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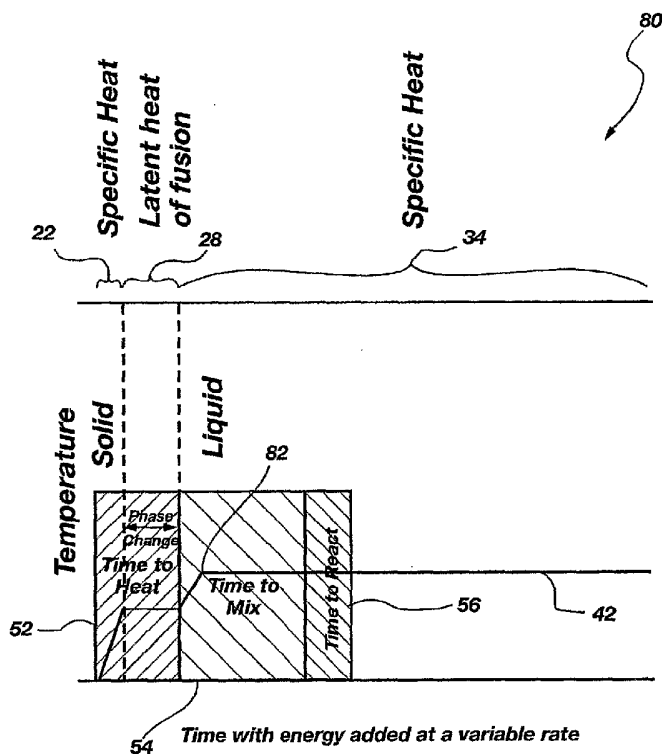
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(54) Title: METHODS AND APPARATUS FOR LABELING USING OPTICAL RADIATION



(57) Abstract: A method is provided for recording graphic image data on a recording medium (208) using an electromagnetic radiation beam (232) to induce a change in an energy level of the recording medium (208), thereby providing a chemical reaction in light sensitive materials on the medium to form an image. The method comprises (a) applying the electromagnetic radiation beam (232) to the recording medium (208) in a first power profile (102), (b) maintaining the first power profile (102) at or below a first power level (102) until a first energy point (32) of the recording medium is reached wherein an energized state of the recording medium (208) provides the chemical reaction sufficient to form the image, (c) changing the power of the electromagnetic radiation beam (232) to a second power profile (108) having an average power level (108) sufficient to keep the energy level (42) of the recording medium below a second energy point (38) at which substantial ablation or disintegration of the recording medium occurs; and (d) maintaining the second power profile (108) at or below a second power level (108) to keep the energy level (42) of the recording medium above the first energy point (32) and below the second energy point (38).



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Declarations under Rule 4.17:

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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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METHODS AND APPARATUS FOR LABELING USING OPTICAL RADIATION

BACKGROUND

Recently, apparatus and methods have been developed with the ability to generate an
5 image on media using a low power laser, such as a laser of the type that is employed to read
and write data on the data side of optical storage discs. Optical discs, such as recordable CDs,
DVDs and the like typically have various types of data written on a data side of a disc by a
laser beam while the disc is rotating. Various data writing strategies have been employed, for
the purposes of creating desirably shaped marks precisely positioned and having sharp edges
10 to enable detection during a subsequent read operation. In some cases, data writing strategies
have included laser beams using modulated power, including laser pulses.

The other side of such a disc is often used for hand-writing or affixing a label with
descriptions and/or illustrations descriptive of the recorded data. Recently, apparatus and
methods have been developed with the ability to generate a label on the non-data side of an
15 optical disc using the same laser that was employed to read and write digital or electronic
data on the data side of the disc. See U.S. Patent Application Publication No. 2003/0108708
(Anderson, et al.), using laser sensitive materials on a disc label that react chemically upon
the application of light and heat, resulting in changes in color and shading on the label. In
such instances, labels may be generated on discs by applying continuous laser power to a
20 label surface. However, this approach may result in undesirable ablation of the recording
medium and power inefficiencies in the apparatus.

SUMMARY OF THE INVENTION

In one embodiment of the present invention, a method is provided for visually marking a recording medium by inducing a phase change in a light-sensitive surface by heat absorption from laser radiation. The method comprises applying the laser radiation to a desired portion of the light-sensitive surface according to a first power profile for a first period sufficient to substantially obtain a color change at the desired portion, and applying the laser radiation to the desired portion of the light-sensitive surface according to a second power profile for a second period sufficient to complete the color change at the desired portion.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a power versus velocity graph for a recording medium on which optically visible marks are formed by an image recording device according to an embodiment of the present invention;

Figure 2 is a temperature versus time graph according to the embodiment represented in Figure 1;

Figure 3 is an optically visible mark timing graph according to the embodiment represented in Figure 1;

Figure 4 is a combined temperature versus time graph and optically visible mark timing graph for a first velocity according to the embodiment represented in Figure 1;

Figure 5 is a combined temperature versus time graph and optically visible mark timing graph for a second velocity according to the embodiment represented in Figure 1;

Figure 6 is a combined temperature versus time graph and optically visible mark timing graph for a varying power level according to another embodiment of the present invention;

Figures 7A and 7B are power versus time graphs according to the embodiment shown in Figure 6.

Figure 8 is a schematic diagram of a laser writing and detection system according to an embodiment of the present invention; and

Figure 9 is a partial schematic view of the diagram shown in Figure 1;

DETAILED DESCRIPTION

Reference will now be made to the exemplary embodiments illustrated in the drawings, and specific language will be used herein to describe the same. It will nevertheless
5 be understood that no limitation of the scope of the invention is thereby intended. Alterations and further modifications of the inventive features illustrated herein, and additional applications of the principles of the inventions as illustrated herein, which would occur to one skilled in the relevant art and having possession of this disclosure, are to be considered within the scope of the invention.

10 In one field of electronic digital data recording technology, a laser is used to write and read digital data on a data side of a rotating disc medium, such as a compact disc (CD), digital versatile disc (DVD) or other such recording media, that is used in a recording device. The present invention involves writing or marking optically visible marks on a light sensitive medium, such as a label side of the recording medium opposite the data side, to form text,
15 graphics, images, or a combination thereof that could be used to describe or represent the data on the recording medium. This imaging technology can be widely used to apply markings to any medium with light sensitive coating. In one embodiment the technology can be used to apply markings to one side of a recording medium that enables the formation of images. This medium may include two or more chemicals that can be liquefied by the application of heat.
20 A laser may be used to apply heat to the chemicals on the label side, such as the same laser that is used to write and read data on the data side of the electronic media. As the chemicals are activated they begin to interact, forming visible marks on the media. By varying the application of the laser energy as it scans across the light-sensitive surface, the marks create images on or in the medium in any desired manner.

