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(71) Applicant: **Kabushiki Kaisha Toyoda Jidoshokki Seisakusho**
Aichi-ken (JP)

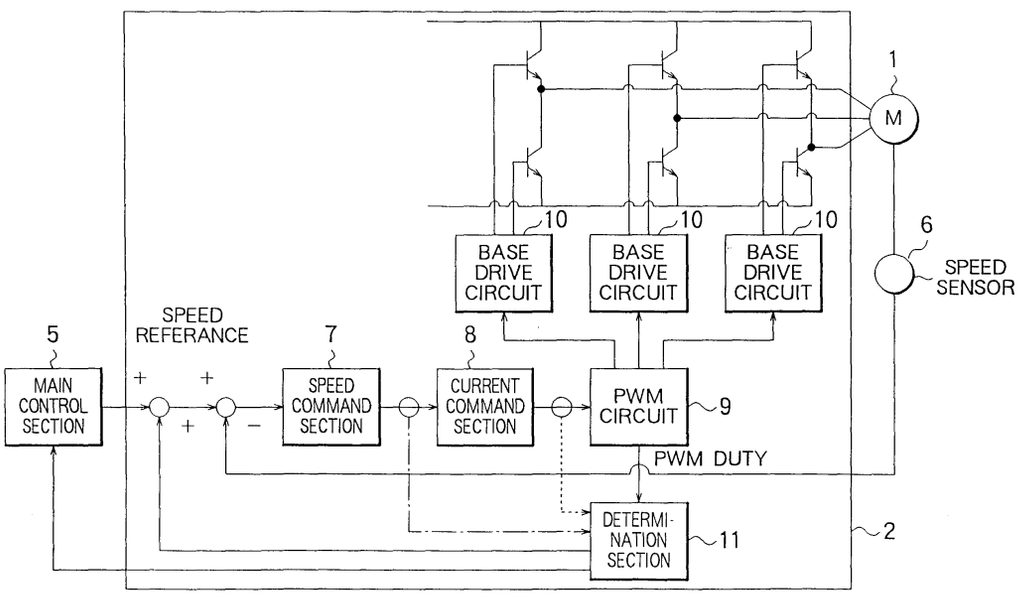
(72) Inventors:
- **Tsuboi, Masayoshi**
  Kariya-shi, Aichi-ken (JP)
- **Shinozaki, Yutaka**
  Kariya-shi, Aichi-ken (JP)
- **Uematsu, Tatsuya**
  Kariya-shi, Aichi-ken (JP)
- **Odachi, Yasuharu**
  Kariya-shi, Aichi-ken (JP)

(74) Representative: **HOFFMANN - EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) Ring spinning machine with individual spindle drives

(57) In a spindle driving apparatus for a ring fine spinning machine, a plurality of spindles have dedicated synchronous motors, inverters and control circuits individually connected thereto, and the control circuits are connected to a common dc power supply. Each control circuit outputs a PWM signal to the corresponding inverter, monitors a PWM duty, detects a drastic change in the driving condition of the corresponding spindle as a result of a change in the PWM duty, and stops the corresponding synchronous motor through that inverter.

FIG. 2



EP 0 999 298 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a single spindle driving ring fine spinning machine.

[0002] It has been known that the spindles of a ring fine spinning machine are driven independently of one another by dedicated motors.

[0003] Such a conventional single spindle driving fine spinning machine uses induction motors 10 for driving the spindles, respectively, as shown in FIG. 4, and these induction motors 10 are collectively driven by only one inverter 11. Note that reference numeral 12 denotes a draft roller drive motor and that reference numeral 13 denotes an inverter for the draft roller drive motor 12.

[0004] Slip occurs in the induction motor. Thus, the induction motor has addressed a shortcoming. That is, slip causes the rotational speed of the motor to change with changing yarn winding amount, and then causes the yarn twisting amount to change with changing rotational speed of the motor. Further, since the only one inverter collectively drives many induction motors, the machine can not stop only the motor that corresponds to a spindle suffering from an abnormality such as a yarn breakage singly and through remote operation. Still further, in order to detect a driving abnormality such as a yarn breakage in each spindle, a special current detector for detecting a current supplied to each driving motor needs to be provided.

