(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 940 657 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
19.01.2022 Bulletin 2022/03

(21) Application number: **20842167.7**

(22) Date of filing: **29.04.2020**

(51) International Patent Classification (IPC):
G07D 11/00 *(2019.01)* ***G07D 11/18*** *(2019.01)*
B65H 3/06 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B65H 3/06; G07D 11/00; G07D 11/18

(86) International application number:
PCT/CN2020/087675

(87) International publication number:
WO 2021/217472 (04.11.2021 Gazette 2021/44)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **METHOD AND APPARATUS FOR REALIZING ELECTRIC MOTOR CONTROL ON BASIS OF FPGA**

(57) The embodiments of the present disclosure provide a method and device of controlling an electric motor based on FPGA, including: when a medium separating instruction has been received, acquiring a phase information of a predetermined separating element; detecting a predetermined medium carrying component by using a predetermined detecting assembly, to generate a detection signal; and based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating assembly. The embodiments of the present disclosure, by quickly, in real time and synchronously acquiring the phase information of the separating element and the detection signal of the detecting assembly, and judging whether the acquired phase information and detection signal satisfy the predetermined conditions, accurately control the timing of the movement of the medium carrying component, thereby accurately controlling the timing of the movement of the medium carrying component.

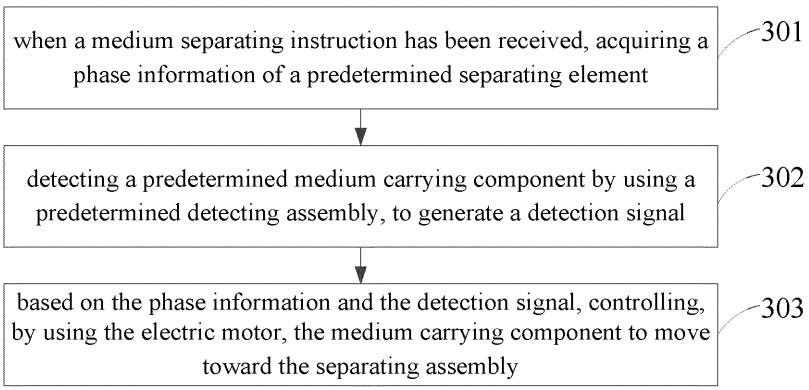

Fig. 3

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to the technical field of signal processing, and particularly relates to a method of controlling an electric motor based on FPGA and a device of controlling an electric motor based on FPGA.

BACKGROUND

[0002] Containers used to store a medium usually involve the problem how to separate the medium inside the container. The separation of the medium inside conventional containers is usually by using the friction between a separating assembly inside the container and the medium, to realize the technical effect of separating the medium out of the container.

[0003] However, during the process of the medium separation, although the rotational speed of the electric motor is constant, because of the differences in the ages, the staining degrees, the masses, the thicknesses and the occupied spaces of the media, the relative position between the separating assembly and the media easily varies. That results in that the friction between the separating assembly and the media is too large or too small, the media and the separating element contact loosely or tightly, the separation of the media is not performed at a constant speed, and thus separation failure or replicated separation of the media happen. That results in that the quality of the separation cannot be effectively ensured. The variations of those parameters such as distance and friction are very subtle, but seriously affects the effect of the medium separation. However, conventional controlling modes cannot realize accurate and real-time adjustment. If they are not timely treated and rectified, the severe consequences might be the damage of the media and the device. Currently, a conventional treatment mode is to control the electric motor by ARM, MCU and so on to drive the separating assembly to separate the medium. The conventional controlling mode can merely solve obvious problems in the separation, and its real-time capability and accuracy are not sufficient to solve the problems in the separation caused by the subtle parameter variations, and cannot realize accurate controlling and accurate separation.

SUMMARY

[0004] In view of the above problems, the embodiments of the present disclosure are proposed to provide a method of controlling an electric motor based on FPGA and a corresponding device of controlling an electric motor based on FPGA that can overcome the above problems or at least partially solve the above problems. By using the techniques of FPGA of operation and controlling, the problems in the separation caused by the subtle parameter variations are solved that cannot be solved by the conventional controlling mode due to the real-time capability and the accuracy.

[0005] An embodiment of the present disclosure discloses a method of controlling an electric motor based on FPGA, wherein the method comprises:

when a medium separating instruction has been received, acquiring a phase information of a predetermined separating element;
detecting a predetermined medium carrying component by using a predetermined detecting assembly, to generate a detection signal; and
based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

[0006] Optionally, the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the step of, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element comprises:
if the phase information satisfies that the separating assembly is in a first predetermined position and any one of the sub-signals is a no-blocking signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

[0007] Optionally, the separating element comprises a leading separating element; the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the step of, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element comprises:
if the phase information satisfies that the leading separating element is in a first predetermined position and any one of the sub-signals is a blocking signal, controlling, by using the electric motor, the medium carrying component to move toward the separating assembly.

[0008] Optionally, the separating element comprises a tailing separating element; the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the step of, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element comprises:
if the phase information satisfies that the tailing separating element is in a first predetermined position and any one of the sub-signals is a blocking signal, not moving the medium carrying component, and generating a movement marking information.

[0009] Optionally, the method further comprises:
if the phase information satisfies that the separating el-

ement is in a second predetermined position, in response to the movement marking information, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

[0010] Optionally, the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the step of, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element comprises:

if the phase information satisfies that the separating element is in a second predetermined position and any one of the sub-signals is a blocking signal, controlling, by using the electric motor, the medium carrying component to move.

[0011] Optionally, the step of, when the medium separating instruction has been received, acquiring the first phase information of the separating element comprises:

when the medium separating instruction has been received, sending a collecting instruction to a predetermined information collecting component; and

if a feedback information that is returned with respect to the collecting instruction has been received within a preset duration, acquiring a phase information of a predetermined separating element.

[0012] Optionally, the method further comprises:

if the feedback information is not received within a preset duration, emitting an alarming signal.

[0013] An embodiment of the present disclosure further discloses a device of controlling an electric motor based on FPGA, wherein the device comprises:

a phase-information acquiring module configured for, when a medium separating instruction has been received, acquiring a phase information of a predetermined separating element;

a detection-signal generating module configured for detecting a predetermined medium carrying component by using a predetermined detecting assembly, to generate a detection signal; and

a movement controlling module configured for, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating assembly.

[0014] Optionally, the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the movement controlling module comprises:

a first moving module configured for, if the phase information satisfies that the separating assembly is in a first predetermined position and any one of the sub-signals is a no-blocking signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

[0015] Optionally, the separating element comprises a leading separating element; the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the movement controlling module comprises:

a second moving module configured for, if the phase information satisfies that the leading separating element is in a first predetermined position and any one of the sub-signals is a blocking signal, controlling, by using the electric motor, the medium carrying component to move.

[0016] Optionally, the separating element comprises a tailing separating element; the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the movement controlling module comprises:

a not-moving module configured for, if the phase information satisfies that the tailing separating element is in a first predetermined position and any one of the sub-signals is a blocking signal, not moving the medium carrying component, and generating a movement marking information.

[0017] Optionally, the movement controlling module further comprises:

a third moving module configured for, if the phase information satisfies that the separating element is in a second predetermined position, in response to the movement marking information, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

[0018] Optionally, the detecting assembly comprises two detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the movement controlling module comprises:

a fourth moving module configured for, if the phase information satisfies that the separating element is in a second predetermined position and any one of the sub-signals is a blocking signal, controlling, by using the electric motor, the medium carrying component to move.