25 The present invention is concerned with controlling the amount of laser power delivered to the recording medium by the recording device so as to maintain the energy input of the recording medium between a minimum level needed to provide the desired chemical changes and a maximum level at which disintegration or mechanical ablation of the recording medium starts to occur. The amount of energy delivered to the recording medium is
30 controlled by the level of power applied, the length of time that power is delivered to the recording medium and the speed at which the recording device is rotating the medium. In addition, there is a specific set of changes in properties of the recording medium which occur

during the process of imaging that are temperature dependent, such as glass transition, viscosity, and molecular mobility changes.

Figure 1 is a graph 10 showing power applied to a recording medium versus rotating velocity of the recording device. A maximum read power level 12 is shown, which is significantly below a minimum write power level 14 needed to write on the recording medium (not shown). The minimum write power line 14 is the minimum laser power needed to create an optically visible mark having acceptable optical density and fade tolerance. The maximum write power line 16 shown is the maximum continuous laser power above which a significant amount of ablation in the recording medium begins to occur.

Without subscribing to, or being limited by one particular theory or set of changes, Figure 2 is a graph 20 representing one possibility of chemical and physical changes to the recording medium and showing the temperature of the recording medium versus time with energy added at a constant rate. In a first time period 22, the temperature 24 rises until the specific heat of the solid medium has been applied, at which point 26, a phase change begins to occur with the solid changing to a glass or a liquid. During the next time period 28, the temperature 30 of the recording medium remains a constant level, as all of the applied power is used to provide the latent heat of fusion, or glass transition, needed for the recording medium to fully change to a glass or a liquid.

At point 32, the latent heat of fusion has been provided. As power is continually applied during a glass or a liquid specific heat period 34, the temperature 36 of the glass or a liquid recording medium again begins to rise. Finally, at an ablation point 38, a phase change from solid, glass or a liquid to vapor begins to occur. During the next period 40, the temperature 42 is held steady as the latent heat of vaporization is provided to the recording medium.

During period 40, undesirable ablation occurs, as the recording medium is vaporized. Accordingly, it is desirable to maintain the power applied to the recording medium for labeling purposes at a level, or in a profile or sequence, such the temperature of the recording medium does not substantially reach the ablation point 38. However, it is also important during the writing period to keep the temperature of the recording medium at a sufficiently high level to continue the label writing process. This result can be achieved by combining power levels with timing periods and rotating speed of the recording medium in the recording device, as will be described in more detail below.

Figure 3 shows an imaged mark timing graph 50, depicting without quantification the time required to make an acceptable mark, according to the present invention. Time period 52 represents a time during which the recording medium (not shown) must be heated to a level at which liquefaction begins. A second longer time period 54 represents a time during which the marking materials become liquefied enough to mix together. Finally, a shorter time period 56 represents a time during which the mixed marking materials react sufficiently to form a desired optically visible mark. The purpose of the process shown in graph 50 is to form a mark having a certain predetermined contrast with the unmarked background of the label. Looking next at Figure 4, a combined graph 60 is shown in which the graph 50 of Figure 3 has been superimposed over the time versus temperature graph 20 of Figure 2. The time to heat 52 coincides with a combination of the periods 22 and 28 in graph 20. This is the time during which the solid recording medium is heated to the point of that the liquefaction phase change has been completed. The time to mix 54 and the time to react 56 both occur during the specific heat period 34 of the glass or a liquid, prior to the time that the undesirable ablation point 38 is reached. The rotating speed of the recording device (not shown) is at a rate (referred to as 1X) such that the time graph 50 ends with the temperature of the recording medium at point 62 before the ablation point 38 is reached.

Accordingly, with the recording device rotating at speed 1X, if the application of power to the recording medium ceases at point 62, no ablation will occur in the write process shown in graph 62. Figure 5 shows a combined graph 70, with the recording device (not shown) rotating at twice the speed (referred to as 2X) as the rotating speed of the recording device relative to the graph 60 shown in Figure 4. Again, graph 70 is a combination of the time graph 50 shown in Figure 2 and the time versus temperature graph shown in Figure 3. As before, the time to heat 52 coincides with the combination of periods 22 and 28 in Figure 2. However, since the recording device is rotating at twice the speed of that shown in Figure 4, the time to mix 54 and the time to react 56 combine to extend to a point 72 that is past ablation point 38 and into the vaporization time period 40. Accordingly, with the recording device rotating at speed 2X, significant ablation of the recording medium will occur before the time to react has been completed.

The slope of the temperature rise in Figure 5 is steeper than the slope of the temperature rise in Figure 4 because the power being used with respect to the graph in Figure 5 is twice as much as the power being used at the rotating speed for the graph shown in Figure 4. In any event, the important aspect being illustrated in Figure 5 is that, at higher

speeds, the reaction time may run into the vaporization region, resulting in ablation, as shown in Figure 5.

It may be desirable to increase the rotating speed to reduce the labeling time. Figures 4 and 5 show that, with the application of constant power, there is a rotating speed limit between 1X and 2X, above which significant ablation occurs in the recording medium. Accordingly, it may be desirable to limit the level of power applied to the recording medium, such that the rotating speed of the recording device is not the controlling parameter in the process of recording images on the label side of the recording device.

Referring now to Figure 6, a combined graph 80 is shown, again superimposing the time graph 50 of Figure 3 over the time versus temperature graph 20 of Figure 2. As before, the time to heat 52 coincides with the specific heat time 22 and the latent heat of fusion time 28, which together result in liquefaction of the recording medium. However, the amount of power provided after liquefaction is no longer constant but has been modified so that the temperature does not exceed a value indicated by point 82. By modulating the power to hold the temperature at the value shown at 82, the glass or a liquid recording medium is maintained without ablation during the time to mix 54, the time to react 56 and beyond. That is, the period 34 of specific heat for the glass or a liquid recording medium extends indefinitely, because the ablation temperature point is never reached. Likewise, the power level maintains the temperature of the recording medium substantially constant, whether the rotating speed of the recording medium is at 1X or 2X or other speeds.

