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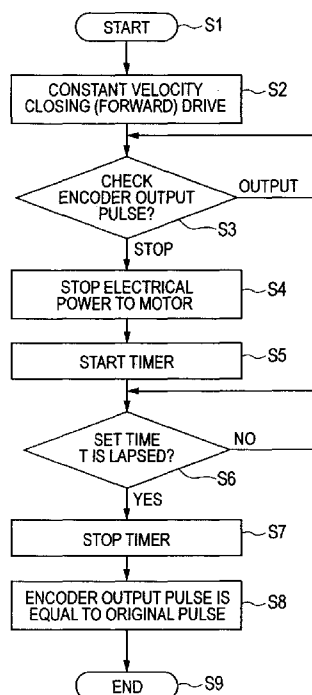
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(54) Title: GRIPPING DEVICE

[Fig. 4]



(57) Abstract: A gripping device capable of detecting an origin with high precision regardless of the elastic deformation of a gripper generated by closing impact is provided. When a pinion 6 which is attached to a drive shaft 2a of an electric motor 2 is rotationally driven, a pair of racks 7 and 7 which mesh with the pinion 6 linearly moves and the pair of grippers 5 and 5 is driven so as to be opened and closed. An encoder 3 is connected to the electric motor 2, and a pulse with the rotation of the drive shaft 2a is output from the encoder 3. A driving control circuit 102 rotationally drives the electric motor 2 so that the pair of grippers 5 and 5 is closed, and the supply of a current to the electric motor 2 is stopped by detecting whether the pair of grippers 5 and 5 come into contact with each other so that the rotation of the electric motor 2 stops based on the pulse output from the encoder 3. Then, the driving control circuit 102 detects the pulse which is output from the encoder 3 as the origin pulse after a predetermined time elapses.



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Description

Title of Invention: GRIPPING DEVICE

Technical Field

[0001] The present invention relates to a gripping device that rotationally drives an electric motor in response to a command (a control signal) from a controller so as to grip and release a gripping subject (hereinafter, referred to as a "work").

Background Art

[0002] Hitherto, in machinery such as an industrial robot or a machine tool, a pair of grippers of a hand that grips a work are operated by an electric motor. In order to control the pair of grippers at a desired opening and closing position, the drive shaft of the electric motor is equipped with an encoder which generates a rotation pulse every predetermined rotation angle of the electric motor. Then, the number of rotation pulses is set from an origin corresponding to the desired opening and closing position, the rotation pulses from the encoder are counted from the origin, and then the electric motor is stopped at a position where the number of counted pulses is equal to the predetermined target number of pulses. In this method, since it is possible to make the resolution of the encoder high, the position may be controlled with high precision.

[0003] On the other hand, in order to count the number of rotation pulses based on the origin which is the reference position of the gripper, the positional control precision depends on the origin detecting precision. Origin detecting types may be largely classified into a sensor type and a mechanical contact type, and the mechanical contact type without a sensor is advantageous from the viewpoint of cost and space efficiency.

[0004] As this mechanical contact type, hitherto, there is a known configuration in which the position of an origin is determined by detecting an increasing current that flows to an electric motor when a shaft of an arm attempts to further move at a mechanical end (see PTL 1). Although the invention of PTL 1 is not contrived for a gripping device that includes a pair of grippers, it is considered that the invention may also be applied to the gripping device. Specifically, a configuration may be considered in which the pair of grippers are moved by the electric motor so as to come into contact with each other and the stop position is detected as the origin.

Citation List

Patent Literature

[0005] PTL 1: Japanese Patent Application Laid-Open No. S62-239204

Summary of Invention

Technical Problem

[0006] Incidentally, in the contact type in which the pair of grippers are moved by the

electric motor so as to come into contact with each other and the stop position is detected as the origin, the pair of grippers needs to be reliably brought into contact with each other so that the pair of grippers do not stop before the contact therebetween. For this action, the speed of the pair of grippers needs to be maintained to a certain extent at the contact position, and the driving force remains in the pair of grippers even after the contact therebetween. Furthermore, when the driving force does not remain in the pair of grippers, the contact between the grippers becomes unstable when vibration or impact is applied thereto.

[0007] However, when the driving force remains in the pair of grippers, each gripper is elastically deformed. Accordingly, the electric motor performs unnecessary rotation as much as each gripper is elastically deformed. At the time when the position is detected by the encoder which is connected to the electric motor, unnecessary rotation is caused by the above-described rotation, and a position deviating from the position of the origin by a number of generated pulses is detected as the origin. Even when the pair of grippers are moved to a predetermined opening and closing position by generating a driving pulse up to the target number of pulses from the deviated position, the pair of grippers stop at a position deviating from the predetermined opening and closing position, and hence the positional control precision degrades.

[0008] With respect to this problem, a method may be considered in which the contact position of the front end of the gripper and the balance position between the driving force and the force caused by the elastic deformation are measured in advance and the deviation data is sampled for correction. However, as this measurement method, various methods may be considered, such as using an optical microscope. However, it is not easy to accurately determine the contact position of the front end of the gripper, the precision of the correction data is reduced, and then the highly-precise correction cannot be performed. Further, for accurate determination, the mechanical components of the gripper or the rotor body need to be processed with high precision, which causes an increase in cost.

[0009] Therefore, it is an object of the invention to provide a gripping device capable of detecting an origin with high precision regardless of the elastic deformation of the pair of grippers.

Solution to Problem

[0010] A gripping device of the invention includes: an electric motor that includes a rotating drive shaft; a rotary-linear motion converting mechanism that converts a rotary motion of the drive shaft into a linear motion; a pair of grippers that is opened and closed by the rotary-linear motion converting mechanism; an encoder that generates a pulse with a rotation position of the drive shaft; closing operation command means for

commanding the pair of grippers to be closed; current supply stopping means for stopping a supply of a current to the electric motor when the closing operation of the pair of grippers using the closing operation command means stops; and origin pulse detecting means for detecting an origin pulse which corresponds to a pulse generated in the encoder at a time point at which the time necessary for stopping the operation of the pair of grippers after stopping the supply of the current to the electric motor using the current supply stopping means elapses.

Advantageous Effects of Invention

- [0011] According to the invention, since the supply of the current to the electric motor is stopped when the pair of grippers come into contact with each other, the driving force which is generated by the electric motor and applied to the pair of grippers is removed, and the elastic deformation of the pair of grippers is solved. Accordingly, since the origin pulse may be detected in a state where the elastic deformation of the pair of grippers is solved, the origin pulse detecting precision is improved.
- [0012] Preferred embodiments of the present invention will now be described in detail in accordance with the accompanying drawings.