SUMMARY OF THE INVENTION

[0005] An object of the present invention is to provide a single spindle driving ring fine spinning machine that has overcome the aforementioned shortcomings that: the yarn twisting amount is changed due to a change in winding amount and due to a change in rotational speed caused by the fact that the induction motor is used as a single spindle driving motor; and a special detector such as a current detector needs to be provided in order to check the driving condition of each spindle, i.e., whether an abnormality such as a yarn breakage has occurred at each spindle.

[0006] According to a first aspect of the present invention, there is provided a single spindle driving ring fine spinning machine comprising single spindle driving motors dedicated to spindles, respectively, wherein the single spindle driving motors are synchronous motors; each of the synchronous motors is subjected to a pulse width modulation control based on a difference between a speed reference inputted from an outside source and a speed of that synchronous motor; and the driving condition of each of the spindles is monitored based on a control signal used for the drive control of a corresponding one of the synchronous motors.

[0007] Synchronous motors are used in place of the conventional induction motors. That is, each spindle is driven by an electric motor such as a brushless dc motor or an SR motor in which the winding is provided on the stator to produce a rotating field, and the rotor having dc magnetic poles is rotated at a synchronous speed that is the same as the speed of the rotating field. Using such a synchronous motor, slip no longer occurs, and thus the rotational speed of the motor does not change even if the yarn winding amount is increased, and hence the problem that the yarn twisting amount is changed is eliminated. Further, when an abnormality such as a yarn breakage has occurred, the synchronous motor maintains its rotational speed constant, and thus the control signal used for the drive control of the synchronous motor undergoes a drastic change. Therefore, by monitoring the control signal, the driving condition of each spindle can be checked.

[0008] According to a second aspect of the present invention, in such a single spindle driving ring fine spinning machine, the control signal is a PWM duty used in the pulse width modulation control. Thus, by monitoring the PWM duty of each synchronous motor on software, the driving condition of each spindle can be checked.

[0009] According to a third aspect of the present invention, as another method, the driving condition of each spindle may be checked by monitoring a current reference used in a speed PI control.

[0010] Further, according to a fourth aspect of the present invention when the control signal corresponding to a spindle has undergone such a drastic change as to exceed a predetermined rate, the synchronous motor for driving such a spindle may be stopped. As a result of this arrangement, the operation of only a spindle at which an abnormality such as a yarn breakage has occurred can be stopped singly as well as through remote operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] In the accompanying drawings:

FIG. 1 is a diagram showing the construction of a ring fine spinning machine according to the present invention;

FIG. 2 is a diagram showing a speed command section of a spindle drive motor shown in FIG. 1;

FIG. 3A is a diagram showing the rotational speed and current of the spindle drive motor according to the present invention in function of winding time;

FIG. 3B is a diagram showing the current and the phase voltage of the winding of the spindle drive motor according to the present invention during normal operation;

FIG. 3C is a diagram showing the current and the phase voltage of the winding of the spindle drive motor according to the present invention at the time of a yarn breakage; and

FIG. 4 is a diagram showing the construction of a conventional ring fine spinning machine.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] An embodiment of the present invention will now be described in detail with reference to the accompanying drawings. In a single spindle driving ring fine spinning machine according to the present invention, a draft roller (not shown) is driven by a draft roller drive motor 12 as shown in FIG. 1. The draft roller drive motor 12 is driven by a commercial alternating current feed line 4 through an inverter 13. Further, many spindles (not shown) are driven by synchronous motors 1 such as brushless dc motors or SR motors for driving spindle. Each spindle drive motor 1 has a dedicated inverter 2 connected thereto, and each inverter 2 is supplied with direct current from a dc power supply 3. Each inverter 2 effects control to drive the corresponding spindle drive motor 1 based on the difference between a speed reference signal from a main control section 5 and a speed signal from a corresponding speed sensor 6.

[0013] The drive control of each spindle driving synchronous motor is effected by the inverter 2 in such a manner as shown in FIG. 2. When the inverter 2 receives a speed reference from the main control section 5, a speed command section 7 of the inverter 2, which is constructed of a speed amplifier, sends a predetermined speed reference signal. Based on the signal from the speed command section 7, the current amplifier of a current command section 8 sends a current reference. In response to the current reference, a PWM circuit 9 sends a predetermined PWM signal to base drive circuits 10, and the corresponding spindle drive motor 1 is driven based on the PWM signal.

