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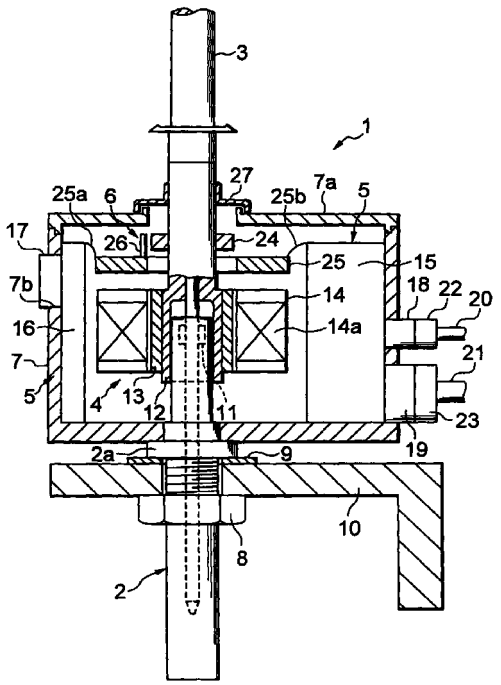
(54) Unitary spindle driving apparatus for spinning machine

(57) A unitary spindle driving apparatus for a spinning machine of a structure which facilitates mounting of the unitary spindle driving apparatus for a spinning machine on a spinning machine frame as in the case of a conventional spindle apparatus while suppressing problems such as breakage of wire interconnecting an electric drive motor and a control unit. The unitary spindle driving apparatus 1 includes a bolster (2), a spindle (3) supported rotatably on the bolster (2), an electric motor (4) for driving the spindle (3), a control unit (5) for controlling the driving motor (4) and a rotation speed monitoring unit (6) for monitoring the rotation of the spindle (3). The motor (4), the control unit (5) and the rotation speed monitoring unit (6) are disposed within a single housing (7). A rotor (13) of the motor (4) is secured to the spindle (3) so as to rotate together therewith. A stator (14) of the motor (4) is fixedly mounted on the housing (7) at a position opposite to the rotor (13). Disposed at a rear side within the housing (7) is a driver circuit substrate (15) on which a driving circuit module is packaged, while disposed within the housing (7) at a front side thereof is a CPU substrate (16) on which a CPU module is packaged. The control unit (5) is constituted by the driver circuit substrate (15) and the CPU substrate (16).

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a unitary spindle driving apparatus which is employed in a spinning machine such as a ring spinning machine, a ring twisting frame or the like for driving a spindle thereof independently of others.

Description of Related Art

[0002] In recent years, there has been proposed such a structure of a spinning machine in which each of individual spindles which support respective bobbins or cops is driven by a dedicated electric motor instead of driving all the spindles of the spinning machine by a single electric motor, with a view to increasing the number of the spindles provided in the spinning machine and/or realizing high-speed rotation of the spindle. In a spinning machine in which the spindles are driven by a dedicated motors, respectively, as mentioned above, occurrence of abnormalities such as yarn breakage or the like makes it necessary to stop the driving motor for the relevant spindle to thereby allow appropriate measures such as piecing to be taken. To this end, the motor is equipped with a switch for stopping and starting the motor, wherein the motor is electrically connected to a control circuit module by means of a multi-core cable composed of signal lines and electric power supply line.

[0003] For a better understanding of the concept underlying the present invention, background techniques thereof will first be reviewed. Referring to Fig. 6 of the accompanying drawings, in an apparatus disclosed in Japanese Patent Laid-open No. 6-57549, an internal power supply line 53 of an electric motor 52 dedicated for driving a spindle 51 is electrically connected to an external power supply line 56 extending from a control circuit module 55 by means of a connector 54 which is disposed at a rear side of the spindle 51. A switch (serving as a control unit) 57, which inputs a control signal to the control circuit module 55, is fixed in an overhang portion 58a provided externally of a housing 58 so that the switch 57 is positioned in front of the spindle 51, wherein the switch 57 is connected to the control circuit module 55 via a signal line 59. The control circuit module 55 is installed at a lower portion of the machine frame so that it is positioned to the rear of the spindle 51.

[0004] On the other hand, referring to Fig. 7 of the accompanying drawings, Japanese Patent Laid-open No. 8-100331 discloses an apparatus in which an openable cover 61 is provided for the housing 58 of a spindle driving motor 52 so as to cover a bolster 60, wherein at least a portion of a control unit for supplying electric power to the motor 52 is disposed within the cover 61. The control unit includes an inverter 62, a stopping unit 63 and a control module 64. Conductors 65 for the power supply and control signals are provided along a spindle rail 66. These conductors 65 are adapted to be electrically connected to conductors 67, respectively, of the control module disposed on the cover 61 via contact members 68 which are also provided on the cover 61, when the cover 61 is disposed in the closed position. On the contrary, when the cover 61 is disposed in an opened position, the conductors 65 are electrically disconnected from the conductors 67.

[0005] In the case of the apparatus disclosed in Japanese Patent Laid-open No. 6-57549, the control circuit module 55 is disposed at a lower portion of the machine frame so that the control circuit module 55 is positioned at the rear side of the spindle 51. Consequently, the external power supply line 56 as well as the signal line 59 are required to electrically connect the switch 57 and the control circuit module 55 to each other. When there is a long wiring extension outside of the housing, there are likely to occur such troubles as breaking of wire or the like as well as erroneous operation due to noise. Further, there is another disadvantage such that a large number of attaching/mounting steps are required. At this juncture, it should further be mentioned that many ring spinning machines are ordinarily equipped with a simultaneous cop changer disposed at a front side of the machine frame, wherein the control circuit module 55 is disposed to the rear of the cop changer. Consequently, it is very difficult to perform attachment and/or maintenance of the control circuit module 55. Furthermore, deposition of fly onto the wire easily occurs, requiring a lot of time for cleaning, to another disadvantage.