[0019] Optionally, the phase-information acquiring module comprises:

a collecting-instruction sending module configured for, when the predetermined medium separating instruction has been received, sending a collecting instruction to a predetermined information collecting component; and

a phase-information acquiring module configured for, if a feedback information that is returned with respect to the collecting instruction has been received within a preset duration, acquiring a phase information of a predetermined separating element.

[0020] Optionally, the phase-information acquiring

module further comprises:
an alarming module configured for, if the feedback information is not received within a preset duration, emitting an alarming signal.

[0021] An embodiment of the present disclosure further discloses an electronic device, wherein the electronic device comprises a memory and a processor, the memory stores a computer program, and when the computer program is executed by the processor, the computer program causes the processor to implement the steps of the method of controlling an electric motor based on FPGA according to the embodiment of the present disclosure.

[0022] An embodiment of the present disclosure further discloses a computer program, wherein the computer program comprises a computer-readable code, and when the computer-readable code is executed on a calculating and processing device, the computer-readable code causes the calculating and processing device to implement the method of controlling an electric motor based on FPGA according to the embodiment of the present disclosure.

[0023] An embodiment of the present disclosure further discloses a computer-readable storage medium, wherein the computer-readable medium stores the computer program according to the embodiment of the present disclosure.

[0024] The embodiments of the present disclosure have the following advantages:

[0025] The embodiments of the present disclosure, by quickly, in real time and synchronously acquiring the phase information of the separating element and the detection signal of the detecting assembly, and judging whether the acquired phase information and detection signal satisfy the predetermined conditions, accurately control the timing of the movement of the medium carrying component, thereby accurately controlling the timing of the movement of the medium carrying component.

[0026] The above description is merely a summary of the technical solutions of the present disclosure. In order to more clearly know the elements of the present disclosure to enable the implementation according to the contents of the description, and in order to make the above and other purposes, features and advantages of the present disclosure more apparent and understandable, the particular embodiments of the present disclosure are provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] In order to more clearly illustrate the technical solutions of the embodiments of the present disclosure or the prior art, the figures that are required to describe the embodiments or the prior art will be briefly introduced below. Apparently, the figures that are described below are embodiments of the present disclosure, and a person skilled in the art can obtain other figures according to these figures without paying creative work.

Fig. 1 is a schematic structural diagram of medium separation within the container according to an embodiment of the present disclosure;

Figs. 2a and 2b are schematic diagrams of the relation between the separating element and the medium according to an embodiment of the present disclosure;

Fig. 3 is a flow chart of the steps of an embodiment of the method of controlling an electric motor based on FPGA according to an embodiment of the present disclosure;

Fig. 4 is a flow chart of the steps of an embodiment of the method of controlling an electric motor based on FPGA according to an embodiment of the present disclosure;

Fig. 5 is a flow chart of an embodiment of the method of controlling an electric motor based on FPGA according to an embodiment of the present disclosure;

Fig. 6 is a structural block diagram of an embodiment of the device of controlling an electric motor based on FPGA according to an embodiment of the present disclosure;

Fig. 7 schematically shows a block diagram of a calculating and processing device for implementing the method according to the present disclosure; and

Fig. 8 schematically shows a storage unit for maintaining or carrying a program code for implementing the method according to the present disclosure.

DETAILED DESCRIPTION

[0028] In order to make the objects, the technical solutions and the advantages of the embodiments of the present disclosure clearer, the technical solutions of the embodiments of the present disclosure will be clearly and completely described below with reference to the drawings of the embodiments of the present disclosure. Apparently, the described embodiments are merely certain embodiments of the present disclosure, rather than all of the embodiments. All of the other embodiments that a person skilled in the art obtains on the basis of the embodiments of the present disclosure without paying creative work fall within the protection scope of the present disclosure.

[0029] Referring to Fig. 1, Fig. 1 shows a schematic structural diagram of medium separation within the container according to an embodiment of the present disclosure. It comprises a separating element 101, a detecting assembly 102, a medium carrying component 103 and an electric motor 104.

[0030] The detecting assembly 102 is used to determine the state of the contact between the medium and the separating element 101. In an example, the detecting assembly 102 may be an infrared sensor, wherein the infrared sensor emits an infrared ray to the surface of the medium, to determine the state of the contact between the medium and the separating element 101 according to the returning of the infrared ray.

[0031] The separating element 101 is used to bring the medium out of the container by using the friction with the medium and the compressional force of the medium carrying component 103.

[0032] The medium may be placed on the surface of the medium carrying component 103, and, by controlling by using the electric motor 104 the medium carrying component 103 to move toward the separating assembly, the medium and the separating element 101 can maintain a certain compressional force therebetween, which facilitates the separating element 101 to bring the medium out of the container by the friction.

[0033] It should be noted that, because the separating element 101 rotates about a center point, as shown in Figs. 2a and 2b, the separating element 101 and the medium 105 have two position relations therebetween, a contactable position relation (as shown in Fig. 2a) and an untouchable position relation (as shown in Fig. 2b). The contacting state between the separating element 101 and the medium 105 according to the present disclosure is generated when the separating element 101 and the medium 105 are in the contactable position relation.

[0034] In Fig. 1, with the medium separation, the compressional force of the separating element 101 to the medium is gradually released, and the state of the medium and the separating element 101 has a state process of being "tight-loose-not contacted". In practical applications, when the medium and the separating element 101 are in the stages of being loose and being not contacted, it is required to move the medium carrying component in the direction where the separating assembly is located, so that, during the medium separation, the separating element 101 and the medium maintain a moderate friction therebetween.

[0035] However, when the separating element 101 and the current medium are in the state of being loose, if the medium carrying component 103 is immediately moved, that will cause the change of the force, which affects the quality of the separation. However, if the medium carrying component 103 is not moved, in the next time of separation, that will be looser, which results in that the quality of the separation cannot be effectively ensured.

[0036] In view of the above problems, the core concept of the embodiments of the present disclosure is to control the movement of the medium carrying component according to the phase information of the separating element and the detection signal generated by the detecting assembly.

[0037] That will be explained in detail with reference to the following embodiments:

[0038] Referring to Fig. 3, Fig. 3 shows a flow chart of the steps of an embodiment of the method of controlling an electric motor based on FPGA according to an embodiment of the present disclosure. The system comprises a container main body, the medium carrying component disposed in the container main body, the detecting assembly, the electric motor and the separating assembly. The separating assembly is disposed between the medium carrying component and the detecting assembly. The separating element covers the surface of the separating assembly. The method may particularly comprise the following steps:

[0039] Step 301: when a medium separating instruction has been received, acquiring a phase information of a predetermined separating element.

[0040] The container according to the embodiments of the present disclosure is a container that can store a medium, including but not limited to a banknote chest for storing banknotes, a bill chest for storing bills, and so on.

[0041] The medium carrying component may be used to carry the medium, and may be controlled by the electric motor to move. The medium carrying component may be, for example, the lifting platform for carrying the medium in a banknote chest.

[0042] The electric motor is used to provide an external driving force.

[0043] The detecting assembly may be used to detect the position where the medium carrying component is located. In an example, the detecting assembly may be a sensor, for example an infrared sensor.

[0044] The medium according to the embodiments of the present disclosure varies with the container. For example, when the container is a banknote chest, the medium may be paper bank notes of a standard size, and, when the container is a bill chest, the medium may be bills of a certain specification.

