Method for Reading the Data from a Rotating Disk-type Recording Medium

The invention concerns a method for reading the data from a rotating disk-type recording medium on which the data are recorded in helical data tracks or in concentric circles in that a scanning device is guided along the data tracks by means of a tracking regulation circuit, in which recording medium, the address of every single point of the recording medium where the scanning device loses the data track is stored in a memory, and in which the tracking regulation circuit calculates and generates a regulating signal in order to guide the scanning device back onto the data track which is to be scanned.

A known playback device for disk-type rotating recoding media with helical data tracks is the CD player.

In a CD player, an optical scanning device scans the helical data tracks of a so-called compact disk by means of a light beam. Using an objective lens, the light beam is focused onto the CD - the everyday abbreviation for compact disk - by a focusing regulation circuit. A tracking regulation circuit guides the optical scanning device such that the light beam is always guided along the data tracks of the CD.

In US-PS-4821251 it is disclosed that in a recording and reproduction apparatus defective sectors of the optical disk are stored in a memory. The erroneous sectors are eliminated from the reading and writing of data.

An optical reproduction apparatus is described in EP-A-0139332, which reads data from an optical disk by means of an optical sensor apparatus.

When tracking is lost, the last correct position of the sensing apparatus before the loss of tracking is stored, in order to return the sensing apparatus as quickly as possible again to the data track to be scanned.

There is known from EP-A-0249781 an optical reproduction device which is provided with an intermediate store. The data read from an optical disk is first stored in the intermediate store, before it is output. If there is a loss of tracking or focus, when no more data can be read, the data held in the intermediate store is output next so that an interruption of the flow of data is avoided. When the light beam is again directed on the correct track and focused, the intermediate store is again filled with data.

However, scratches or contamination on the disk, for example, dust or fingerprints, impair the reproduction of the music. If the light beam arrives at a point which is contaminated, for example, by dust or a fingerprint, it runs uncontrolled over the data tracks because the data are no longer readable and because the tracking regulation circuit, therefore, cannot generate a regulating signal any more. As soon as the light beam scans a clean (uncontaminated) data track on the disk again the tracking regulation circuit checks whether the light beam is still focused on the data track which is to be scanned. In most cases it is displaced by a few data tracks radially inwards or outwards. The tracking regulation circuit now calculates and generates a regulating signal so that the light beam returns to the data track to be scanned.

The data located between the point where the light beam left the data track to be scanned and the point where it returned to it is, therefore, not reproduced. An interruption in the playback of the music can still be avoided with a CD player if the lost data can be bridged

over by interpolation. However, if the contaminated or damaged spot on the disk is too large, then the listening enjoyment is spoilt by a disturbing interruption in the reproduction of the music.

Therefore, it is the object of the invention to design a method according to the preamble of claim 1 or 2 in such a way that the data loss caused by contaminated or damaged spots on the recording medium is as small as possible.

The invention solves this task in that in a first method step a modified regulating signal is calculated from this first regulating signal and is stored in the memory, and that during every subsequent reading of the data on the recording medium and upon reaching each one of the stored points, the tracking regulation circuit immediately receives from the memory the modified regulating signal belonging to the point which has been reached in order to keep the scanning device as near as possible to the data track to be scanned.

A second solution of the invention provides that, in a first method step, the data on the recording medium are read for a first time, that the address of every single point of the recording medium where the scanning device loses the data track is stored in a memory during the initial reading of the data, that a first modified regulating signal is calculated from the regulating signal generated by the tracking regulation circuit, in order to guide the scanning device back onto the data track to be scanned, said signal then being stored in a memory, that, in a second method step, each stored point is approached by the scanning device, that the tracking regulation circuit receives the stored associated first modified regulating signal from the memory immediately upon reaching each

one of these points, in order to keep the scanning device as near as possible to the data track to be scanned, that a second modified regulating signal is calculated from the regulating signal generated by the tracking regulation circuit in order to guide the scanning device onto the data track to be scanned, said signal then being stored in the memory, that the second procedure step is repeated untilL the direction of the tracking deviation or the sign of the modified regulating signal reverses, and that either the modified regulating signal causing the reversal of direction or the modified regulating signal determined immediately before the reversal of direction is retained during every subsequent reading of the data of the recording medium and that said signal is sent to the tracking regulation circuit from the meory immediately upon reaching each one of the stored points.

There is shown in:

Fig.1. a playback device for executing the memthod according to the invention;

Fig.2. a section of a compact disk with a contaminated spot.