[0006] On the other hand, in the case of the apparatus disclosed in Japanese Patent Laid-open No. 8-100331, the electric power supply line for the motor 52 and the signal line are disposed within the cover 61. With such arrangement, the wiring length can be certainly reduced, which is favorable in that troubles such as wire breakage or the like and erroneous operation due to noise are less likely to occur. However, electrical interconnection of the conductors 67 of the control module for the motor 52 with the conductors 65 such as the power supply line (feeder line) and the signal line can be realized only when the cover 61 mounted on the housing 58 of the motor 52 is disposed in the closed position. Consequently, when the orientation and the position of the motor 52 are changed, there may arise the unwanted possibility of connection failure taking place between the conductors 67 of the control module and the conductors 65 such as the power supply line, the signal line and the like. Further, because the spindle of the spinning machine is rotated at a high speed, centering or positioning with high accuracy represents a very important factor. Under the circumstances, centering work is carried when the spindle is attached or upon maintenance service for the spindle. In this conjunction,

it is however noted that since the cover 61 is so mounted as to cover the bolster 60, the cover 61 has to be in the opened position for mounting and centering the motor 52, giving rise to a problem that the work involved is very troublesome.

SUMMARY OF THE INVENTION

[0007] In light of the state of the art described above, it is an object of the present invention to provide a unitary spindle driving apparatus for a spinning machine of a structure which facilitates mounting of the unitary spindle driving apparatus on a spinning machine frame as in the case of a conventional spindle while making it difficult for troubles such as wire breakage between an electric drive motor and a control unit occur.

[0008] In view of the above and other objects which will become apparent as the description proceeds, there is provided according to an aspect of the present invention a unitary spindle driving apparatus for a spinning machine, which apparatus includes an electric motor for driving a spindle, wherein a housing of a control unit is provided integrally with a housing of the electric motor above a portion of a bolster which projects downwardly from the housing of the electric motor, and wherein wire for electrically interconnecting the electric motor and the control unit is disposed within both housings.

[0009] By virtue of the structure of the unitary spindle driving apparatus according to the present invention in which the housing of the control unit is provided integrally with the housing of the motor above the portion of the bolster which projects downwardly from the housing of the motor, as described above, the housing of the control unit provides no obstacle to mounting the unitary spindle driving apparatus on the spinning machine frame, and thus the work as involved can be performed easily as in the case of the conventional spindle. Further, because the wire interconnecting the motor and the control unit is not exposed outside of the housing, not only can the wire be protected against entangling or deposition of the fly but also trouble such as the breaking of wire can be avoided.

[0010] In a preferred mode for carrying out the present invention, the housing of the motor and the housing of the control unit may be formed integrally with each other. With such arrangement, the number of attaching or mounting steps can be decreased when compared with a structure in which the motor and the control unit are first disposed within respective separate housings to be subsequently combined or assembled together.

[0011] In another mode for carrying out the present invention, the control unit should preferably be disposed at a side opposite an inner side of the machine frame at which the unitary spindle driving apparatus is mounted on the spinning machine, while a motor power input unit and a control power input unit should preferably be disposed at the same side as the control unit.

[0012] In other words, the control unit should be mounted on the machine frame at the side opposite the inner side of the machine frame of the spinning machine while the motor power input unit and the control power input unit should be disposed at the side opposite the inner side of the machine frame. Thus, the wire interconnecting the housing of the control unit and the power input unit is not an obstacle to the work performed by the cop changer. Further, when a simultaneous cop changer equipped with intermediate pegs are provided on the machine frame of the spinning machine, the control unit is not disposed at the outer side relative to the machine frame when compared with the spindle. Consequently, no obstacle is presented to the operation of the cop changer. Furthermore, because the motor power input unit and the control unit are disposed near each other, wiring operations can be greatly facilitated.

[0013] In yet another mode for carrying out the present invention, a rotation speed monitoring unit for the spindle should preferably be accommodated within the housing of the electric motor, while the control unit should preferably be so designed as to perform a feedback control of the electric motor on the basis of an output signal of the rotation speed monitoring unit.

[0014] With the arrangement mentioned above, the rotation speed of the spindle can be monitored by the rotation speed monitoring unit accommodated within the housing of the motor. Further, the feedback control of the motor can be carried out by the control unit on the basis of the output signal of the rotation speed monitoring unit. As a result, the rotation speed monitoring unit can monitor the rotation speed without being influenced by the fly and thus the spindle can be controlled to rotate at a predetermined rotation speed with high accuracy.

[0015] In still another mode for carrying out the present invention, the rotation speed monitoring unit should preferably be equipped with a Hall IC module for detecting rotation of a magnet which rotates together with the spindle, and the Hall IC module should preferably be disposed above the stator of the electric motor.

[0016] With such structure as mentioned above, the rotation speed monitoring unit can detect the rotation of the permanent magnet which rotates together with the spindle by means of the Hall IC module. Also, since the Hall IC module is disposed above the stator of the motor, it can be mounted more easily when compared with the structure in which it is disposed below the stator.

[0017] In a further mode for carrying out the present invention, the control unit should preferably be provided with a driver circuit substrate provided with a driving circuit module for controlling a driving current supplied to the electric motor, and a CPU substrate provided with a CPU module for issuing a control command to the driving circuit module, wherein the driver circuit substrate and the CPU substrate are disposed, respectively, at positions distanced from each other with the electric

motor being interposed therebetween. By virtue of the above-mentioned arrangement, the CPU substrate is unlikely to be influenced by temperature increase in the driver circuit substrate.