[0045] In the embodiments of the present disclosure, during the medium separation, the separating element of the medium separating assembly contacts the medium on the medium carrying component along with the rotation of the separating element, and brings the medium out of the container by using the compressional force and the friction between the separating element and the medium, thereby realizing the medium separation. However, during the process in which the media are gradually separated, the quantity of the media on the medium carrying component is gradually reduced, and the compressional force and the friction between the separating element and the medium gradually decrease and finally disappear, which affects the effect of the medium separation. In addition, the media have different ages, different qualities and different smoothnesses, and even if the same quantities of the media have been separated, the spaces that are released are different. For example, an conventional system sets that each time 10 paper banknotes have been separated, the banknote holding plate is moved, to cause the upper surface of the uppermost paper banknote to be flush with the predetermined position. Even so, because of the above factors, such states that affect the quality of the medium separation still exist: tight-loose-not contacted. Therefore, it is required to in real time and quickly detect the state of the media and the medium carrying component, and, when the medium separation has proceeded to a certain extent, it is required to adjust in real time the position of the medium

carrying component, to enable the separating element and the medium to maintain compressional force and friction therebetween of a certain level.

[0046] Given that the process of the medium separation proceeds continuously, the movement of the medium carrying component must avoid affecting the effect of the medium separation. Moreover, because the medium separation is realized by using the compressional force and the friction between the separating element and the medium, in the embodiments of the present disclosure, the different contact relations between the separating element and the medium may be used to analyze whether the movement of the medium carrying component will influence the medium separation.

[0047] The phase information of the separating element may be obtained by providing the detecting unit to detect it. In an example, because the separating element covers the separating assembly, the diameter from the outer surface of the separating element to the center of the separating assembly is greater than that of the parts that do not have the separating element. Therefore, the detecting unit may be provided at a particular position that has the distance of one radius from the circle center of the separating assembly. Taking the vertical movement of the medium carrying component as the example, the detecting unit (for example, a sensor) may be provided at the position downward in the gravity direction of the separating assembly and having the distance of one radius from the separating assembly, to detect the phase information of the separating element and the medium by using the detecting element. In another example, a synchronizing assembly (fanning strip) that moves synchronously with the separating element may be provided, to feed back the movement state of the separating element. The phase information of the separating element is determined by disposing the detecting element at the corresponding position of the synchronizing assembly.

[0048] Therefore, in an embodiment of the present disclosure, when a predetermined medium separating instruction has been received, the phase information of the separating element may be acquired firstly. The medium separating instruction may be triggered by the user clicking an operation interface; for example, the user clicks a withdrawal operation on a teller machine, or the user performs issuing operation on a billing machine. That may also be triggered in other forms of interaction, which is not particularly limited in the present disclosure.

[0049] Step 302: detecting a predetermined medium carrying component by using a predetermined detecting assembly, to generate a detection signal.

[0050] In an embodiment of the present disclosure, the detecting assembly is provided inside the container, and provided at a position directly facing the medium, and the detecting assembly determines the state of the contact between the medium and the separating element by emitting a signal to the medium and receiving the returned signal.

[0051] In an example, the detecting assembly may be formed by a sensor. Taking an infrared sensor as the example, the infrared sensor may comprise an emitting end and a receiving end, wherein the emitting end may emit an infrared ray to the medium, and the receiving end determines the state of the contact between the medium and the separating element by receiving the infrared ray fed back by the medium.

[0052] Step 303: based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

[0053] In an embodiment of the present disclosure, after the phase information of the separating element and the detection signal of the detecting assembly have been acquired, the electric motor may be used to control the process of the movement of the medium carrying component toward the separating element, including controlling the medium carrying component to move toward the separating assembly and controlling the medium carrying component to stop moving toward the separating assembly.

[0054] It should be noted that the process of the movement of the medium carrying component toward the separating element may be a process of moving vertically in the gravity direction, and may also be a process of moving horizontally in the horizontal direction.

[0055] The embodiments of the present disclosure, by quickly, in real time and synchronously acquiring the phase information of the separating element and the detection signal of the detecting assembly, and judging whether the acquired phase information and detection signal satisfy the predetermined conditions, accurately control the timing of the movement of the medium carrying component, thereby accurately controlling the timing of the movement of the medium carrying component.

[0056] Referring to Fig. 4, Fig. 4 shows a flow chart of the steps of an embodiment of the method of controlling an electric motor based on FPGA according to an embodiment of the present disclosure, which may particularly comprise the following steps:

[0057] Step 401: when the medium separating instruction has been received, sending a collecting instruction to an information collecting component.

[0058] In an embodiment of the present disclosure, the information collecting component may be a fanning strip that is connected to the separating assembly via a gear, and may feed back the position information of the separating element.

[0059] After the banknote chest has received the medium separating instruction, it may send a collecting instruction to an information processing unit of the fanning strip, thereby acquiring the feedback information of the fanning strip.

[0060] Step 402: if a feedback information that is returned with respect to the collecting instruction has been received within a preset duration, acquiring a phase information of a predetermined separating element.

[0061] In an embodiment of the present disclosure, the

separating element is used to, by using its own movement and the contact friction with the medium, drive the medium to move. It may be made from rubber or another abrasion-resistant material that can provide a certain friction.

[0062] When a state information that is fed back by the fanning strip is received within a preset duration, that indicates that the fanning strip is operating normally and can normally feed back the related data of the separating element, and at this point a first phase information of the separating element may be acquired.

[0063] In an embodiment of the present disclosure, if the feedback information is not received within a preset duration, that indicates that the fanning strip is not operating normally, and an alarming signal is emitted.

[0064] In practical applications, if the feedback information of the information collecting component is not received within a preset duration, that indicates that the information collecting component is damaged, and at this point the alarming signal may be emitted to notice the user that the information collecting component is malfunctioning and should be repaired timely, to prevent its long-time failure during the medium separation. The state of the damage of the medium may particularly be expressed as a real-time pop-up window in the user interface to notice the user, or a signal lamp may be provided, to notice the user by using the flicker of the signal lamp. For example, a machine administrator at the background of a bank or a maintainer of a self-service machine for self-service selling air tickets or high-speed rail tickets can timely receive the breakdown signal, and timely inspect the banknote chest or the ticket chest. The mode of the signal notice is not particularly limited in the embodiments of the present disclosure.

[0065] Step 403: detecting a predetermined medium carrying component by using a predetermined detecting assembly, to generate a detection signal.

[0066] In an embodiment of the present disclosure, the detecting assembly is provided inside the container, and provided at a position directly facing the medium, and the detecting assembly determines the state of the contact between the medium and the separating element by emitting a signal to the medium and receiving the returned signal.

[0067] In an example, the detecting assembly may be formed by a sensor. Taking an infrared sensor as the example, the infrared sensor may comprise an emitting end and a receiving end, wherein the emitting end may emit an infrared ray to the medium, and the receiving end determines the state of the contact between the medium and the separating element by receiving the infrared ray fed back by the medium.

[0068] It should be noted that, in the actual working scenes, the medium separation is a very quick process, and the magnitudes of the signals that are required to be collected by the detecting unit for detecting the separating element and the detecting assembly for detecting the state of the medium are of the order of millisecond. In order to accurately collect the pulse signals, in an example of the present disclosure, the pulse signals may be collected by using FPGA (Field-Programmable Gate Array). The response speed of FPGA can easily reach the order of nanosecond, and the precision can reach the order of picosecond. In addition, FPGA can parallelly collect multiple signals; for example, it can parallelly collect at a high speed the phase information of the separating element and the position information of the medium carrying component. Therefore, it can accurately collect the pulse signals generated by the detecting assembly, whereby the contact relation between the separating element and the medium can be accurately determined.

[0069] Step 404: based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating assembly.

[0070] In an embodiment of the present disclosure, after the phase information of the separating element and the detection signal of the detecting assembly have been acquired, the electric motor may be used to control the process of the movement of the medium carrying component toward the separating element, including controlling the medium carrying component to move toward the separating assembly and controlling the medium carrying component to stop moving toward the separating assembly.

[0071] It should be noted that the process of the movement of the medium carrying component toward the separating element may be a process of moving vertically in the gravity direction, and may also be a process of moving horizontally in the horizontal direction.