By way of an example, Figure 1 shows a CD player which is suitable for executing the method according to the invention.

A motor M1 turns the compact disk CD which is scanned by an optical scanning device AV by means of a light beam L. The light beam L is focused onto the disk CD by means of an objective lens O. Using a fine drive F, the objective lens O can be moved relative to the scanning device AV a small amount radially inwards or outwards, as indicated by the double-headed arrow.

The optical scanning device AV is mounted on a spindle SP which is driven by a motor M2. Therefore, the optical scanning device AV can be moved in a radial direction so that the light beam L can be guided along the data tracks on the disk CD. The spindle SP and the motor M2 are designated the coarse drive.

In the normal regulating mode, a regulating circuit MP receives a tracking error signal TE from the optical scanning device AV; the regulating circuit MP generates, from the tracking error signal TE, a regulating signal TF for the fine drive and a regulating signal TG for the coarse drive. The fine and coarse drives work together in such a way that the light beam L is guided along the data tracks of the disk CD. Apart from that, the optical scanning device AV sends the address AD of each currently scanned point on the disk CD to the regulating circuit MP. If the light beam now reaches, for example, a contaminated spot, the regulating circuit MP no longer receives a tracking error signal TE. According to the method described in claim 1, the regulating circuit MP now causes the address of the last point registered to be stored in the memory S. As soon as the regulating circuit MP receives a tracking error signal TE again, it determines the deviation of the light beam L

from the data track to be scanned and calculates from this tracking deviation a regulating signal in order to direct the light beam L back onto the data track to be scanned. A modified regulating signal is calculated from this regulating signal and is stored in the memory S as belonging to the stored point.

This method is repeated at every contaminated or damaged spot on the disk CD in order to store the addresses of all points and the associated modified regulating signals. Therefore, not only all the points of the disk CD where the light beam loses the the data track are stored but also the modified regulating signal belonging to each point.

If in the playback mode the light beam L arrives at one of the stored points, the regulating circuit MP detects this through comparison with the stored address. When the address supplied by the optical scanning device AV is identical to the address stored in the memory S, the regulating circuit MP calls up the modified regulating signal belonging to this point from of the memory S and sends this signal to the tracking regulation circuit in order to direct the light beam back onto the data track to be scanned as quickly as possible.

The modified regulating signals generated according to the method from claim 2 are also stored in the memory S.

With the method according to claim 2, the addresses of the contaminated or damaged spots as well as the associated first modified regulating signals are stored in the memory S after the initial playback of the disk CD. In the second procedure step, the regulating circuit MP has the effect that each of the stored points is approached by the optical scanning device AV and the associated modified first regulating signal, which is stored in the memory S, is sent

to the tracking regulation circuit. The tracking regulation circuit now generates a regulating signal in order to direct the light beam L back onto the data track to be scanned. A second modified regulating signal is calculated from this regulating signal or from the tracking deviation and is stored in the memory S instead of the first modified regulating signal.

This second procedure step is repeated for each stored point until either the direction of the tracking deviation or the (preceding) sign of the regulating signal reverses. Then either the modified regulating signal stored immediately in the procedure step before the sign reversal or the modified regulating signal calculated upon reversal of the sign remains in the memory S; it is no longer overwritten by a new modified regulating signal.

During the playback of the CD, every time the light beam L arrives at one of the stored points, the regulating circuit MP calls up the associated modified regulating signal from the memory S in order to direct the light beam back onto the data track to be scanned as close as possible behind the contaminated or damaged spot.

The effect of the invention-type method according to claim 1 or 2 will now be explained by means of Figure 2.

A section of a compact disk CD with five helical data tracks A, B, C, D and E is shown in Figure 2. A grain of dust SK covers a part of the data tracks B and C. The disk CD rotates in the direction indicated by the arrow. Therefore, the light beam L moves in the direction of the arrow from left to right along the data track B.

When the light beam arrives at point 1, no more data can be read owing to the grain of dust SK and, therefore, a

tracking error signal TE can no longer be generated. The address of point 1 is stored in the memory S.

However, without tracking error signal TE the light beam L runs uncontrolled over the data tracks beyond point 1. In Figure 2 it runs, for example, three data tracks radially inwards to data track E where the tracking regulation circuit recaptures it and guides it on the data track E from point 2 onwards. After a short time, when the light beam is at point 3, the regulating circuit MP has recognized that the light beam is displaced three data tracks too far radially inwards. Therefore, it sends out a regulating signal to the tracking regulating circuit which guides the light beam to point 4 on the data track B which is to be scanned. A modified regulating signal is calculated from this regulating signal and this is also stored in the memory S with the address of point 1.

