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(54) ROBOT CONTROL DEVICE, NUMERICAL CONTROL SYSTEM, AND NUMERICAL CONTROL METHOD

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(57) **ABSTRACT**

Provided is a robot control device making it possible to implement interlocking control with a numerical control device that has a plurality of control systems, without creating further complication. A robot control device **3** is provided with: a program input unit **32** for acquiring, from a storage unit **31**, a robot control program for controlling a robot **30**; an analysis unit **33** for analyzing the robot control program inputted from the program input unit **32**, and acquiring a read command and a write command with which are set a variable of a numerical control program for controlling a numerical control device **2** and system information for identifying a subject system from among the plurality of control systems of the numerical control device; a system setting unit **37** for outputting a command for reading/writing a variable of the subject system on the basis of the information acquired by the analysis unit **33**; and a data communication unit **39** for transmitting the command for reading/writing the variable of the subject system to the numerical control device **2**, thereby causing the numerical control device **2** to update the variable of the subject system.

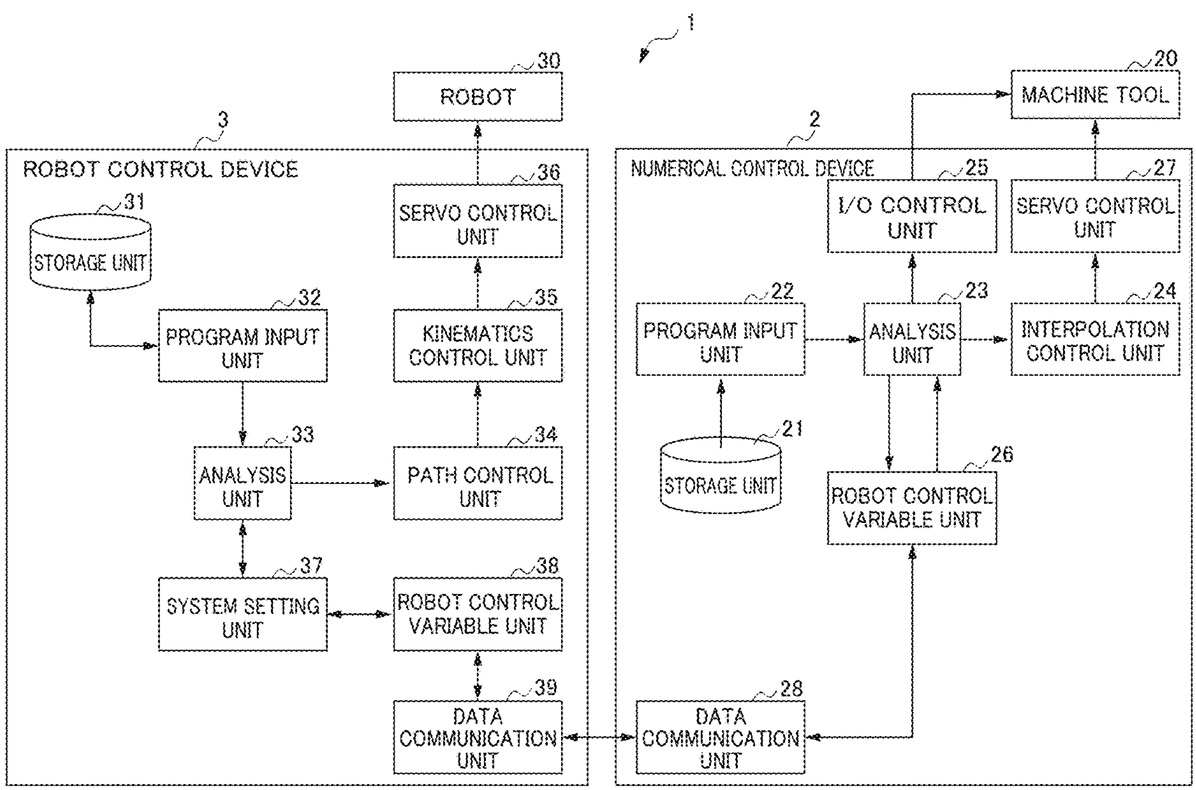


FIG. 1

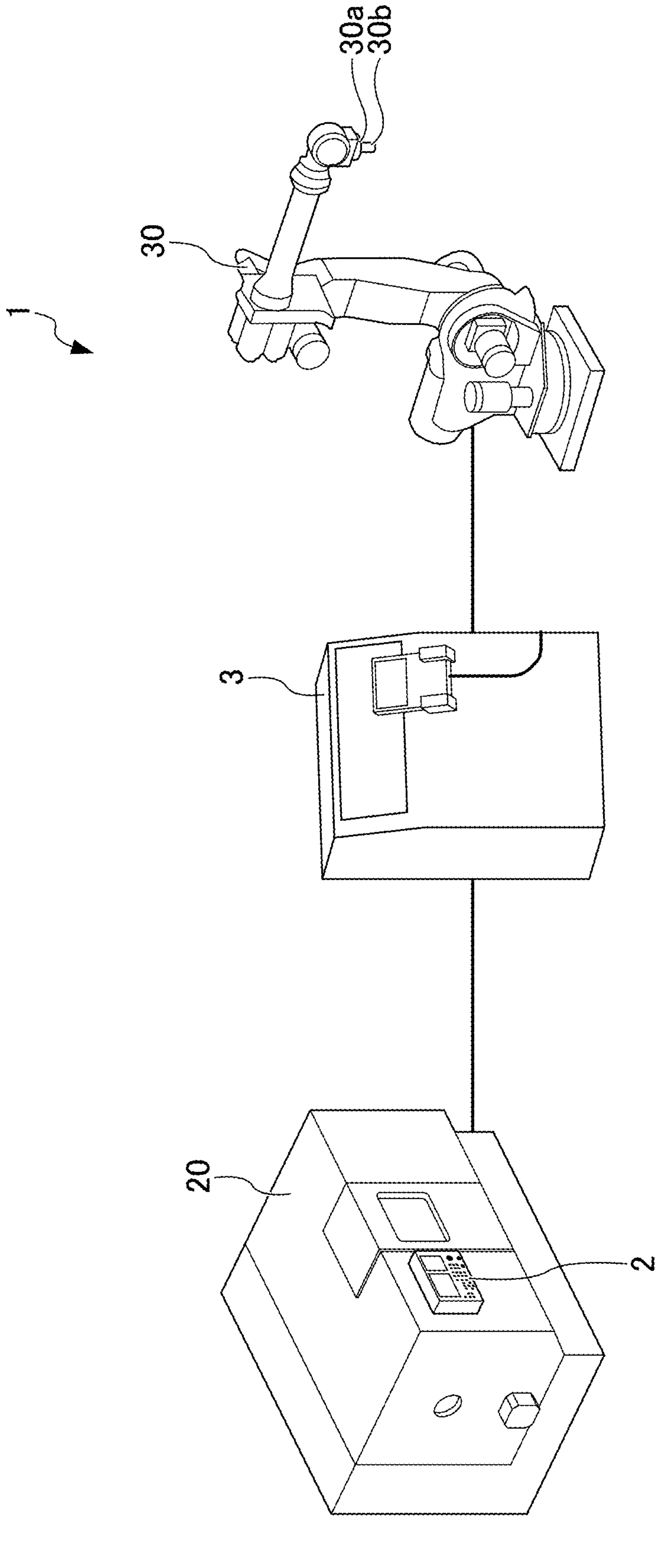


FIG. 2

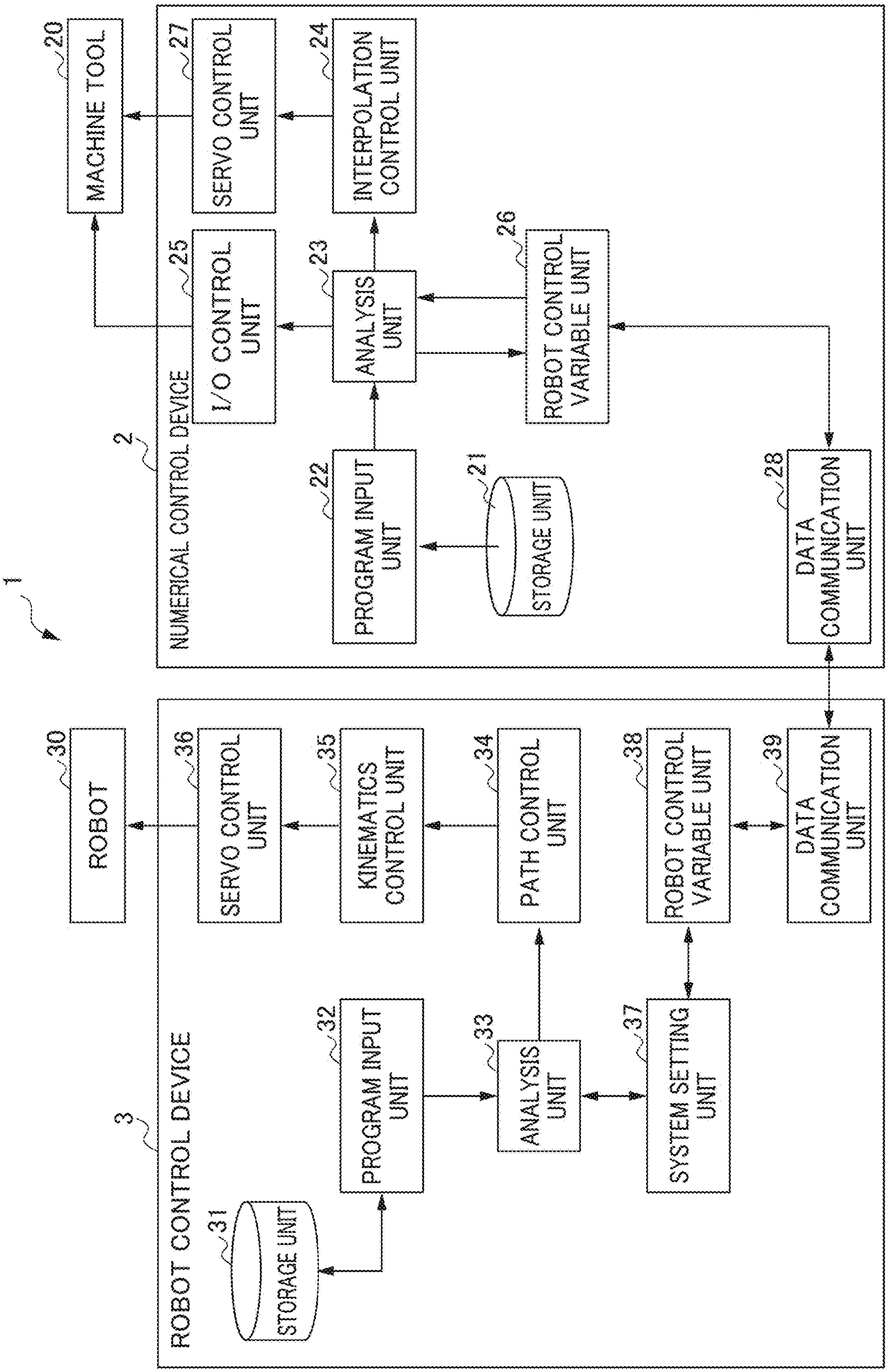
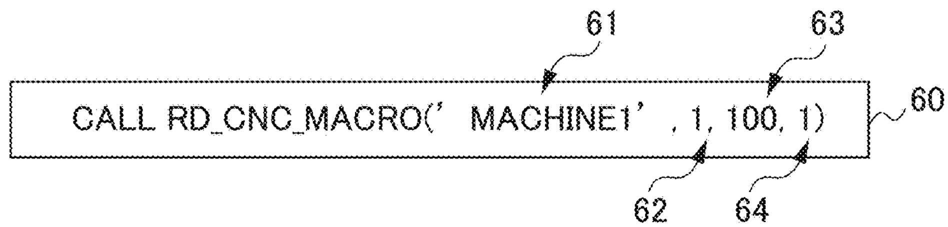
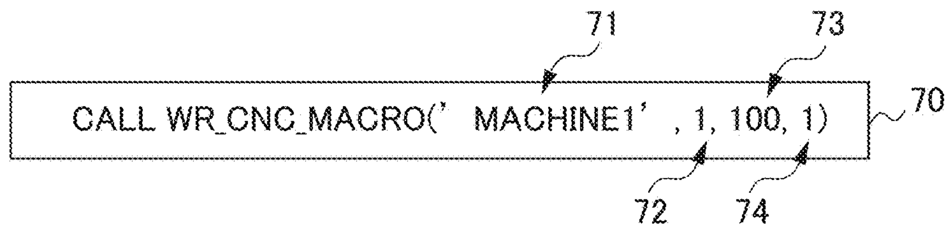