[0072] In an embodiment of the present disclosure, the separating element may be formed by two parts, a leading separating element and a tailing separating element, wherein the leading separating element, in the process of the rotation following the separating assembly, contacts the medium earlier than the tailing separating element.

[0073] The detecting assembly comprises one or more detecting elements, which may simultaneously emit signals toward the medium to acquire the signals returned by the medium.

[0074] In the actual scenes, the separating element and the medium have three states of contact therebetween, including a tight state in which the compressional force is sufficient, a loose state in which the compressional force is not sufficient, and a not-contacted state in which a compressional force does not exist. During the process of the medium separation, if the medium carrying component does not move, the state of contact between the separating element and the medium will change from being tight to being loose and then to being not contacted. Moreover, at the moment of being loose, in order to ensure the effect of the medium separation, it is required to adjust the medium carrying component, whereby the state of contact between the separating element and the medium reaches the degree of being tight, to reach the suitable separation pressure and friction.

[0075] In an embodiment of the present disclosure, it may be judged by using the sub-signals detected by the at least one detecting element whether the separating element and the medium are in the state of being loose. In an example, taking two detecting elements as the example, when any one of the sub-signals is a no-blocking signal, it can be determined that the separating element and the medium are in the state of being loose. If it is detected that the separating element and the medium are in the state of being loose, by referring to the phase information of the separating element, it can be determined whether the medium carrying component is required to be moved.

[0076] In a scene, if the phase information satisfies that the separating assembly is in a first predetermined position and any one of the sub-signals is a blocking signal, the medium carrying component is controlled by using the electric motor to move.

[0077] The first predetermined position refers to such a position: when the separating element is in the position, the separating element blocks the signal of the detecting unit, thereby generating a blocking signal. When the separating element is in such a position, the separating element contacts the medium; in other words, when the separating element is in such a position, the separating element can bring the medium out of the container by using the compressional force and the friction with the medium.

[0078] When the separating assembly is in the first predetermined position, if at this point the separating element and the medium are in the state of being loose, the state of contact between the separating element and the medium can be adjusted to the state of being tight by properly moving the medium carrying component, thereby effectively realizing the medium separation.

[0079] In a scene, if the phase information satisfies that the leading separating element is in a first predetermined position and any one of the sub-signals is a no-blocking signal, the medium carrying component is controlled by using the electric motor to move.

[0080] When the leading separating element is in the first predetermined position, the separating element has just contacted the medium, and has not driven the medium to move. If at this point the separating element and the medium are in the state of being loose, the state of contact between the separating element and the medium can be adjusted to the state of being tight by properly moving the medium carrying component, thereby effectively realizing the medium separation.

[0081] In another scene, if the phase information satisfies that the tailing separating element is in a first predetermined position and any one of the sub-signals is a no-blocking signal, the medium carrying component is not moved, and a movement marking information is generated.

[0082] When the tailing separating element is in the first predetermined position, the separating element is driving the medium to move. If at this point the separating element and the medium are in the state of being loose, when the medium carrying component is being moved, the force between the separating element and the medium will change. Moreover, changing the borne force of the medium in the process of moving the medium largely prejudices the current movement action of the medium, which affects the medium separation. For example, the current medium that is being separated might, because of the increased friction, be dragged and thus be not able to be separated, or be obliquely separated. Therefore, in this case, the medium carrying component should not be immediately moved.

[0083] However, when the separating element and the medium are in the state of being loose, if the state of contact is not adjusted, in the next time of the operation of the medium separation, the contacting borne force between the separating element and the medium will become smaller, whereby the medium separation is affected, and the medium might not be able to be separated. Therefore, before the starting of the next time of separation, it is required to move the medium carrying component to adjust the state of contact between the separating element and the medium. Moreover, at the stage when the tailing separating element and the medium are contacting, a movement marking information may be generated, to mark that it is required to subsequently perform the corresponding processing based on the movement marking information.

[0084] Particularly, if the phase information satisfies that the separating element is in a second predetermined position, in response to the movement marking information, the medium carrying component is controlled by using the electric motor to move toward the separating element.

[0085] The second predetermined position refers to a position where the separating element does not block the signal generated by the detecting unit. When the separating element is in such a position, the separating element does not contact the medium, and at this point the separating assembly and the medium have a certain spatial difference therebetween, and the medium does not move. Therefore, at this point, moving the medium carrying component will not influence the effect of the medium separation. Therefore, when the separating element is in the second predetermined position, it may be inspected whether the movement marking information was generated previously, and if yes, in response to the movement marking information, the medium carrying component is controlled by using the electric motor to move toward the separating assembly.

[0086] In yet another scene, if the phase information satisfies that the separating element is in a second predetermined position and any one of the sub-signals is a no-blocking signal, the medium carrying component is controlled by using the electric motor to move.

[0087] In an embodiment of the present disclosure, the second predetermined position refers to a position where the separating element does not block the signal gener-

ated by the detecting unit. When the separating element is in such a position, the medium is in a not-moving state, and if at this point it is detected that any of the sub-signals is a blocking signal, that indicates that, when the separating element and the medium contact, the state of contact between the separating element and the medium is the state of being loose. At this point, the medium carrying component should be moved, whereby, in the next time of the operation of the medium separation, the medium and the separating element are in the state of being tight.

[0088] The embodiments of the present disclosure, by quickly, in real time and synchronously acquiring the phase information of the separating element and the detection signal of the detecting assembly, and judging whether the acquired phase information and detection signal satisfy the predetermined conditions, accurately control the timing of the movement of the medium carrying component, thereby accurately controlling the timing of the movement of the medium carrying component.

[0089] In order to enable a person skilled in the art to better understand the embodiments of the present disclosure, the embodiments of the present disclosure will be described below by using particular examples.

[0090] Referring to Fig. 5, Fig. 5 shows a flow chart of an embodiment of the method of controlling an electric motor based on FPGA according to an embodiment of the present disclosure.

[0091] After the preparation for the separation has been done, when a medium separating instruction has been received, firstly, it is required to send a collecting instruction to an information collecting component, and, if the feedback information is not received within a preset duration, that indicates that the information collecting component is damaged, and at this point the operation may be ended and an alarming signal may be emitted. If a feedback information has been received within the preset duration, the phase information of the separating element may be acquired.

[0092] If the phase information of the separating element is a blocking information, it is judged whether the current stage is within the duration T1 when the leading separating element contacts the medium or within the duration T2 when the tailing separating element contacts the medium.

[0093] If it is within the T1, at this point the separating element is about to drive the medium to move. It is judged that whether any one of top sensors is in a no-blocking state. If yes, the medium carrying component is immediately moved upwardly, which can enable the friction between the separating element and the medium to satisfy the requirement on the separation of the medium. If no, the process is returned to the step of judging whether the information collecting component is damaged. If the medium carrying component has been adjusted sufficiently in place, the adjusting of the medium carrying component is ended, and the step of judging whether the information collecting component is damaged is re-executed. If the medium carrying component has not been adjusted sufficiently in place, the medium carrying component is continuously moved upwardly till the medium carrying component has been adjusted sufficiently in place.

[0094] If it is within the T2, at this point the separating element is driving the medium to move, and the medium is in the moving state. It is judged that whether any one of top sensors is in a no-blocking state. If yes, the current state is marked (at this point the medium carrying component should not be moved immediately, to prevent abnormal separation of the medium during the movement due to the variation of the force), till the phase information of the separating element is a no-blocking information, and, in response to the marked state, the medium carrying component is moved upwardly. If no, the process is returned to the step of judging whether the information collecting component is damaged. If the medium carrying component has been adjusted sufficiently in place, the adjusting of the medium carrying component is ended, and the step of judging whether the information collecting component is damaged is re-executed. If the medium carrying component has not been adjusted sufficiently in place, the medium carrying component is continuously moved upwardly till the medium carrying component has been adjusted sufficiently in place.

