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

(11) EP 2 674 262 A1

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

(43) Date of publication:
18.12.2013 Bulletin 2013/51

(21) Application number: **12744616.9**

(22) Date of filing: **06.02.2012**

(51) Int Cl.:
B25F 5/00 *(2006.01)* ***B25B 23/14*** *(2006.01)*

(86) International application number:
PCT/JP2012/052588

(87) International publication number:
WO 2012/108372 (16.08.2012 Gazette 2012/33)

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

(30) Priority: **07.02.2011 JP 2011024116**

(71) Applicant: **Panasonic Corporation**
Osaka 571-8501 (JP)

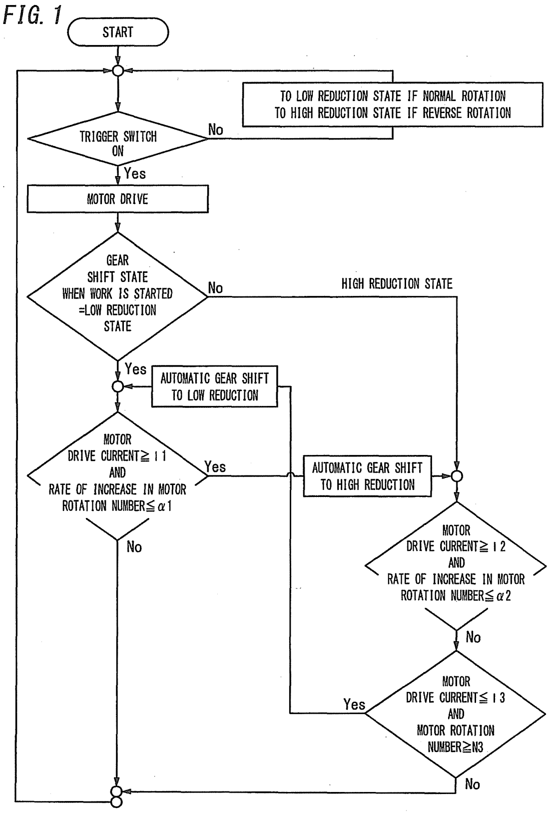
(72) Inventors:
- **ARIMURA, Tadashi**
  Osaka 540-6207 (JP)
- **YAMADA, Yutaka**
  Osaka 540-6207 (JP)
- **INAGAKI, Kenichiro**
  Osaka 540-6207 (JP)
- **ATSUMI, Masatoshi**
  Osaka 540-6207 (JP)
- **KAIZO, Hiroyuki**
  Osaka 540-6207 (JP)

(74) Representative: **Appelt, Christian W.**
Boehmert & Boehmert
Pettenkoferstrasse 20-22
80336 München (DE)

(54) POWER TOOL

(57) A power tool includes: a motor that serves as a rotational power source and is rotatable in a normal rotation direction and a reverse rotation direction; an output unit that is driven by the motor to be rotated; and a transmission that is located between the motor and the output unit and switches a reduction ratio. The power tool further includes a control means. The control means makes the transmission perform switching operation of the reduction ratio in response to a workload, and changes an initial reduction ratio in the transmission when work is started, in response to a rotation direction of the motor. The initial reduction ratio is set as the reduction ratio in an initial setting.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The invention relates generally to power tools and, more particularly, to a power tool that includes a gear shifting means.

BACKGROUND ART

[0002] When performing work, such as tightening of a screw or drilling, using a power tool which is capable of switching a reduction ratio in response to a workload's volume, at first, a user starts performing the work at a low reduction ratio, that is, a low-torque high-speed rotation, and then increases the reduction ratio, and changes toward a high-torque low-speed rotation side, in order to perform effectively the work. However, with respect to the power tool that requires shifting gear by the user's hand for switching the reduction ratio, the user needs to set to the low reduction ratio at the start of the work, and to switch toward the high reduction ratio side in middle of the work. Therefore, such a power tool increases the burden on the user.

[0003] For this reason, in the following Patent literature 1, a power tool has been proposed which detects change in a load torque directly or indirectly and shifts gear automatically in response to the change.

[0004] However, with respect to the conventional power tool that performs automatic gear shift, the low reduction ratio is fixed at the start of the work, and in addition, the low reduction ratio is fixed also when a motor is rotated in a reverse rotation direction.

[0005] Therefore, not in the case where the power tool tightens the screw by a normal rotation of the motor but in the case where the power tool loosens the screw by a reverse rotation of the motor, because the low reduction ratio is fixed, the work is started by the low-torque high-speed rotation in spite of needing the high-torque at the start of the work. As a result, the power tool increases the burden on the motor and the like. If the user starts loosening the screw after setting to the high reduction ratio by the user's hand, the burden on the motor and the like can be reduced. However, under such hand operation, the user cannot take advantage of the automatic gear shift.

PRIOR ART DOCUMENTS

PATENT LITERATURE

[0006] Patent literature 1: Japanese patent application publication No. 2009-78349

SUMMARY OF THE INVENTION

PROBLEMS TO BE RESOLVED BY THE INVENTION

[0007] It is an object of the invention to provide a power tool, which can shift gear automatically, and further can start at reduction ratios respectively suitable for both of works performed by a normal rotation and a reverse rotation of a motor.

MEANS OF SOLVING THE PROBLEMS

[0008] A power tool of the present invention comprises: a motor serving as a rotational power source, the motor being rotatable in a normal rotation direction and a reverse rotation direction; an output unit driven by the motor to be rotated; and a transmission located between the motor and the output unit, the transmission switching a reduction ratio, and wherein the power tool further comprises a control means that makes the transmission perform switching operation of the reduction ratio in response to a workload, the control means changing an initial reduction ratio in the transmission when work is started, in response to a rotation direction of the motor, the initial reduction ratio being set as the reduction ratio in an initial setting.

[0009] In the power tool, preferably, the initial reduction ratio when the rotation direction of the motor is the reverse rotation direction is set higher than the initial reduction ratio when the rotation direction of the motor is the normal rotation direction. Or, preferably, the initial reduction ratio when the rotation direction of the motor is the reverse rotation direction is set lower than the initial reduction ratio when the rotation direction of the motor is the normal rotation direction. Or, preferably, the initial reduction ratio when the rotation direction of the motor is the normal rotation direction is set at a non-low reduction ratio side, and the initial reduction ratio when the rotation direction of the motor is the reverse rotation direction is also set at the non-low reduction ratio side. The power tool can suitably use the above-mentioned configurations.

[0010] The power tool may further comprise a work-start gear shift setting means that changes the initial reduction ratio in the transmission through user operation when the work is started.

[0011] In the power tool, the transmission may be capable of switching the reduction ratio in three speed stages or more.

[0012] In the power tool, the power tool may further comprise an indicating means that indicates the initial reduction ratio to a user.

EFFECT OF THE INVENTION

[0013] The power tool of the present invention can start at reduction ratios respectively suitable for both of works performed by a normal rotation and a reverse rotation of the motor. Therefore, the burden on the power tool can be reduced, and the work efficiency can be improved, and the user can work with comfort.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a flow chart showing operation of one example of a power tool according to an embodiment of the present invention.
Fig. 2 is a block diagram showing one example of the power tool according to the embodiment of the present invention.
Figs. 3(a) and 3(b) are illustration diagrams of torque changes with respect to tightening (loosening) of a screw, and Fig. 3(a) is an illustration diagram in the case where a motor is rotated in a normal rotation direction, and Fig. 3(b) is an illustration diagram in the case where the motor is rotated in a reverse rotation direction.
Fig. 4 is a flow chart showing operation of another example of the power tool according to the embodiment of the present invention.
Figs. 5(a) and 5(b) are illustration diagrams of torque changes with respect to tightening (loosening) of a reverse-threaded screw, and Fig. 5(a) is an illustration diagram in the case where the motor is rotated in the normal rotation direction, and Fig. 5(b) is an illustration diagram in the case where the motor is rotated in the reverse rotation direction.
Fig. 6 is a flow chart showing operation of yet another example of the power tool according to the embodiment of the present invention.
Figs. 7(a) and 7(b) are illustration diagrams of torque changes about works respectively.
Fig. 8 is a block diagram showing another example of the power tool according to the embodiment of the present invention.
Fig. 9 is a flow chart showing operation of said another example of the power tool according to the embodiment of the present invention.
Fig. 10 is a flow chart showing operation of yet another example of the power tool according to the embodiment of the present invention.
Fig. 11 is an illustration diagram of torque change about work of drilling.
Fig. 12 is a block diagram showing another example of the power tool according to the embodiment of the present invention.
Fig. 13 is a plain view showing said another example of the power tool according to the embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0015] The present invention will be explained below in detail based on examples shown in Figures. A power tool shown in Fig. 2 is an electric drill driver. The power tool includes: a motor **10** that serves as a power source and is rotatable in a normal rotation direction and a reverse rotation direction; an output unit **12**; and a transmission **11** that has a gear shifting function to switch a reduction ratio. Then, the rotational output of the motor **10** is outputted to the output unit **12** through the transmission **11**. The reference number **18** shown in Fig. 18 represents a battery pack.

[0016] The transmission **11** is capable of switching the reduction ratio through an electromagnetic member such as a solenoid. The switching operation of the reduction ratio is performed under control of a control circuit **13**.