All data located between points 1 and 4 on the data track B have not been scanned by the light beam L. The invention is now based on the knowledge that not all data located between points 1 and 4 but only a part thereof are covered by the grain of dust SK.

In accordance with the method according to the invention described in claim 1, the modified regulating signal present in the memory S is sent to the tracking regulation circuit when the disk is played back if the light beam scans point 1 on data track B. Therefore, the light beam is no longer shifted to data track E but, for example, only as far as data track D where it is captured by the tracking regulation circuit at point 5. At point 6 on data track D, the regulating circuit MP has recognized that the light beam has to be offset by two data tracks radially outwards in order to again meet the data track B which is to be scanned. Therefore, the regulating circuit MP generates a regulating

signal so that the light beam moves from point 6 on data track D to point 7 of the data track B which is to be scanned. The area of data which has not been read has shrunk because it now only extends from point 1 to point 7 on data track B.

The area of data which has not been scanned is further restricted with the method specified in claim 2.

Upon initial reading of the data, the light beam moves from point 1 to point 2, further to point 3 and from there to point 4 on data track B. Like in the method according to claim 1, the address of point 1 and the associated first modified regulating signal are stored in the memory S; said modified regulating signal is calculated in the same manner as with the method according to claim 1.

In a second procedure step, point 1 is approached and the stored first modified regulating signal is sent to the tracking regulation circuit. The light beam L is now captured by the tracking regulation circuit at point 5 on data track D. The regulating circuit MP recognizes at point 6 that the light beam has to be shifted two data tracks radially outwards in order to again meet the data track B which is to be scanned. Therefore, it generates a regulating signal which has the effect that the light beam is steered from point 6 on data track D to point 7 on data track B. A second modified regulating signal is calculated from this regulating signal and stored in the memory S.

In a further procedure step, the light beam once again travels to point 1; as the tracking regulation circuit now receives the second modified regulating signal stored in the memory S, the light beam is already captured after data track C and directed to point 8 on data track C. The regulating circuit MP has calculated and generated a

regulating signal at point 9 of data track C which steers the light beam onto point 10 of the data track B which is to be scanned. A third modified regulating signal is calculated from this regulating signal and stored in the memory S.

Point 1 is now approached for a third time by the light beam L. The tracking regulation circuit receives the third modified regulating signal from the memory S. However, the third modified regulating signal now has the effect that the light beam is deflected outwards to data track A. The tracking regulation circuit catches the light beam L and steers it to point 11 of data track A. At point 12 of data track A, the regulating circuit MP, after it has recognized at point 11 that the light beam has been displaced by one data track radially outwards from the data track B which is to be scanned, sends a regulating signal to the tracking regulation circuit so that the light beam is directed onto the data track B which is to be scanned. However, as with this procedure step the sign of the tracking deviation, and consequently the regulating signal too, has reversed, the third modified regulating signal remains in the memory S.

However, it is also possible to calculate a fourth modified regulating signal from the regulating signal generated last and to store this in the memory S. As in both cases the optimum modified regulating signal is found and stored, the play mode can begin.

When in the play mode the light beam arrives at point 1 on data track B, the regulating circuit MP sends the optimum modified regulating signal belonging to point 1, which is stored in the memory S, to the tracking regulation circuit. This signal is either the third or the fourth modified regulating signal.

If the third modified regulating signal is stored in the memory S as the optimum modified regulating signal, then the light beam moves from point 1 to point 2, on further to point 8 on the data track C, then to point 9 on data track C and from there to point 10 on the data track B which is to be scanned.

On the other hand, the light beam moves from point 2 to point 11 on data track A, on further to point 12 on data track A and from there to point 13 on the data track B, which is to be scanned, if the fourth modified regulating signal is stored in the memory S as the optimum modified regulating signal.

The quantity of data which has not been scanned, as can be seen from Figure 2, is considerably reduced by the method according to the invention of claim 2.

The extent by which the quantity of unscanned data is reduced mainly depends on the size and shape of the contaminated or damaged spots on the disk. The method explained by way of the example of the grain of dust SK is performed at all the contaminated or damaged spots on the disk.

A first examplary embodiment described in claim 3 provides for the rotational speed of the disk to be increased while the optimum modified regulating signal is being determined step by step. The time required for executing the method is thereby shortened.