[0018] In yet a further mode for carrying out the present invention, the housing of the electric motor should preferably be provided with a Hall IC module for detecting rotation of a magnet which rotates together with the spindle, and the Hall IC substrate, wherein the CPU module and the driving circuit module are electrically interconnected by a printed circuit formed on the Hall IC substrate. With the arrangement mentioned above, interconnection of the driver circuit module with the CPU module can be facilitated, while the CPU module can perform feedback control of the motor in accordance with the output signal of the Hall IC module.

[0019] The above and other objects, features and attendant advantages of the present invention will more easily be understood by reading the following description of the preferred embodiments thereof taken, only by way of example, in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] In the course of the description which follows, reference is made to the drawings, in which:

Fig. 1 is a vertical sectional view showing schematically a unitary spindle driving apparatus for a spinning machine according to a first embodiment of the present invention;
Fig. 2 is a schematic front view showing partially the spindle apparatus shown in Fig. 1;
Fig. 3 is a vertical sectional view showing schematically a unitary spindle driving apparatus for a spinning machine according to a second embodiment of the present invention;
Fig. 4 is a vertical sectional view showing schematically a unitary spindle driving apparatus for a spinning machine according to a third embodiment of the present invention;
Fig. 5 is a vertical sectional view showing another structure of a rotation speed monitoring unit employed in the apparatus shown in Fig. 1;
Fig. 6 is a vertical sectional view showing, by way of example, a hitherto known or conventional unitary spindle driving apparatus for a spinning machine; and
Fig. 7 is a vertical sectional view showing schematically another conventional unitary spindle driving apparatus for a spinning machine.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] The present invention will be described in detail in conjunction with what is presently considered as preferred or typical embodiments thereof by reference to the drawings. In the following description, like reference characters designate like or corresponding parts throughout the several views.

Embodiment 1

[0022] Now, a unitary spindle driving apparatus according to a first embodiment incarnating the present invention will be described by reference to Figs. 1 and 2. The unitary spindle driving apparatus (hereinafter referred to simply as the spindle apparatus) 1 is comprised of a bolster 2, a spindle 3 supported rotatably on the bolster 2, an electric motor 4 for driving the spindle 3, a control unit 5 for controlling the driving motor 4 and a rotation speed monitoring unit 6 for monitoring the rotation of the spindle 3. The motor 4, the control unit 5 and the rotation speed monitoring unit 6 are disposed within a single housing 7.

[0023] The bolster 2 is provided with a flange portion 2a at an intermediate portion, wherein the bolster 2 is fixedly secured to the housing 7 with a portion of the bolster extending upwardly from the flange portion 2a into the housing 7. The bolster 2 is secured by being clamped to a spindle rail 10 of a spinning machine at a predetermined position together with the housing 7 by means of a nut 8 which screws onto a male thread portion formed at a portion of the bolster 2 extending downwardly from the flange portion 2a and a washer 9 disposed below the flange portion 2a. A bearing 11 is incorporated in the bolster 2. The spindle 3 has a downwardly extending portion or lower portion which is inserted into the bolster 2 and is supported rotatably by means of the bearing 11.

[0024] Provided at an intermediate portion of the spindle 3 is a cylindrical supporting portion 12 which covers the top end portion of the bolster 2, wherein a rotor 13 formed of a permanent magnet is secured externally to the supporting portion 12 so that the rotor 13 can rotate together with the supporting portion 12. A stator 14 is fixedly mounted on the housing 7 at a position opposite to the rotor 13. The rotor 13 and the stator 14 cooperate to constitute the driving motor 4.

[0025] Disposed at a rear side within the housing 7, i.e., at a side (right-hand side as viewed in Fig. 1) facing in opposition to the inner side of the machine frame when the spindle apparatus 1 is mounted in the spinning machine is a driver circuit substrate 15 on which a driving circuit module (e.g. inverter circuit) is packaged. Further disposed within the housing 7 at the front side thereof is a CPU (central processing unit) substrate 16 on which a CPU module for supplying a control signal to the driving circuit module is packaged. The control unit 5 mentioned previously is comprised of the driver circuit substrate 15 and the CPU substrate 16. According to the teaching of the invention incarnated in the instant embodiment, the housing of the motor 4 and that of the control unit 5 are formed integrally with each other.

[0026] Further provided on the CPU substrate 16 is a switch 17 for commanding starting and stopping of the motor 4. The switch 17 may be implemented in the form of a push button switch designed to be mounted on the circuit substrate. This type of switch is commercially available as a general-purpose switch. At this juncture, it should be mentioned that the switch 17 is mounted on the CPU substrate 16 in such a manner that a surface of the button constituting a part of the switch 17 is exposed externally of the housing 7 through a hole 7b formed in the front wall of the housing 7.

[0027] Provided at a rear side of the housing 7 are a motor power input unit 18 and a control power input/communication signal input/output unit 19, wherein both the motor power input unit 18 and the control power input/communication signal input/output unit 19 are mounted on the driver circuit substrate 15 in the state in which connector portions project externally of the housing 7. The motor power input unit 18 and the control power input/communication signal input/output unit 19 are designed to be connected to connectors 22 and 23 of a power supply line (feeder line) 20 and a control input line 21, respectively.

[0028] Mounted fixedly on the spindle 3 is a permanent magnet 24 at a position above the rotor 13 so as to be rotatable together with the spindle 3. Further, a Hall IC substrate 25 is disposed within the housing 7 at a position intermediate the rotor 13 and the permanent magnet 24. The Hall IC substrate 25 is realized in an annular form having an outer peripheral surface at a portion where the Hall IC substrate 25 is fixedly secured to the inner wall of the housing 7. A hole formed in the inner side of the annular Hall IC substrate 25 is dimensioned so as to allow the rotor 13 to pass therethrough upon insertion of the spindle 3 into the bolster 2 or upon withdrawing the spindle 3 from the bolster 2. A Hall IC module 26 is packaged or mounted on the Hall IC substrate 25 which is disposed within the housing 7 so that the Hall IC module 26 is positioned above the stator 14. The permanent magnet 24 and the Hall IC module 26 cooperate to constitute the rotation speed monitoring unit 6 for monitoring the rotation speed (rpm) of the spindle 3. The Hall IC module 26 is designed to supply to the CPU module packaged on the CPU substrate 16 an output signal corresponding to the rotation speed of the permanent magnet 24 and hence that of the spindle 3. On the other hand, the CPU module performs a feedback control of the motor 4 on the basis of the output signal of the rotation speed monitoring unit 6.