Brief Description of Drawings

- [0013] [fig.1]Fig. 1 is a perspective view illustrating a schematic configuration of a gripping device according to a first embodiment of the invention.
- [fig.2A]Fig. 2A and 2B are diagrams illustrating an encoder, where Fig. 2A is a schematic diagram illustrating the structure of the encoder.
- [fig.2B]Figs. 2A and 2B are diagrams illustrating an encoder, where Fig. 2B is a diagram illustrating an output signal of the encoder.
- [fig.3A]Figs. 3A and 3B are diagrams illustrating a driving control circuit, where Fig. 3A is a configuration diagram illustrating the driving control circuit.
- [fig.3B]Figs. 3A and 3B are diagrams illustrating a driving control circuit, where Fig. 3B is a functional block diagram illustrating the driving control circuit.
- [fig.4]Fig. 4 is a flowchart illustrating a control operation of a controller when an origin pulse is detected.
- [fig.5A]Fig. 5A is schematic diagram illustrating a gripper state of each step of Fig. 4.
- [fig.5B]Fig. 5B is schematic diagram illustrating a gripper state of each step of Fig. 4.
- [fig.5C]Fig. 5C is schematic diagram illustrating a gripper state of each step of Fig. 4.
- [fig.6A]Fig. 6A is schematic diagram illustrating a gripper state of each step of Fig. 4.
- [fig.6B]Fig. 6B is schematic diagram illustrating a gripper state of each step of Fig. 4.
- [fig.6C]Fig. 6C is schematic diagram illustrating a gripper state of each step of Fig. 4.
- [fig.7]Fig. 7 is a functional block diagram illustrating a controller of a gripping device according to a second embodiment of the invention.

[fig.8]Fig. 8 is a flowchart illustrating a control operation of the controller when an origin pulse is detected.

Description of Embodiments

[0014] Hereinafter, embodiments of the invention will be described in detail by referring to the drawings.

First embodiment

[0015] Fig. 1 is a perspective view illustrating a schematic configuration of a gripping device according to a first embodiment of the invention. A gripping device 100 shown in Fig. 1 includes a hand 101 and a driving control circuit 102.

[0016] First, the configuration of the hand 101 will be described. The hand 101 includes a planar base 1, a stator (not shown), and a rotor (not shown), and further includes an electric motor 2 which is fixed to one surface of the base 1 and an encoder 3 which is connected to the electric motor 2. Further, the hand 101 includes a rotary-linear motion converting mechanism 4 which is disposed on the other surface of the base 1 and converts a rotary motion of a drive shaft 2a of the electric motor 2 into a linear motion and a pair of grippers 5 and 5 which are opened and closed by the rotary-linear motion converting mechanism 4 so as to grip a work W corresponding to a gripping subject.

[0017] The electric motor 2 is, for example, an AC servo motor. The drive shaft 2a which is a part of the rotor of the electric motor 2 protrudes toward the other surface side of the base 1 through the base 1. When a current is supplied to a coil (not shown) of the electric motor 2, the rotor (the drive shaft 2a) may be rotated. The rotor of the electric motor 2 is configured to be rotatable in the forward rotation direction and the reverse rotation direction, and the rotation direction of the rotor may be changed by changing a current supply pattern in which a current is supplied to the coil of the electric motor 2. The encoder 3 is a rotary encoder which generates and outputs a pulse synchronized with the rotation direction and the rotation angle of the rotor (the drive shaft 2a) of the electric motor 2. The rotary-linear motion converting mechanism 4 is configured as a rack-and-pinion mechanism, and includes a pinion 6 which is provided in the drive shaft 2a of the electric motor 2 and a pair of racks 7 and 7 which meshes with the pinion 6 with the pinion 6 interposed therebetween and converts the rotary motion of the pinion 6 into the linear motion.

[0018] Further, the hand 101 includes a pair of rear guide rails 8 and 8 which are fixed to the other surface of the base 1 so as to be parallel to each other. Further, the hand 101 includes a pair of linear guides 9 and 9 each of which includes a guide groove 9a fitted to the rear guide rail 8 and is fixed to each rack 7 so as to be movably supported by the rear guide rail 8.

[0019] Each gripper 5 includes base end portions 5a which are fixed to the rack 7, linear

portions 5b which extend from the base end portion 5a so as to be parallel to each other and are elastically deformable (in a bending manner), and gripping portions 5c which protrude from the front ends of the linear portions 5b so as to face each other and come into contact with the work W.

[0020] With the above-described configuration, when the pinion 6 rotates forward and reversely with the rotational driving of the electric motor 2, the pair of racks 7 and 7 is linearly driven in the opposite directions along the pair of rear guide rails 8 and 8, and the grippers 5 and 5 are opened and closed.

[0021] Next, the encoder 3 will be in detail described by referring to Figs. 2A and 2B. Fig. 2A illustrates the structure of the encoder 3, and the encoder 3 includes a disk 13 which is fixed to the rotary shaft 2a of the electric motor 2 and an LED 14 and two photo diodes (PDs) 15 and 16 which are disposed so as to face each other with the disk 13 interposed therebetween.

[0022] The disk 13 is provided with plural slits 13a and 13b which are formed so as to be concentric with the rotary shaft 2a of the electric motor 2. The slits 13a and 13b are formed so as to be deviated from each other by the slit width of $1/2$. The LED 14 illuminates both the slits 13a and 13b, and the PDs 15 and 16 are arranged so as to respectively face the slits 13a and 13b. Accordingly, the light flux which passes through the slits 13a is received by the PD 15 and the light flux which passes through the slits 13b is received by the PD 16.

[0023] Fig. 2B illustrates the pulse output which is obtained by binarizing the signals from PDs 15 and 16. Since the pulse output corresponds to the rotation angle of the rotor of the electric motor 2, the rotation position of the rotor of the electric motor 2 may be detected. Further, since the slits 13a and 13b are formed so as to be offset from each other by the slit width of $1/2$, the respective pulse outputs are deviated from each other by a phase of $1/4$. Accordingly, the forward rotation and the reverse rotation of the rotor of the electric motor 2 may be detected from the rising and falling timings of the pulse.

[0024] Fig. 3A illustrates the driving control circuit 102 of the electric motor 2 which includes a controller 11 and a driving circuit 12 serving as a driving section. The controller 11 includes a microcomputer with a CPU 11a, a ROM 11b, a RAM 11c, an input section 11d, and an output section 11e and a peripheral device (not shown), and outputs a control signal representing a current command to the driving circuit 12. When the control signal is output from the output section 11e of the controller 11 to the driving circuit 12, the driving circuit 12 supplies a current according to the control signal to the electric motor 2. Accordingly, the controller 11 performs the position control (the forward rotation and the reverse driving) of the electric motor 2 and the torque control thereof. The operation of the electric motor 2 is detected as the pulse

output of the encoder 3, and is fed-back to the controller 11.

- [0025] The ROM 11b of the controller 11 stores a control program in advance, and the control program is operated in the CPU 11a. When the CPU 11a reads the control program from the ROM 11b and performs the control program, the CPU serves as the respective sections to be described later. Furthermore, the ROM 11b is a rewritable non-volatile memory, and various setting values may be changed therefrom.
- [0026] Fig. 3B is a functional block diagram illustrating the driving control circuit 102 with the controller 11. The controller 11 includes a first counting section 21 which serves as counting means, a target pulse number setting section 22 which serves as target number pulse setting means, and a first command section 23 which serves as command means.
- [0027] The first counting section 21 counts the number of pulses generated in the encoder 3 up or down. When the drive shaft 2a rotates forward, the number of pulses is counted up. Then, when the drive shaft 2a rotates reversely, the number of pulses is counted down. The first counting section 21 counts the number of pulses based on the origin pulse which is generated in the encoder 3 when the pair of grippers 5 and 5 are closed (the gripping portions 5c of the pair of grippers 5 and 5 come into contact with each other). Here, in the first embodiment, the forward rotation is set to a case where the rotary shaft 2a rotates in a direction in which the pair of grippers 5 and 5 are closed, and the reverse rotation is set to a case where the rotary shaft 2a rotates in a direction in which the pair of grippers 5 and 5 are opened. That is, when the rotary shaft 2a rotates so that the pair of grippers 5 and 5 are closed, the number of pulses is counted up. Then, when the rotary shaft 2a rotates so that the pair of grippers 5 and 5 are opened, the number of pulses is counted down.
- [0028] The target pulse number setting section 22 sets the target number of pulses so that the pair of grippers 5 and 5 move to the target opening and closing position. Here, the meaning of setting the target number of pulses indicates that the data signal representing the target number of pulses is input from the input section 11d and is stored in a storage section such as a ROM 11b (or a RAM 11c) so as to be read out as the target number of pulses by the CPU 11a.
- [0029] The first command section 23 outputs a control signal that commands the supply of the current with respect to the electric motor 2 to the driving circuit 12 so that the number of pulses counted by the first counting section 21 becomes the predetermined target number of pulses. The control signal is output from the output section 11e of the controller 11.
- [0030] Incidentally, the CPU 11a of the controller 11 needs to recognize which pulse is the origin pulse among the pulses output from the encoder 3. In the first embodiment, the controller 11 performs an operation in which the origin pulse is detected in advance