1
2
NUMERICAL CONTROL DEVICE
20
MACHINE TOOL
27
SERVO CONTROL UNIT
24
INTERPOLATION CONTROL UNIT
25
I/O CONTROL UNIT
23
ANALYSIS UNIT
26
ROBOT CONTROL VARIABLE UNIT
22
PROGRAM INPUT UNIT
21
STORAGE UNIT
28
DATA COMMUNICATION UNIT
3
ROBOT CONTROL DEVICE
30
ROBOT
36
SERVO CONTROL UNIT
35
KINEMATICS CONTROL UNIT
34
PATH CONTROL UNIT
38
ROBOT CONTROL VARIABLE UNIT
39
DATA COMMUNICATION UNIT
32
PROGRAM INPUT UNIT
33
ANALYSIS UNIT
37
SYSTEM SETTING UNIT
31
STORAGE UNIT

FIG. 3

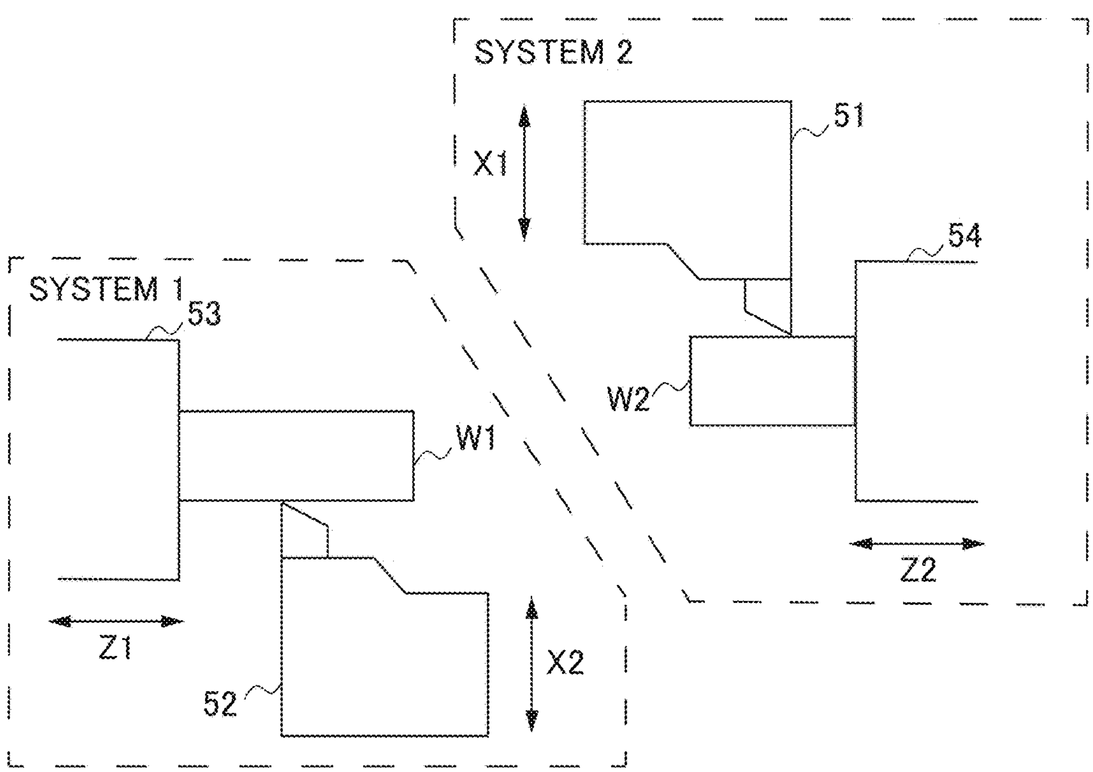


61
63
CALL RD_CNC_MACRO(' MACHINE1', 1, 100, 1)
60
62
64



71
73
CALL WR_CNC_MACRO(' MACHINE1', 1, 100, 1)
70
72
74

FIG. 4



SYSTEM 2
X1
51
54
SYSTEM 1
53
W2
W1
Z2
Z1
X2
52

FIG. 5

```
MACHINE PROCESSING REQUEST

1:LABEL [1]
2:CALL WR_CNC_MACRO('MACHINE1',1,101,1)
3:CALL WR_CNC_MACRO('MACHINE1',2,101,1)
4:LABEL [2]
5:WAIT 10.0sec