[0014] The spindle drive motor 1 has the speed sensor 6. A signal from the speed sensor 6 is fed back to the input side of the speed command section 7. Further, in this embodiment, the PWM duty set by the PWM circuit 9, which serves as a control signal, is fed back to the input side of the speed command section 7 via a determination section 11.

[0015] The PWM duty is monitored as follows. FIG. 3A schematically shows the rotational speed of the spindle drive motor 1 and its current changes in function of winding time. If it is supposed that the rotational speed of the spindle drive motor 1 is maintained constant in function of the winding time, then the load increases with a gradual increase in the winding amount from the winding start, and thus the current supplied to the spindle drive motor 1 also increases. However, when a yarn breakage has occurred for some reason, the load gets reduced, and as a result, the current supplied to the spindle drive motor 1 gets reduced drastically and remains almost constant at such a reduced level. The current supplied to the spindle drive motor 1 and the phase voltage of its winding exhibit such values as shown in FIG. 3B during normal operation. That is, when the spindle drive motor 1 is in the steady state, the phase voltage of its winding is repeatedly turned on and off at a predetermined pulse width, and thus the current supplied to the spindle drive motor 1 is maintained on and off within a predetermined range defined by an average value. The PWM duty under this condition is as follows: PWM duty = ON time x 100% / {(ON time) + (OFF time)}.

[0016] On the other hand, when the load of the spindle is reduced due to, e.g., a yarn breakage, the average current is reduced. The phase voltage of each winding of the spindle drive motor 1 exhibits a longer OFF time than its ON time as shown in FIG. 3C. Thus, when a drastic change of the PWM duty from the state shown in FIG. 3B to the state shown in FIG. 3C is detected by monitoring the PWM duty, a load fluctuation due to, e. g., a yarn breakage can be located. When the determination section 11 determines such a load fluctuation, the determination section 11 outputs an abnormality signal to the main control section 5. In response to the abnormality signal, the main control section 5 stops the spindle drive motor 1 for the spindle of interest. It may also be designed so that the abnormality of the spindle of interest is only displayed on a display unit (not shown) without stopping the corresponding spindle drive motor 1.

[0017] While the PWM duty is inputted to the determination section 11 from the PWM circuit 9 in the aforementioned embodiment, an abnormality such as a yarn breakage can be determined by causing the current command section 8 to input the current reference to the determination section 11 as shown by the broken line in FIG. 2, the current reference serving as a control signal to be inputted from the current command section 8 to the PWM circuit 9. Further, as shown by the one-dot chain line in FIG. 2, an abnormality can be determined by causing the speed command section 7 to input the speed reference signal to the determination section 11, the speed reference signal serving as a control signal to be inputted from the speed command section 7 to the current command section 8.

[0018] Further, the spindle drive motor 1 can be stopped in the following ways. A control signal such as the PWM duty in the inverter 2 is outputted directly to the main control section 5, so that a determination section commonly used by the spindles is provided in the main control section 5. Further, the speed reference from the main control section 5 is invalidated based on the determination result obtained by the determination section 11 of each inverter 2.

[0019] According to the present invention, by effecting PWM control of a synchronous motor that serves as a single spindle driving motor of a single spindle driving ring fine spinning machine, the rotational speed of the spindle drive motor can be maintained at a predetermined value independently of a change in the winding amount, and thus the shortcoming that the twisting amount of a yarn is changed due to a change in the rotational speed of the motor that is caused by a change in the winding amount can be eliminated.

[0020] Further, according to the present invention, the driving conditions of the spindles can be detected on

control software by monitoring a control signal used for the drive control of each of the synchronous motors, and thus abnormalities can be detected without using current sensors.

Claims

1. A single spindle driving ring fine spinning machine comprising single spindle driving motors dedicated to spindles, respectively, characterized in that

   said single spindle driving motors are synchronous motors,
   each of said synchronous motors is subjected to a pulse width modulation control based on a difference between a speed reference inputted from an outside source and a speed of said synchronous motor and
   the driving condition of each of the spindles is monitored based on a control signal used for the drive control of a corresponding one of said synchronous motors.

2. The single spindle driving ring fine spinning machine according to claim 1, wherein said control signal is a PWM duty used in the pulse width modulation control.

3. The single spindle driving ring fine spinning machine according to claim 1, wherein said control signal is a current reference used in a speed PI control.

4. The single spindle driving ring fine spinning machine according to any one of claims 1 to 3, wherein when said control signal corresponding to a spindle has undergone such a drastic change as to exceed a predetermined rate, said synchronous motor for driving the spindle is stopped.