before the operation of the first command section 23 based on the target number of pulses. Specifically the controller 11 includes: a second counting section 24; a second command section 25 which serves as closing operation command means and current supply stopping means; a time setting section 26 which serves as time setting means; a timer section 27 which serves as timer means; and an origin pulse detecting section 28 which serves as origin pulse detecting means.

- [0031] Fig. 4 is a flowchart illustrating the control operation of the controller 11 when the origin pulse is detected, and Figs. 5A to 5C and Figs. 6A to 6C are schematic diagrams illustrating the state of the grippers 5 and 5 of each step in Fig. 4. Hereinafter, the control operation of the respective sections 24 to 28 will be described in detail by referring to Figs. 3A to 6C.
- [0032] First, the controller 11 starts the origin detecting routine (S1). At this time, the pair of grippers 5 and 5 are present at an opening and closing position where the grippers are distant from each other by a predetermined distance as shown in Fig. 5A. Next, the second command section 25 outputs a control signal of commanding the supply of the current with respect to the electric motor 2 to the driving circuit 12 so that the pair of opened grippers 5 and 5 are closed at a constant speed (S2: closing operation command means).
- [0033] Accordingly, the pair of grippers 5 and 5 are closed as shown in Fig. 5B, and the gripping portions 5c of the front ends of the grippers 5 and 5 come into contact with each other as shown in Fig. 5C. When the closing operation of the pair of grippers 5 and 5 is continued in this contact state, the pair of grippers 5 and 5 are elastically deformed (in a bending manner). In the embodiment, the linear portion 5b of the gripper 5 is mainly elastically deformed. Then, as shown in Fig. 6A, the closing operation of the pair of grippers 5 and 5 stop at a point where the elastic deforming force of the pair of grippers 5 and 5 and the driving force of the electric motor 2 are balanced.
- [0034] In the meantime, the second counting section 24 counts the number of pulses generated in the encoder 3, and the second command section 25 monitors the count of the second counting section 24 by checking the output of the encoder shown in Fig. 4 (S3). Then, when the closing operation of the pair of grippers 5 and 5 stop so that the output of the encoder 3 stops and the counting operation using the second counting section 24 stops, the second command section 25 stops the supply of the current with respect to the electric motor 2 (S4: current supply stopping means). That is, the second command section 25 outputs a control signal which represents the stop of the supply of the current with respect to the electric motor 2 to the driving circuit 12. With the stop of the supply of the current, the driving force which is generated by the electric motor 2 and is applied to the pair of grippers 5 and 5 is removed. Accordingly, the pair of

grippers 5 and 5 which is elastically deformed moves toward the opening direction by the elastic deforming force as shown in Fig. 6B.

[0035] At this time, the second command section 25 stops the supply of the current with respect to the electric motor 2 and starts the timekeeping in the timer section 27. Accordingly, the timer section 27 starts the timekeeping from a time point at which the supply of the current to the electric motor 2 is stopped by the second command section 25 (S5: timer means).

[0036] Here, the time setting section 26 sets a setting time T at which the timekeeping is performed in the timer section 27 in advance. The meaning of setting the setting time T indicates that the data signal representing the setting time T is input from an external device (not shown) through the input section 11d and is stored in a memory section such as a ROM 11b (or a RAM 11c) so as to be read out as the information of the setting time T when the CPU 11a performs the timekeeping. That is, the timer section 27 performs the timekeeping as much as the setting time T which is set from the time point at which the electric motor 2 is stopped. Furthermore, the setting time T is a time which is necessary for removing the elastic deformation of the pair of grippers 5 and 5, and is a time which is obtained in advance by an experiment.

[0037] The timer section 27 resumes the timekeeping when the setting time T does not elapses (S6: No), and stops the timekeeping (S7) when the setting time T elapses (S6: Yes). At this time, when the opening operation of the pair of grippers 5 and 5 using the biased elastic deforming force ends, the grippers 5 and 5 stop in a state where the front ends thereof come into contact with each other as shown in Fig. 6C. Then, in response to the stop of the timekeeping using the timer section 27, the origin pulse detecting section 28 detects the origin pulse which corresponds to the pulse generated in the encoder 3 at a time point at which the timekeeping using the timer section 27 ends (S8: origin pulse detecting means). The origin pulse position is stored in, for example, the RAM 11c of the controller 11. With the above-described operation, the origin detecting routine is terminated (S9).

[0038] The timer means does not need to be essentially provided, but when the timer means is provided, it is possible to prevent the origin pulse from being erroneously detected before the bending of the gripper 5 is removed. With the above-described configuration, since the supply of the current to the electric motor 2 is stopped when the pair of grippers 5 and 5 come into contact with each other, the driving force which is generated by the electric motor 2 and is applied to the pair of grippers 5 and 5 is removed, and the elastic deformation of the pair of grippers 5 and 5 is solved. Then, the origin pulse may be detected in a state where no contact force acts on the grippers 5 and 5 and the bending of the linear portions 5b of the grippers 5 and 5 is solved. Accordingly, it is possible to solve the positional deviation caused by the bending of the

pair of grippers 5 and 5 and detect the origin pulse with high precision.

[0039] Further, since the supply of the current to the electric motor 2 is stopped by detecting whether the rotational driving of the electric motor 2 stops due to the contact between the pair of grippers 5 and 5 based on the pulse of the encoder 3, the current does not need to be continuously supplied to the electric motor 2 in order to maintain the state where the grippers 5 and 5 come into contact with each other. Accordingly, the heating of the electric motor 2 due to the contact may be prevented, the durability and the reliability may be improved, and the electric power may be saved.

[0040] Furthermore, in the first embodiment, the supply of the current to the electric motor 2 is stopped after the electric motor stops, the releasing time data until the bending generated in the grippers 5 and 5 is solved is obtained, and the releasing time obtained from the data is set as the setting time T. Then, the pulse output which is output from the encoder 3 after the setting time T elapses is detected as the origin pulse. Accordingly, it is possible to prevent the origin pulse from being erroneously detected before the bending generated in the grippers 5 and 5 is solved and detect the origin with high reliability.

Second embodiment

[0041] Next, a gripping device according to a second embodiment of the invention will be described. Fig. 7 is a functional block diagram illustrating a controller 11A according to the second embodiment of the invention. Furthermore, in the second embodiment, the same reference numerals will be given to the same configurations as those of the first embodiment, and the description thereof will not be repeated.