6:CALL RD_CNC_MACRO('MACHINE1', 1,101,1)
   IF REGISTER [1] = ON, JUMP LABEL 2
7:LABEL [3]
8:WAIT 1.0sec
9:CALL RD_CNC_MACRO('MACHINE1', 2,101,2)
   IF REGISTER [2] = ON, JUMP LABEL 3

[END]
```

FIG. 6

<CUSTOM MACRO VARIABLE ALLOTMENT EXAMPLE>

#100 : PROGRAM STOP REQUEST	0: REQUEST OFF/1: REQUEST ON
#101 : MACHINING REQUEST	0: REQUEST OFF/1: REQUEST ON
#102 : DOOR OPEN REQUEST	0: REQUEST OFF/1: REQUEST ON
#103 : DOOR CLOSE REQUEST	0: REQUEST OFF/1: REQUEST ON
#104 : CHUCK OPEN REQUEST	0: REQUEST OFF/1: REQUEST ON
#105 : CHUCK CLOSE REQUEST	0: REQUEST OFF/1: REQUEST ON
...	

FIG. 7

```
<MAIN PROGRAM>
O0001
N10
IF[#101 EQ 1] GOTO20;
IF[#102 EQ 1] GOTO30;
IF[#103 EQ 1] GOTO40;
IF[#104 EQ 1] GOTO50;
IF[#105 EQ 1] GOTO60;
IF[#100 EQ 1] GOTO100;

...
N20 M98 P1000;
GOTO10;
N100
M30;
```

```
<SUB PROGRAM>
O1000
G00 X2=100. Z1=100;
G01 Z1=0. F1000;

#101 = 0 (REQUEST OFF)
M99;
```