[0095] If the phase information of the separating element is a no-blocking information, it is judged that whether any one of top sensors is in a no-blocking state. If yes, the medium carrying component is immediately moved upwardly. If no, the process is returned to the step of judging whether the information collecting component is damaged. If the medium carrying component has been adjusted sufficiently in place, the adjusting of the medium carrying component is ended, and the step of judging whether the information collecting component is damaged is re-executed. If the medium carrying component has not been adjusted sufficiently in place, the medium carrying component is continuously moved upwardly till the medium carrying component has been adjusted sufficiently in place.

[0096] It should be noted that, regarding the process embodiments, for brevity of the description, all of them are expressed as the combination of a series of actions, but a person skilled in the art should know that the embodiments of the present disclosure are not limited by the sequences of the actions that are described, because according to the embodiments of the present disclosure, some of the steps may have other sequences or be performed simultaneously. Secondly, a person skilled in the art should also know that all of the embodiments described in the description are preferable embodiments, and not all of the actions that they involve are required by the embodiments of the present disclosure.

[0097] Referring to Fig. 6, Fig. 6 shows a structural block diagram of an embodiment of the device of controlling an electric motor based on FPGA according to an embodiment of the present disclosure, which may particularly comprise the following modules:

a phase-information acquiring module 601 configured for, when a medium separating instruction has been received, acquiring a phase information of a predetermined separating element;

a detection-signal generating module 602 configured for detecting a predetermined medium carrying component by using a predetermined detecting assembly, to generate a detection signal; and

a movement controlling module 603 configured for, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating assembly.

[0098] In an embodiment of the present disclosure, the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the movement controlling module 603 comprises:

a first moving module configured for, if the phase information satisfies that the separating assembly is in a first predetermined position and any one of the sub-signals is a no-blocking signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

[0099] In an embodiment of the present disclosure, the separating element comprises a leading separating element; the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the movement controlling module 603 may comprise:

a second moving module configured for, if the phase information satisfies that the leading separating element is in a first predetermined position and any one of the sub-signals is a no-blocking signal, controlling, by using the electric motor, the medium carrying component to move.

[0100] In an embodiment of the present disclosure, the separating element comprises a tailing separating element; the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the movement controlling module 603 may comprise:

a not-moving module configured for, if the phase information satisfies that the tailing separating element is in a first predetermined position and any one of the sub-signals is a no-blocking signal, not moving the medium carrying component, and generating a movement marking information.

[0101] In an embodiment of the present disclosure, the movement controlling module 603 further comprises:

a third moving module configured for, if the phase information satisfies that the separating element is in a second predetermined position, in response to the movement marking information, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

[0102] In an embodiment of the present disclosure, the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the movement controlling module 603 may comprise:

a fourth moving module configured for, if the phase information satisfies that the separating element is in a second predetermined position and any one of the sub-signals is a no-blocking signal, controlling, by using the electric motor, the medium carrying component to move.

[0103] In an embodiment of the present disclosure, the phase-information acquiring module 601 may comprise:

a collecting-instruction sending module configured for, when the medium separating instruction has been received, sending a collecting instruction to an information collecting component; and

a phase-information acquiring module configured for, if a feedback information that is returned with respect to the collecting instruction has been received within a preset duration, acquiring a phase information of a predetermined separating element.

[0104] In an embodiment of the present disclosure, the phase-information acquiring module 501 may further comprise:

an alarming module configured for, if the feedback information is not received within a preset duration, emitting an alarming signal.

[0105] An embodiment of the present disclosure further discloses an electronic device, wherein the electronic device comprises a memory and a processor, the memory stores a computer program, and when the computer program is executed by the processor, the computer program causes the processor to implement the steps of the method of controlling an electric motor based on FPGA according to the embodiment of the present disclosure.

[0106] An embodiment of the present disclosure further discloses a computer program, wherein the computer program comprises a computer-readable code, and when the computer-readable code is executed on a calculating and processing device, the computer-readable code causes the calculating and processing device to implement the method of controlling an electric motor based on FPGA according to any one of the embodiments of the present disclosure.

[0107] An embodiment of the present disclosure further discloses a computer-readable storage medium, wherein the computer-readable medium stores the computer program according to the embodiment of the present disclosure. The computer-readable storage medium includes any mechanism for storing or transmitting information in a form readable by a computer (for example, a computer). For example, the computer-readable storage medium includes a read-only memory (ROM), a random access memory (RAM), a magnetic-disk storage medium, an optical storage medium, a flash storage me-

dium, a propagation signal in an electric, optical, acoustic or other form (for example, a carrier wave, an infrared signal and a digital signal) and so on.

[0108] The above-described device embodiments are merely illustrative, wherein the units that are described as separate components may or may not be physically separate, and the components that are displayed as units may or may not be physical units; in other words, they may be located at the same one location, and may also be distributed to a plurality of network units. Part or all of the modules may be selected according to the actual demands to realize the purposes of the solutions of the embodiments. A person skilled in the art can understand and implement the technical solutions without paying creative work.

[0109] Each component embodiment of the present disclosure may be implemented by hardware, or by software modules that are operated on one or more processors, or by a combination thereof. A person skilled in the art should understand that some or all of the functions of some or all of the components of the calculating and processing device according to the embodiments of the present disclosure may be implemented by using a microprocessor or a digital signal processor (DSP) in practice. The present disclosure may also be implemented as apparatus or device programs (for example, computer programs and computer program products) for implementing part of or the whole of the method described herein. Such programs for implementing the present disclosure may be stored in a computer-readable medium, or may be in the form of one or more signals. Such signals may be downloaded from an Internet website, or provided on a carrier signal, or provided in any other forms.

[0110] For example, Fig. 7 shows a calculating and processing device that can implement the method according to the present disclosure. The calculating and processing device traditionally comprises a processor 710 and a computer program product or computer-readable medium in the form of a memory 720. The memory 720 may be electronic memories such as flash memory, EEPROM (Electrically Erasable Programmable Read Only Memory), EPROM, hard disk or ROM. The memory 720 has the storage space 730 of the program code 731 for implementing any steps of the above method. For example, the storage space 730 for program code may contain program codes 731 for individually implementing each of the steps of the above method. Those program codes may be read from one or more computer program products or be written into the one or more computer program products. Those computer program products include program code carriers such as hard disk, compact disk (CD), memory card or floppy disk as shown in Fig. 8. Such computer program products are usually portable or fixed storage units. The storage unit may have storage segments or storage spaces with similar arrangement to the memory 720 of the calculating and processing device in Figure 7. The program codes may for example be compressed in a suitable form. Generally, the storage unit contains a computer-readable code 731', which can be read by a processor like 710. When those codes are executed by the calculating and processing device, the codes cause the calculating and processing device to implement each of the steps of the method described above.

[0111] The "one embodiment", "an embodiment" or "one or more embodiments" as used herein means that particular features, structures or characteristics described with reference to an embodiment are included in at least one embodiment of the present disclosure. Moreover, it should be noted that here an example using the wording "in an embodiment" does not necessarily refer to the same one embodiment.

[0112] The description provided herein describes many concrete details. However, it can be understood that the embodiments of the present disclosure may be implemented without those concrete details. In some of the embodiments, well-known processes, structures and techniques are not described in detail, so as not to affect the understanding of the description.