FIG. 1

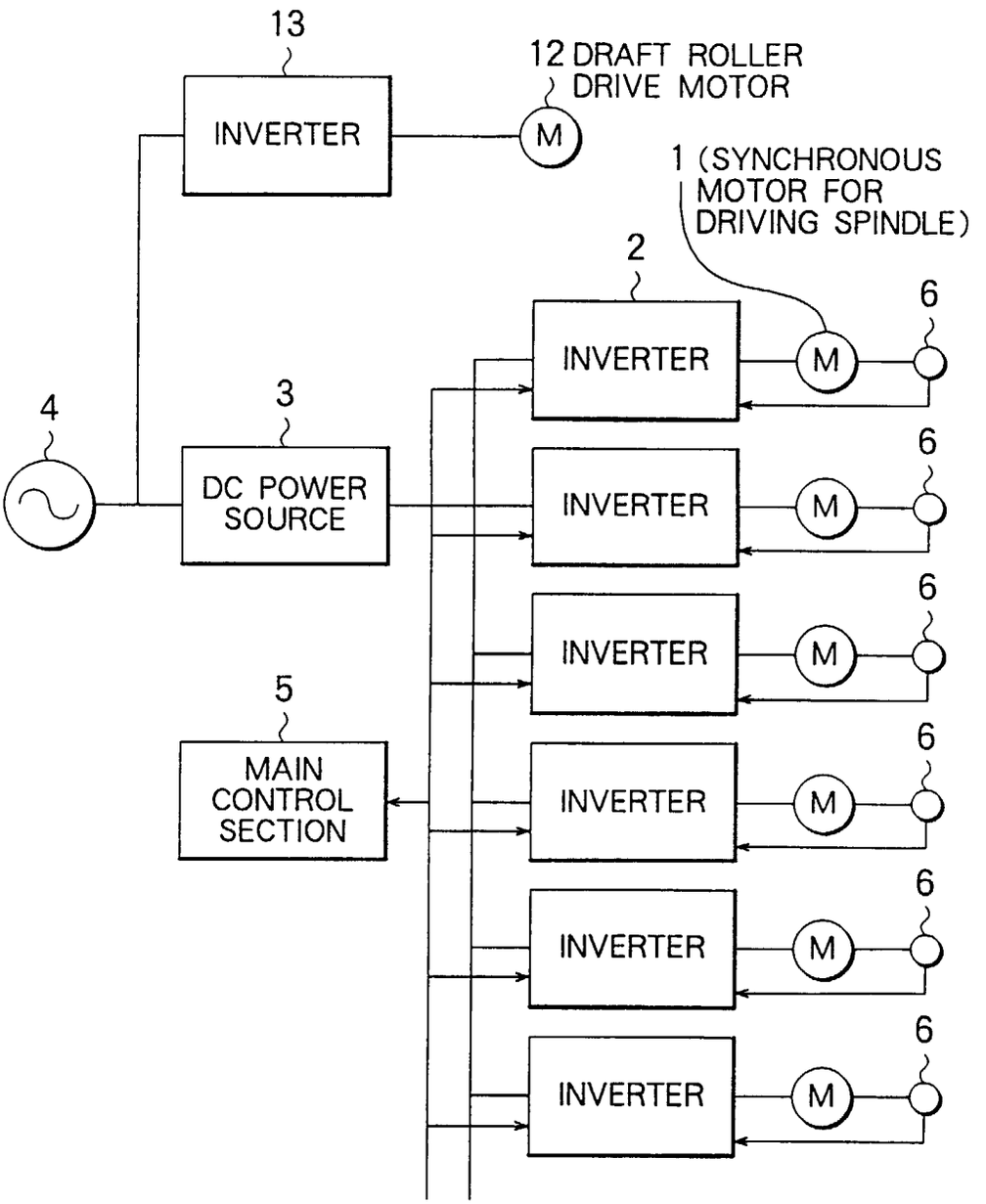

13
INVERTER
12 DRAFT ROLLER DRIVE MOTOR
M
1 (SYNCHRONOUS MOTOR FOR DRIVING SPINDLE)
2
6
INVERTER
M
4
3
DC POWER SOURCE
INVERTER
INVERTER
INVERTER
5
MAIN CONTROL SECTION
INVERTER
INVERTER
INVERTER