[0029] The CPU substrate 16 is electrically connected to a printed circuit (not shown) formed on the Hall IC substrate 25 by means of a wiring 25a which interconnects the CPU substrate 16 and the Hall IC substrate 25. On the other hand, the driver circuit substrate 15 is electrically connected to a printed circuit (not shown) formed on the Hall IC substrate 25 by means of a wiring 25b which interconnects the driver circuit substrate 15 and the Hall IC substrate 25. Thus, the driver circuit substrate 15 and the CPU substrate 16 are interconnected via the printed circuit (not shown) formed on the Hall IC substrate 25. Further, the coil 14a of the stator 14 has an end portion electrically connected to an output line of the driver circuit module via the printed circuit (not shown) formed on the Hall IC substrate 25.

[0030] The housing 7 is formed in a box-like shape having the top wall 7a realized as a removable cover with a view to facilitating the attachment as well as inspection of the various parts on the individual substrates 15, 16 and 25 and the stator 14 on the housing 7. Furthermore, a cover member 27 is secured onto the spindle 3 so as to be rotatable together with the spindle 3 with the cover member 27 covering a hole formed in the top wall 7a when the spindle 3 is inserted in the bolster 2 and supported thereby.

[0031] Next, description will be made of mounting, maintenance service and operation of the spindle apparatus 1 implemented in the structure described above.

[0032] For mounting the spindle apparatus 1 on the spindle rail 10, the washer 9 is first placed on the lower surface of the flange portion 2a of the bolster 2. In this state, the lower portion of the bolster 2 is inserted through a mounting hole formed in the spindle rail 10, wherein the spindle apparatus 1 is secured by clamping with the nut 8 in the state where the spindle apparatus 1 has been disposed properly at a predetermined position. Subsequently, the connector 22 of the power supply line 20 and the connector 23 of the control input line 21 are connected to the motor power input unit 18 and the control power input/communication signal input/output unit 19, respectively.

[0033] When the motor 4 or the control unit 5 is to be inspected during maintenance service, the spindle 3 is first withdrawn together with the rotor 13, and then the top wall 7a of the housing 7 is removed, to thereby allow the inspection to be carried out when the inspection is of a simple nature. On the other hand, when it is required to remove the spindle apparatus 1, the connectors 22 and 23 are first detached, whereon the spindle apparatus 1 is dismounted from the bolster 2 by loosening the nut 8 to thereby allow the spindle apparatus 1 to be subsequently detached from the spindle rail 10. Further, in the case of the maintenance service for spindle oil of the bolster 2, the spindle 3 is withdrawn together with the rotor 13 in the state in which the bolster 2 remains secured to the spindle rail 10. In this state, inspection of the spindle oil and/or oil exchange can be carried out.

[0034] During operation of the spinning machine, individual spindles 3 supporting respective bobbins are driven independently from one another. The CPU module issues a control command to the driving circuit module packaged on the driver circuit substrate 15 in response to a command signal issued from a main control apparatus (not shown) which is in charge of controlling operation of the spinning machine. Additionally, the CPU module performs feedback control of the motor 4 in accordance with the output signal of the Hall IC mod-

ule 26.

[0035] When an abnormal event such as yarn breakage occurs in a bobbin or cop supported by a given one of the spindles 3, requiring the given spindle 3 to stop to cope with each abnormality, the operator or an piecing device pushes the switch 17 provided in association with a given spindle. Then, the motor 4 is made to stop under the control of the CPU module provided on the CPU substrate 16. Then, when the switch 17 is pushed when the motor 4 is stopped, the motor 4 is started.

[0036] The unitary spindle driving apparatus according to the instant embodiment of the invention provides the advantageous actions and effects mentioned below.

(1) By virtue of such arrangement that the motor 4 and the control unit 5 are disposed within a single housing 7 so that the housing of the control unit 5 is integral with the housing of the motor 4 above the portion of the bolster 2 which projects downwardly from the housing of the motor 4, the housing of the control unit 5 provides no obstacle in mounting or dismounting the spindle apparatus 1 onto or from the machine frame, whereby the work can be performed easily as in the case of a general spindle.

(2) Owing to the arrangement in which the wiring for electrically interconnecting the motor 4 and the control unit 5 is disposed within the housing 7, it can be covered by the housing 7, troubles such as wire breakage can be reduced to a minimum. Further, the wiring can be protected against entangling or deposition of fly.

(3) Because the housing of the motor 4 and that of the control unit 5 are formed integrally with each other, the number of attaching steps can be decreased when compared with a structure in which the motor 4 and the control unit 5 are disposed within respective separate housings to be subsequently mounted on the machine frame.

(4) Since the driver circuit substrate 15 constituting the control unit 5 is disposed at the side opposite the inner side of the machine frame at which the spindle apparatus 1 is mounted on the spinning machine, the motor power input unit 18 and the control power input unit 19 can be disposed at the same side as the control unit 5. Consequently, since the driver circuit substrate 15 which requires a relatively large space in a simultaneous cop changer in which intermediate pegs are provided for the machine frame of the spinning machine need not be disposed farther outside of the machine frame than with the spindles 3, it does not interfere with the operation of the cop changer. Furthermore, because the motor power input unit 18 and the driver circuit substrate 15 are disposed near to each other, wiring can be greatly facilitated.

