The invention relates to a method for the counting of markings which are scanned by a scanner.

CD players, video disc players, DRAW-disc players or magneto-optic recording and reproducing devices are equipped for example with an optical scanning device.

The construction and method of operation of an optical scanning device, a so-called optical pick-up, are described in "Electronic Components & Applications", Vol. 6, No 4, 1984 on pages 209 - 215..

The light beam emitted by a laser diode is focused by means of lenses onto the compact disc and reflected from there onto a photo-detector. The data stored on the compact disc and the current values for the focusing and for the tracking control loop are obtained from the output signal of the photo-detector. In the said document, the deviation of the current value from the reference value for the focusing control loop is referred to as "focusing error" while the expression "radial tracking error" is selected for the deviation of the current value from the reference value for the tracking control loop.

A coil, by means of whose magnetic field an objective lens can be moved along the optical axis, serves as control member for the focusing control loop. The focusing control loop now ensures, by displacement of the objective lens, that the light beam emitted by the laser diode is always focused on the compact disc. The optical scanning device is displaceable in a radial direction with reference to the compact disc by means of the tracking control loop which is often referred to as a radial drive. Thereby, the light beam can be guided onto the spirally shaped data track of the compact disc.

In some devices, the radial drive is constructed from a so-called coarse and a so-called fine adjustment means. The coarse adjustment means is implemented for example as a screw by means of which the whole optical scanning device consisting of the laser diode, the lenses, the prismatic beam splitter and the photo-detector is radially displaceable. The light beam is displaceable additionally in the radial direction or e.g. is deflectable through a predetermined small angle by the fine adjustment means. Consequently, the light beam can be moved a small distance - about 1 mm - along a radius of the compact disc by means of the fine adjustment means.

In order to achieve a perfect reproduction of the data, be it now e.g. picture and sound in a video disc player or merely the

sound from a CD player or the data on a magneto-optic disc, in addition to an exact focusing of the light beam on the disc, a precise guidance along the data track of the disc is required.

In the Fig. 1, the photo-detector PD of the optical scanning device of a CD player is shown, in which three laser beams L1, L2 and L3 are focused on the compact disc. The laser beams L2 and L3 are the diffraction beams of +1 and -1 order. An optical scanning device of this type is referred to as a three-beam-pick-up in the aforementioned document because it works with three light beams.

Four square shaped photodiodes A, B, C and D are so arranged in the photo-detector that they themselves form a square. A rectangular photodiode E is located in front of the square formed by the four photodiodes A, B, C and D; a further photodiode F is provided behind the square. The central laser beam L1, which is focused on the four photodiodes A, B, C and D produces the data signal HF = AS + BS + CS + DS and the focusing error signal FE = (AS + CS) - (BS + DS). The two outer light beams L2 and L3, of which the front one L3 falls on the photodiode E and the rear one L2 on the photodiode F, produce the tracking error signal T = ES - FS. The photoelectric voltages of the diodes A, B, C, D, E and F are respectively referenced AS, BS, CS, DS, ES and FS.

In the Figure 1, the central light beam L1 exactly follows the middle of a track S. The tracking error signal TE has the value zero.

$$TE = ES - FS = 0.$$

If the central light beam deviates from the middle of a track S, the one diffraction beam moves more towards the middle of the track whilst the other diffraction beam shines on the intervening space between two tracks S. However, because the properties of reflection for a track and an intervening space are different, the one diffraction beam is reflected more strongly than the other.

The case is illustrated in the Figure 2 that the laser beams L1, L2 and L3 are displaced to the right of the track S. The tracking error signal adopts a negative value:

$$TE = ES - FS < 0.$$

The adjusting member of the tracking control loop now moves the optical scanning device to the left until such time as the tracking error signal TE is zero.

In the opposite case, when the laser beams are displaced to the left of the track, the tracking error signal is positive: TE = ES - FS > 0. The adjusting member of the tracking control loop now moves the optical scanning device to the right until such time as the tracking error signal TE is zero. This case is shown in Figure 3.

If the light beam L1 and the appertaining diffraction beams L2 and L3 cross several data tracks, the tracking error signal TE adopts the sinusoidal waveform shown in Figure 4.

A tracking control loop in which it is detected from the lower and upper envelopes of the HF signal whether the light beam is crossing data tracks is known from the JP -OS 60 10429. If the light beam runs over a plurality of data tracks then the HF signal regularly collapses between two tracks.

In order to determine the number of tracks that are swept over by the light beam, the envelope of the HF signal is formed and converted into a rectangular signal which is supplied to the counting input of an up-down counter. The collapses of the HF are counted in this manner by the up-down counter.