FIG. 8

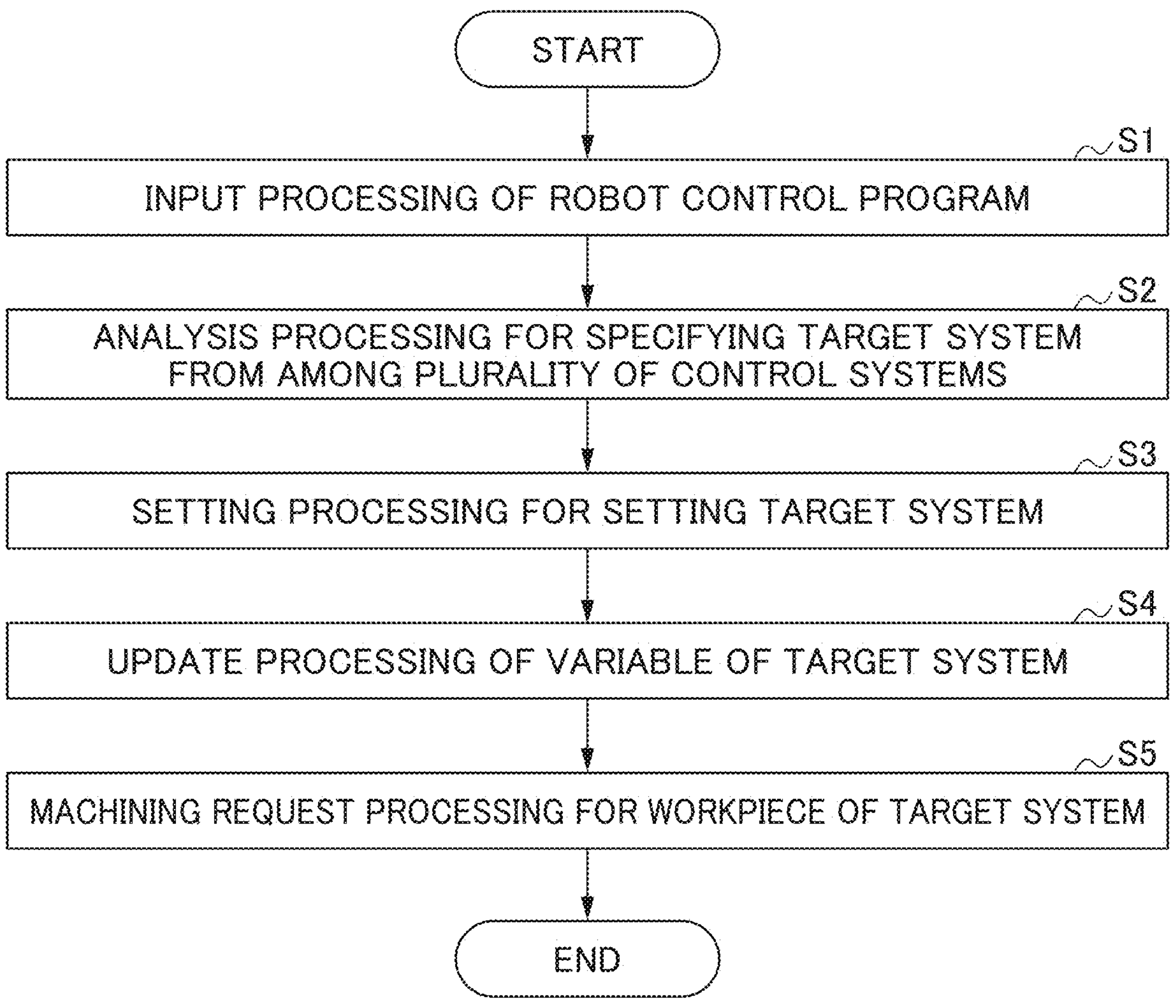
```
<MAIN PROGRAM>
O0002
N10
IF[#101 EQ 1] GOTO20;
IF[#102 EQ 1] GOTO30;
IF[#103 EQ 1] GOTO40;
IF[#104 EQ 1] GOTO50;
IF[#105 EQ 1] GOTO60;
IF[#100 EQ 1] GOTO100;

...
N20 M98 P2000;
GOTO10;
N100
M30;
```

```
<SUB PROGRAM>
O2000
G00 X1=200. Z2=0;
G01 Z2=1000. F1000;

#101 = 0
M99;
```

FIG. 9


START
S1
INPUT PROCESSING OF ROBOT CONTROL PROGRAM
S2
ANALYSIS PROCESSING FOR SPECIFYING TARGET SYSTEM FROM AMONG PLURALITY OF CONTROL SYSTEMS
S3
SETTING PROCESSING FOR SETTING TARGET SYSTEM
S4
UPDATE PROCESSING OF VARIABLE OF TARGET SYSTEM
S5
MACHINING REQUEST PROCESSING FOR WORKPIECE OF TARGET SYSTEM
END

ROBOT CONTROL DEVICE, NUMERICAL CONTROL SYSTEM, AND NUMERICAL CONTROL METHOD

TECHNICAL FIELD

[0001] The present disclosure relates to a robot control device, a numerical control system, and a numerical control method.