(5) With the arrangement such that the rotation speed monitoring unit 6 for the spindle 3 is accommodated within the housing 7 of the motor 4 and the control unit 5 performs the feedback control of the motor 4 on the basis of the output signal of the rotation speed monitoring unit 6, the rotation speed monitoring unit 6 can monitor the rotation speed without being influenced by fly. Thus the spindle 3 can be controlled so as to rotate at a predetermined rotation speed with high accuracy.

(6) With the structure in which the rotation speed monitoring unit 6 is equipped with the Hall IC module 26 for detecting the rotation of the permanent magnet 24 which rotates together with the spindle 3 and in which the Hall IC module 26 is disposed above the stator 14 of the motor 4, the Hall IC module 26 can be more easily mounted than with a structure in which it is disposed below the stator 14.

(7) Owing to such arrangement that the end portion of the coil 14a of the stator 14 is electrically connected to the output line of the driver circuit substrate 15 by way of the printed circuit (not shown) formed on the Hall IC substrate 25, wiring for electrically interconnecting the output line of the driver circuit substrate 15 and the coil 14a can be simplified and facilitated.

(8) Because the driver circuit substrate 15 and the CPU substrate 16 are disposed at distanced positions with the rotor 13 and the stator 14 being interposed therebetween, the CPU substrate 16 can be protected against influence of temperature rises in the driver circuit substrate 15.

(9) Since the driver circuit substrate 15 and the CPU substrate 16 are electrically interconnected via the printed circuit (not shown) formed on the Hall IC substrate 25, wiring for interconnecting the driver circuit substrate 15 and the CPU substrate 16 can be facilitated even though the driver circuit substrate 15 and the CPU substrate 16 are disposed at positions distanced from each other.

Embodiment 2

[0037] Figure 3 shows a unitary spindle driving apparatus for a spinning machine according to a second embodiment of the invention. As can be seen in the figure, the driver circuit substrate 15 and the CPU substrate 16 are implemented in an integrally combined structure and disposed at a rear side of the housing 7, wherein the switch 17 is packaged on the Hall IC substrate 25. The switch 17 and the CPU substrate 16 are interconnected by way of a printed circuit (not shown) formed on the Hall IC substrate 25. With this structure, the signal line (inclusive of the printed circuit) which interconnects the driving circuit module on the driver circuit substrate 15 and the CPU module packaged on the CPU substrate 16 can be realized with a short length, which means that noise picked up by the signal line can be reduced significantly when compared with a long sig-

nal line, whereby wrong or erroneous operation can be suppressed, to advantageous effect. Further, the space occupied by the housing 7 positioned at the front side of the spindle 3 can be reduced, which in turn means that the space extending at the front of the spindle rail 10 is widened, accordingly, the cop changing work performed by a cop changer in a spinning machine equipped with a simultaneous cop changer can be carried out in a much facilitated manner.

Embodiment 3

[0038] Figure 4 shows a unitary spindle driving apparatus for a spinning machine according to a third embodiment of the present invention. As can be seen in the figure, the housing 7 of the motor 4 and a housing 28 of the control unit 5 are implemented as separate members, respectively, wherein the CPU substrate 16 and the driver circuit substrate 15 are disposed within the housing 28. A connector 29 connected electrically to a coil 14a is disposed at an upper portion of the housing 7 at a rear side thereof, whereas a connector 30 connected to the output line of the driver circuit substrate 15 is provided at the front side of the housing 28. By coupling both the connectors 29 and 30 to each other, both the housings 7 and 28 are mechanically connected, while the coil 14a of the motor 4 and the driving circuit module are electrically interconnected. With the structure described above, the housing 28 can be. combined integrally with the housing 7 above the portion of the bolster 2 projecting downwardly below the housing 7 of the motor 4, wherein the wiring for electrically interconnecting the motor 4 and the control unit 5 can be accommodated within the housings 7 and 28. By virtue of this arrangement, the housing 28 of the control unit 5 provides no obstacle in mounting or dismounting of the spindle apparatus 1 on or from the machine frame, and thus the spindle apparatus can be mounted or dismounted easily as in the case of the conventional spindle. Furthermore, when the control unit 5 suffers from a defect or failure, the control unit 5 can be repaired by removing the housing 7 from the housing 28 without the need for dismounting the spindle apparatus 1 as a whole from the spindle rail 10. Thus, labor involved in the dismounting and attachment of the control unit 5 can be reduced when compared with the structure which requires that the spindle apparatus 1 as a whole be dismounted for servicing the control unit.

Embodiment 4

[0039] Figure 5 shows another structure of the rotation speed monitoring unit 6 according to a fourth embodiment of the invention. Referring to the figure, in the instant structure of the rotation speed monitoring unit 6, the permanent magnet separated from the rotor 13 is not employed as the permanent magnet 24 constituting a part of the rotation speed monitoring unit 6 but the rotor 13 is formed longer than the stator 14, wherein the Hall IC module 26 is provided at a position corresponding to the projecting portion of the rotor 13. Thus, according to the teaching of the invention incarnated in the instant embodiment, not only the number of parts constituting the spindle apparatus but also the number of attaching steps involved in manufacturing or assembling the spindle apparatus 1 can be decreased.

[0040] In the foregoing, the embodiments of the present invention which are considered preferable at present and alternative, embodiments thereof have been described in detail by reference to the drawings. It should, however, be noted that the present invention is not to be restricted to these embodiments but other various additional modifications of the unitary spindle driving apparatus can be easily conceived.

[0041] By way of example, the modifications or changes in design mentioned below can be adopted with substantially the same effects.