In order to determine in which direction the light beam was moved, a so-called directional logic is required. It is known for example, to feed the tracking error signal TE to the D input of a D flip flop and the envelope of the HF signal to its clock input. Consequently, the D flip flop always receives a pulse at its clock input when the light beam crosses a data track. However, because the prefix sign of the tracking error signal TE is dependent on the direction in which the light beam leaves a data track, the D flip flop is set - its output goes "HIGH" - for the one direction, whereas for the other direction, its output remains at "LOW". The signal at the Q output of the D flip flop can therefore serve for determining the counting direction - up or down - of an up-down counter. Consequently, in the case of the one direction, the up-down counter counts up while it counts down in the case of the other direction.

A disadvantage of this known tracking control loop however, consists in that one must pay attention to the phase angle of the signals generating the counting pulses and the tracking error signal upon the change of direction of the light beam because errors can occur in the case of adverse phase angles.

The object of the invention is therefore to reduce the error rate in a method for the counting of markings or data tracks.

This object is achieved by the invention in that, a first counter receives a counting pulse on each occasion that the scanner jumps from one marking to the next in the wanted direction, that a second counter receives a counting pulse on each occasion that the scanner jumps from one marking to the next in the unwanted direction, that the count of the first counter is set to a first predetermined value for jumping over m markings while the count of the second counter is set to a second predetermined value, that the counts of the two counters are compared with each other and that, upon equality of the counts a signal for stopping the scanner is emitted.

There is shown in:

Figure 5 a first embodiment

Figure 6 a second embodiment

Figure 7 a third embodiment of the invention.

The invention will now be described and thereafter explained with the aid of the embodiment shown in Figure 5.

By means of a controllable switch US which is controlled by a directional logic RL, the counting pulses ZI, which are obtained from the envelope of the HF signal, are supplied to the counting input V of an n-bit counter Z1 whenever the light beam moves in the wanted direction, for example radially inwards towards the centre of the disc, when jumping over the tracks. If, however, the light beam jumps in the opposite direction radially outwards towards the edge of the disc, for example as a result of a vibration or a jolt, then the counting pulses ZI are applied to the counting input V of an n-bit counter Z2 by the controllable switch US. The outputs of the n-bit counter Z1 and of the n-bit counter Z2 are connected by a chain of n EQUIVALENCE gates E1 to En in such a way that two equally significant outputs of the two counters Z1 and Z2 are connected to the two inputs of a respective EQUIVALENCE gate. The outputs of the EQUIVALENCE gates E1 to En are connected to the inputs of a NAND gate N.

If it is intended that the light beam should jump radially inwards by 200 tracks for example, the counter Z2 is loaded up to 200 while the counter Z1 is reset to zero. For this purpose,

a not shown control device, for example a microprocessor, emits a pulse to the interconnected loading inputs L of the two counters Z1 and Z2. Because the counting input V of the counter Z1 is now receiving the counting pulses obtained from the envelope of the HF signal, it counts on upwards from zero. The count of the counter Z2 remains at 200 since it is not receiving any counting pulses. The respective bits, which are present on the equally significant outputs of the two counters Z1 and Z2, are now compared with each other in the n EQUIVALENCE gates E1 to En. All of the n EQUIVALENCE gates E1 to En only emit a logical zero from their outputs, when all of the equally significant bits at the outputs of the two counters Z1 and Z2 coincide with one another - this is the case when both counts are equally large. The NAND gate N now emits a logical one from its output which means that the light beam has now jumped over 200 tracks and causes it to come to a stop on the wanted track.

In some optical scanning devices, the count of the second counter Z2 is not set to m for jumping over m tracks but rather, to a smaller value. If the light beam needs ten tracks for example for braking, then the counter Z2 is loaded up to m - 10. Consequently, the braking of the light beam is begun ten tracks before the intended track in order for it to stop on the wanted track. The value, to which the counter Z2 is to be loaded, depends on the type of optical scanning device and on the control loop. It can be determined by experiment for example.

Now it can happen however, that while track-jumping over the 200 tracks, the light beam jumps a few tracks in the wrong direction as a result of a vibration for example. CD players which are built into vehicles for example are subject to strong vibrations and jolts of this type.