[0042] In the second embodiment, the origin pulse detecting operation in the controller 11A is different from the origin pulse detecting operation in the controller 11 of the first embodiment. Furthermore, the hardware configuration of the controller 11A is the same as that of the controller 11 of the first embodiment, and the control program stored in the ROM 11b is different from that of the first embodiment.

[0043] In the controller 11A of the second embodiment, as shown in Fig. 7, in the same manner as the first embodiment, the controller includes the first counting section 21 which serves as the counting means, the target pulse number setting section 22 which serves as the target number pulse setting means, and the first command section 23 which serves as the command means. Further, the controller 11A includes the second counting section 24, a second command section 25A which serves as the closing operation command means and the current supply stopping means, the time setting section 26 which serves as the time setting means, and the timer section 27 which serves as the timer means. Further, the controller 11A includes the third counting section 29 which serves as the current stop time counting means, the pulse number upper and lower limit value setting section 30 which serves as the pulse number upper-

lower limit value setting means, the comparison section 31 which serves as the comparison means, and the origin pulse detecting section 28A which serves as the origin pulse detecting means.

[0044] Fig. 8 is a flowchart illustrating the control operation of the controller 11A when the origin pulse is detected. Hereinafter, the control operations of the respective functional sections of the controller will be described in detail by referring to Figs. 7 and 8.

[0045] First, the controller 11A starts the origin detecting routine (S11). At this time, the pair of grippers 5 and 5 are present at a position where the grippers are opened by a predetermined distance. Next, the second command section 25A outputs a control signal of commanding the supply of the current with respect to the electric motor 2 to the driving circuit 12 so that the pair of opened grippers 5 and 5 are closed at a constant speed (S12: closing operation command means).

[0046] Accordingly, the pair of grippers 5 and 5 are closed, the gripping portions 5c of the front ends of the grippers 5 and 5 come into contact with each other, and then the grippers 5 and 5 are continuously closed while being further elastically deformed (in a bending manner). Then, the closing operation of the pair of grippers 5 and 5 stop at a point where the elastic deforming force of the pair of grippers 5 and 5 and the driving force of the electric motor 2 are balanced.

[0047] In the meantime, the second counting section 24 counts the number of pulses generated in the encoder 3, and the second command section 25A monitors the count of the second counting section 24 by checking the encoder output (S13). Then, when the closing operation of the pair of grippers 5 and 5 is stopped so that the output of the encoder 3 stops and the count using the second counting section 24 stops, the second command section 25A stops the supply of the current with respect to the electric motor 2 (S14: current supply stopping means). That is, the second command section 25A outputs a control signal representing a command of stopping the supply of the current with respect to the electric motor 2 to the driving circuit 12.

[0048] Then, the second command section 25A stops the supply of the current with respect to the electric motor 2 and starts the timekeeping in the timer section 27. Accordingly, the timer section 27 starts the timekeeping from a time point at which the supply of the current to the electric motor 2 is stopped by the second command section 25A (S15: timer means).

[0049] Furthermore, in the second embodiment, the second command section 25A outputs a trigger which starts the counting of the number of pulses generated in the encoder 3 in the third counting section 29 to the third counting section 29. Accordingly, the third counting section 29 counts the number of pulses generated in the encoder 3 from a time point at which the timekeeping using the timer section 27 starts (S16).

[0050] Next, the timer section 27 resumes the timekeeping when the setting time T does not

elapses (S17: No), and stops the timekeeping when the setting time T elapses (S17: Yes) (S18). Further, the timer section 27 stops the timekeeping and outputs a trigger which stops the counting of the number of pulses in the third counting section 29 to the third counting section 29. Accordingly, the third counting section 29 ends the counting of the number of pulses generated in the encoder 3 (S19). That is, the third counting section 29 counts the number of pulses generated in the encoder 3 from a time point at which the timekeeping starts by the timer section 27 to a time point at which the timekeeping ends.

[0051] The pulse number upper and lower limit value setting section 30 sets the upper limit value A and the lower limit value B of the number of pulses which will be compared with the counted number of pulses in the comparison section 31.

[0052] Here, in the second embodiment, in the same manner as the first embodiment, the number of pulses is counted up in the case of the forward rotation in which the rotary shaft 2a rotates so as to close the pair of grippers 5 and 5. Further, the number of pulses is counted down in the case of the reverse rotation in which the rotary shaft 2a rotates so as to open the pair of grippers 5 and 5. Accordingly, since the pair of grippers 5 and 5 moves in the opening direction while the timekeeping is performed in the timer section 27, the rotary shaft 2a rotates reversely and the third counting section 29 counts the number of pulses which increases in the negative direction. Accordingly, the upper limit value A and the lower limit value B which are set have negative values. Then, in the magnitude (the absolute value), the lower limit value B is larger than the upper limit value A. Here, the meaning of setting the upper limit value A and the lower limit value B indicates that the data signal representing the upper limit value A and the lower limit value B is input from the external device through the input section 11d and is stored in a storage section such as a ROM 11b (or a RAM 11c) so as to be read out as the upper limit value A and the lower limit value B by the CPU 11a.

[0053] Next, the comparison section 31 compares the number of pulses counted by the third counting section 29 with the upper limit value A and the lower limit value B (S20). Specifically, the comparison section 31 determines whether the number of pulses counted by the third counting section 29 is within the numerical value range between the lower limit value B and the upper limit value A.

[0054] Here, the upper limit value A and the lower limit value B are the upper limit value and the lower limit value of a value which is supposed that the number of pulses counted by the third counting section 29 is counted when the elastic deformation of the pair of grippers 5 and 5 is solved.

[0055] As a result of the comparison process, when the number of pulses counted by the third counting section 29 is within the range between the upper limit value A and the lower limit value B (S20: Yes), the comparison section 31 allows the origin pulse

detecting section 28A to detect the origin pulse. That is, the origin pulse detecting section 28A detects the origin pulse which corresponds to the pulse generated in the encoder 3 at a time point at which the timekeeping using the timer section 27 ends (S21). The origin pulse position is stored in, for example, the RAM 11c of the controller 11. With the above-described operation, the origin detecting routine ends (S22).

[0056] Further, as a result of the comparison process, when the number of pulses counted by the third counting section 29 is out of the range between the upper limit value A and the lower limit value B (S20: No), the comparison section 31 commands the second command section 25A to perform the origin detecting routine again. The second command section 25A which receives the command outputs a control signal which represents a command of opening the pair of grippers 5 and 5 at a constant speed with a predetermined width to the driving circuit 12 (S23). Then, returning to the process of starting the origin detecting routine (S11), the origin detecting routine is started again.

[0057] That is, it is considered that an excessive load acts on the pair of grippers 5 and 5 when the number of pulses counted by the third counting section 29 is larger than the upper limit value A. Further, it is considered that vibration or impact acts on the pair of grippers 5 and 5 when the number of pulses counted by the third counting section 29 is smaller than the lower limit value B. In such a case, when the pulse at that time is not detected as the origin pulse and the origin detecting routine is performed again, the origin may be detected with higher reliability.

[0058] As described above, in the second embodiment, since the supply of the current to the electric motor 2 is stopped when the pair of grippers 5 and 5 come into contact with each other, the driving force which is generated by the electric motor 2 and is applied to the pair of grippers 5 and 5 is removed, and the elastic deformation of the pair of grippers 5 and 5 is solved. Then, in a state where no striking force acts on the grippers 5 and 5 and the bending of the linear portions 5b of the grippers 5 and 5 is solved, the origin pulse may be detected. Accordingly, the positional deviation caused by the bending of the pair of grippers 5 and 5 may be solved, and the origin pulse may be detected with high precision.