(a) The feedback control of the motor 4 may be carried out by the CPU module on the basis of a command issued by the main control apparatus without providing the rotation speed monitoring unit 6.

(b) In place of the structure in which the Hall IC substrate 25 is formed in an annular shape and in which a portion of the wiring for electrically interconnecting the coil 14a of the stator 14 and the output line of the driver circuit module is constituted by the printed circuit (printed conductor), the end portion of the coil 14a may be electrically connected to the output line by electrical wiring. In that case, the Hall IC module 26 may be mounted directly on the inner wall surface of the housing 7.

(c) The rotation speed monitoring unit 6 may be disposed externally of the housing 7. It should however be mentioned that in this case, the rotation speed monitoring unit 6 may be subjected to adverse influences such as deposition of fly and the like.

(d) In the case of the spindle apparatus 1 which is designed for employment in a spinning machine which is not equipped with the simultaneous cop changer including the intermediate pegs, the driver circuit substrate 15 may be disposed at the front side of the housing 7 of the motor 4.

(e) The position at which the motor power input unit 18 and the control power input/communication signal input/output unit 19 are disposed is not limited to the rear side of the spindle apparatus 1. The motor power input unit 18 and the control power input/communication signal input/output unit 19 may be disposed at a bottom side, lateral side or upper side.

(f) Instead of adopting the combination of the permanent magnet and the Hall IC module 26 which cooperate to constitute the rotation speed monitoring unit 6, a reflection-type photo-sensor and a

reflector plate mounted on the spindle 3 rotatably together with the latter may be employed.

(g) Instead of forming the rotor 13 by a permanent magnet, it may be constituted by an iron core or the like.

[0042] Accordingly, all suitable modifications and equivalents may be resorted to, falling within the spirit and scope of the invention.

Claims

1. A unitary spindle driving apparatus for a spinning machine, comprising:

an electric motor for driving a spindle,
wherein a housing of a control unit is provided integrally with a housing of said electric motor above a portion of a bolster which projects downwardly from said housing of said electric motor; and
wherein wiring for electrically interconnecting said electric motor and said control unit is disposed within both of said housings.

2. A unitary spindle driving apparatus for a spinning machine according to claim 1,

wherein the housing of said electric motor and the housing of said control unit are formed integrally with each other.

3. A unitary spindle driving apparatus for a spinning machine according to claim 1 or 2,

wherein said control unit is disposed at a side opposite an inner side of a machine frame at which said unitary spindle driving apparatus is mounted on said spinning machine, and

wherein a motor power input unit and a control power input unit are disposed at the same side as said control unit.

4. A unitary spindle driving apparatus for a spinning machine according to any one of claims 1 to 3,

wherein a rotation speed monitoring unit for said spindle is accommodated within said housing of said electric motor; and

wherein said control unit is designed so as to perform a feedback control of said electric motor on the basis of an output signal of said rotation speed monitoring unit.

5. A unitary spindle driving apparatus for a spinning machine according to claim 4,

said rotation speed monitoring unit including:
a Hall IC module for detecting rotation of a magnet which rotates together with said spindle,
wherein said Hall IC module is disposed above a stator of said electric motor.

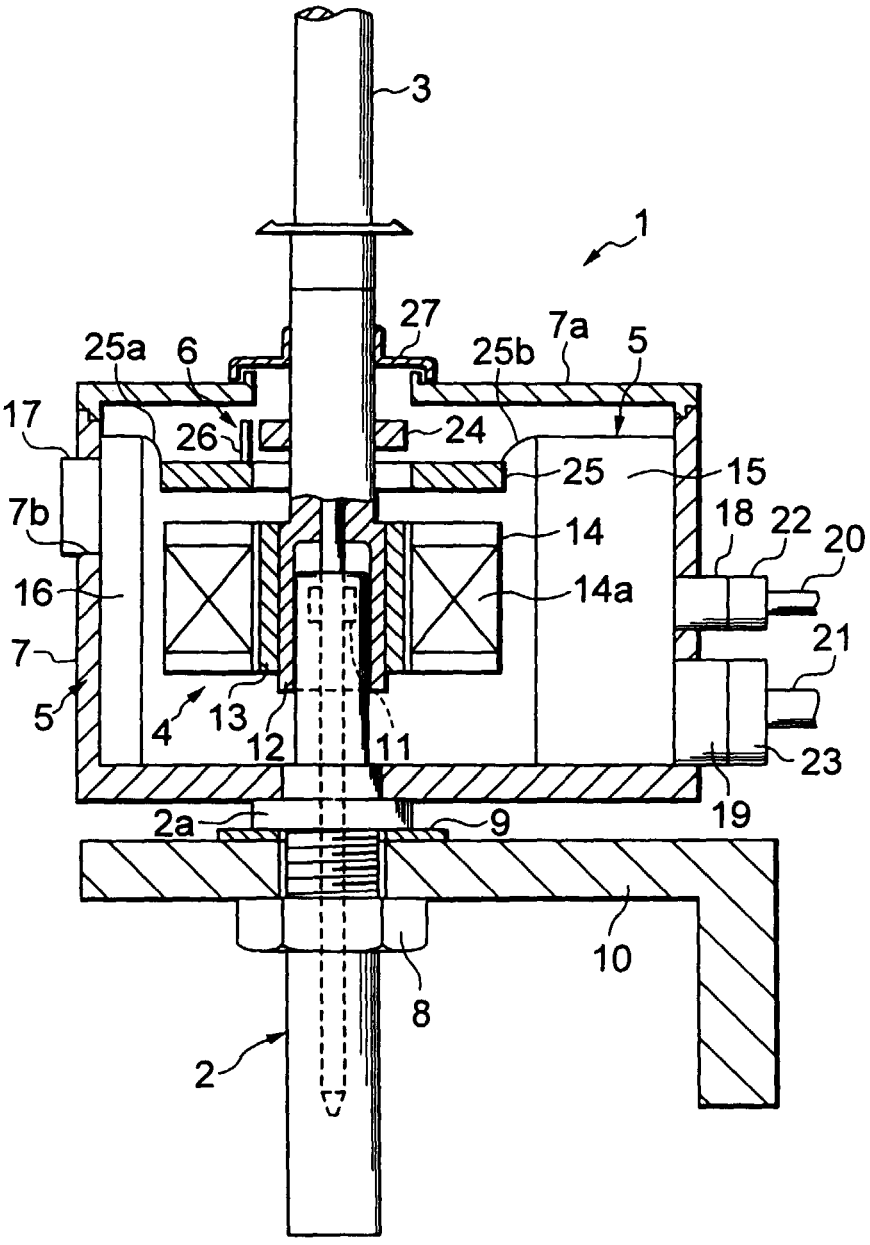
6. A unitary spindle driving apparatus for a spinning machine according to claim 1 or 2,