[0017] The control circuit 13 controls rotation of the motor **10** in response to the operation of a trigger switch **14**. The control circuit **13** drives the motor 10 through a motor drive circuit 15, and is connected to: a rotation number detection means **16** that detects the rotation number **N** of the motor **10**; and a current detection means **17** that detects a motor drive current **I**. When the switching operation of the reduction ratio is performed automatically in response to the workload, the control circuit **13** directs the transmission **11** to switch the reduction ratio in the transmission **11** in response to a detection output of a drive status detection means that is constituted by the rotation number detection means **16** and the current detection means **17**.

[0018] Here, in the case where an output load is small when the motor **10** is started, the motor drive current **I** increases, and also the rate of increase in the motor rotation number **N** increases. In the case where the output load is large, the motor drive current **I** similarly increases, but the rate of increase in the motor rotation number **N** decreases or reduces to zero.

[0019] Therefore, with respect to the control circuit **13** that is constituted by one-chip microcomputer or the like in this power tool, the reduction ratio is set at a low side (the reduction ratio 1 in Fig. 1) in an initial setting. Then, when two conditions: "the motor drive current **I** >= **I1** (A)"; and "the rate of increase in the motor rotation number **N** <= α**1**" are fulfilled, the reduction ratio is automatically changed to a high side (the reduction ratio 2 in Fig. 1).

[0020] Accordingly, in the case where the output load is small at the time of start and the workload gradually increases with progression of the work, the motor drive current **I** gradually increases and the motor rotation number **N** decreases. Then, upon fulfillment of the two conditions: "the motor drive current **I** >= **I1** (A)"; and "the rate of increase in the motor rotation number **N** <= α**1**", the control circuit **13** makes the transmission **11** change automatically the reduction ratio to the high side. In the decrease in the motor rotation number **N**, the rate of increase in the motor rotation number **N** may become a negative value.

[0021] The automatic gear shift is performed under the above-mentioned conditions. Therefore, even if there is an inrush current generated when the motor **10** is started or an inrush current generated when the user repeatedly performs operation for turning on the trigger switch **14** under non-load state of output in order to return to the brink of the off-state, incorrect switching for the automatic gear shift can be prevented by setting a value of the above-mentioned α**1** as a determinable rate in increase.

[0022] In the case where the workload decreases with progression of the work, the reduction ratio is changed toward a direction to be reduced. When the workload decreases, the motor drive current I decreases and the motor rotation number **N** increases. Therefore, when two conditions: "the motor drive current **I** <= **I3** (A)"; and "the motor rotation number **N** >= **N3**" are fulfilled, the reduction ratio is automatically changed to a low reduction ratio (that is, the high-speed side).

[0023] Here, the power tool, such as an electric drill driver, is often used for tightening a screw by rotating the motor **10** in a normal rotation direction. In this case, the workload is small at the start of the work and increases with progression of tightening of the screw. For this reason, preferably, when the above-mentioned automatic gear shift is performed, the reduction ratio is set at the low reduction ratio (a low-torque high-speed rotation) in the initial state as explained above. Preferably, when the workload increases, automatically the reduction ratio is changed to a high reduction ratio (a high-torque low-speed rotation), and when the work is completed and the trigger switch **14** is turned off, the reduction ratio is returned to the low reduction ratio that has been set in the initial state.

[0024] Here, when considering the case where the work is performed by rotating the motor **10** in a reverse rotation direction, there is the work for loosening of the screw that has been tightened, as the major example. In this case, as shown in Fig. 3(b), the workload is large at the early period of the work. At this time, if the low reduction ratio is similarly set in the initial setting, a large load is added to the motor **10** at the start of the work, and further, the actual work for loosening of the screw starts after the reduction ratio is switched to the high reduction ratio. As a result, loss of time may be generated. Also, motor lock may be generated at the start of the work. When not assembling work but disassembling work is performed, most works are performed by rotating the motor in the reverse rotation direction. For this reason, if the initial reduction ratio is set in the case of the reverse rotation direction in the same manner as the case of the normal rotation direction, such a power tool runs into many problems.

[0025] Accordingly, in the power tool, the initial reduction ratio is set at the low reduction ratio when the motor is rotated in the normal rotation direction, and is set at the high reduction ratio when the motor is rotated in the reverse rotation direction, in response to a rotation direction that has been set by a rotation direction switching means **19** that switches the rotation direction of the motor **10**. It is preferred that switching of the reduction ratio for this is performed at a timing of when the rotation direction switching means **19** switches the rotation direction of the motor **10**.

[0026] Because the initial reduction ratio is switched in response to the rotation direction of the motor **10**, as described above, the control circuit **13** in the power tool controls the transmission **11** to start operation in the state of the low reduction ratio when the motor **10** is rotated in the normal rotation direction, and then automatically to switch the reduction ratio to the high reduction ratio with the increase in the workload, and then to return to the low reduction ratio when the work is completed and the trigger switch **14** is turned off.

[0027] When the rotation direction switching means **19** sets the rotation direction of the motor **10** to the reverse rotation direction, the transmission **11** is switched to the state of the high reduction ratio at this time. Therefore, the user can start work in the state of the high-torque low-speed rotation upon turning on the trigger switch **14**. Then, the workload gradually decreases, and then if the above-mentioned conditions are fulfilled, the reduction ratio in the transmission **11** is automatically changed to the low reduction ratio side. Then, when the work is completed and the trigger switch **14** is turned off, the reduction ratio in the transmission **11** is automatically returned to the high reduction ratio side.

[0028] The power tool has the advantage that there is no need to separately perform switching operation of the reduction ratio in the transmission **11** not only upon tightening of the screw but also upon loosening of the screw, and further the reduction ratio at the start of each work is set so as to become suitable for the work. Therefore, the user can use the power tool with good usability.

[0029] Here, as a type of the screw, there is a so-called reverse-threaded screw. Tightening of this reverse-threaded screw is performed by rotating the motor **10** in the reverse rotation direction. Loosening of the reverse-threaded screw is performed by rotating the motor **10** in the normal rotation direction. Therefore, in the case where the reverse-threaded screw is used as the work's object, the reverse of setting in the above-mentioned example may be performed. Specifically, the initial reduction ratio may be set to the high reduction ratio when the motor is rotated in the normal rotation direction, and may be set to the low reduction ratio when the motor is rotated in the reverse rotation direction, in response to the rotation direction that has been set by the rotation direction switching means **19**. Fig. 4 shows a flow chart in this case. Fig. 5(a) shows torque change when the reverse-threaded screw is loosened by rotating the motor in the normal rotation direction. Fig. 5(b) shows torque change when the reverse-threaded screw is tightened by rotating the motor in the reverse rotation direction.

[0030] In this case, because the reduction ratio is set to the high reduction ratio when the motor **10** is rotated in the normal rotation direction, the user can start work in the state of the high-torque low-speed rotation upon turning on the trigger switch **14**. Then, the workload gradually decreases, and then if the predetermined conditions are fulfilled, the reduction ratio is automatically changed to the low reduction ratio side. When the work is completed and the trigger switch **14** is turned off, the reduction ratio in the transmission **11** is automatically returned to the high reduction ratio side.

[0031] When the rotation direction switching means **19** sets the rotation direction of the motor **10** to the reverse rotation direction, the transmission **11** is switched to the state of the low reduction ratio at this time. Therefore, the user can start work in the state of the low reduction ratio upon turning on the trigger switch **14**. When the workload increases, the reduction ratio in the transmission **11** is automatically changed to the high reduction ratio. Then, when the work is completed and the trigger switch **14** is turned off, the reduction ratio is returned to the low reduction ratio.

[0032] For this reason, in the case of this example, the power tool can be also used for tightening or the like of the reverse-threaded screw that is the exact opposite of tightening of the normal screw.

[0033] In addition, there is a case where the tightening torque change is different, depending on the type of the work's object, with respect to the work performed by rotating the motor in the normal rotation direction. When a screw with a small diameter is tightened, the torque is changed as shown in Fig. 7(a), and it can be expected that the work is effectively performed by starting at the low-torque high-speed rotation in the low reduction ratio side. On the other hand, when a screw with a large diameter (e.g., a coach screw) is tightened, the torque is changed as shown in Fig. 7(b), and it can be expected that the motor lock is generated soon after the start of the work when the work is started in the low reduction ratio side.

[0034] In this case where high tightening torque is needed soon after the start of the work, the user can effectively perform the work by starting at the high reduction ratio, and the burden on the power tool, caused by the motor lock or the like, can be reduced. Then, when the tightened screw is loosened, high torque is needed at the start of loosening. As a result, also in this case, the high-torque low-speed rotation in the high reduction ratio is suitable for the start of the work. Therefore, in the case where high torque is needed at the start of the work with respect to both of the normal and reverse rotations, as shown in Fig. 6, it is preferred that the high reduction ratio is set in the initial state.

[0035] When it is considered that desirable initial reduction ratio is different depending on the type of the work's object, preferably, the power tool has the configuration that the initial reduction ratio can be set through the user operation. Fig. 8 shows the power tool that further includes a work-start gear shift setting means **20** in which the initial reduction ratio is set through the user operation. The control circuit **13** stores a reduction ratio that has been set by the work-start gear shift setting means **20**, and then controls the transmission **11** so as to use the stored reduction ratio as the initial reduction ratio. Fig. 9 shows a flow chart with respect to the power tool.