[0113] In the claims, any reference signs between parentheses should not be construed as limiting the claims. The word "comprise" does not exclude elements or steps that are not listed in the claims. The word "a" or "an" preceding an element does not exclude the existing of a plurality of such elements. The present disclosure may be implemented by means of hardware comprising several different elements and by means of a properly programmed computer. In unit claims that list several devices, some of those devices may be embodied by the same item of hardware. The words first, second, third and so on do not denote any order. Those words may be interpreted as names.

[0114] Finally, it should be noted that the above embodiments are merely intended to explain the technical solutions of the present disclosure, and not to limit them. Although the present disclosure is explained in detail by referring to the above embodiments, a person skilled in the art should understand that he can still modify the technical solutions set forth by the above embodiments, or make equivalent substitutions to part of the technical features of them. However, those modifications or substitutions do not make the essence of the corresponding technical solutions depart from the spirit and scope of the technical solutions of the embodiments of the present disclosure.

Claims

1. A method of controlling an electric motor based on FPGA, wherein the method comprises:

   when a medium separating instruction has been received, acquiring a phase information of a predetermined separating element;
   detecting a predetermined medium carrying

component by using a predetermined detecting assembly, to generate a detection signal; and
based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

2. The method according to claim 1, wherein the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the step of, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element comprises:
if the phase information satisfies that the separating assembly is in a first predetermined position and any one of the sub-signals is a no-blocking signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

3. The method according to claim 1, wherein the separating element comprises a leading separating element; the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the step of, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element comprises:
if the phase information satisfies that the leading separating element is in a first predetermined position and any one of the sub-signals is a no-blocking signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element.

4. The method according to claim 3, wherein the separating element further comprises a tailing separating element; and the step of, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element further comprises:
if the phase information satisfies that the tailing separating element is in a first predetermined position and any one of the sub-signals is a no-blocking signal, not moving the medium carrying component, and generating a movement marking information.

5. The method according to claim 4, wherein the method further comprises:
if the phase information satisfies that the separating element is in a second predetermined position, in response to the movement marking information, controlling, by using the electric motor, the medium carrying component to move toward the separating assembly.

6. The method according to claim 1, wherein the detecting assembly comprises one or more detecting elements; the detection signal comprises sub-signals that are generated by each of the detecting elements; and the step of, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating element comprises:
if the phase information satisfies that the separating element is in a second predetermined position and any one of the sub-signals is a no-blocking signal, controlling, by using the electric motor, the medium carrying component to move.

7. The method according to claim 1, wherein the step of, when the medium separating instruction has been received, acquiring the phase information of the predetermined separating element comprises:

when the medium separating instruction has been received, sending a collecting instruction to a predetermined information collecting component; and
if a feedback information that is returned with respect to the collecting instruction has been received within a preset duration, acquiring a phase information of a predetermined separating element.

8. The method according to claim 7, wherein the method further comprises:
if the feedback information is not received within a preset duration, emitting an alarming signal.

9. A device of controlling an electric motor based on FPGA, wherein the device comprises:

a phase-information acquiring module configured for, when a medium separating instruction has been received, acquiring a phase information of a predetermined separating element;
a detection-signal generating module configured for detecting a predetermined medium carrying component by using a predetermined detecting assembly, to generate a detection signal; and
a movement controlling module configured for, based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating assembly.

10. An electronic device, wherein the electronic device comprises a memory and a processor, the memory stores a computer program, and when the computer

program is executed by the processor, the computer program causes the processor to implement the steps of the method of controlling an electric motor based on FPGA according to any one of claims 1 to 8.

11. A computer program, wherein the computer program comprises a computer-readable code, and when the computer-readable code is executed on a calculating and processing device, the computer-readable code causes the calculating and processing device to implement the method of controlling an electric motor based on FPGA according to any one of claims 1 to 8.

12. A computer-readable medium, wherein the computer-readable medium stores the computer program according to claim 10.

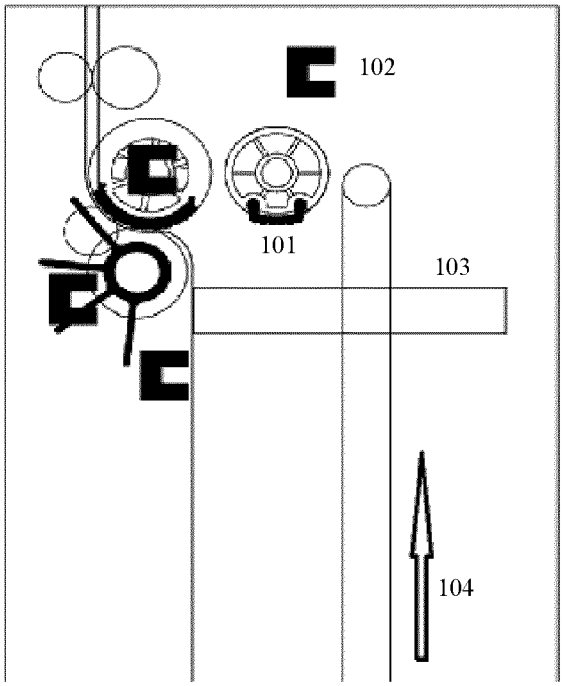

Fig. 1

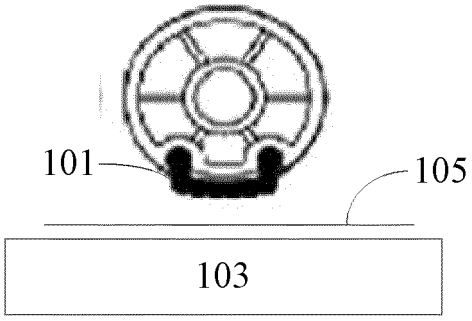

Fig. 2a

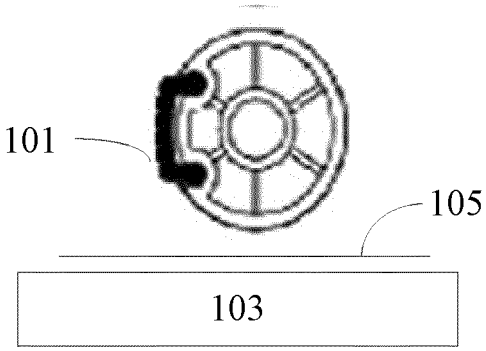

Fig. 2b

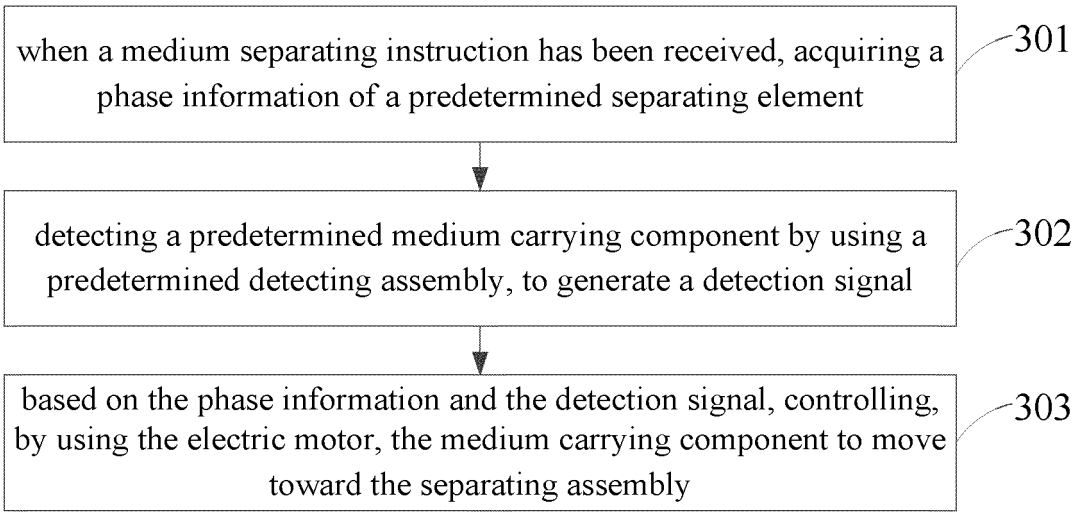
when a medium separating instruction has been received, acquiring a phase information of a predetermined separating element
301
detecting a predetermined medium carrying component by using a predetermined detecting assembly, to generate a detection signal
302
based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating assembly
303