It will now be assumed that the light beam now crosses ten tracks in the wrong direction - radially outwards - as a result of a jolt which may be caused by a pot-hole for example, after it has already jumped 50 tracks in the correct direction. Because the directional logic RL detects the change of direction of the light beam, it actuates the controllable switch US so that the counter Z2 now receives ten counting pulses. Its count is therefore increased to 210. As soon as the effect of the jolt has ceased, which in the assumed example should be the case after ten tracks, the light beam again moves in the correct direction radially inwards. The directional logic RL now causes the counting pulses ZI to be supplied again to the counter Z1 by switching-over the controllable switch US. However, because the count of the counter Z2 was increased from 200 to 210, the signal for stopping the light beam is only given when the

counter Z1 has counted up to 210. It is thus ensured that the light beam is stopped exactly on the wanted track and not ten tracks sooner which would have been the case if the count of the counter Z2 had not been increased by 10 from 200 to 210.

However, because it may be necessary to jump over 1000 and more tracks when seeking a wanted piece of music in CD players, the cost for the counters and the EQUIVALENCE gates quickly mounts up. Two 10 bit counters and ten EQUIVALENCE gates have to be provided for jumping over 1000 tracks. It is desirable however, to keep the outlay for counters and gates as low as possible.

The second embodiment depicted in Figure 6 is organised in such a way that as many tracks as one wishes can be jumped over using two 9 bit counters. It is supplemented by a delay member and a flip flop as will be described hereinafter.

The output of the NAND gate N is connected to the reset input R of an RS flip flop FF whose Q output, from which the signal LS for stopping the light beam is derivable, is connected to the reset input G for the ninth bit of the counter Z1 and to the set input H for the ninth bit of the counter Z2. The counting input V of the counter Z1 is connected to the first input of two NOR gates N1 and N2; the counting input V of the counter Z2 is connected to the second input of the NOR gates N1 and N2. The output of the NOR gate N1 is connected to an input of the NAND gate N while the output of the NOR gate N2 is connected to the set input S of the RS flip flop FF.

It will now be explained how a jump of the light beam by 700 tracks for example is carried out. In order for the light beam to jump from its present position, the start of the first piece of music for example on a CD disc, to the third piece of music which the listener would like to hear, a microprocessor in the CD player calculates in known manner how many tracks there are between the present position of the light beam and the beginning of the wanted piece of music. In the assumed numerical example, the number of tracks between the current and the wanted position of the light beam might amount to 700.

In order to count to 700, a 9 bit counter has to count to 256 twice and then once to 188 since 2 * 256 + 188 = 700. For the assumed numerical example, the counter Z2 is loaded up to 188 whereas the counter Z1 is set to zero. Thereafter, the counter Z1 begins to count. The counts of the two counters Z1 and Z2 are equal for the first time after 188 counting pulses. The RS flip flop FF is therefore reset. The negative pulse at its Q output now has the effect that the 9th bit in the counter Z2 is set to

1 whereas in the counter Z1 it is set to 0. The counter Z1 now counts on until, after 256 counting pulses, it reaches the same count as the counter Z2 and the RS flip flop FF emits a negative pulse at its Q output for the second time when this equal count occurs. Consequently, the 9th bit is set to 1 in the counter Z2 whereas in the counter Z1 it is set to 0. Because the counts of the two counters Z1 and Z2 are again equal after a further 256 counting pulses, the RS flip flop FF emits a negative pulse at its Q output for the third time. The microprocessor recognises by this third negative pulse that once, 188 and twice, 256 i.e. 700 pulses altogether, have been counted.

If, whilst jumping over the 700 tracks, the light beam jumps in the wrong direction as the result of jolts for example, then, in the same manner as for the first embodiment, the count of the counter Z2 is increased by as much as the total number of tracks that the light beam has jumped over in the wrong direction; for it can happen, that during the course of a large jump the light beam jumps several times in the wrong direction because of vibrations on bumpy roads.

In order to avoid a false evaluation of the counts in such cases, the most significant bit in the counter Z1 is set to 0 whereas in the counter Z2 it is set to 1 when there are equal counts. When, after 188 counting pulses, the counts are equal for the first time, then the counter Z1 counts-on so long as the light beam is crossing tracks in the wanted direction. Now however, if after 12 tracks for example, with a count of 200 in the counter Z1, the light beam is displaced by 20 tracks in the unwanted direction as a result of a vibration, then the counter Z2 counts from 188 up to 188 + 20 = 208. At 200, the counts would, however, have been equal if the most significant bit of the counter Z1 had not previously been set to 0 while that of the counter Z2 had not been previously set to 1 at the equal count of 188. Without these measures, a pulse would have been emitted by the microprocessor. Because the light beam is crossing the tracks in the correct direction again after the vibration, the counter Z1 counts from 200 on upwards. However, because, as a result of the vibration, the count of the counter Z2 no longer amounts to 188, but rather to 208, equal counts would be established for the third time - now with a count of 208 in the counter Z1 - although the light beam has only crossed 200 tracks in the wanted direction as calculated from the starting point, if the most significant bit in the counter Z1 had not been set to 0, while that of the counter Z2 had not been set to 1 when there were equal counts of 188.