FIG. 2

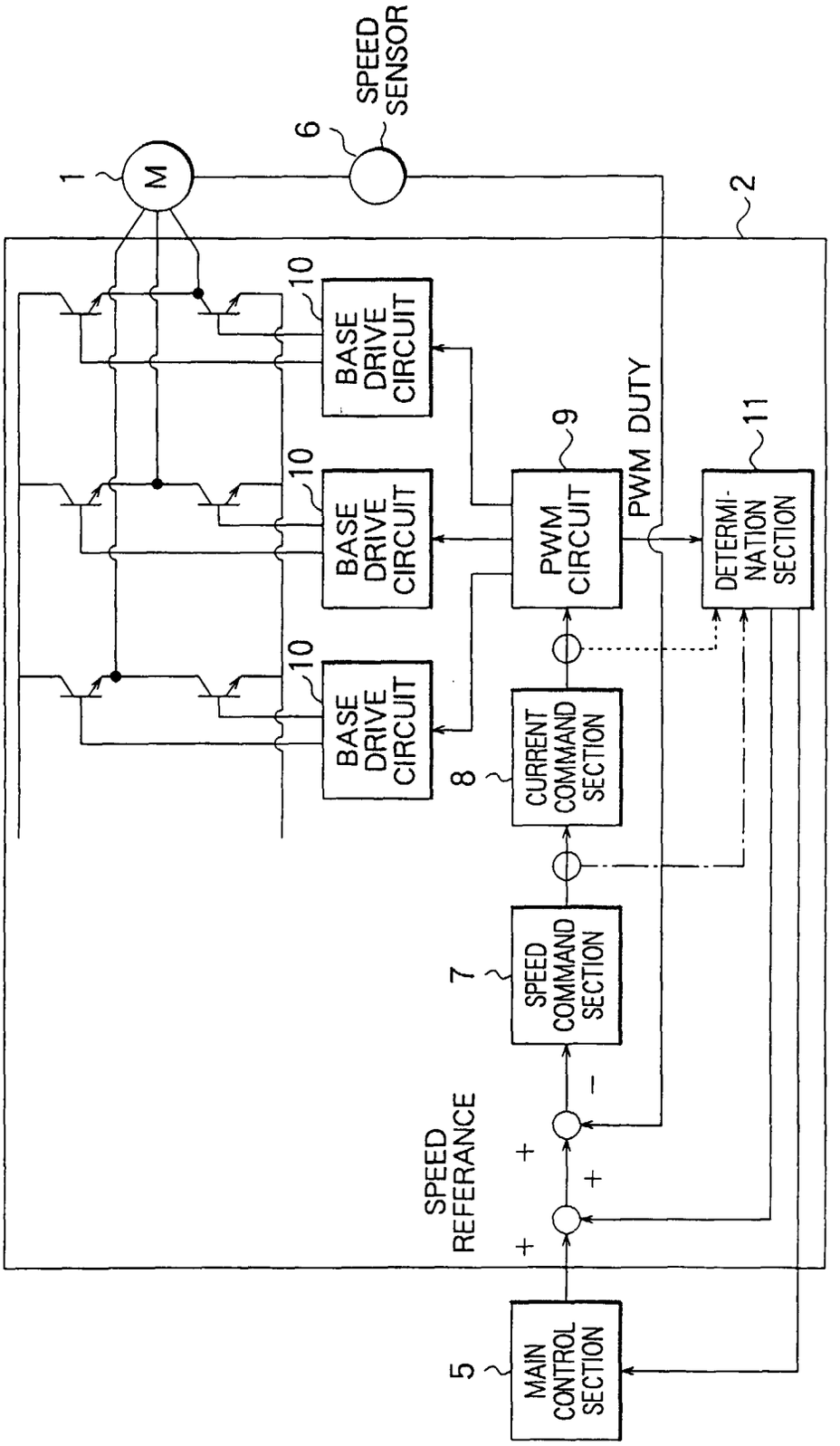

1
M
6
SPEED SENSOR
2
10
BASE DRIVE CIRCUIT
10
BASE DRIVE CIRCUIT
10
BASE DRIVE CIRCUIT
9
PWM CIRCUIT
PWM DUTY
11
DETERMI-NATION SECTION
8
CURRENT COMMAND SECTION
7
SPEED COMMAND SECTION
SPEED REFERANCE
+
+
+
−
5
MAIN CONTROL SECTION