[0036] In the case where the power tool is adopted to include for example a push switch as the work-start gear shift setting means **20**, the initial reduction ratio that is used at the start of the work under the normal rotation state is switched by operating the push switch when the power tool is in the halting state and the rotation direction has been set to the normal rotation direction by the rotation direction switching means **19**. The initial reduction ratio that is used at the start of the work under the reverse rotation state is switched by operating the push switch when the power tool is in the halting state and the rotation direction has been set to the reverse rotation direction. Further, the power tool has the configuration that the initial reduction ratio is switched sequentially by repeating the ON operation of the push switch. Of course, the work-start gear shift setting means **20** is not limited to the push switch. As described above, the power tool has the configuration that the initial reduction ratio is changed in response to the rotation direction that has been set by the rotation direction switching means 19, and therefore, the power tool can perform the setting operations for the initial reduction ratio when the motor is rotated in the normal rotation direction and the initial reduction ratio when the motor is rotated in the reverse rotation direction, while being reduced in the number of components. Further, the power tool can provide the user good usability.

[0037] There is a case where the user performs the same work continuously. In this case, the user can perform the same work continuously in the state, by setting the initial reduction ratio only once in response to the contents of the work. Therefore, the work efficiency can be improved, and the efficiency in the use of one power tool can be also improved.

[0038] The power tool of the present invention may have the configuration that the transmission **11** is capable of switching the reduction ratio in three speed stages. Fig. 10 shows a flow chart in this case.

[0039] In the state where the reduction ratio is set in the lowest stage, the reduction ratio is switched to the middle reduction ratio that is one stage higher than the lowest reduction ratio, upon fulfillment of two conditions: "the motor drive current **I** >= **I1** (A)"; and "the rate of increase in the motor rotation number **N** <= α**1**". In this state, further, when two conditions: "the motor drive current **I** >= **I2** (A)"; and "the rate of increase in the motor rotation number **N** <= α**2**" are fulfilled, the reduction ratio is automatically changed to a higher side.

[0040] On the other hand, in the state where the reduction ratio is set in the highest stage, the reduction ratio is switched to the middle reduction ratio, upon fulfillment of two conditions: "the motor drive current **I** <= **I4** (A)"; and "the motor rotation number **N** >= **N4**". In this state, when two conditions: "the motor drive current **I** <= **I3** (A)"; and "the motor rotation number **N** >= **N3**" are fulfilled, the automatic gear shift to a high-speed side is performed.

[0041] As described above, in the case where the transmission **11** is capable of switching the reduction ratio in three speed stages, preferably, the initial reduction ratio is switched to the middle reduction ratio (a middle-torque middle-speed rotation), in both cases of the normal rotation direction and the reverse rotation direction. Here, in the case of drilling a hole in wood, the user may need to make holes with various diameters, such as φ 10mm to φ 30mm. Fig. 11 shows the torque characteristic with respect to drilling the hole in wood. As shown in Fig. 11, the torque increases at the start of the drilling and then decreases gradually and then becomes stable. Finally, when the drill penetrates through wood, the torque reduces to zero. For this reason, when the work is started at the low reduction ratio, the reduction ratio is changed to the middle reduction ratio side soon after the start of the drilling, and then the work is completed while the middle reduction ratio is maintained. If the work needs high torque, the middle reduction ratio is further changed to the high reduction ratio and the work is then completed. That is, in the case of drilling a hole in wood, there is little need to perform the work at the low reduction ratio. Therefore, by starting at the middle reduction ratio, the work can be effectively performed without unnecessary gear shift and the burden on the user can be reduced.

[0042] When it is also considered that the power tool is applied to the above-mentioned tightening or the like of the screw, it is preferred that the power tool includes the work-start gear shift setting means **20** that is capable of changing the initial reduction ratio through user operation.

[0043] Figs. 12 and 13 show the power tool that further includes an indicating means **21** indicating the above-mentioned initial reduction ratio that has been initially set to a user. Preferably, this indicating means **21** is provided with three light emitting diodes located at the upper side of the power tool for example. The respective three light emitting diodes correspond to the low reduction ratio (H), the middle reduction ratio (M), and the high reduction ratio (L). In this case, the indicating means **21** turns on a light emitting diode corresponding to the initial reduction ratio at the start of the work in the rotation direction that has been set by the rotation direction switching means **19**. In this way, the indicating means **21** notifies the user of the initial reduction ratio in the present rotation direction of the motor.

[0044] In addition, the indicating means **21** may be provided with a total of six light emitting diodes, three of which are used for the normal rotation direction, and the remaining three are used for reverse rotation direction. Because the user can easily recognize whether it is a predetermined initial reduction ratio, or an initial reduction ratio that has been set by the user, the power tool can prevent failure of the work caused by performing the work at the wrong initial reduction ratio.

[0045] As explained above, the power tool of the present invention includes the motor **10**, the transmission **11** and the output unit **12**, as shown in Fig. 2. The motor **10** is defined as a rotational power source. The motor **10** is configured to be rotatable in regard to normal and reverse rotations. More specifically, the motor **10** is configured to be rotatable in regard to the normal and reverse rotations, thereby being rotated in the normal rotation direction and in the reverse rotation direction. The output unit **12** is configured to be driven by the motor **10** to be rotated.

[0046] The power tool further includes the control means. The control means is configured to make the transmission **11** perform the switching operation of the reduction ratio in response to the workload. The control means changes the initial reduction ratio in the transmission **11** when work is started, in response to a rotation direction of the motor **10**. The initial reduction ratio is set as the reduction ratio in an initial setting.

[0047] The control means is the control circuit **13** as shown in Fig. 2 for example.

[0048] As shown in the flow chart of Fig. 1, the initial reduction ratio when the rotation direction of the motor **10** is the reverse rotation direction is set higher than the initial reduction ratio when the rotation direction of the motor **10** is the normal rotation direction.

[0049] When explained from other aspect, the control means sets the reduction ratio, so that the initial reduction ratio when the rotation direction of the motor **10** is the reverse rotation direction is set higher than the initial reduction ratio when the rotation direction of the motor **10** is the normal rotation direction.

[0050] When further explained from other aspect, the rotation direction switching means **19** is configured to switch the rotation direction of the motor **10.** This makes the motor **10** rotate in the normal rotation direction or in the reverse rotation direction, in response to the rotation direction of the motor **10** that has been set by the rotation direction switching means **19**. When the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the normal rotation direction, the control means is configured to rotate the motor **10** at a first reduction ratio. When the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the reverse rotation direction, the control means is configured to rotate the motor **10** at a second reduction ratio. In this case, the second reduction ratio is higher than the first reduction ratio.

[0051] The rotation direction switching means **19** may be a switch or a lever provided with the power tool for example, but is not limited to those. That is, as long as the rotation direction switching means **19** is a component that is capable of switching the rotation direction of the motor **10**, anything can be adopted.

[0052] Also, there is a case where the power tool is used for a reverse-threaded screw.

[0053] Therefore, as shown in the flow chart of Fig. 4, the initial reduction ratio when the rotation direction of the motor **10** is the reverse rotation direction may be set lower than the initial reduction ratio when the rotation direction of the motor **10** is the normal rotation direction.

[0054] When explained from other aspect, the control means sets the reduction ratio, so that the initial reduction ratio when the rotation direction of the motor **10** is the reverse rotation direction is set lower than the initial reduction ratio when the rotation direction of the motor **10** is the normal rotation direction.

[0055] When further explained from other aspect, the rotation direction switching means **19** is configured to switch the rotation direction of the motor **10**. This makes the motor **10** rotate in the normal rotation direction or in the reverse rotation direction, in response to the rotation direction of the motor **10** that has been set by the rotation direction switching means **19**. When the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the reverse rotation direction, the control means is configured to rotate the motor **10** at the first reduction ratio. When the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the normal rotation direction, the control means is configured to rotate the motor **10** at the second reduction ratio. In this case, the second reduction ratio is higher than the first reduction ratio.

[0056] The initial reduction ratio when the rotation direction of the motor **10** is the normal rotation direction may be set at a non-low reduction ratio side and also the initial reduction ratio when the rotation direction of the motor 10 is the reverse rotation direction may be also set at the non-low reduction ratio side.

[0057] As shown in Fig. 8, the power tool further includes the work-start gear shift setting means **20** that changes the initial reduction ratio in the transmission **11** through user operation when the work is started.

[0058] As shown in Fig. 10, the transmission **11** is capable of switching the reduction ratio in three speed stages or more.

[0059] As shown in Fig. 13, the power tool further includes the indicating means that indicates the initial reduction ratio to a user.

[0060] Further, as shown in Fig. 2, the power tool includes the rotation direction switching means **19**. The rotation direction switching means **19** is configured to switch the rotation direction of the motor **10**. This makes the motor **10** rotate in the normal rotation direction or in the reverse rotation direction, in response to the rotation direction of the motor **10** set by the rotation direction switching means **19**. When the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the normal rotation direction, the transmission **11** is configured to set the reduction ratio to be lower than a predetermined reduction ratio. When the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the reverse rotation direction, the transmission **11** is configured to set the reduction ratio to be higher than a predetermined reduction ratio.

[0061] Further, as shown in Fig. 2, the power tool includes the motor rotation number detection means **16** and the motor current detection means **17**. The motor rotation number detection means **16** is configured to detect the rotation number of the motor **10**. The control means is configured to detect whether or not the information obtained from the rotation number of the motor **10** fulfills a first rotation condition. Then, the motor current detection means **17** is configured to detect a drive current in the motor **10**. The control means is configured to detect whether or not a current value of the drive current in the motor **10** fulfills a first current state. When the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the normal rotation direction, the control means is configured to control the transmission **11** to set the reduction ratio to be lower than a predetermined reduction ratio. When the control means detects: that the rotation information detected by the motor rotation number detection means **16** fulfills the first rotation condition; and that the current value of the drive current in the motor **10** detected by the motor current detection means **17** fulfills the first current state, and further the rotation direction switching means **19** makes the motor **10** rotate in the normal rotation direction, the control means is configured to control the transmission **11** to set the reduction ratio to be higher than a predetermined reduction ratio.