Fig. 3

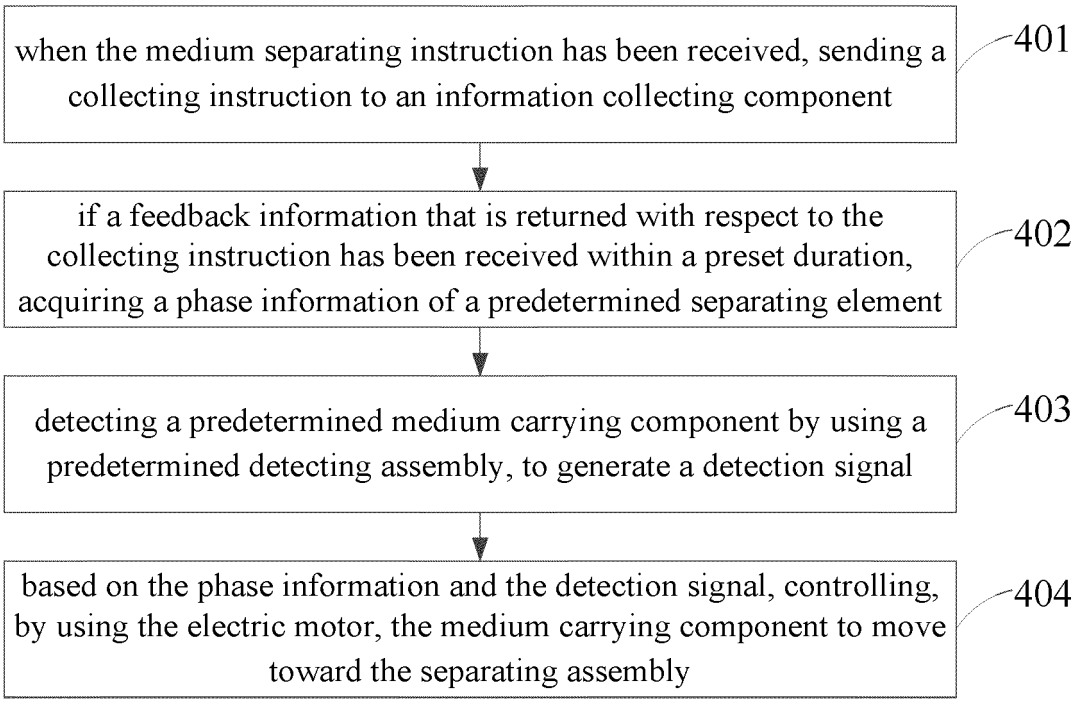
when the medium separating instruction has been received, sending a collecting instruction to an information collecting component
401
if a feedback information that is returned with respect to the collecting instruction has been received within a preset duration, acquiring a phase information of a predetermined separating element
402
detecting a predetermined medium carrying component by using a predetermined detecting assembly, to generate a detection signal
403
based on the phase information and the detection signal, controlling, by using the electric motor, the medium carrying component to move toward the separating assembly
404

Fig. 4

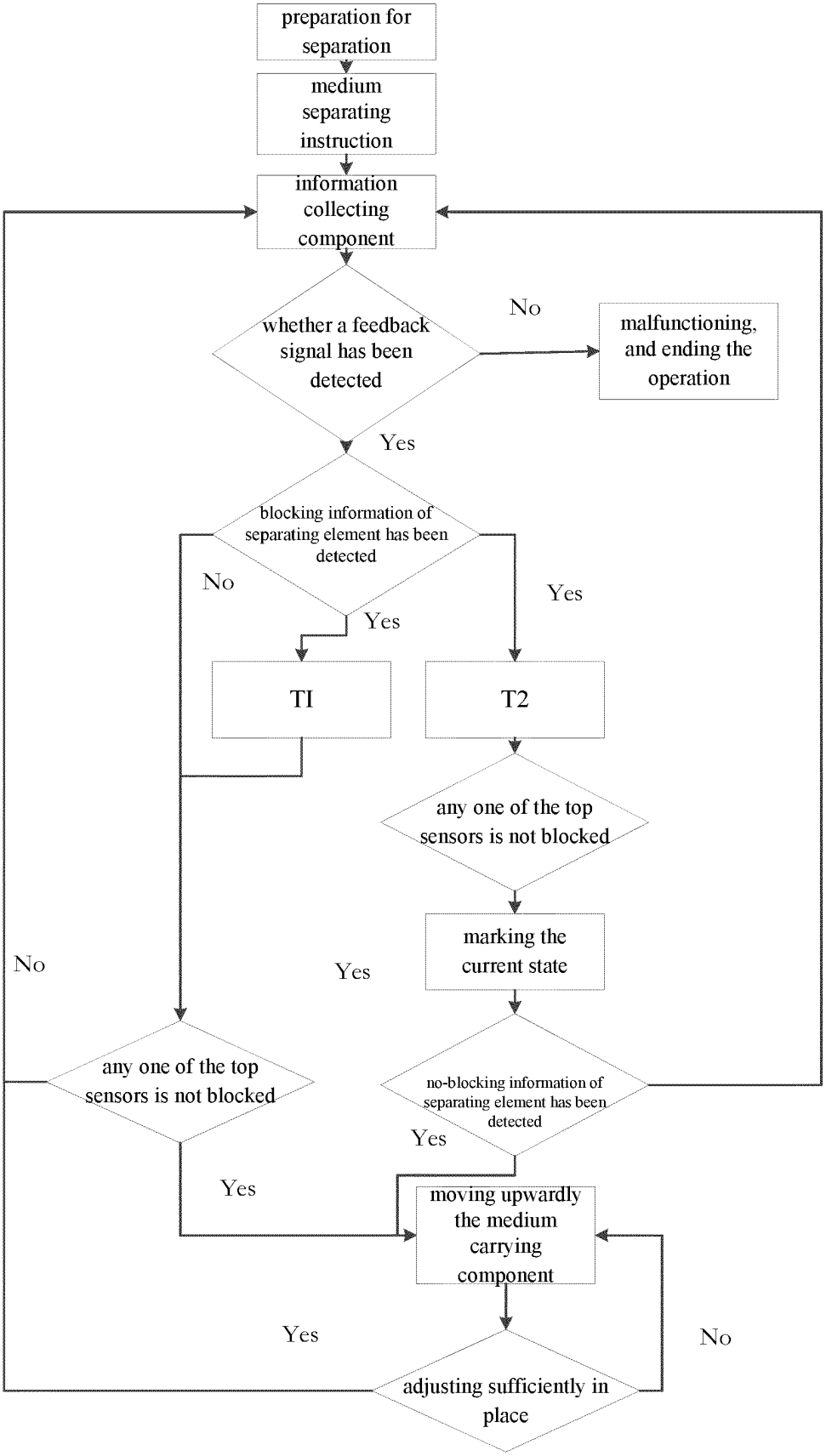
preparation for separation
medium separating instruction
information collecting component
whether a feedback signal has been detected
No
malfunctioning, and ending the operation
Yes
blocking information of separating element has been detected
No
Yes
Yes
TI
T2
any one of the top sensors is not blocked
marking the current state
No
Yes
any one of the top sensors is not blocked
no-blocking information of separating element has been detected
Yes
Yes
moving upwardly the medium carrying component
Yes
No
adjusting sufficiently in place