FIG. 3A

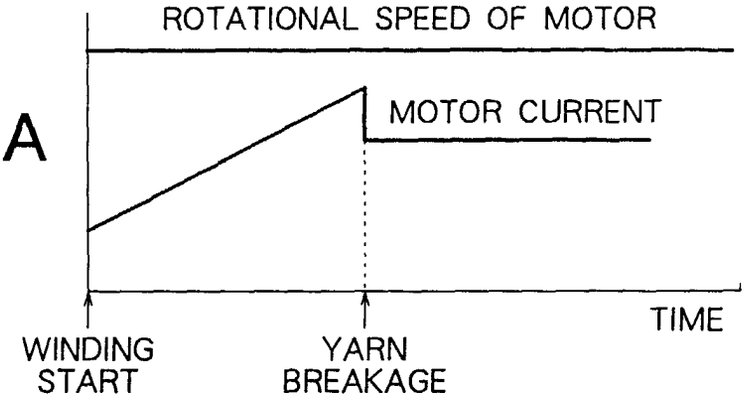


FIG. 3B

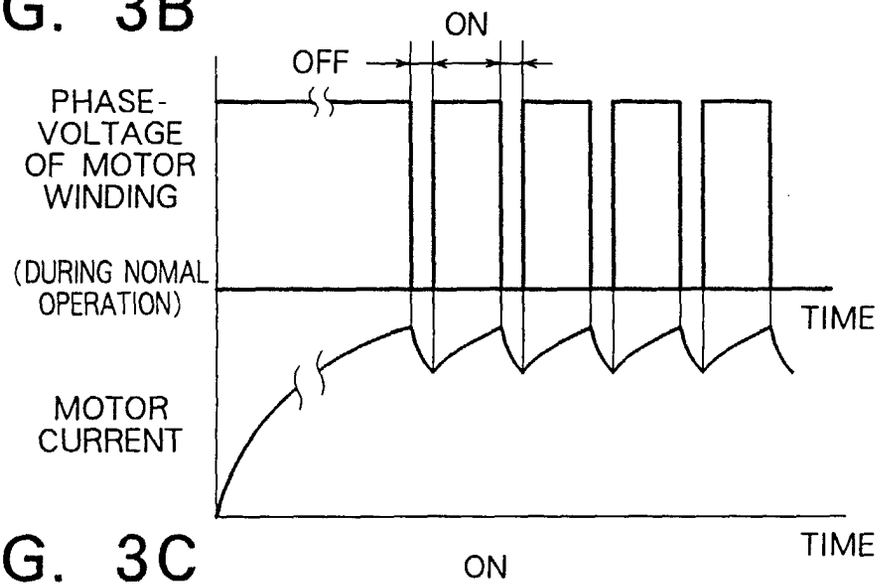


FIG. 3C

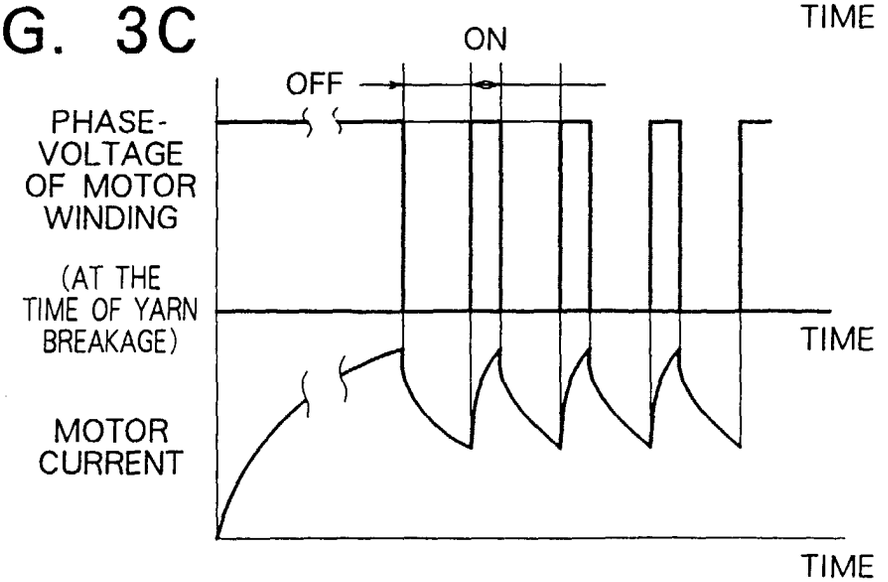
