such high data rates by means of focussed light beams. Permanent optical storage discs for archival purposes are known in which recording is accomplished by a high-intensity focussed data-modulated light beam, which forms a permanent pattern of data-representative pits on the record track. The pits have a reflectivity which differs from that of the surrounding surface of the disc medium, and their presence or absence may be detected by the changes in the magnitude of the light reflected by the recorded and unrecorded portions of the disc in response to a low-intensity read light beam. Reusable recording media are also known in which a data-modulated high-intensity light beam makes reversible changes in the polarization characteristics of the medium surface. Such media may be erased by the annealing effect of a gradually-decreasing intensity erase light beam. Reading is accomplished in one such system by comparing the polarization of the reflections from recorded and unrecorded portions of the surface of the medium when illuminated by a low-intensity read light beam.

In optical data recorders, the light-emitting device is often a solid-state laser diode or array of laser diodes. At the present state of the art, such laser diodes have light-emitting characteristics as a function of drive current which change from time to time as the diodes age. Also, probably because of the relatively high electrical drive required to achieve the intense light required for recording onto the record medium or for erasing erasable media, the laser diodes are subject to failure. When a laser diode of a laser diode array fails, it may be possible to switch to an unused diode of the array. Ultimately, however, the laser diode or laser diode array must be replaced.

When the laser diode or laser diode array of a recorder is replaced, the light-emitting point of the replacement diode(s) must be placed in precisely the same position as that of the previous diode in order to achieve focus at the surface of the disc, or the optical system must be realigned in order to achieve the desired performance. Exact placement of the laser diode is difficult to accomplish because the laser diode, when in operation, may produce a great deal of heat, which changes its temperature and that of the surrounding support structures. As known, the dimensions of the support structures may change under the influence of temperature, thereby affecting the point of focus. Realignment of the optics may require specialized test fixtures, and may also require the changing of lenses.

The recorder may be used at a location at which specialized optical alignment gear and techniques are

not readily available. In that event, the data recorder in which the laser diode has failed must be returned to the factory for installation of a new laser diode(s) and for realignment. As a result, the data recorder is unavailable to its user for a protracted period, or the user must keep on hand spare units, which may be a considerable expense, as well as requiring inventory control.

It is desirable to arrange an optical data recorder with a light-emitting module which can be readily interchanged by relatively unskilled personnel.

SUMMARY OF THE INVENTION

A data recorder/playback apparatus (recorder) using a light-sensitive medium includes means for generating relative motion between the medium and a light beam. A mutually orthogonal reference plane and reference axis are provided in the recorder, and an optical system accepts light leaving the reference plane parallel with the reference axis and translates it to the medium. A modular combination of a light-emitting device and a lens includes a second mutually orthogonal reference plane and axis, and is prealigned to cause the light to leave parallel with the second axis, and to focus at a predetermined distance from the reference plane. The reference plane and axis of the modular combination are readily made congruent with the reference plane and axis of the recorder, so that any prealigned modular combination may be used with the recorder, without further complex alignment.

According to another aspect of the invention, the modular combination includes a focussing lens and a light-emitting device which may require cooling during operation. A heat pump including a cold surface and a hot surface is adapted to be energized for cooling the light-emitting device. A first mechanical and thermal coupler is coupled to the cold surface of the heat pump, to the light-emitting device, and to the lens, for holding the lens in a selectable position on the axis and before the light-emitting device, at least thermally cantilevered from the cold surface of the heat pump. The first mechanical and thermal coupler is constructed from materials, dimensioned and thermally isolated from adjacent structures such that, during operation, a substantially uniform temperature is maintained over the entirety of the first mechanical and thermal coupler. A second mechanical and thermal coupler is connected to the hot side of the heat pump for holding the first mechanical and thermal coupler and its associated lens and light-emitting device, and the heat pump, at least thermally cantilevered in position with the axis substantially orthogonal to a reference plane, and for sinking heat received from the hot side of the heat pump. The selectable position of the lens is selected, and the lens is fixed in the selected position, under normal operating conditions, with the light beam focussed at a predetermined distance before the reference plane.

DESCRIPTION OF THE DRAWING

FIG. **1** is a simplified schematic view of an optical recorder including an optical disc recording medium, a motor for spinning a turntable, a recorder housing, a common reference plane and common axis, a modular light source, and an optical system;

FIGS. **2***a* and **2***b*, referred to jointly as FIG. **2**, illustrate in FIG. **2***a* a simplified schematic view, partially exploded, of the optical system including a common reference plane and axis, the recorder housing and the modular light source of FIG. **1**, and in FIG. **2***b* illustrates a cross-section of the recorder housing illustrating the reference surface and axis;

FIG. 3 is an exploded perspective or isometric view of the modular light source of FIGS. **1** and **2**, illustrating a cylindrical module housing which mates with the recorder housing of FIGS. **1** and **2** to make the reference planes and axes congruent, first and second mechanical and thermal coupling elements coupled to the cold and hot sides, respectively, of a thermoelectric cooler, a laser diode and mount, and a lens and lens mount;

FIGS. 4*a*, 4*b* and 4*c*, referred to jointly as FIG. 4, are cross-sections of the module housing of FIG. 3;

FIGS. 5*a*, 5*b* and 5*c*, referred to jointly as FIG. 5, are elevation, cross-sectional and plan views, respectively, of the second mechanical and thermal coupling element of FIG. 3;

FIGS. 6*a* and 6*b*, referred to jointly as FIG. 6, are axial and cross-sectional views, respectively, of the first mechanical and thermal coupling element of FIG. 3;

FIGS. 7*a*, 7*b* and 7*c*, referred to jointly as FIG. 7, in FIGS. 7*a* and 7*b* are laser-side and rear, respectively, perspective or isometric views of the laser diode mount of FIG. 3, and an end view of the laser diode illustrating its relationship to the axis; and

FIGS. 8*a* and 8*b*, referred to jointly as FIG. 8, are axial and cross-sectional views, respectively, of the lens mount of FIG. 3.