[0062] As one example, the rotation information represents the rate of increase in the rotation number of the motor **10**. The control means is configured to detect whether or not the first rotation condition is fulfilled: the rate of increase in the rotation number of the motor **10** is less than or equal to a predetermined rate of increase. The control means is configured to detect whether or not the first current state is fulfilled: the current value of the drive current in the motor **10** is more than or equal to a first current value.

[0063] As one example, the rotation information is the rotation number of the motor **10**, but is not limited to that. That is, the rotation information may be the rate of increase in the rotation number of the motor **10**. Or, the rotation information may be information that corresponds to the rotation number of the motor **10**. Or, the rotation information may be information that corresponds to the rate of increase in the rotation number of the motor **10**.

[0064] The control means further includes the motor rotation number detection means **16** and the motor current detection means **17**. The motor rotation number detection means **16** is configured to detect the rotation number of the motor **10**. The control means is configured to detect whether or not the rotation information obtained from the rotation number of the motor **10** fulfills a second rotation condition. The motor current detection means **17** is configured to detect the current value of the drive current in the motor **10**. The control means is configured to detect whether or not a current value of the drive current in the motor **10** fulfills a second current state. When the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the reverse rotation direction, the transmission **11** is configured to set the reduction ratio to be higher than a predetermined reduction ratio. When the control means detects: that the rotation information detected by the motor rotation number detection means **16** fulfills the second rotation condition; and that the current value of the drive current in the motor **10** detected by the motor current detection means **17** fulfills the second current state, and further the rotation direction switching means **19** makes the motor **10** rotate in the reverse rotation direction, the transmission **11** is configured to set the reduction ratio to be lower than a predetermined reduction ratio.

[0065] As one example, the rotation information represents the rotation number of the motor **10**. The control means is configured to detect whether or not the second rotation condition is fulfilled: the rotation number of the motor **10** is more than or equal to a predetermined rotation number. The control means is configured to detect whether or not the second current state is fulfilled: the current value of the drive current in the motor **10** is less than or equal to a second current value.

[0066] The power tool further includes the work-start gear shift setting means **20**. The work-start gear shift setting means **20** is configured to change the reduction ratio when operation of the motor **10** is started.

[0067] The work-start gear shift setting means **20** is configured to have a first setting state or a second setting state selectively. When the work-start gear shift setting means **20** has the first setting state and the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the normal rotation direction, the transmission **11** is configured to set the reduction ratio to be lower than a predetermined reduction ratio. When the work-start gear shift setting means **20** has the second setting state and the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the normal rotation direction, the transmission **11** is configured to set the reduction ratio to be higher than a predetermined reduction ratio.

[0068] As explained above, the power tool may be used for removing a screw, and may be used with respect to a reverse-threaded screw.

[0069] In those cases, the work-start gear shift setting means **20** is configured to have a first setting state or a second setting state selectively. When the work-start gear shift setting means **20** has the first setting state and the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the reverse rotation direction, the transmission **11** is configured to set the reduction ratio to be higher than a predetermined reduction ratio. When the work-start gear shift setting means **20** has the second setting state and the rotation direction switching means **19** sets the rotation direction of the motor **10** so that the motor **10** is rotated in the reverse rotation direction, the transmission **11** is configured to set the reduction ratio to be lower than a predetermined reduction ratio.

[0070] In the above-mentioned explanations, the rotation direction of the motor **10** when the motor **10** is rotated in the normal rotation direction is a direction opposite to the rotation direction of the motor **10** when the motor **10** is rotated in the reverse rotation direction. Accordingly, in the case where the rotation direction of the motor **10** is defined as the rotation direction to the right when the motor **10** is rotated in the normal rotation direction, the rotation direction of the motor **10** is defined as the rotation direction to the left when the motor **10** is rotated in the reverse rotation direction. In the case where the rotation direction of the motor **10** is defined as the rotation direction to the left when the motor **10** is rotated in the normal rotation direction, the rotation direction of the motor **10** is defined as the rotation direction to the right when the motor **10** is rotated in the reverse rotation direction.

EXPLANATION OF REFERENCE NUMERALS

[0071]

10 Motor

11 Transmission

12 Output unit

13 Control unit

14 Trigger switch

15 Motor drive circuit

16 Motor rotation number detection means

17 Motor current detection means

18 Battery pack

19 Rotation direction switching means

20 Work-start gear shift setting means

21 Indicating means

Claims

1. A power tool, comprising:

a motor serving as a rotational power source, the motor being rotatable in a normal rotation direction and a reverse rotation direction;
an output unit driven by the motor to be rotated; and
a transmission located between the motor and the output unit, the transmission switching a reduction ratio,
wherein the power tool further comprises a con-

trol means that makes the transmission perform switching operation of the reduction ratio in response to a workload, the control means changing an initial reduction ratio in the transmission when work is started, in response to a rotation direction of the motor, the initial reduction ratio being set as the reduction ratio in an initial setting.

2. The power tool according to claim **1**, wherein the initial reduction ratio when the rotation direction of the motor is the reverse rotation direction is set higher than the initial reduction ratio when the rotation direction of the motor is the normal rotation direction.

3. The power tool according to claim **1**, wherein the initial reduction ratio when the rotation direction of the motor is the reverse rotation direction is set lower than the initial reduction ratio when the rotation direction of the motor is the normal rotation direction.

4. The power tool according to claim 1, wherein the initial reduction ratio when the rotation direction of the motor is the normal rotation direction is set at a non-low reduction ratio side, the initial reduction ratio when the rotation direction of the motor is the reverse rotation direction being also set at the non-low reduction ratio side.

5. The power tool according to any one of claims 1 to 4, further comprises a work-start gear shift setting means that changes the initial reduction ratio in the transmission through user operation when the work is started.

6. The power tool according to any one of claims 1 to 5, wherein the transmission is capable of switching the reduction ratio in three speed stages or more.

7. The power tool according to any one of claims 1 to 6, further comprises an indicating means that indicates the initial reduction ratio to a user.

FIG. 1

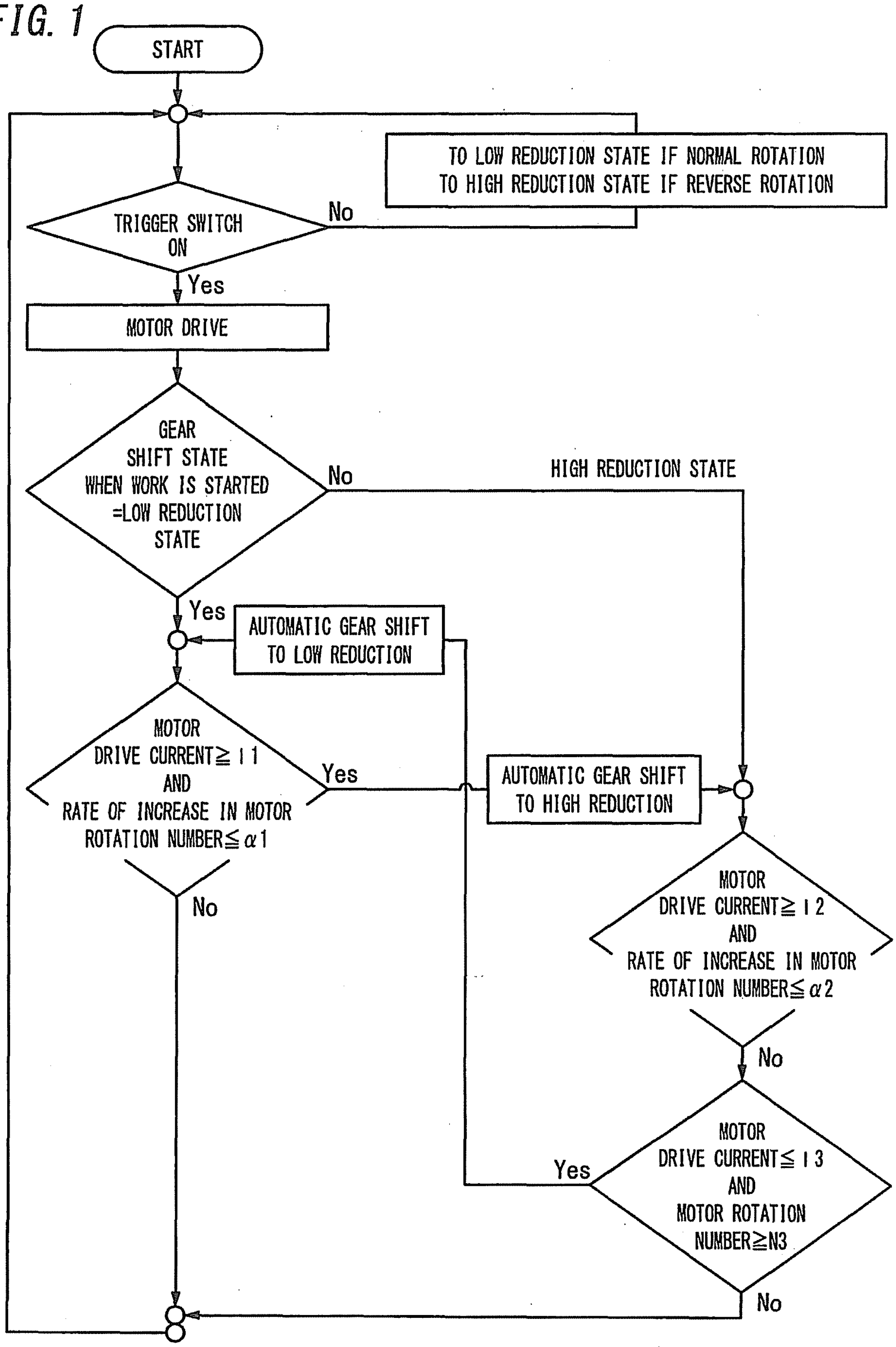

START
TO LOW REDUCTION STATE IF NORMAL ROTATION
TO HIGH REDUCTION STATE IF REVERSE ROTATION
TRIGGER SWITCH ON
No
Yes
MOTOR DRIVE
GEAR SHIFT STATE WHEN WORK IS STARTED =LOW REDUCTION STATE
No
HIGH REDUCTION STATE
Yes
AUTOMATIC GEAR SHIFT TO LOW REDUCTION
MOTOR DRIVE CURRENT≧I1 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α1
Yes
AUTOMATIC GEAR SHIFT TO HIGH REDUCTION
No
MOTOR DRIVE CURRENT≧I2 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α2
No
Yes
MOTOR DRIVE CURRENT≦I3 AND MOTOR ROTATION NUMBER≧N3
No