[0059] Further, since the supply of the current to the electric motor 2 is stopped by detecting whether the rotational driving of the electric motor 2 stops due to the contact between the pair of grippers 5 and 5 based on the pulse of the encoder 3, the current does not need to be continuously supplied to the electric motor 2 in order to maintain the state where the grippers 5 and 5 come into contact with each other. Accordingly, the heating of the electric motor 2 due to the contact may be prevented, the durability and the reliability may be improved, and the electric power may be saved.

[0060] Furthermore, in the second embodiment, the supply of the current to the electric

motor 2 is stopped after the electric motor stops, the releasing time data until the bending generated in the grippers 5 and 5 is solved is obtained, and the releasing time obtained from the data is set as the setting time T. Then, the pulse output which is output from the encoder 3 after the setting time T elapses is detected as the origin pulse. Accordingly, it is possible to prevent the origin pulse from being erroneously detected before the bending generated in the grippers 5 and 5 is solved and detect the origin with high reliability.

[0061] Furthermore, the invention has been described based on the above-described embodiments, but the invention is not limited thereto. In the second embodiment, when the number of pulses counted by the third counting section 29 is out of the range between the upper limit value A and the lower limit value B, the origin detecting routine is performed again, but the invention is not limited thereto. The error information may be notified to the operator without performing the origin detecting routine again.

[0062] Further, in the second embodiment, a case has been described in which the number of pulses is counted up in the forward rotation in which the rotary shaft 2a rotates so as to close the pair of grippers 5 and 5. Further, a case has been described in which the number of pulses is counted down in the reverse rotation in which the rotary shaft 2a rotates so as to open the pair of grippers 5 and 5. However, the invention is not limited thereto, and the number of pulses may be counted in the forward rotation in which the rotary shaft 2a rotates so as to open the pair of grippers 5 and 5. Then, the number of pulses may be counted down in the reverse rotation in which the rotary shaft 2a rotates so as to close the pair of grippers 5 and 5. In this case, since the pair of grippers 5 and 5 moves in the opening direction while the timekeeping is performed in the timer section 27, the rotary shaft 2a rotates forward, and the third counting section 29 counts the number of pulses which increases in the positive direction. Accordingly, the upper limit value A and the lower limit value B which are set have positive values. Then, in the magnitude (the absolute value), the upper limit value A is larger than the lower limit value B.

[0063] In the same manner, in the first embodiment, a configuration may be adopted in which the number of pulses is counted in the forward rotation in which the rotary shaft 2a rotates so as to open the pair of grippers 5 and 5. Then, the number of pulses may be counted down in the reverse rotation in which the rotary shaft 2a rotates so as to close the pair of grippers 5 and 5.

[0064] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent

structures and functions.

[0065] This application claims the benefit of Japanese Patent Application No. 2011-084446, filed April 6, 2011, which is hereby incorporated by reference herein in its entirety.

Reference Signs List

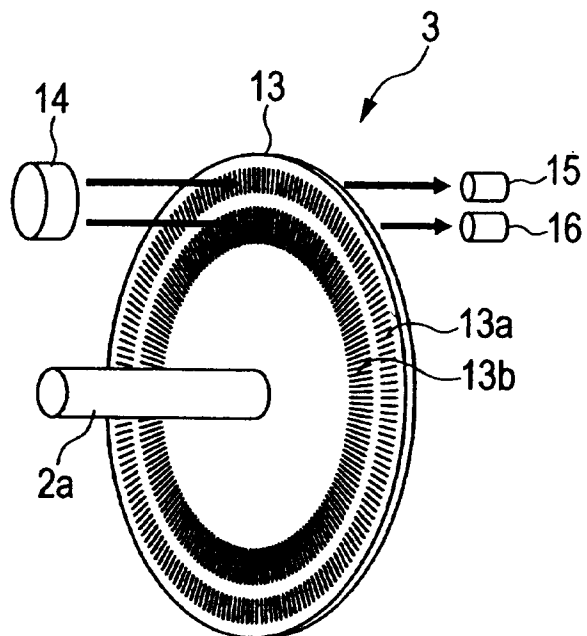
[0066] 2 electric motor
2a drive shaft
3 encoder
4 rotary-linear motion converting mechanism
5 gripper
12 driving circuit
21 first counting section
22 target pulse number setting section
23 first command section
24 second counting section
25 second command section
25A second command section
26 time setting section
27 timer section
28 origin pulse detecting section
28A origin pulse detecting section
29 third counting section
30 pulse number upper and lower limit value setting section
31 comparison section
100 gripping device

Claims

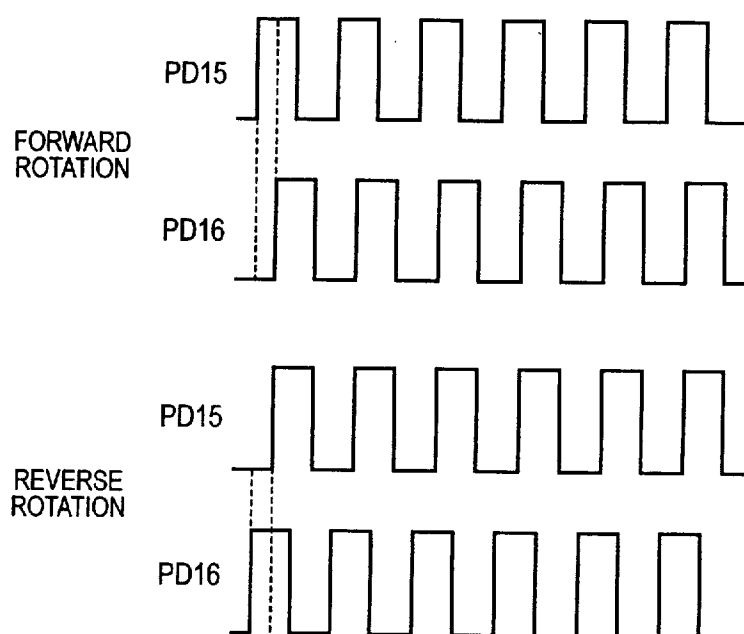
- [Claim 1] A gripping device comprising:
an electric motor that includes a rotating drive shaft;
a rotary-linear motion converting mechanism that converts a rotary motion of the drive shaft into a linear motion;
a pair of grippers that is opened and closed by the rotary-linear motion converting mechanism;
an encoder that generates a pulse with a rotation position of the drive shaft;
closing operation command means for commanding the pair of grippers to be closed;
current supply stopping means for stopping a supply of a current to the electric motor when the closing operation of the pair of grippers using the closing operation command means stops; and
origin pulse detecting means for detecting an origin pulse which corresponds to a pulse generated in the encoder at a time point at which the time necessary for stopping the operation of the pair of grippers after stopping the supply of the current to the electric motor using the current supply stopping means elapses.
- [Claim 2] The gripping device according to claim 1, further comprising:
timer means for starting timekeeping from a time point at which the supply of the current to the electric motor is stopped by the current supply stopping means; and
time setting means for setting a time at which the timer means starts the timekeeping,
wherein the origin pulse detecting means detects the origin pulse which corresponds to the pulse generated in the encoder at a time point at which the timekeeping using the timer means ends.
- [Claim 3] The gripping device according to claim 2, further comprising:
current stop time counting means for counting the number of pulses generated in the encoder from a time point at which the timekeeping starts using the timer means to a time point at which the timekeeping ends;
pulse number upper-lower limit value setting means for setting of upper and lower limit values of the number of pulses; and
comparison means for comparing the upper limit value and the lower limit value of the number of pulses counted by the counting means

when the supply of the current stops,
wherein when the number of pulses counted by the current stop time counting means is within the range between the upper limit value and the lower limit value as a comparison result using the comparison means, the origin pulse detecting means detects the origin pulse which corresponds to the pulse generated in the encoder at a time point at which the timekeeping using the timer means ends.