As discussed above, by changing the power level after liquefaction, and maintaining that level below the ablation point, no substantial ablation will occur. Although not shown in Figure 6, this change might be achieved by reducing the average power level, or by making some other change in the average power level sufficient to keep the energy level of the recording medium below a second energy level at which substantial ablation or disintegration of the recording medium occurs.

Figures 7A and 7B illustrate two ways in which the power may be modulated to achieve the result shown in Figure 6. In Figure 7A, a time versus laser power graph 100 is shown, in which the laser power level is maintained at a high level 102 during the time period to heat 104 and part of the time period to mix 106. Then the laser power is dropped to a lower level 108 for the remaining mixing time period and through the shorter time period to react 110. Both levels 102 and 108 are sufficiently high to maintain a write on the medium.

After the desired reaction time period 110 has ended, the laser power is dropped to a standby level or off 112.

In Figure 7B, another time versus laser power graph 120 is shown, in which the laser power is maintained at a high level 122 during the time period to heat 124 and during part of the time period to mix 126. Then the laser power level is delivered in a series of pulses 128 modulating from level 122 to a low or off level 130. Again, after the desired reaction time period 130 is completed the laser power drops to the low or off level 132.

Figures 8 and 9 show a data storage device 200 according to an embodiment of the invention, in which a laser is used for writing marks on an optical disc and for detection of the written marks to determine the results of the write operation. The data storage device 200 is used for reading from and/or writing to an optical disc 202. More specifically, the data storage device 200 is used for reading and/or writing to an optically writable data side 204 of the optical disc 202. After the data writing operation is completed, in one embodiment the optical disc is turned over so that the label side 206 of optical disc may be written upon, for the purpose of labeling and otherwise marking the optical disc 202. In another embodiment, the data side and the label side may be the same side of the optical disc. An optical pickup unit (OPU) 210 provides the energy beam, lenses and other devices necessary to provide energy beams for reading and writing the medium, as explained below.

The storage device 200 includes a spindle motor 212 and a spindle 214 for rotating the optical disc 202. Specifically, the optical disc 202 is situated on the spindle 214, which is rotated or moved by the spindle motor 212 to a position specified by an input control signal 216. A controller 218 provides control signal 216, and is comprised of control hardware and/or software.

The storage device 200 further includes a sled motor 220 and a sled rail 222 for moving a sled (not shown) that supports the OPU 210. Specifically, the OPU 210 is situated on the sled that is moved on the sled rail 222 by the sled motor 220 to a given position specified by a sled control signal 224 coming from controller 218.

The OPU 210 writes and reads label data on label side 206 of optical disc 202. In one embodiment, the optical disc 202 is rotated by spindle 214 as the label data is written on optical disc 202. The sled causes the OPU 210 to move radially so that the label data is written in radial increments that may or may not constitute tracks on optical disc 202. The manner of moving the spindle 214 and sled to cause the OPU 210 to write label data is not a part of this invention and may vary in different applications of the invention.

Again referring to Figure 8, controller 218 generates laser control signals 227 to a laser diode driver 228 to drive the OPU 210. A tracking voice coil 260 is connected to a fine adjustment mechanism 262 to make small adjustments to the tracking operation of the sled and sled motor 220. Concentric or spiral tracks, such as are typically used on the data side 204 of optical disc 202 may not be needed on the label side 206. Instead, the sled may move in small increments, such as about 250 micron steps, to provide the desired image labeling. A focus actuator 264 is associated with lens 242 to adjust focus of lens 242 as desired. A tracking control signal 266 is directed from controller 218 to the tracking voice coil 260. A focus control signal 270 is directed from the controller 218 to the focus actuator 264.

Next, looking at Figure 9, the OPU 210 is shown in greater detail. A laser 230 is disposed to generate a laser beam 232 that is directed to lens 234, changing the diverging beam to a substantially collimated beam. The beam 232 then passes to a dichroic mirror 236 that causes a portion of the beam to be reflected and pass through the polarizing beam splitter 240. The remainder of beam 232 passes through dichroic mirror 236 to a front sense diode 238 that senses the strength of beam 232. After passing through polarizing beam splitter 240, beam 232 is directed through a quarter wave plate 241 and a focusing lens 242 to write on label surface 206 of optical disc 202.

The quarter wave plate 241 changes linearly polarized light from the laser (P polarized) into circularly polarized light. The circularly polarized light is reflected from the disc 202 and is changed back into linearly polarized light (S polarized) by the quarter wave plate 241. The resulting light is at 90 degrees polarization to the original light from the laser. This allows the returned S polarized light to be reflected by the polarizing beam splitter 240. The quarter wave plate 241 is required for the beam splitter 240 to operate.

During detection, laser 230 again generates beam 232 that passes through a lens 234, acting to change the beam 232 to a substantially collimated beam. Beam 232 passes through dichroic mirror 236 polarizing beam splitter 240 to impinge upon the image written earlier on label surface 206 by focused beam 232. The reflected beam 253 passes back through lens 242 and quarter wave plate 241 to polarizing beam splitter 240. A portion of the reflected beam 253 is intercepted by four photo-detectors 256. A SUM signal 258 is generated by photo-detectors 256 and sent to a processor 259, shown in Figure 8. This SUM signal corresponds to the reflected light from the disc surface.

In a label writing operation, laser 230 may be an rf diode laser emitting a light beam having a wavelength of, in one embodiment, about 780 nanometers in order to effectively interact with chemicals on the medium and cause image marking to take place. Different

wavelength light beams may be emitted in other embodiments to effectively interact with different chemistries for making marks. The focus actuator 264 and tracking voice coil 260 are used in writing data on the data side 204 of optical disc 202.

When writing to the label side 206, the tracking voice coil 260 may not be used, since
5 there may not be any tracks to follow. The laser diode driver 228 may utilize a digitally enabled current source set to a selected current value by an external resistor. The four photo-detectors 256 represent four quadrant sensors used to generate servo control signals that may drive focus and tracking control signals from controller 218.

The laser diode driver 228 may utilize a digitally enabled current source set to a
10 selected current value by an external resistor. The four photo-detectors 256 represent four quadrant sensors used to generate an output signal 258 to the processor 259. In turn, the processor 259 may cause the controller 218 to generate control signals 227 to the laser diode driver 228, to thereby adjust the power level of laser 230.