The controllable switch US may, as is illustrated in Figure 7, be so extended that the counting pulses ZI are supplied to the counter Z1 or Z2 in dependence on the wanted and the actual direction of movement of the light beam.

This third embodiment which is shown in Figure 7 will now be described and explained.

If the light beam moves radially inwards, counting pulses ZI1 are conducted to the first input of an AND gate U1, whilst counting pulses ZI2 are supplied to the first input of an AND gate U2 if the light beam moves radially outwards. The interconnected second inputs of the two AND gates U1 and U2 are connected to the output of an inverter I1. The output of the AND gate U1 is connected to the first input of two AND gates U3 and U4. The output of the AND gate U2 is connected to the first input of two AND gates U5 and U6. The output of an inverter I2, whose input is connected to the second input of the AND gates U4 and U6, is connected to the second input of the AND gates U3 and U5. The output of an OR gate O1, whose first input is connected to the output of the AND gate U4 and whose second input is connected to the output of the AND gate U5, is connected to the counting input V of the counter Z2. The output of an OR gate O2, whose first input is connected to the output of the AND gate U3 and whose second input is connected to the output of the AND gate U6, is connected to the counting input V of the counter Z1.

Because all of the AND gates U1 to U6 are blocked due to a logical one at the input of the inverter I1, the counters too are blocked. In contrast, a logical zero at the input of the inverter I1 opens the AND gates U1 and U2 for the counting pulses. A logical one at the input of the inverter I2 and thus too at the second input of the AND gates U4 and U6 has the effect that the counting pulses supplied to the first input of the AND gate U1 are conducted to the counter Z2, whereas the counting pulses supplied to the first input of the AND gate U2 are supplied to the counter Z1.

With a logical zero at the input of the inverter I2, the connections for the counting pulses are interexchanged. The counting pulses which are present at the first input of the AND gate U1 now reach the counter Z1, while the counting pulses which are present on the first input of the AND gate U2 run to the counter Z2.

If the wanted direction for the jump is radially inwards, there is a logical one on the input of the inverter I2 in the third embodiment shown in Figure 7; in contrast, a logical zero at the

input of the inverter I2 means that the wanted direction for the jump is radially outwards.

The invention is generally suitable for counting devices for counting markings. It is of no consequence whether the markings or data tracks are scanned mechanically or without making contact. The invention may, in advantageous manner, be utilised for example in control loops for the positioning of a unit, a scanner for example, in which the unit is positioned by optical scanning and counting of markings. It is especially suitable for tracking control loops such as are encountered for example in CD players, video disc players, DRAW disc players or magneto-optic recording and reproduction devices.

Claims

1. Method for the counting of markings which are scanned by a scanner, characterised in that, a first counter (Z1) receives a counting pulse (ZI) on each occasion that the scanner jumps from one marking to the next in the wanted direction, that a second counter (Z2) receives a counting pulse (ZI) on each occasion that the scanner jumps from one marking to the next in the unwanted direction, that the count of the first counter (Z1) is set to a first predetermined value for jumping over m markings while the count of the second counter (Z2) is set to a second predetermined value, that the counts of the two counters (Z1, Z2) are compared with each other and that, upon equality of the counts, a signal (LS) for stopping the scanner is emitted.

2. Method in accordance with Claim 1, characterised in that, for jumping over m markings, the count of the first counter (Z1) is set to 0 and the count of the second counter (Z2) is set to m.

3. Method in accordance with Claim 1, characterised in that, two n-bit counters are provided for the two counters (Z1, Z2), that, for jumping over m markings, the second counter (Z2) is set to the remainder which results from the quotient m/n, and that the first counter (Z1) is set to 0.

4. Method in accordance with Claim 3, characterised in that, when there are equal counts, the most significant bit in the first counter (Z1) is set to 0 whereas in the second counter (Z2) it is set to 1.

5. Method in accordance with Claim 1, 2, 3 or 4, characterised in that, each two equally significant outputs of the counters (Z1, Z2) are connected to the inputs of a respective EQUIVALENCE gate (E1, ..., En) and that the outputs of the EQUIVALENCE gates (E1, ..., En) are connected to the inputs of a NAND gate (N) from whose output the signal (LS) for stopping the scanner is derivable.