FIG. 2

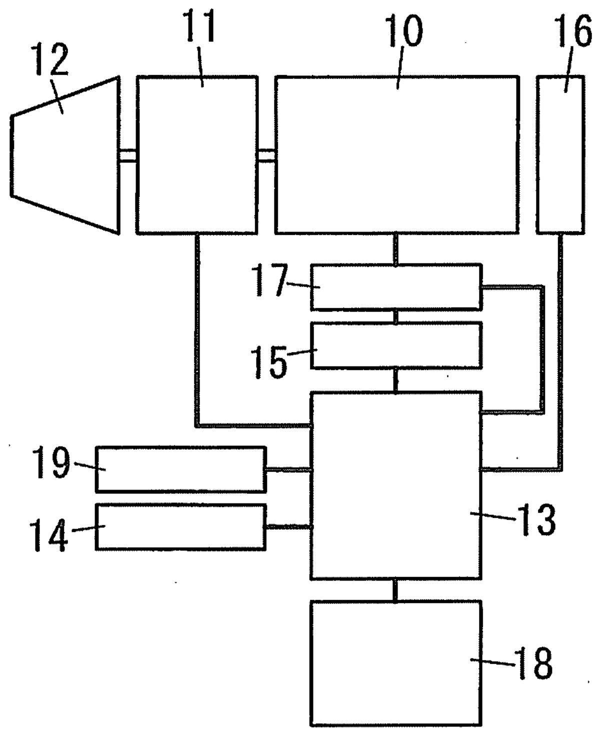


FIG. 3 (a)

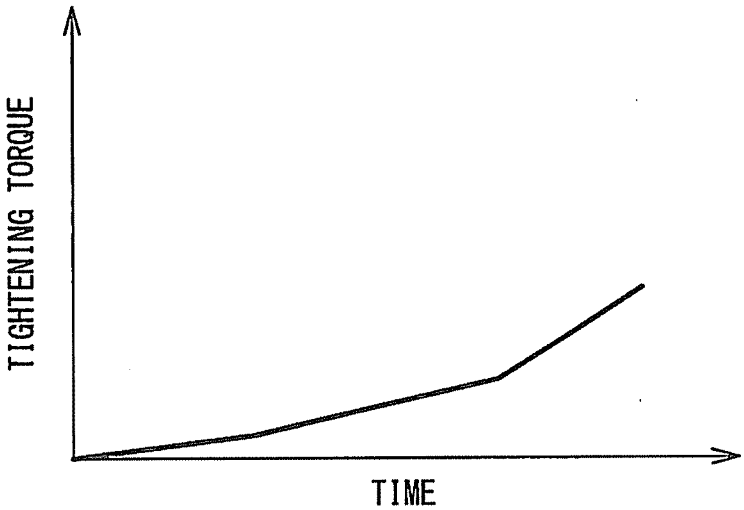


FIG. 3 (b)

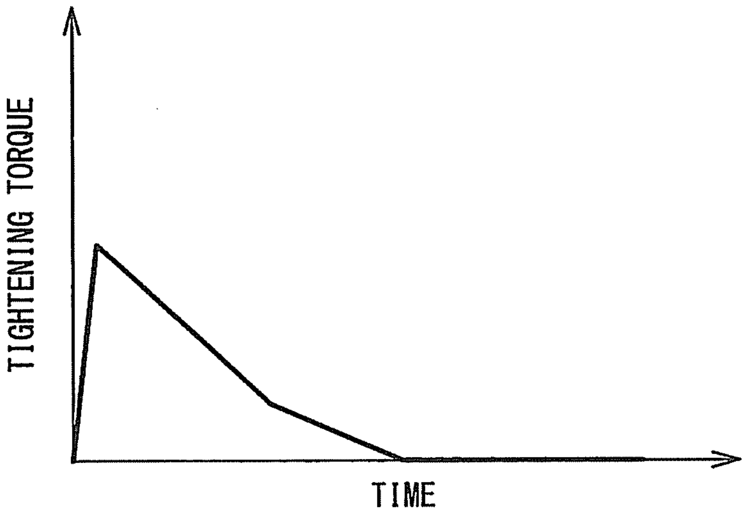


FIG. 4

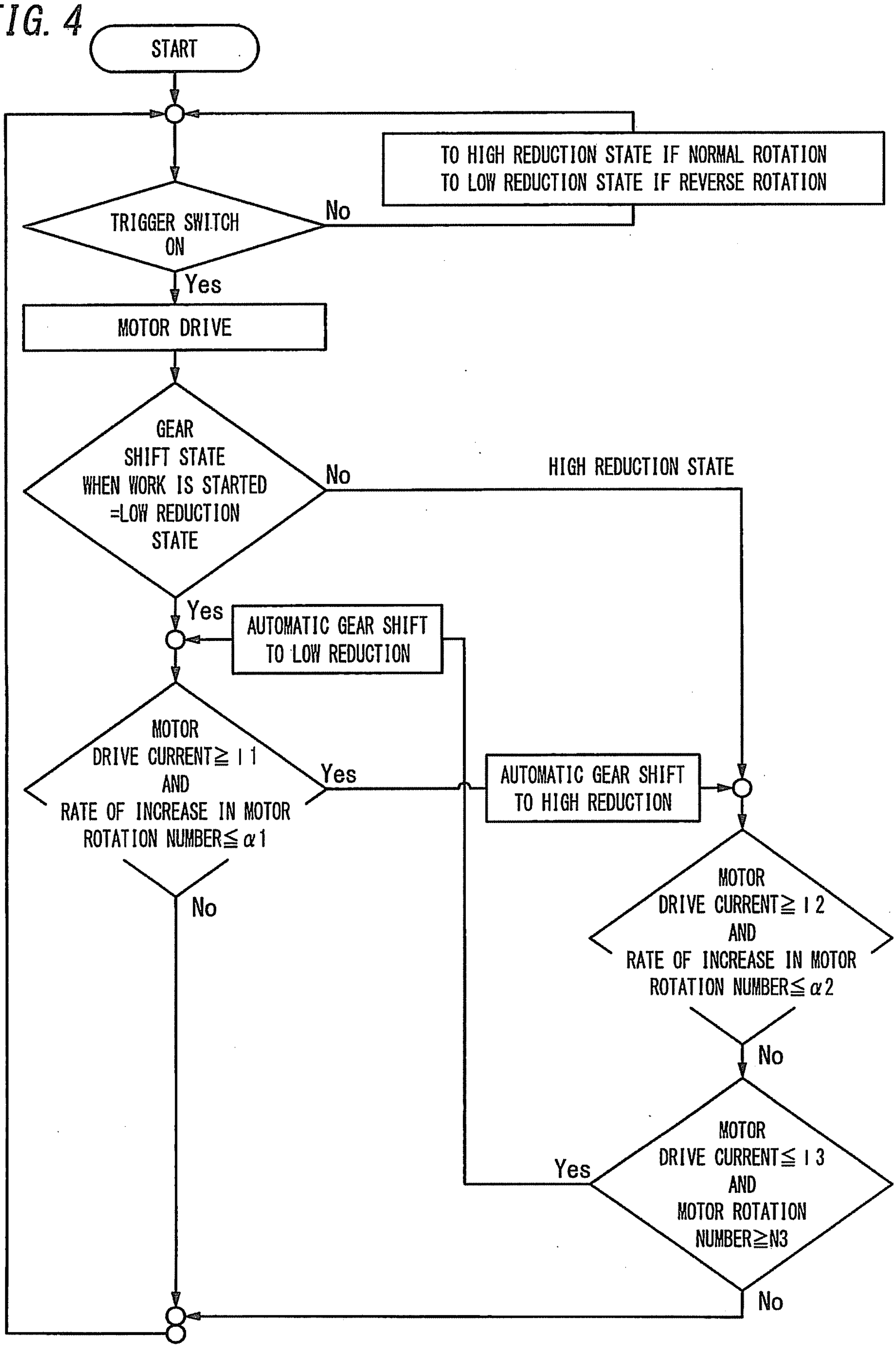

START
TO HIGH REDUCTION STATE IF NORMAL ROTATION
TO LOW REDUCTION STATE IF REVERSE ROTATION
TRIGGER SWITCH ON
No
Yes
MOTOR DRIVE
GEAR SHIFT STATE WHEN WORK IS STARTED =LOW REDUCTION STATE
No
HIGH REDUCTION STATE
Yes
AUTOMATIC GEAR SHIFT TO LOW REDUCTION
MOTOR DRIVE CURRENT≧I1 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α1
Yes
AUTOMATIC GEAR SHIFT TO HIGH REDUCTION
No
MOTOR DRIVE CURRENT≧I2 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α2
No
Yes
MOTOR DRIVE CURRENT≦I3 AND MOTOR ROTATION NUMBER≧N3
No