Fig. 5

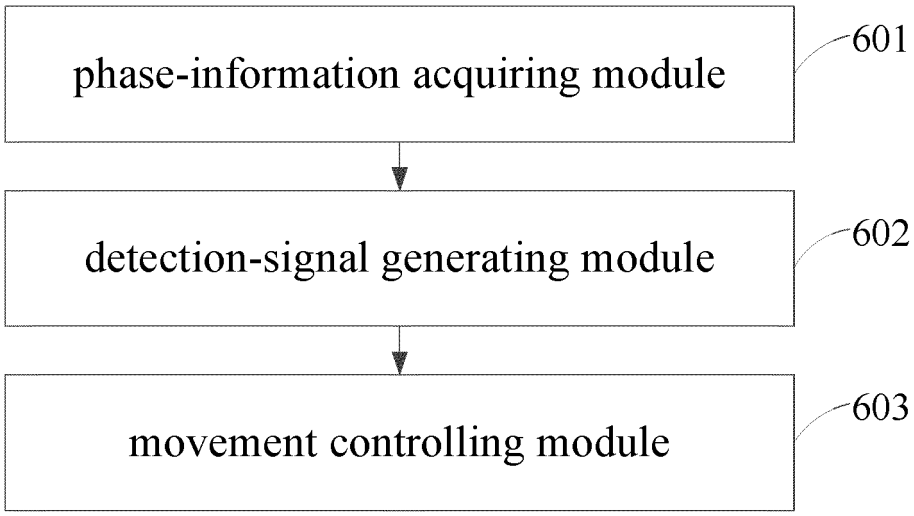
phase-information acquiring module
601
detection-signal generating module
602
movement controlling module
603

Fig. 6

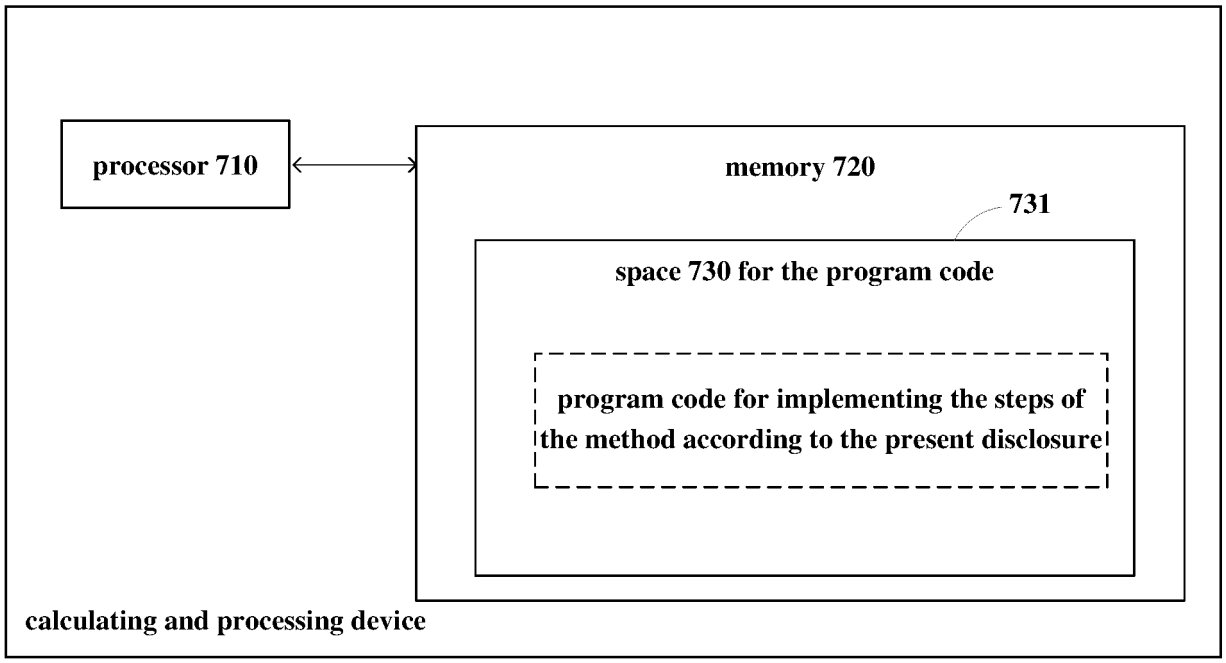
processor 710
memory 720
731
space 730 for the program code
program code for implementing the steps of the method according to the present disclosure
calculating and processing device

Fig. 7

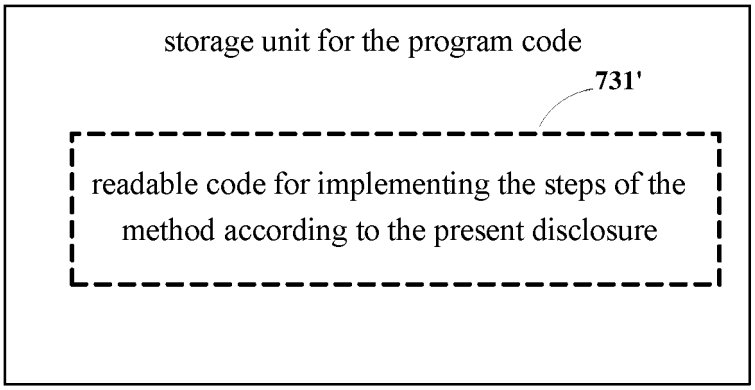
storage unit for the program code
731'
readable code for implementing the steps of the method according to the present disclosure

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/087675

A. CLASSIFICATION OF SUBJECT MATTER

G07D 11/00(2019.01)i; G07D 11/18(2019.01)i; B65H 3/06(2006.01)i

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)

G07D B65H

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 practicable, search terms used)

CNTXT; CNABS; CNKI; SIPOABS; DWPI; USTXT; WOTXT; EPTXT: 怡化, 分离, 介质, 纸钞, 钞票, 发票, 票据, 橡胶, 摩擦, 接触, 凸起, 突起, 突出, 凸出, 承载, 装载, 板, 位置, 相位, 检测, 传感, 监测, separat+, medium, money, invoice, bill, latex, rubber, prominency, tuber, position, phase, detect+, sens+, sampl+, monitor+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 105654612 A (NDT SCIENCE & TECHNOLOGY CO., LTD.) 08 June 2016 (2016-06-08) description, paragraphs [0016]-[0026], and figures 1-10	1-12
A	CN 107369246 A (SHENZHEN YIHUA COMPUTER CO., LTD. et al.) 21 November 2017 (2017-11-21) entire document	1-12
A	CN 110246264 A (SHANGHAI GUAO ELECTRONIC TECHNOLOGY CO., LTD.) 17 September 2019 (2019-09-17) entire document	1-12
A	CN 208126489 U (SHANDONG NEW BEIYANG INFORMATION TECHNOLOGY CO., LTD.) 20 November 2018 (2018-11-20) entire document	1-12
A	JP 2006024033 A (TOSHIBA CORP.) 26 January 2006 (2006-01-26) entire document	1-12

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 December 2020	**18 January 2021**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China**	Authorized officer
Facsimile No. **(86-10)62019451**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/087675

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	105654612	A	08 June 2016	CN	105654612	B	17 August 2018
CN	107369246	A	21 November 2017	CN	107369246	B	20 September 2019
CN	110246264	A	17 September 2019	CN	209993030	U	24 January 2020
CN	208126489	U	20 November 2018		None		
JP	2006024033	A	26 January 2006		None		

Form PCT/ISA/210 (patent family annex) (January 2015)