It should be understood that the above-referenced arrangements are illustrative of the
15 application for the principles of the present invention. It will be apparent to those of ordinary skill in the art that numerous modifications can be made without departing from the principles and concepts of the invention as set forth in the claims.

CLAIMS

What is claimed is:

1. A method for recording graphic image data on a recording medium (208) using an
5 electromagnetic radiation beam (232) to induce a change in an energy level of the recording
medium (208), thereby providing a chemical reaction in light sensitive materials on the
medium to form an image, comprising:
 - (a) applying the electromagnetic radiation beam (232) to the recording medium (208)
in a first power profile (102);
 - 10 (b) maintaining the first power profile (102) at or below a first power level (102)
until a first energy point (32) of the recording medium is reached wherein an
energized state of the recording medium (208) provides the chemical reaction
sufficient to form the image;
 - (c) changing the power of the electromagnetic radiation beam (232) to a second
15 power profile (108) having an average power level (108) sufficient to keep the
energy level (42) of the recording medium below a second energy point (38) at
which substantial ablation or disintegration of the recording medium occurs; and
 - (d) maintaining the second power profile (108) at or below a second power level (108)
to keep the energy level (42) of the recording medium above the first energy point
20 (32) and below the second energy point (38).
2. The method of claim 1, wherein the step of applying the first power profile (102)
comprises applying power sufficient to raise the energy level (42) of the recording medium
(208) to substantially obtain the chemical reaction.
3. The method of claim 1, wherein the step of applying the second power profile (108)
25 comprises reducing power in the second power profile (108) so that the average power level
is less than that of the first power profile (102) to maintain the energy level (42) of the
recording medium below the ablation point (38).
4. The method of claim 1, wherein the first power profile (102) comprises a steady level of
power at a first amplitude (102) and the second power profile (108) comprises a steady
30 second level of power at a second amplitude (108) lower than the first amplitude (102).
5. The method of claim 1, wherein the step of maintaining the first power profile (102) is
carried out until the recording medium has transitioned from a solid to a glass or a liquid.
6. The method of claim 1, wherein the step of maintaining the second power profile (108) is
carried out until the chemical reaction has been substantially complete.

7. The method of claim 1, wherein the step of maintaining the second power profile (108) comprises applying pulses of power (128) from the electromagnetic radiation beam (232).

8. The method of claim 1, wherein the step of maintaining the second power profile (108) comprises controlling the energy level (42) of the recording medium (208) over time to

5 achieve a predetermined delta contrast between the image being formed and the background area having no image.

9. The method of claim 1, wherein the step of reducing the electromagnetic radiation beam power (232) to a second power level (108) comprises reducing the electromagnetic radiation beam power (232) to the steady-state second power level (108) lower than the first power

10 level (102).

10. The method of claim 1, wherein the step of reducing the electromagnetic radiation beam power (232) to a second power level (108) comprises providing the electromagnetic radiation beam power (232) in pulses 128 to achieve an average power lower than that of the first power profile (102).

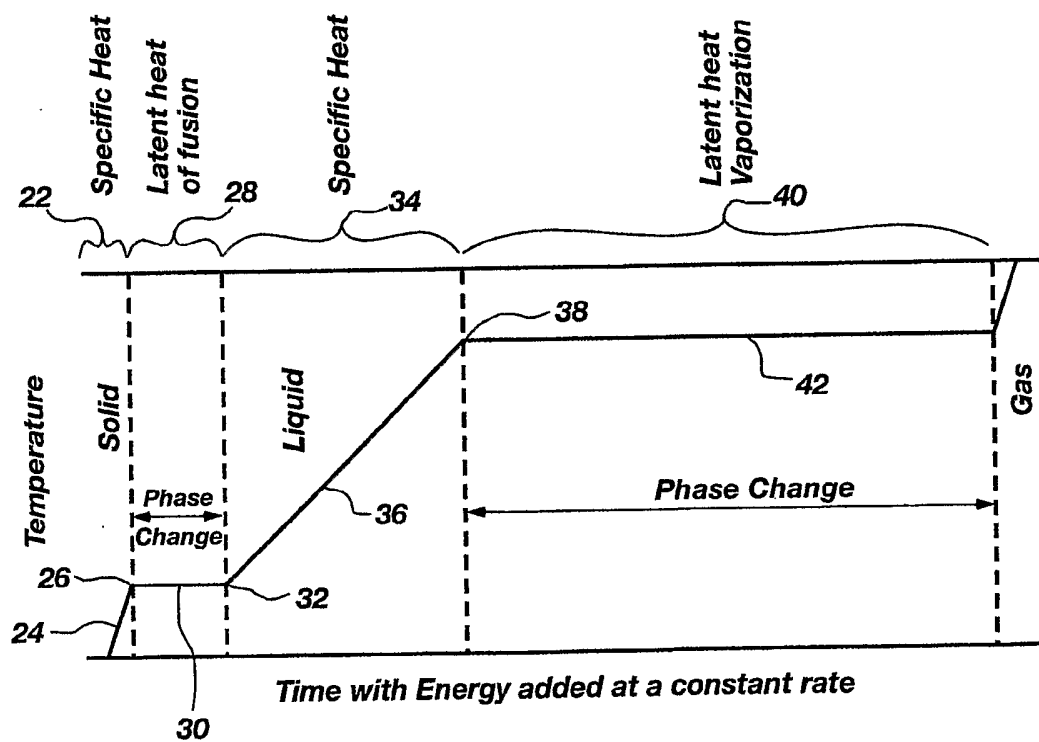
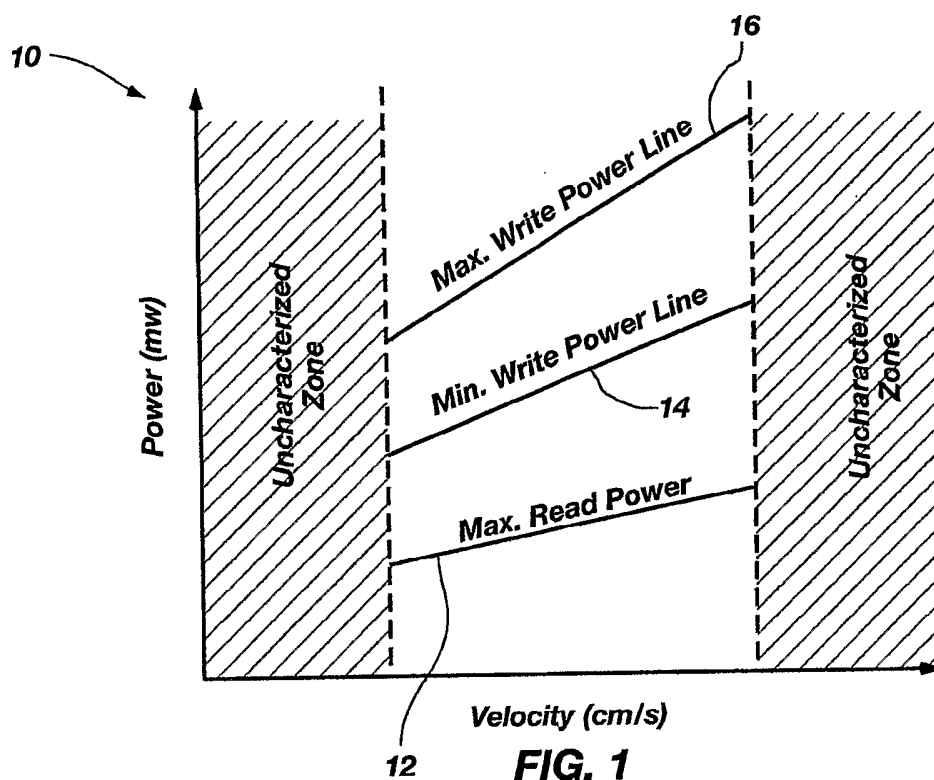