FIG. 5(a)

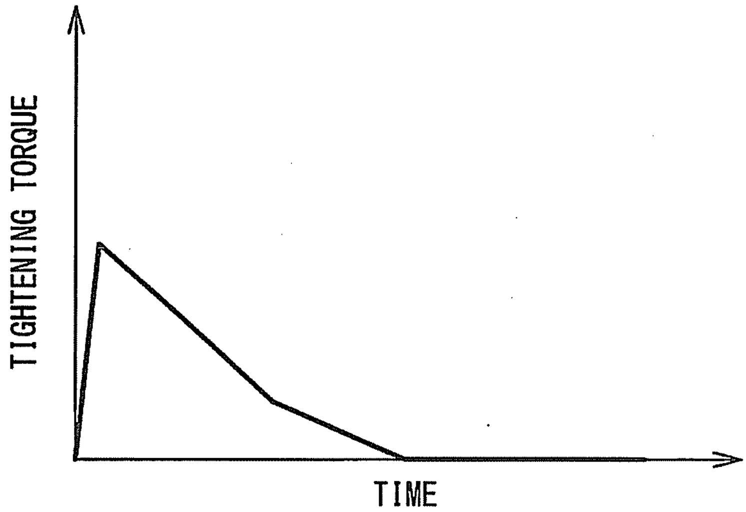


FIG. 5(b)

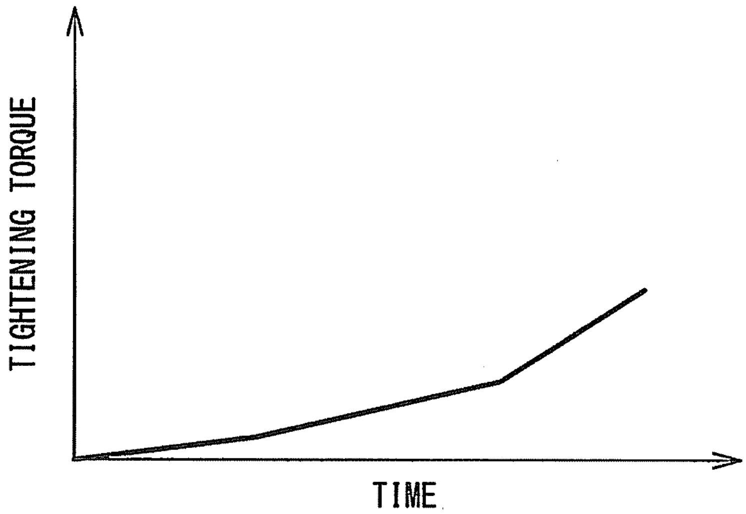


FIG. 6

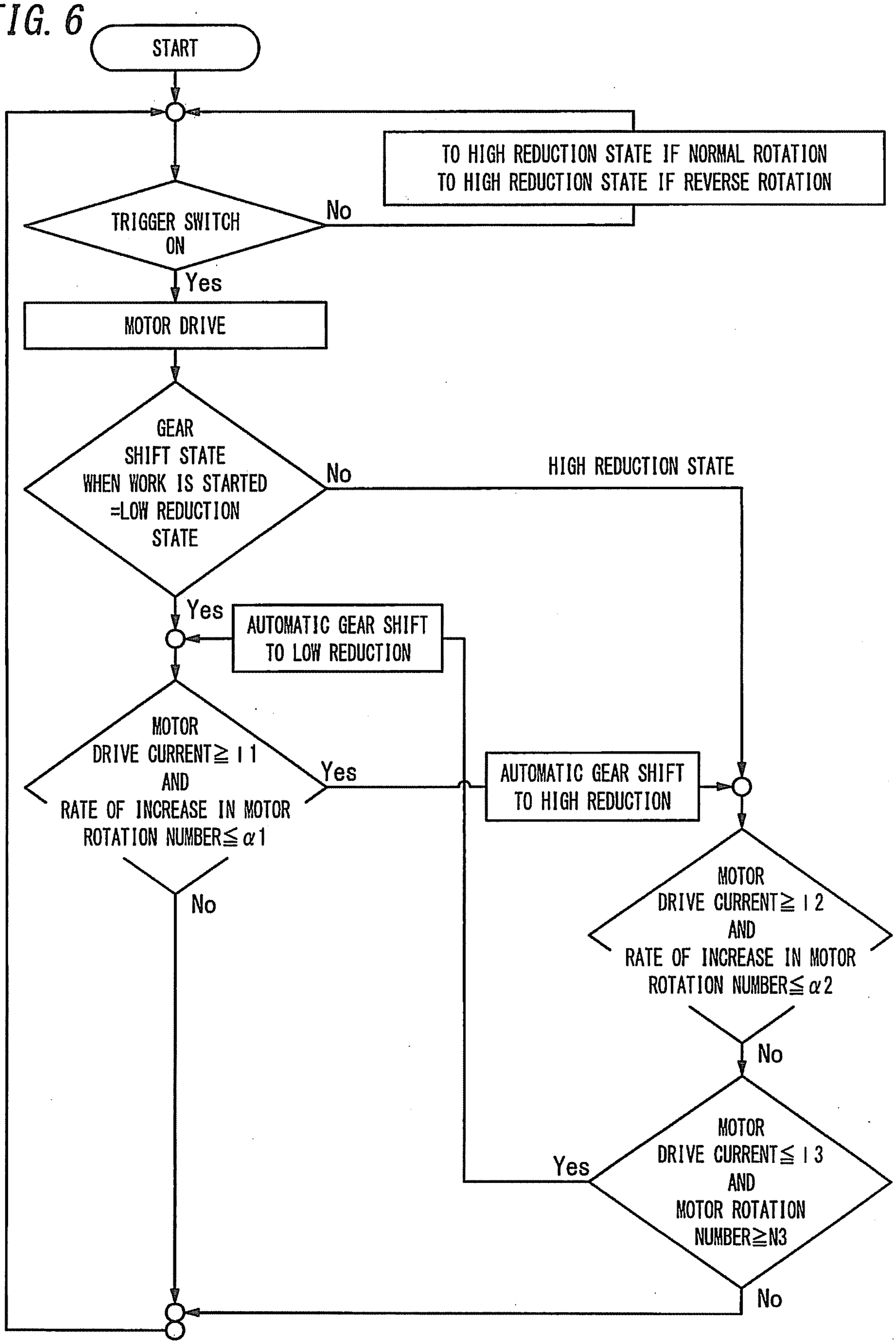

START
TO HIGH REDUCTION STATE IF NORMAL ROTATION
TO HIGH REDUCTION STATE IF REVERSE ROTATION
TRIGGER SWITCH ON
No
Yes
MOTOR DRIVE
GEAR SHIFT STATE WHEN WORK IS STARTED =LOW REDUCTION STATE
No
HIGH REDUCTION STATE
Yes
AUTOMATIC GEAR SHIFT TO LOW REDUCTION
MOTOR DRIVE CURRENT≧ I 1 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α1
Yes
AUTOMATIC GEAR SHIFT TO HIGH REDUCTION
No
MOTOR DRIVE CURRENT≧ I 2 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α2
No
MOTOR DRIVE CURRENT≦ I 3 AND MOTOR ROTATION NUMBER≧N3
Yes
No

FIG. 7(a)

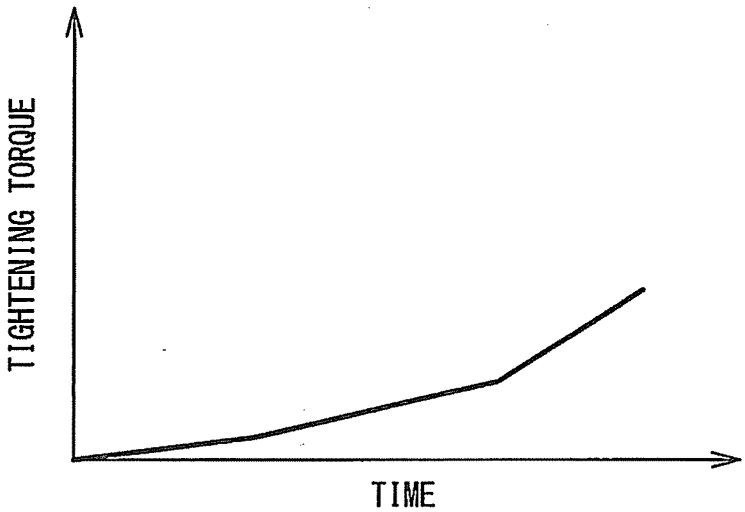


FIG. 7(b)