New Claims 6, 7 and 8

6. Counting device for carrying out the method according to Claim 4 or 5, characterised in that, a first counter (Z1) receives a counting pulse (ZI) on each occasion that the scanner jumps from one marking to the next in the wanted direction, that a second counter (Z2) receives a counting pulse (ZI) on each occasion that the scanner jumps from one marking to the next in the unwanted direction, that the count of the first counter (Z1) is set to a first predetermined value for jumping over m markings while the count of the second counter (Z2) is set to a second predetermined value, that the counts of the two counters (Z1, Z2) are compared with each other, that upon equality of the counts, a signal (LS) for stopping the scanner is emitted, that each two equally significant outputs of the counters (Z1, Z2) are connected to the inputs of a respective EQUIVALENCE gate (E1, ..., En), that the outputs of the EQUIVALENCE gates (E1, ..., En) are connected to the inputs of a NAND gate (N) from whose output the signal (LS) for stopping the scanner is derivable, that the one output of a controllable switch (US) is connected to the counting input (V) of the first counter (Z1) and the other output is connected to the counting input (V) of the second counter (Z2), that the control input of the controllable switch (US) is connected to the output of a directional logic (RL) and that the counting pulses (ZI) are supplied to the input of the controllable switch (US).

7. Counting device for carrying out the method according to Claim 4 or 5, characterised in that, a first counter (Z1) receives a counting pulse (ZI) on each occasion that the scanner jumps from one marking to the next in the wanted direction, that a second counter (Z2) receives a counting pulse (ZI) on each occasion that the scanner jumps from one marking to the next in the unwanted direction, that the count of the first counter (Z1) is set to a first predetermined value for jumping over m markings while the count of the second counter (Z2) is set to a second predetermined value, that the counts of the two counters (Z1, Z2) are compared with each other, that upon equality of the counts, a signal (LS) for stopping the scanner is emitted, that each two equally significant outputs of the counters (Z1, Z2) are connected to the inputs of a respective EQUIVALENCE gate (E1, ..., En), that the outputs of the EQUIVALENCE gates (E1, ..., En) are connected to the inputs of a NAND gate (N), that the counting input (V) of the first counter (Z1) is connected to the first input of a first and of a second NOR gate (N1, N2), that the counting input (V) of the second counter (Z2) is connected to the second input of the first and second NOR gates (N1, N2), that the output of the first NOR gate (N1) is

connected to an input of the NAND gate (N) whose output is connected to the resetting input (R) of an RS flip flop (FF), that the output of the second NOR gate (N2) is connected to the setting input (S) of the RS flip flop (FF), that the signal (LS) for stopping the scanner is derivable from the Q- output of the RS flip flop (FF) which is connected to the resetting input (G) of the first counter (Z1) and to the setting input (H) of the second counter (Z2) for the most significant bit, that the one output of a controllable switch (US) is connected to the counting input (V) of the first counter (Z1) and the other output is connected to the counting input (V) of the second counter (Z2), that the control input of the controllable switch (US) is connected to the output of a directional logic (RL) and that the counting pulses (ZI) are supplied to the input of the controllable switch (US).

8. Counting device according to Claim 5, 6 or 7, characterised in that, counting pulses (ZI1) are supplied to the first input of a first AND gate (U1) and counting pulses (ZI2) are supplied to the first input of a second AND gate (U2), that the second inputs of the first and second AND gates (U1, U2) which are connected to one another are connected to the output of a first inverter (I1), that the output of the first AND gate (U1) is connected to the first input of a third and a fourth AND gate (U3, U4), that the output of the second AND gate (U2) is connected to the first input of a fifth and a sixth AND gate (U5, U6), that the second inputs of the third and fifth AND gates (U3, U5) which are connected to one another are connected to the output of a second inverter (I2) whose input is connected to the second input of the fourth and the sixth AND gates (U4, U6), that the output of the fourth AND gate (U4) is connected to the first input of a first OR gate (O1) whose second input is connected to the output of the fifth AND gate (U5), that the output of the sixth AND gate (U6) is connected to the first input of a second OR gate (O2) whose second input is connected to the output of the third AND gate (U3), that the output of the first OR gate (O1) is connected to the counting input (V) of the second counter (Z2), that the output of the second OR gate (O2) is connected to the counting input (V) of the first counter (Z1), that a digital signal at the input of the second inverter (I2) determines as to which of the two counters (Z1, Z2) the counting pulses (ZI1, ZI2) are supplied and that the counting pulses (ZI1, ZI2) are supplied either to the first or to the second counter (Z1, Z2) in dependence on the wanted and the actual direction of movement of the light beam.