FIG. 2

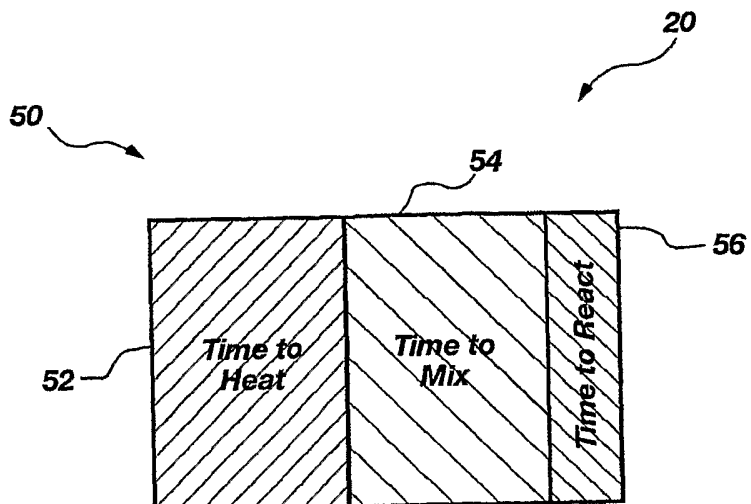


FIG. 3

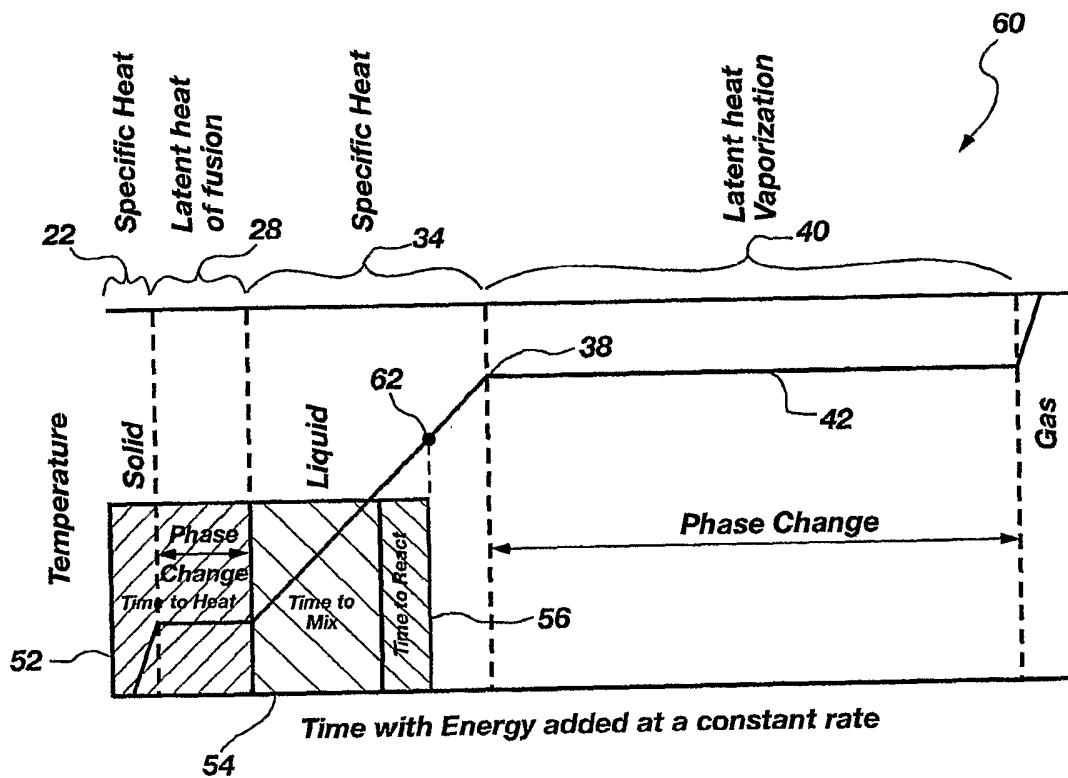