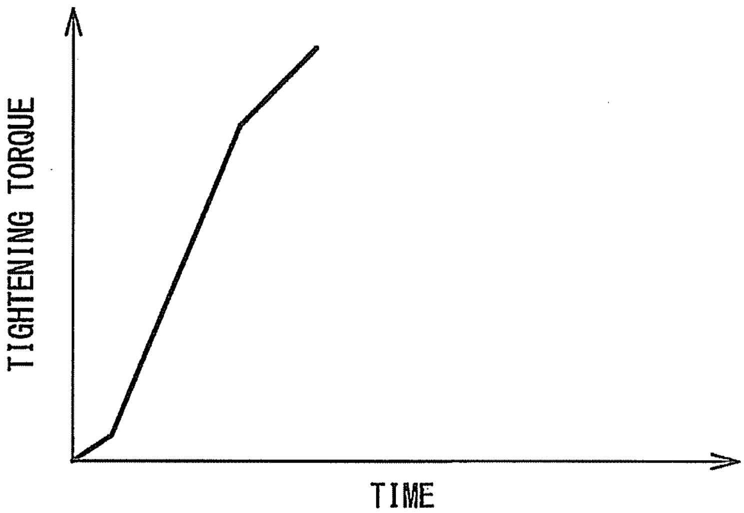


FIG. 8

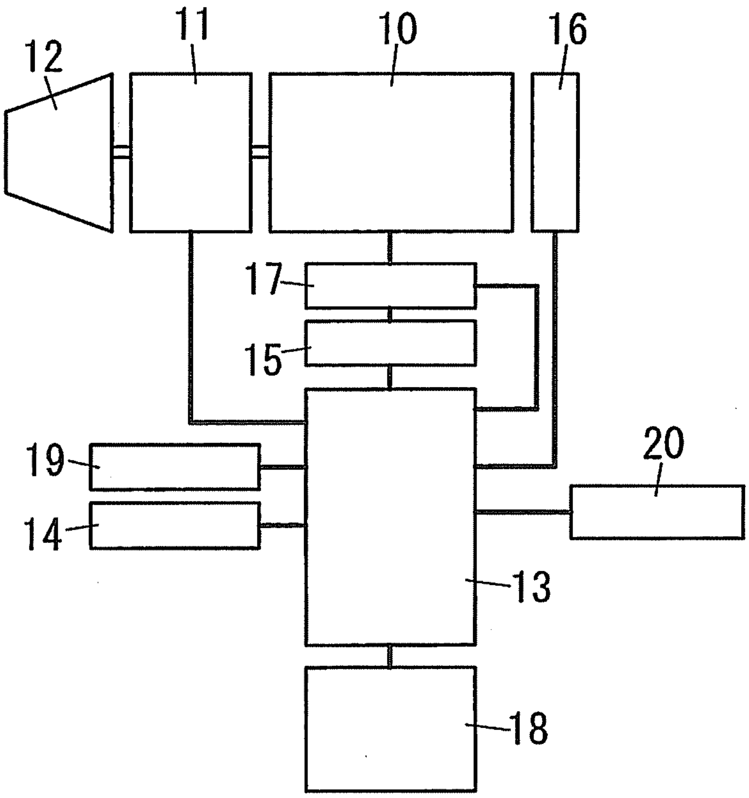


FIG. 9

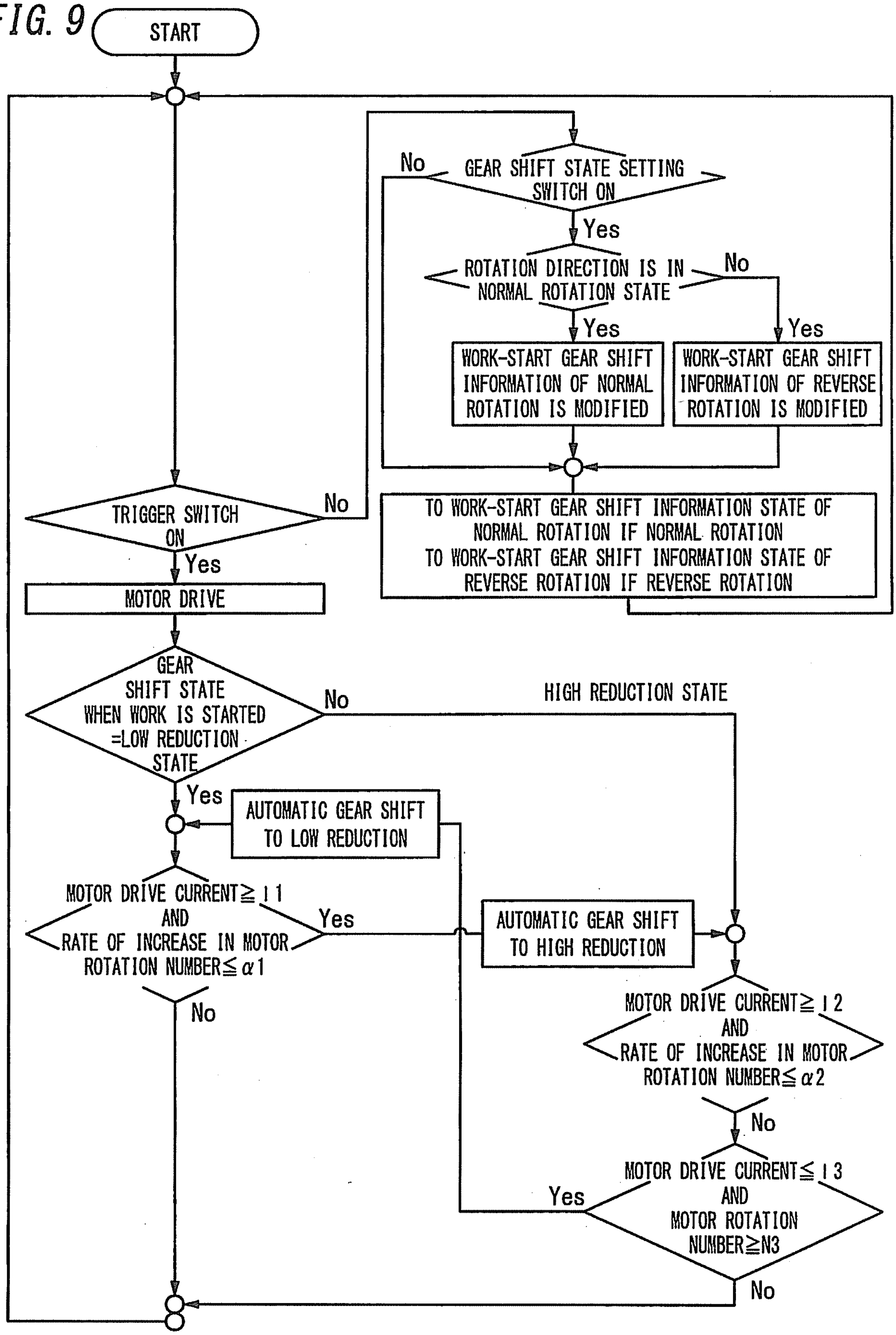

START
GEAR SHIFT STATE SETTING SWITCH ON
No
Yes
ROTATION DIRECTION IS IN NORMAL ROTATION STATE
No
Yes
Yes
WORK-START GEAR SHIFT INFORMATION OF NORMAL ROTATION IS MODIFIED
WORK-START GEAR SHIFT INFORMATION OF REVERSE ROTATION IS MODIFIED
TRIGGER SWITCH ON
No
Yes
TO WORK-START GEAR SHIFT INFORMATION STATE OF NORMAL ROTATION IF NORMAL ROTATION
TO WORK-START GEAR SHIFT INFORMATION STATE OF REVERSE ROTATION IF REVERSE ROTATION
MOTOR DRIVE
GEAR SHIFT STATE WHEN WORK IS STARTED =LOW REDUCTION STATE
No
HIGH REDUCTION STATE
Yes
AUTOMATIC GEAR SHIFT TO LOW REDUCTION
MOTOR DRIVE CURRENT≧I1 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α1
Yes
AUTOMATIC GEAR SHIFT TO HIGH REDUCTION
No
MOTOR DRIVE CURRENT≧I2 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α2
No
MOTOR DRIVE CURRENT≦I3 AND MOTOR ROTATION NUMBER≧N3
Yes
No