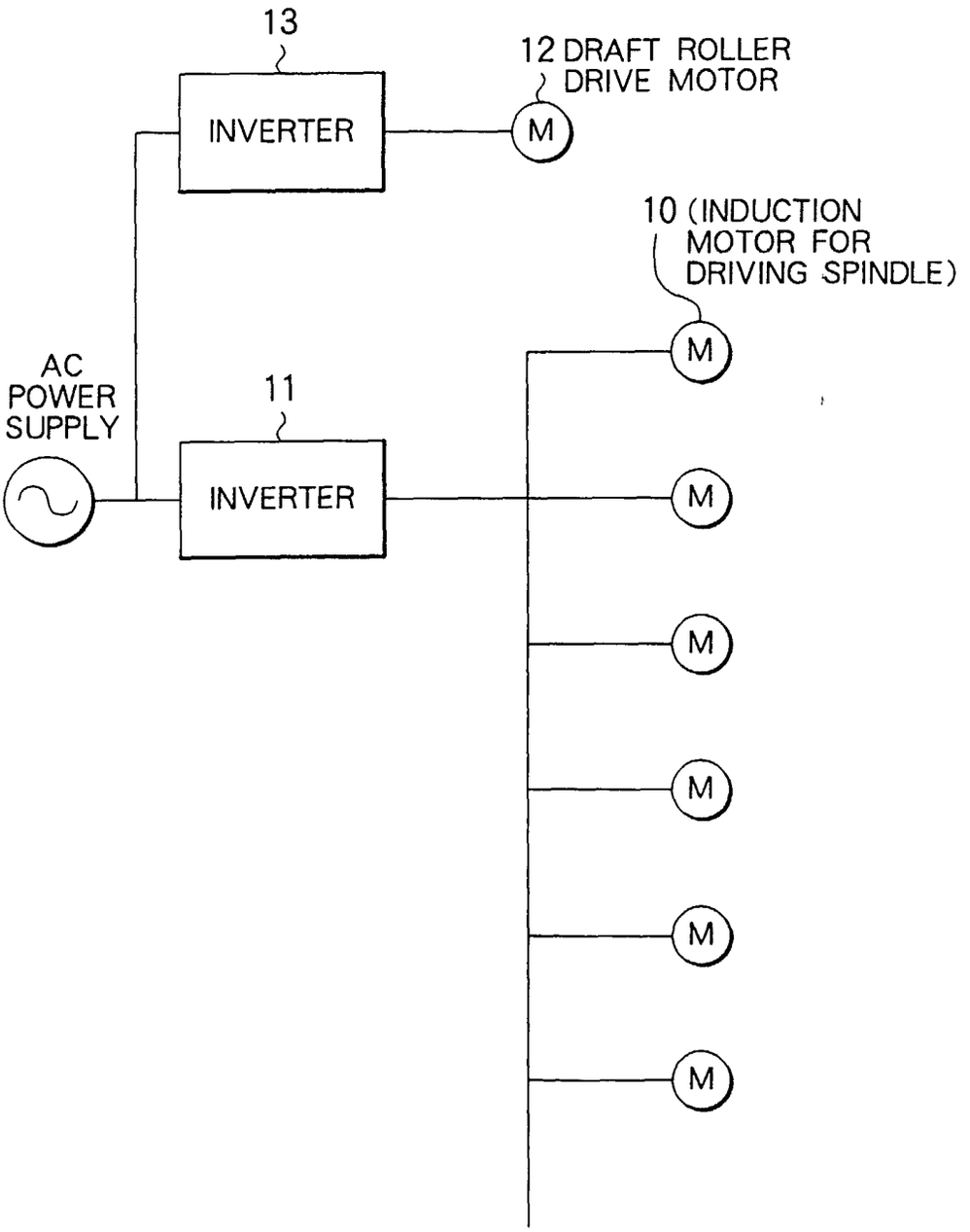


FIG. 4


13
12 DRAFT ROLLER DRIVE MOTOR
INVERTER
M
10 (INDUCTION MOTOR FOR DRIVING SPINDLE)
AC POWER SUPPLY
11
INVERTER
M
M
M
M
M
M