FIG. 4

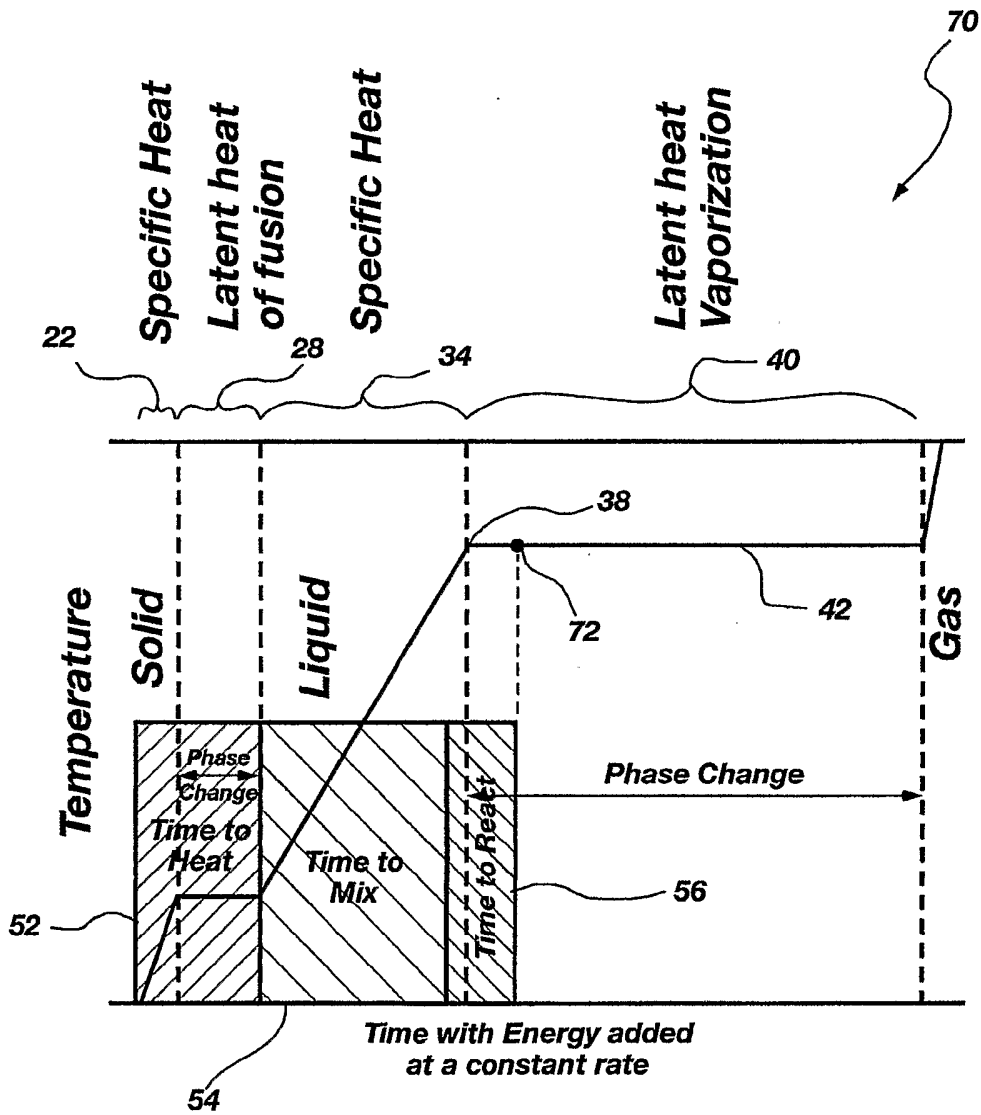
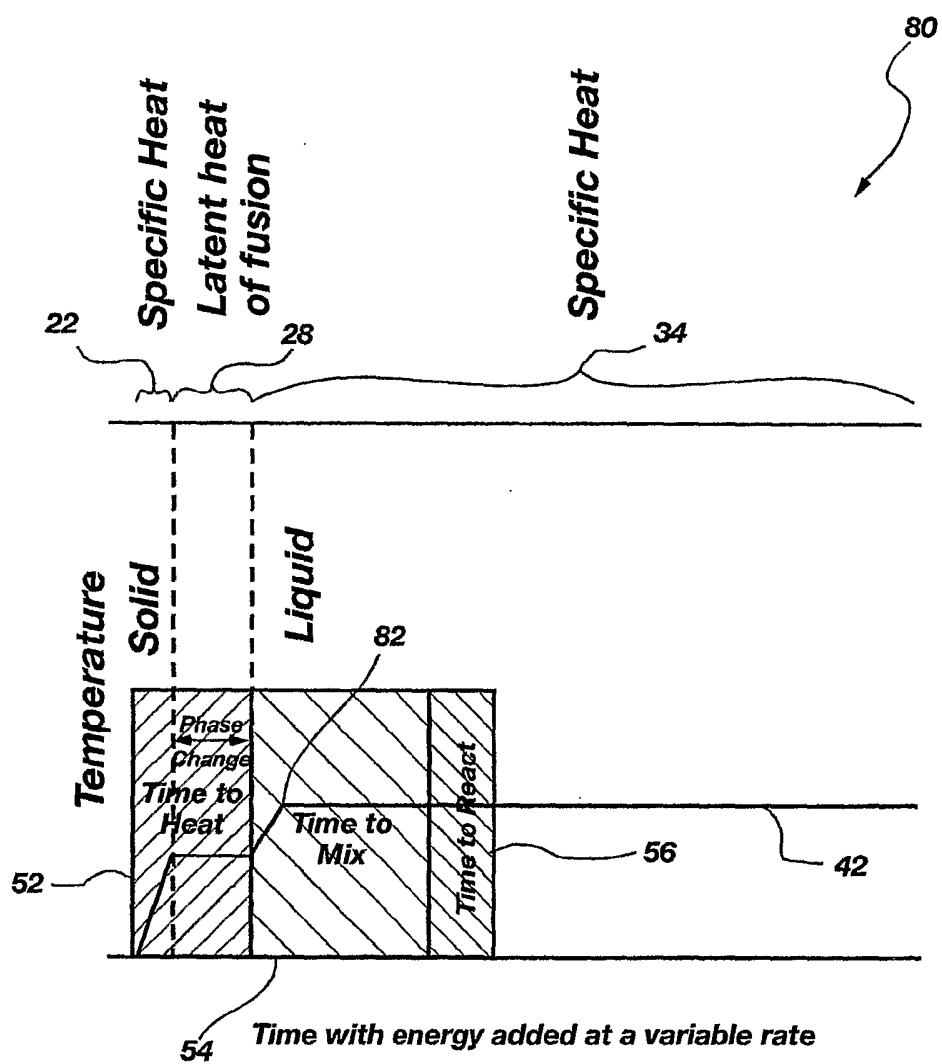