said control unit including:
a driver circuit substrate provided with a driving circuit module for controlling a driving current supplied to said electric motor; and
a CPU substrate provided with a CPU module for issuing a control command to said driving circuit module,
wherein said driver circuit substrate and said CPU substrate are disposed, respectively, at positions distanced from each other with said electric motor being interposed therebetween.

7. A unitary spindle driving apparatus for a spinning machine according to claim 6,

said housing of said electric motor including:
a Hall IC module for detecting rotation of a magnet which rotates together with said spindle; and
a Hall IC substrate,
wherein said CPU module and said driving circuit module are electrically interconnected by way of a printed circuit formed on said Hall IC substrate.

FIG. 1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25b
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7b
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2a
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19
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8
2

FIG. 2

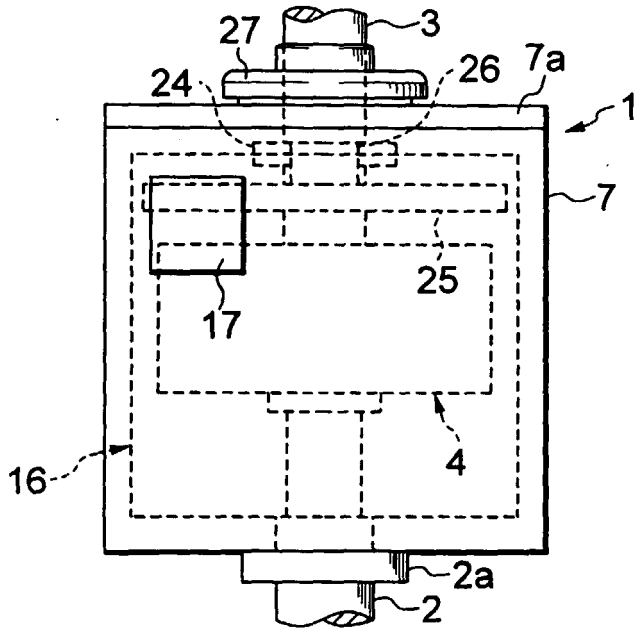

FIG. 3

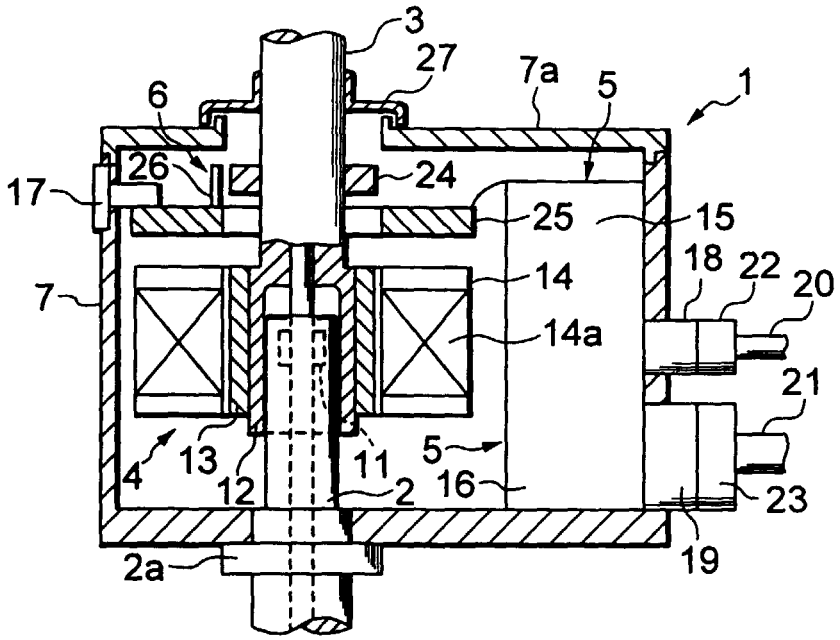

FIG. 4

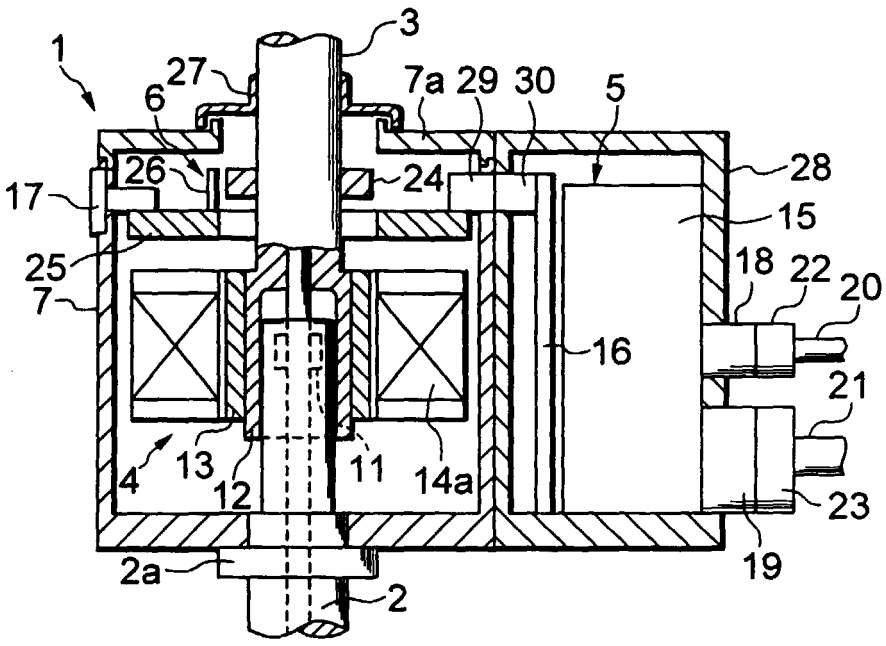
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FIG. 5

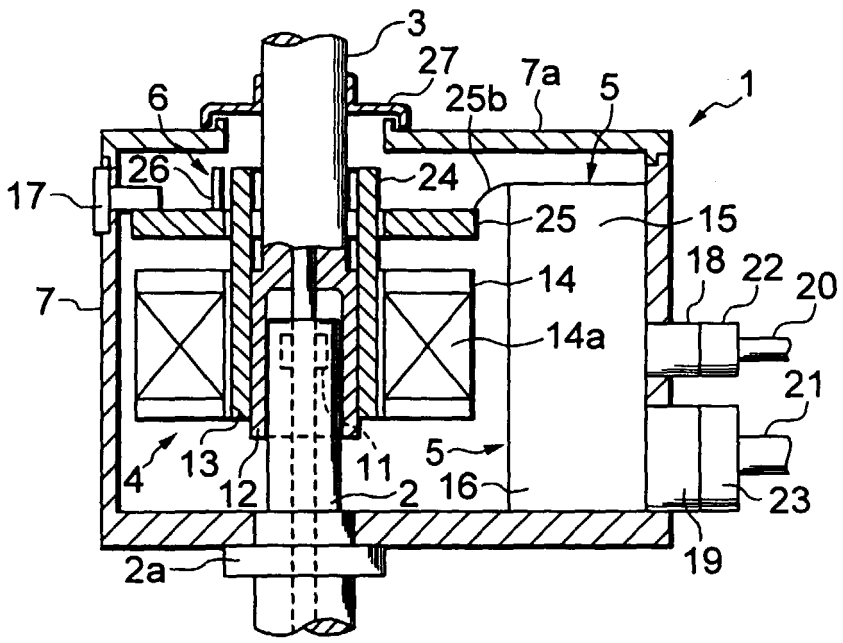
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FIG. 6

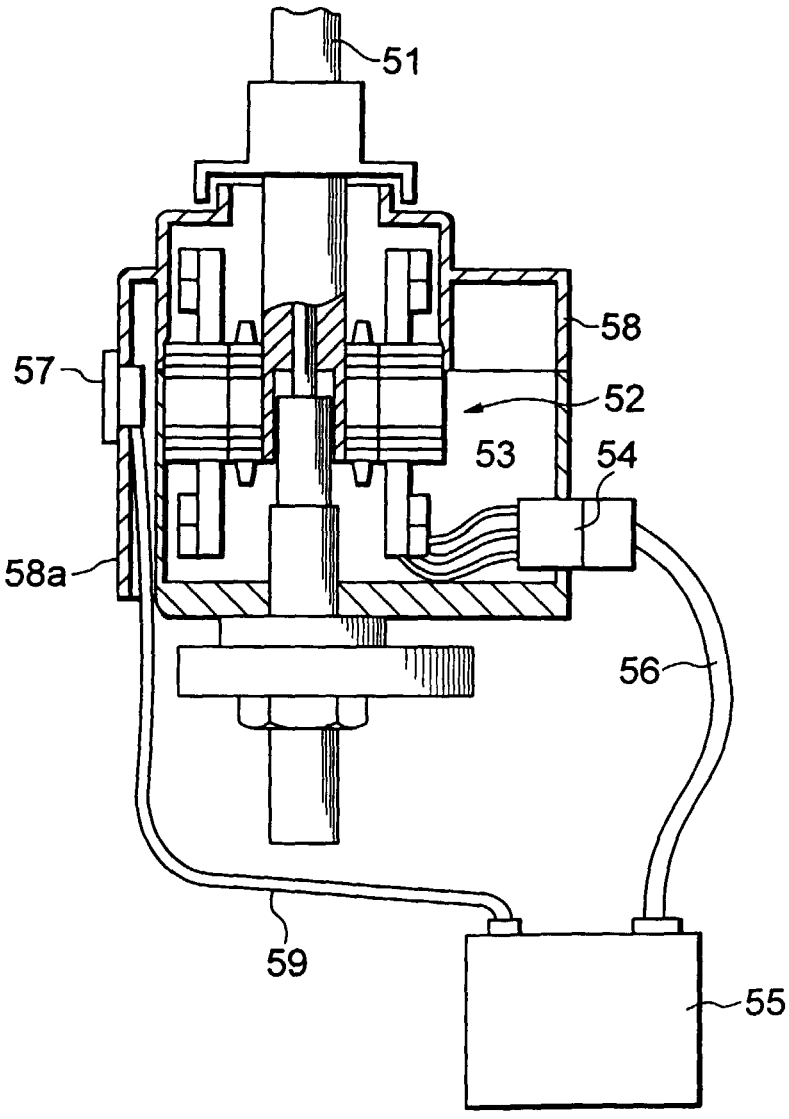

FIG. 7