FIG. 10

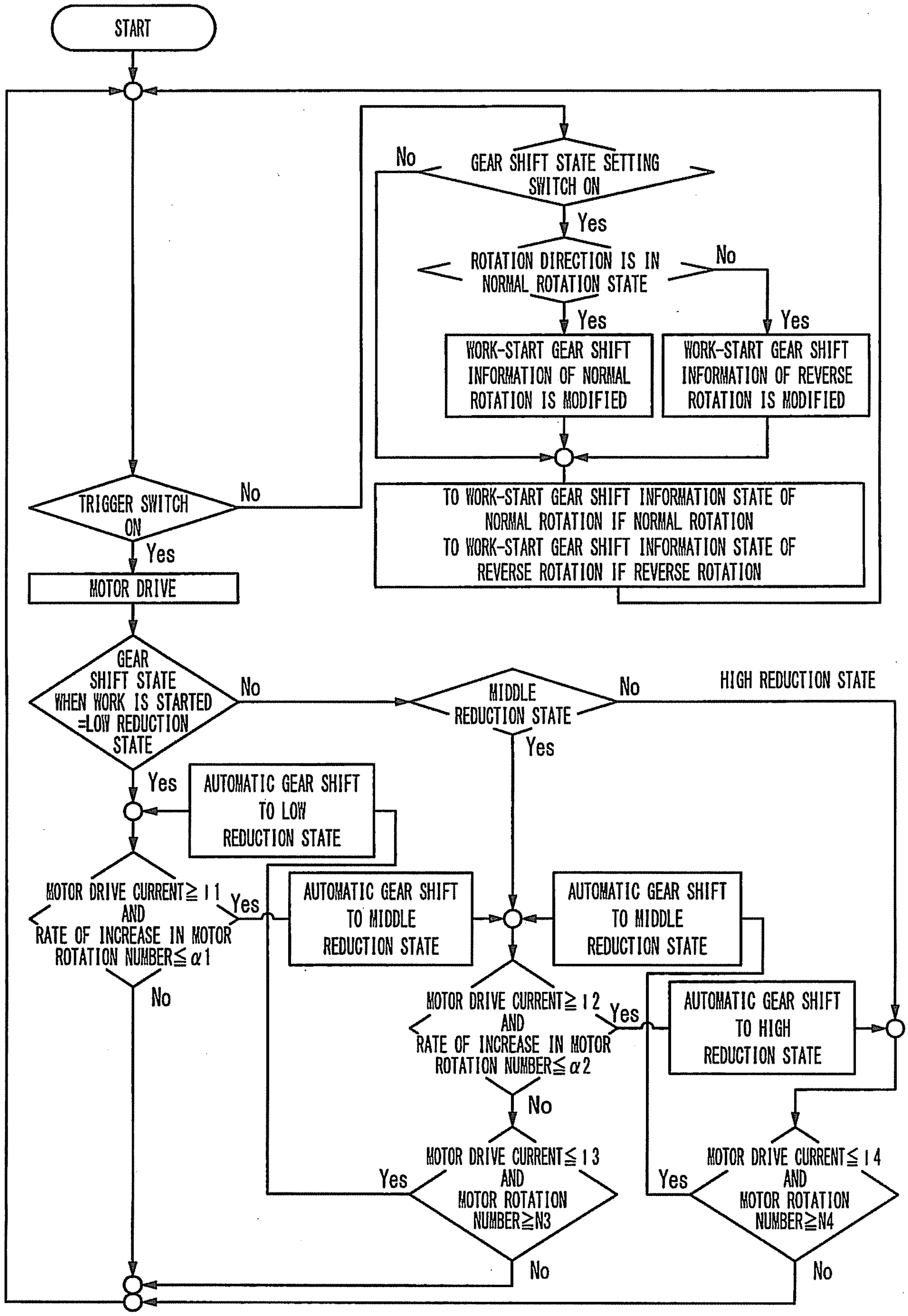

START
GEAR SHIFT STATE SETTING SWITCH ON
No
Yes
ROTATION DIRECTION IS IN NORMAL ROTATION STATE
No
Yes
Yes
WORK-START GEAR SHIFT INFORMATION OF NORMAL ROTATION IS MODIFIED
WORK-START GEAR SHIFT INFORMATION OF REVERSE ROTATION IS MODIFIED
TRIGGER SWITCH ON
No
TO WORK-START GEAR SHIFT INFORMATION STATE OF NORMAL ROTATION IF NORMAL ROTATION
TO WORK-START GEAR SHIFT INFORMATION STATE OF REVERSE ROTATION IF REVERSE ROTATION
Yes
MOTOR DRIVE
GEAR SHIFT STATE WHEN WORK IS STARTED =LOW REDUCTION STATE
No
MIDDLE REDUCTION STATE
No
HIGH REDUCTION STATE
Yes
Yes
AUTOMATIC GEAR SHIFT TO LOW REDUCTION STATE
MOTOR DRIVE CURRENT≧I1 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α1
Yes
AUTOMATIC GEAR SHIFT TO MIDDLE REDUCTION STATE
AUTOMATIC GEAR SHIFT TO MIDDLE REDUCTION STATE
No
MOTOR DRIVE CURRENT≧I2 AND RATE OF INCREASE IN MOTOR ROTATION NUMBER≦α2
Yes
AUTOMATIC GEAR SHIFT TO HIGH REDUCTION STATE
No
MOTOR DRIVE CURRENT≦I3 AND MOTOR ROTATION NUMBER≧N3
Yes
No
MOTOR DRIVE CURRENT≦I4 AND MOTOR ROTATION NUMBER≧N4
Yes
No

FIG. 11

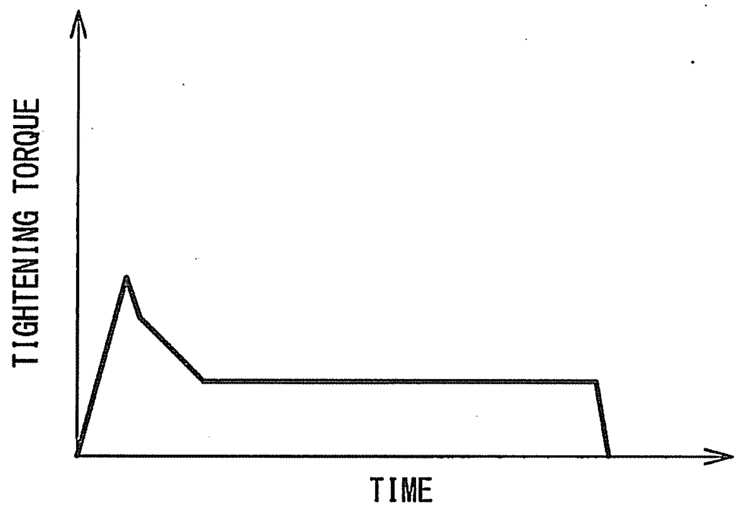


FIG. 12

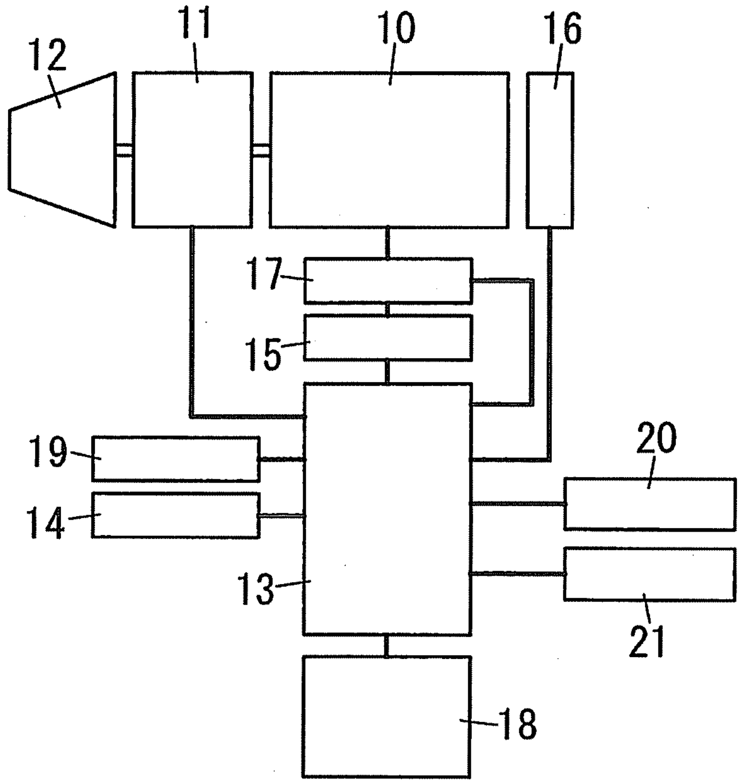
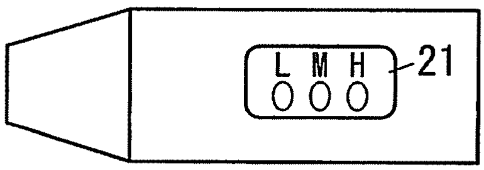


FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/052588

A. CLASSIFICATION OF SUBJECT MATTER
B25F5/00(2006.01)i, *B25B23/14*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B25F5/00, B25B23/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2010/134431 A1 (Makita Corp.), 25 November 2010 (25.11.2010), paragraphs [0002] to [0004], [0007] to [0019]; all drawings & JP 2010-264578 A	1,2 3-7
Y	JP 2006-000993 A (Maeda Metal Industries, Ltd.), 05 January 2006 (05.01.2006), paragraph [0010] & US 2005/0279198 A1 & EP 1632312 A2	3,5-7
Y	JP 10-000565 A (Makita Corp.), 06 January 1998 (06.01.1998), paragraph [0054] (Family: none)	3,5-7

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

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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 May, 2012 (21.05.12)	29 May, 2012 (29.05.12)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/052588

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2009-125909 A (Panasonic Electric Works Co., Ltd.), 11 June 2009 (11.06.2009), paragraph [0011] (Family: none)	4-7
Y	JP 2009-125910 A (Panasonic Electric Works Co., Ltd.), 11 June 2009 (11.06.2009), paragraph [0005] (Family: none)	4-7
Y	JP 2008-213052 A (Matsushita Electric Works, Ltd.), 18 September 2008 (18.09.2008), paragraphs [0017], [0022]; fig. 2 (Family: none)	5-7
Y	JP 2007-001013 A (Matsushita Electric Works, Ltd.), 11 January 2007 (11.01.2007), paragraph [0019]; fig. 4, 5 (Family: none)	5-7
Y	JP 2005-324265 A (Matsushita Electric Works, Ltd.), 24 November 2005 (24.11.2005), paragraph [0019]; fig. 3, 4 & US 2005/0263304 A1 & EP 1595650 A2 & CN 1695898 A	5-7

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Patent documents cited in the description

- JP 2009078349 A **[0006]**