In a second examplary embodiment of the invention, which is described in claim 4, the operator can select whether to start or stop the method according to the invention.

The third examplary embodiment, specified in claim 5, provides for the addresses of any points and the associated modified regulating signals to be automatically deleted in the memory if the light beam no longer loses the data track at these points. This can be the case if, for example, the user has carefully cleaned the disk to remove contamination and fingerprints.

A fourth examplary embodiment, which is specified in claim 6, offers the operator the possibility of manually deleting the addresses and the associated modified regulating signals in the memory at any time.

According to a fifth examplary embodiment, described in claim 7, the disks are provided with an identification; the addresses of the contaminated or damaged spots as well as the associated modified regulating signals are stored for each identified disk.

It is also possible, as the examplary embodiment specified in claim 8 shows, to provide the disks in a magazine with an identification which characterizes them as belonging to the magazine. The addresses of the points and the associated modified regulating signals are stored in order according to disk and magazine.

As the spots where the light beam loses the data track are in most cases contaminated by dust or fingerprints, it is advisable to recommend cleaning of the disk to the operator by means of an visual and/or acoustic signal if there are one or more spots on the disk where the light beam leaves the data track to be scanned. A criterion for this could be, for example, the content of the memory. The visual and/or acoustic signal can be generated as soon as an address of a point is stored in the memory. For example, the text "Clean disk" can appear on an indicator device, a so-called display.

The invention is suitable for playback devices which scan a disk-type rotating recording medium without making contact, for example, by means of a light beam. Examples of this are CD players, video-disk players, DRAW-disk players and magneto-optical recording and reproducing devices.

Patent Claims

1. Method for reading the data from a rotating disk-type recording medium (CD) on which the data are recorded in helical data tracks (A,B,C,D,E) or in concentric circles in which a scanning device (AV) is guided along the data tracks by means of a tracking regulation circuit, during the initial reading of the data of the disk-type recording medium (CD), the address of every single point (1) of the recording medium where the scanning device (AV) loses the data track (B) is stored in a memory (S), and in which the tracking regulation circuit calculates and generates a regulating signal in order to guide the scanning device (AV) back onto the data track (B) which is to be scanned, characterised in that in a first method step a modified regulating signal is calculated from this regulating signal and then stored in the memory (S), that upon reaching any one of the stored points (1) during each subsequent reading of the data of the recording medium (CD), the tracking regulation circuit immediately receives the stored modified regulating signal belonging to the point (1) which has been reached in order to keep the scanning device (AV) on the data track (B) which is to be scanned.

2. Method according to claim 1, characterised in that the tracking regulation circuit generates a second regulating signal in order to guide the scanning device (AV) onto the data track (B) which is to be scanned, that a second modified regulating signal is calculated from this second regulating signal and then stored in the memory (S), that the second procedure step is repeated until the direction of the tracking deviation or the sign of the regulating

signal generated by the tracking regulation circuit reverses, that during each subsequent reading of the data of the recording medium (CD) either the modified regulating signal causing the reversal of the tracking deviation or the modified regulating signal determined immediately before the reversal of the tracking deviation is retained and sent from the memory (S) to the tracking regulation circuit immediately upon reaching each one of the stored points (1).

3. Method according to claim 2, characterised in that during the second procedure step and its repetition, the rotational speed of the disk (CD) is increased in order to shorten the time required for the method.

4. Method according to claim 1, 2 or 3, characterized in that the operator can select whether to start or stop the method.

5. Method according to claim 1, 2, 3 or 4, characterized in that the data present in the memory (S) is automatically deleted for each point which no longer causes a tracking deviation.

6. Method according to claim 1, 2, 3, 4 or 5, characterized in that the data present in the memory (S) can be deleted by the operator at any time.

* C L M S *

7. Method according to claim 1, 2, 3, 4, 5 or 6, characterized in that the individual recording media (CD) are provided with an identification and that the points where the scanning device (AV) loses the data track and the associated modified regulating signals can be stored for each of the identified recording media.

8. Method according to claim 7, characterized in that the recording media in a magazine and the magazine itself are provided with an identification, that the points where the scanning device loses the data track and the associated modified regulating signals can be stored in an order according to recording medium and according to magazine.

9. Method according to one or more of the preceding claims, **characterised in that** a visual and/or acoustic signal recommends to the operator that recording medium should be cleaned if one or more points are found on the disk where the scanning device loses the data track.