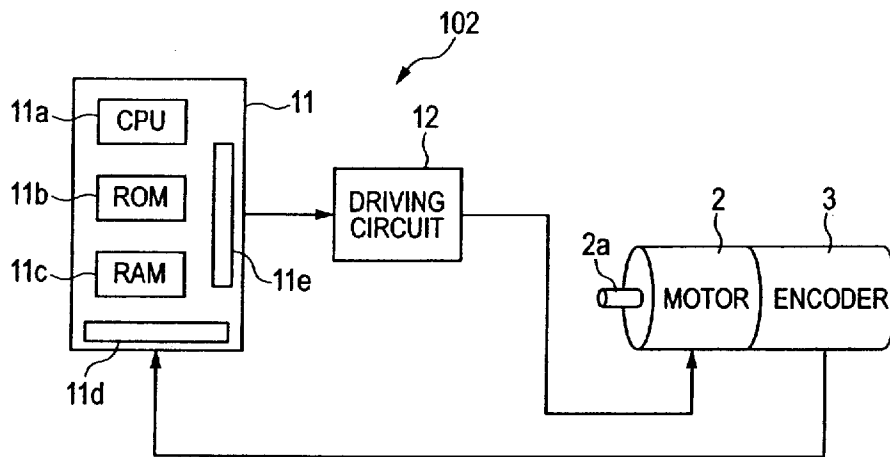
[Fig. 2A]



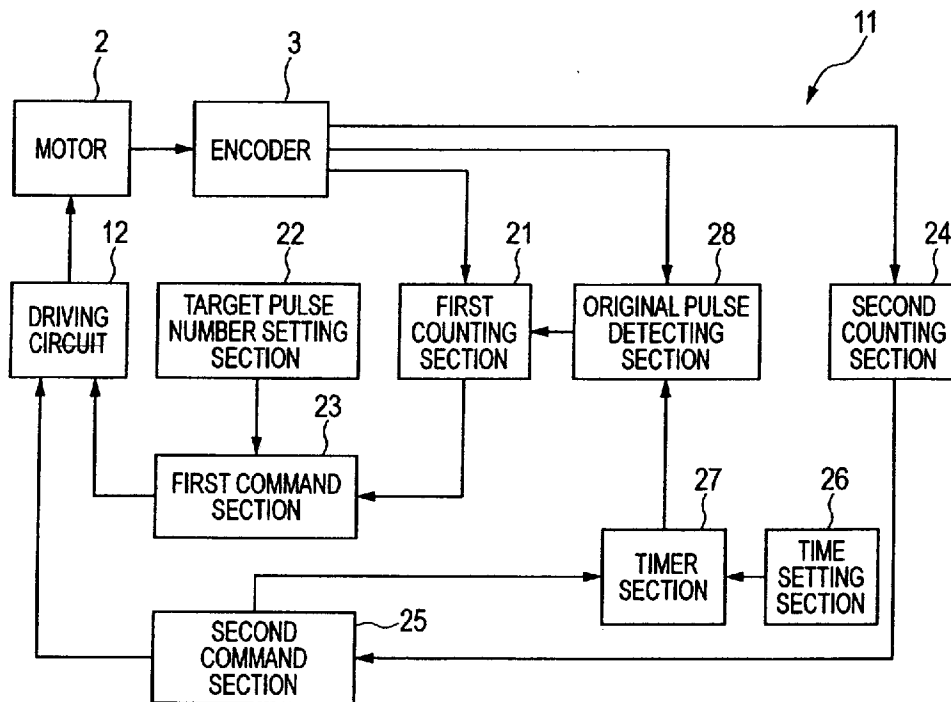
[Fig. 2B]



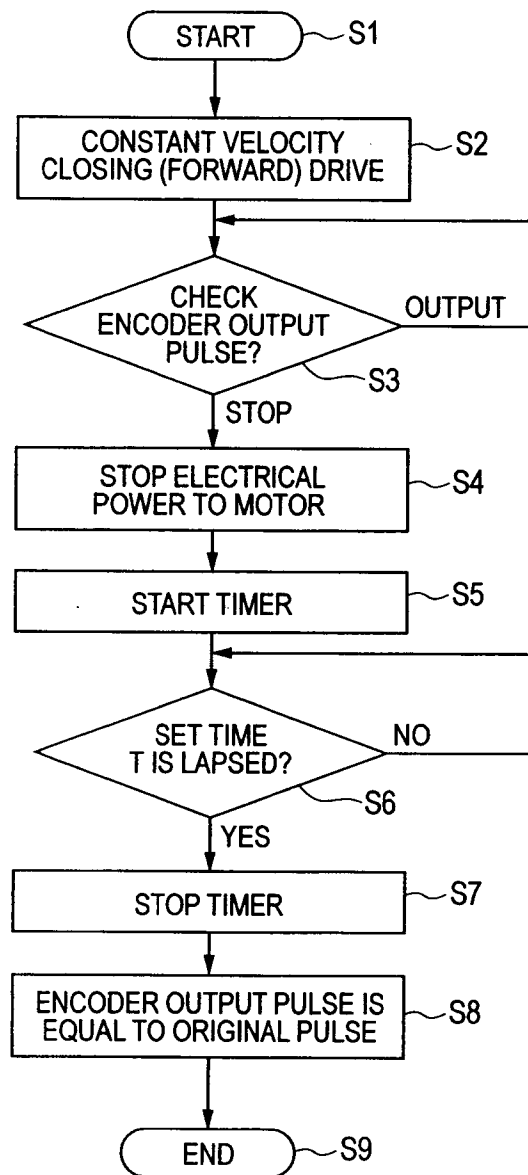
[Fig. 3A]



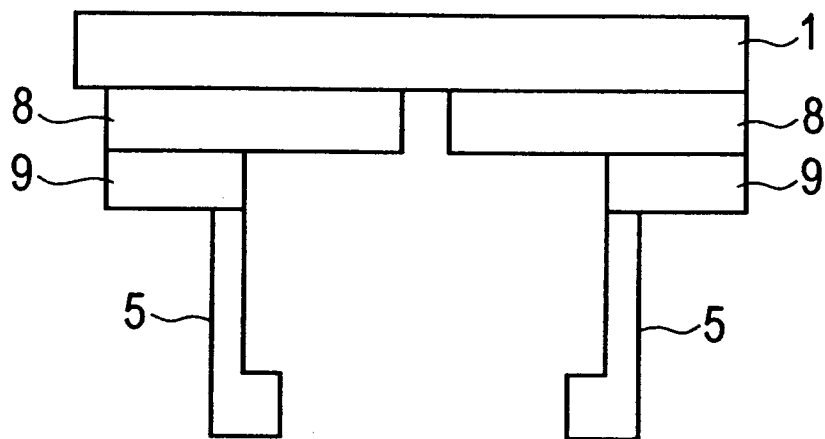
[Fig. 3B]