DESCRIPTION OF THE INVENTION

FIG. 1 is a simplified schematic representation of an optical disc recorder/playback arrangement (recorder) **10**. Recorder **10** of FIG. 1 includes a turntable **12** driven by a motor **14** for rotary motion. Motor **14** is fixed to the housing **18** of the recorder. A photosensitive disc **16** is mounted on turntable **12** for rotation therewith. Also fixed to housing **18** of the recorder is an optical system including beam expanding prisms **20** and **22**, a further prism **24** having a mirrored face for reflecting a light beam or beams, illustrated as a line **26**, toward the disc, spectrum limiting wave plates and gratings illustrated together as **28**, and other optics represented as **27** required to translate a light beam **26** entering the optical system along or parallel with an optical axis **30** to the disc. Translation of the light beam(s) may include control of the polarization, focussing or defocussing in response to operating mode, beam expansion or contraction, control of the cross-sectional dimensions, beam splitting or combining, offset position and other functions required for operation of the recorder.

In FIG. 2, elements corresponding to those of FIG. 1 are designated by corresponding reference numerals. FIG. 2*a* illustrates recorder housing **18**, with a removable modular light source **200** insertable into a cavity **212** therein. FIG. 2*b* is a cross-section of the arrangement of FIG. 1*a*, with module **200** removed, taken in the direction of section lines 2*b*—2*b*. Modular light source **200** has the general shape of a right circular cylinder and it fits fully into a right circularly cylindrical cavity **212**. Cavity **212** has a central axis **30**. Since modular light source **200** has an external shape which is cylindrical to match the shape of cavity **212**, modular light source **200** is also symmetrical about axis **30** when inserted into cavity **212**, and may be rotated about the axis for adjustment. A cavity dust cover **218** covers the right end of cavity **212** and is held in place by screws, one of which is illustrated as **219**. In operation, modular light source **200** emits light beam(s) **26** congruent with or parallel with axis **30**.

The left end of modular light source **200** as illustrated in FIG. 2*a* includes a flat reference surface illustrated as **220** which is orthogonal to axis **30**. Surface **220** is congruent with a reference plane, and is hereafter referred to as reference plane **220** for modular light source **200**. Cavity **212** includes matching flat reference surface or reference plane **220'**, against which reference plane or surface **220** mates when modular light source **200** is fully inserted into cavity **212**. When assembled, therefore, the axes **30** are congruent and the, reference planes **220** of cavity **212** and of modular light source **200** are congruent.

Also illustrated in FIG. 2 is a lever **230** fitted into a sectional notch **232** cut into recorder housing **18** to a depth, as viewed in FIG. 2*b*, below reference surface **220'**. The inner end of lever **230** is attached to an optical grating **28'** to permit small rotary positional adjustments thereof, for controlling polarization-sensitive characteristics of the light beam. A spectrum-limiting waveplate is illustrated as **28"** in FIG. 2.

FIG. 3 is an exploded perspective or isometric view of modular light source **200** of FIGS. **1** and **2**. In FIG. **3**, an outer housing **410** of modular light source **200** has the exterior shape of a right circular cylinder centered on axis **30**. At the left end of module housing **410** of FIG. **3**, reference surface **220** defined by the end of module housing **510** can be seen to be annular, and coincident with a reference x–y plane which is orthogonal to axis **30**. Housing **410** is formed from a thermally conductive material such as aluminum. As described below, housing **410** provides mechanical and thermal support for structures supporting the light emitting device, which may be a laser diode.

Housing **410**, which is illustrated in axial and side cross-sectional views in FIGS. 4*a* and 4*b*, includes a through central cavity **412** having a cross-section over the principal portion of its length which includes mutually opposed first and second straight sides **414** and **416**. Other portions **415**, **417** of the interior of cavity **412** are curved or circular. Housing **410**, as illustrated in FIG. 3, is partially cut away to reveal interior details. At the extreme rear end of housing **410** is a circular aperture **418** having a smaller diameter than the diameter between circular surfaces **415** and **417**. A dust cover **320** is affixed to the rear of housing **410** by a plurality of screws, one of which is illustrated as **322**, for covering aperture **418**.

Referring to FIGS. 3 and 4, a pair of coaxial apertures **424**, **426** are defined through the walls of housing **410**, centered between the upper and lower sides of flat portions **414**, **416**. A further pair of curved through slots **428**, **429** penetrate the walls of housing **410** with a radius centered on the axis of apertures **424**, **426**. As illustrated in the cross-section of FIG. 4*c*, the outer portion of the walls of housing **410** in the region around slots **428**, **429** is undercut by depressions **427**, **430**, respectively, for the purpose of countersinking the heads of screws described below. A pair of coaxial jackscrews **332**, **332'**, with their common axis disposed parallel with the Y axis, are threaded into threaded through holes **434**, **434'**, respectively, formed in the sides of housing **410**, as illustrated in FIG. 3.

In FIG. 4*a*, threaded apertures **422'** formed in the back wall of housing **410** are visible. Threaded apertures **422'** accept screws **322** (FIG. 3) for holding dust cover **320** (FIG. 3) onto housing **410**.

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