FIG. 5

**FIG. 6**

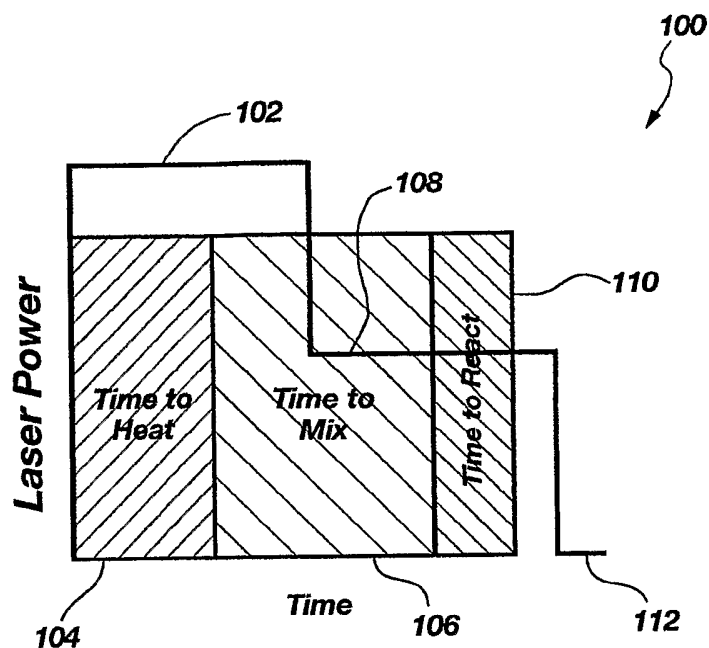


FIG. 7A

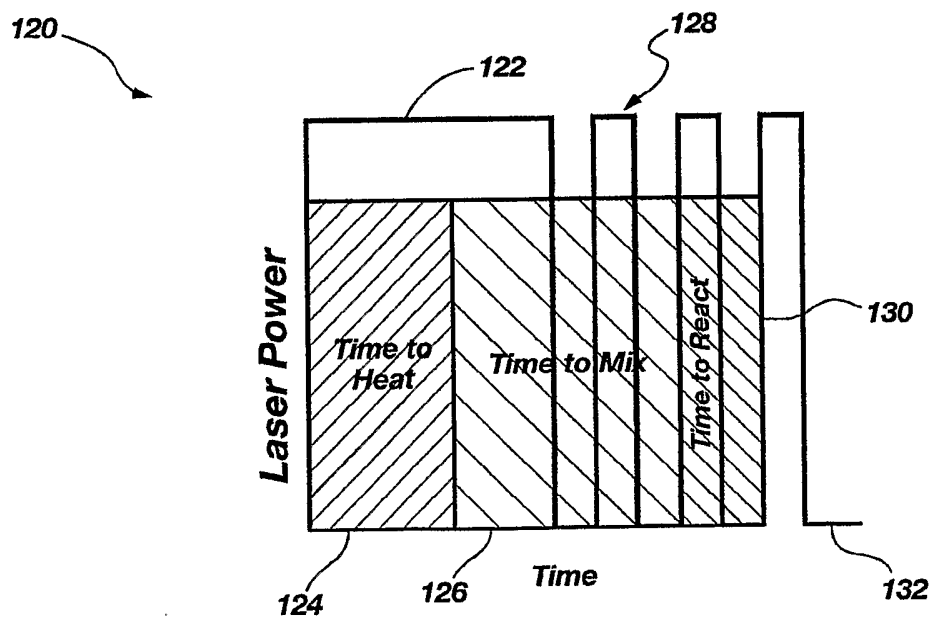


FIG. 7B

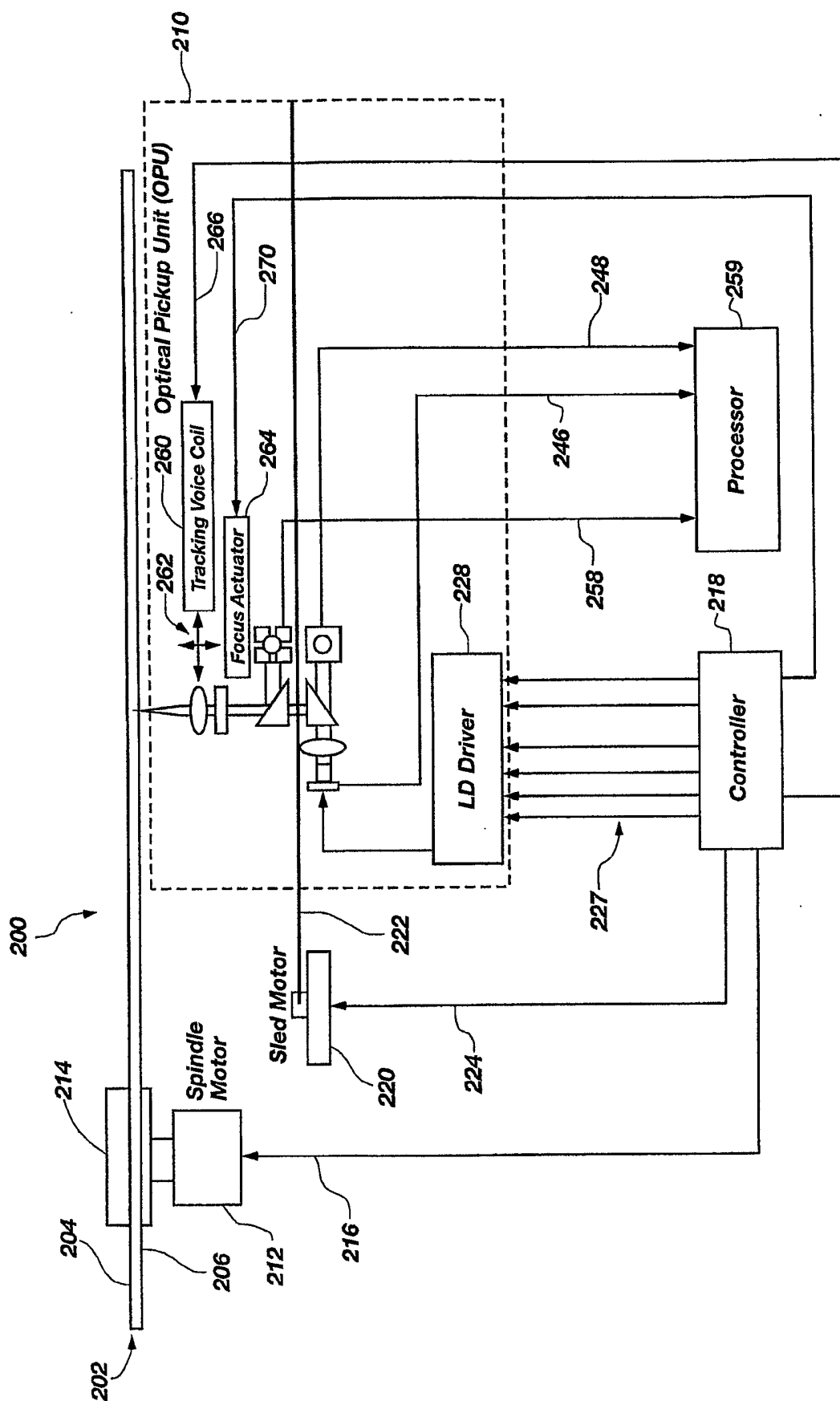


FIG. 8

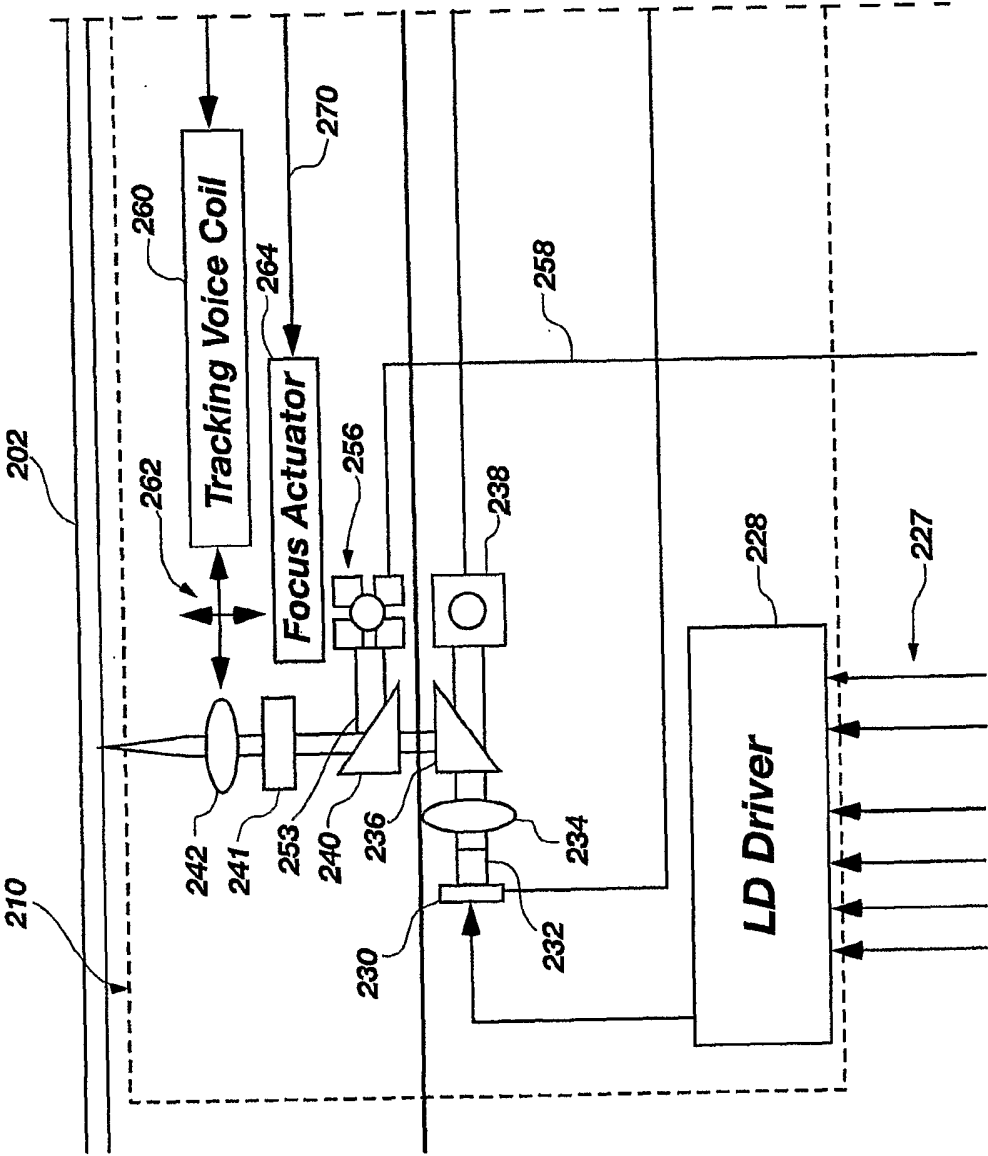


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2005/035280

A. CLASSIFICATION OF SUBJECT MATTER
G11B23/40

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)
G11B

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2004/057602 A (INTERNATIONAL BUSINESS MACHINES CORPORATION; IBM DEUTSCHLAND GMBH; BOE) 8 July 2004 (2004-07-08) the whole document	1-10
A	US 2003/222965 A1 (FIELD MARSHALL) 4 December 2003 (2003-12-04) the whole document	1-10
A	US 2004/056944 A1 (BRONSON BARRY) 25 March 2004 (2004-03-25) paragraphs '0035! - '0037!	1-10
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Date of the actual completion of the international search

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Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2005/035280

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2002/191517 A1 (HONDA KAZUHIKO ET AL) 19 December 2002 (2002-12-19) paragraph '0047!	1-10
A	US 6 754 158 B1 (KOBAYASHI SEIJI ET AL) 22 June 2004 (2004-06-22) the whole document	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2005/035280

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2004057602 A	08-07-2004	AU 2003298323 A1	14-07-2004
US 2003222965 A1	04-12-2003	AU 2003234676 A1	19-12-2003
		BR 0311531 A	26-04-2005
		CA 2487804 A1	11-12-2003
		CN 1656559 A	17-08-2005
		EP 1509919 A1	02-03-2005
		JP 2005528730 T	22-09-2005
		WO 03102952 A1	11-12-2003
US 2004056944 A1	25-03-2004	US 2003133005 A1	17-07-2003
		US 2004051778 A1	18-03-2004
		US 2004169717 A1	02-09-2004
US 5748607 A	05-05-1998	JP 8194972 A	30-07-1996
US 2002191517 A1	19-12-2002	US 2005281149 A1	22-12-2005
US 6754158 B1	22-06-2004	CN 1266527 A	13-09-2000
		CN 1632866 A	29-06-2005
		WO 0021078 A1	13-04-2000
		JP 2000113451 A	21-04-2000