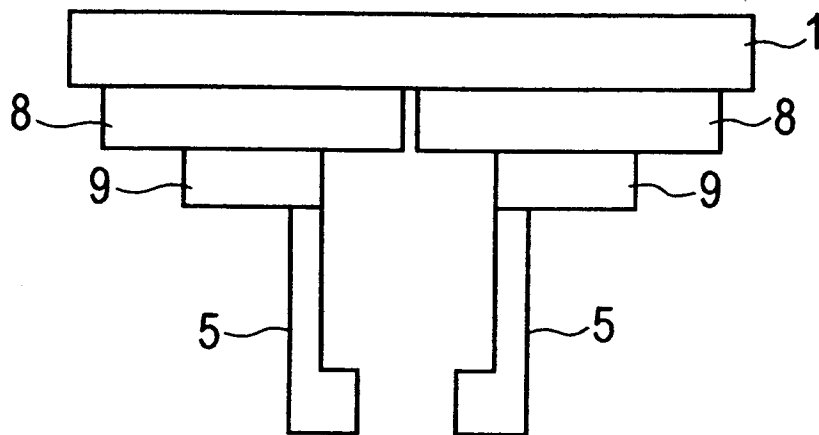
[Fig. 4]



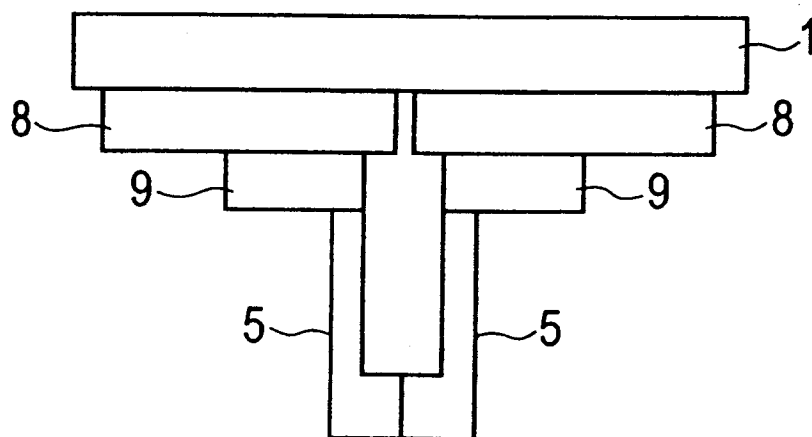
[Fig. 5A]



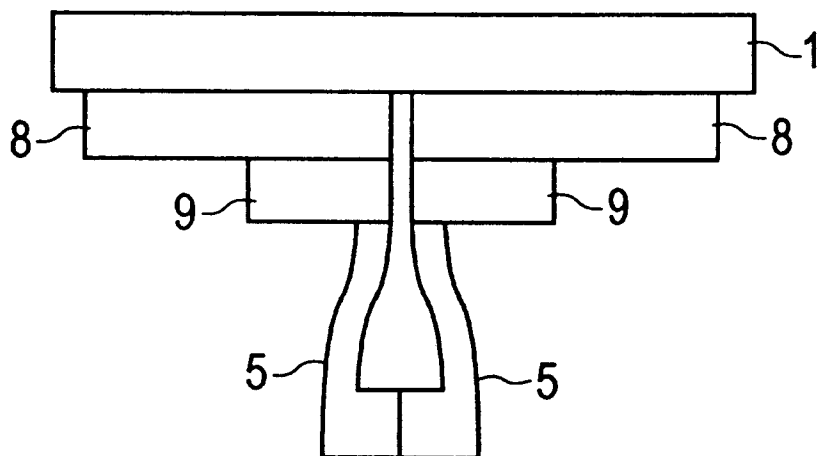
[Fig. 5B]



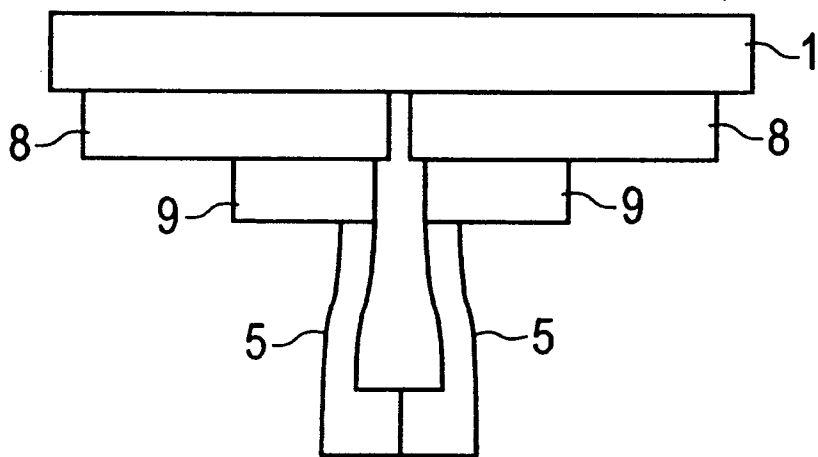
[Fig. 5C]



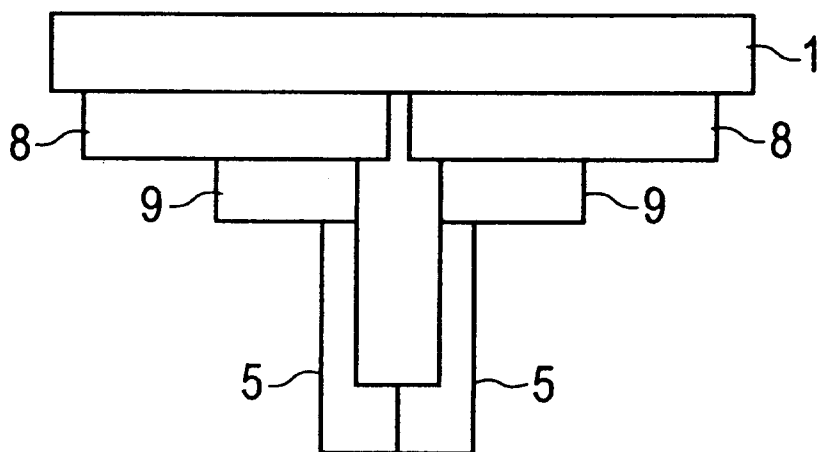
[Fig. 6A]



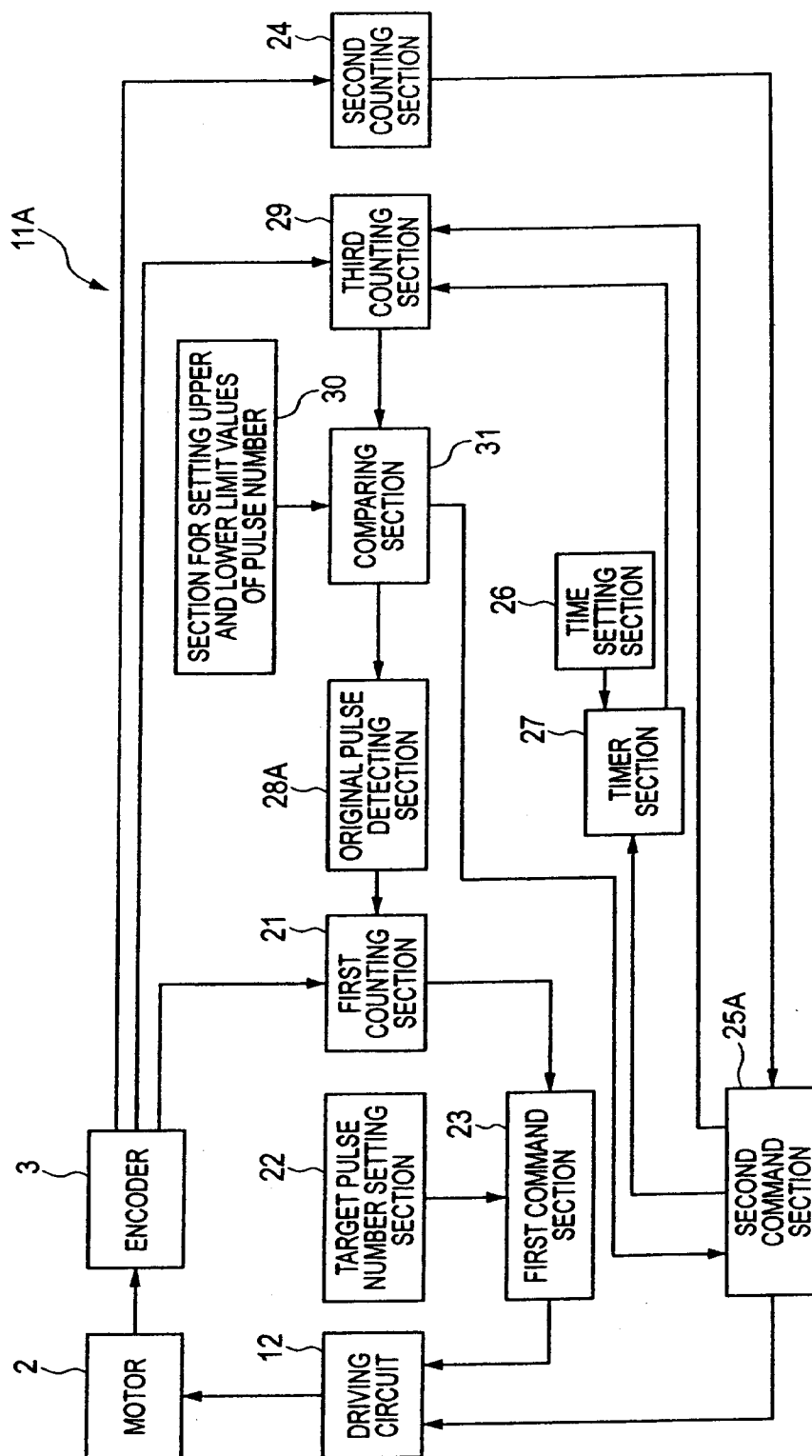
[Fig. 6B]



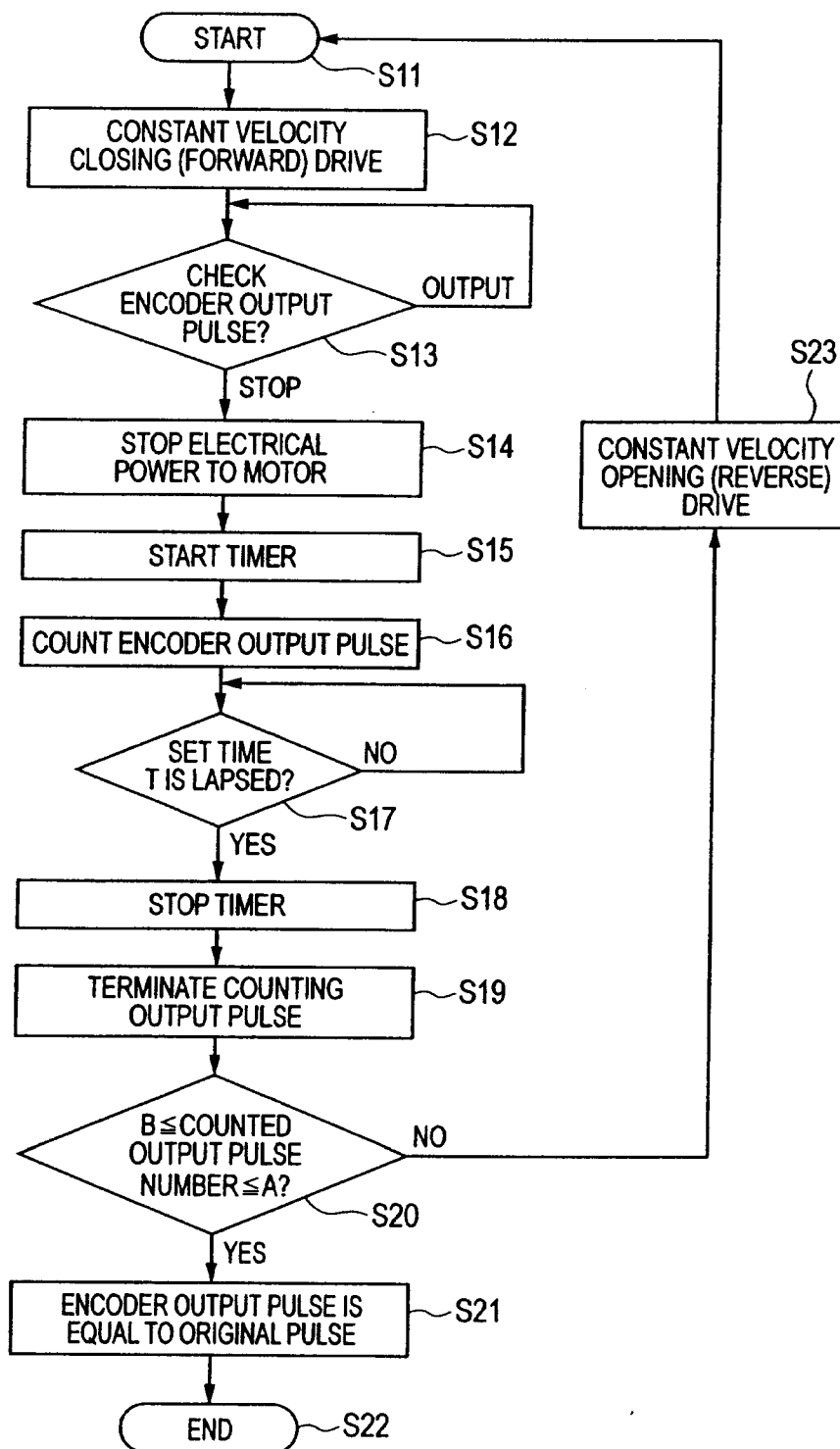
[Fig. 6C]



[Fig. 7]



[Fig. 8]



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2012/001574

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25J9/16
ADD.

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)
B25J G05B

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)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 632 631 A (DUNLAP RAYMOND R [US]) 30 December 1986 (1986-12-30) column 2, line 44 - column 3, line 31; figures 1-6	1-3
A	DE 37 42 573 C1 (GILDEMEISTER AG) 16 March 1989 (1989-03-16) column 3, line 16 - column 4, line 64; figures 1-7	1-3



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"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

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"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

27 July 2012

Date of mailing of the international search report

06/08/2012

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European Patent Office, P.B. 5818 Patentlaan 2
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Fax: (+31-70) 340-3016

Authorized officer

Nettesheim, Johannes

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/JP2012/001574

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4632631	A	30-12-1986	NONE	

DE 3742573	C1	16-03-1989	NONE	