BACKGROUND ART

[0002] Conventionally, a system has been constructed which connects the respective controllers of a machine tool, robot, etc. in order to automate a processing machine. Patent Document 1 and Patent Document 2 are examples of documents relating to this kind of technology.

[0003] Patent Document 1 describes that, in a numerical control device, a comparative relationship between parameters related to settings of the numerical control device is stored in a comparative relationship storage unit, data having a comparative relationship is extracted from among parameters related to settings of the numerical control device based on the comparative relationship stored in the comparative relationship storage unit, and the data having this comparative relationship is displayed on a display unit to be associated with each other.

[0004] Patent Document 2 describes that, in a machining system including a machine controller and a robot controller, the machine controller includes a communication unit configured so as to read setting data and a robot operation program corresponding to a machining type set by a setting unit from a storage unit, and transmit the setting data and the robot operation program to the robot controller, when a determination unit determines that a mobile robot is arranged at a predetermined position adjacent to a machining device.

CITATION LIST

Patent Document

[0005] Patent Document 1: Japanese Unexamined Patent Application, Publication No. 2021-009480

[0006] Patent Document 2: Japanese Unexamined Patent Application, Publication No. 2018-124910

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0007] However, in a system including a robot and a machine tool, a robot control device that controls the robot may interlock operation of the robot and the machine tool by reading/writing macro variables of the machine tool. For example, the robot control device may perform processing such that acquires the operation state by turning on an operation request to the machine tool through the macro variable, and reading the macro variable of the machine tool, and turns off the operation request when the operation state reaches operation completion, and then proceeds to the next sequence. However, since there is no concept of a control system of a machine in a conventional robot control apparatus, it is not possible to interlock operation with an existing machine constituted by a plurality of groups of tool posts and spindles such as a multifunction machine tool via macro variables.

[0008] An object of the present disclosure is to provide a robot control device, a numerical control system, and a numerical control method capable of realizing interlocking control with a numerical control device having a plurality of control systems without complicating the control.

Means for Solving the Problems

[0009] As aspect of the present disclosure relates to a robot control device which includes: a program input unit which acquires a robot control program for controlling a robot from a storage unit; an analysis unit which analyzes the robot control program inputted from the program input unit, and acquires a read command and a write command in which a variable of a numerical control program controlling a numerical control device and system information specifying a target system from a plurality of control systems possessed by the numerical control device are set; a system setting unit which outputs a command for reading and writing a variable of the target system based on information acquired by the analysis unit; and a data communication unit which causes update of the variable of the target system to be executed in the numerical control device, by transmitting a command for reading and writing the variable of the target system to the numerical control device.

[0010] Additionally, an aspect of the present disclosure relates to a numerical control system which includes: a numerical control device having a plurality of control systems; and a robot control device which interlocks with the numerical control device to controls a robot, in which the robot control device includes: a program input unit which acquires a robot control program for controlling a robot from a storage unit; an analysis unit which analyzes the robot control program inputted from the program input unit, and acquires a read command and a write command in which a variable of a numerical control program controlling the numerical control device and system information specifying a target system from a plurality of control systems possessed by the numerical control device are set; a system setting unit which outputs a command for reading and writing a variable of the target system based on information acquired from the analysis unit; and a data communication unit which transmits a command for reading and writing a variable of the target system to the numerical control device, and in which the numerical control device executes update of the variable of the target system based on a command for reading and writing a variable of the target system received from the robot control device.

[0011] Furthermore, an aspect of the present invention relates to a numerical control method for interlock controlling a robot control device and a numerical control device with each other, the numerical control method including: a program input step of acquiring a robot control program for controlling a robot from a storage unit; an analysis step of analyzing the robot control program inputted in the program input step, and acquiring a read command and a write command in which a variable of a numerical control program controlling the numerical control device and system information specifying a target system from a plurality of control systems possessed by the numerical control device are set; a system setting step of outputting a command for reading and writing a variable of the target system based on information acquired in the analysis step; and an updating step of the robot control device causing update of a variable of the target system to be executed in the numerical control device, by transmitting a command for reading and writing the variable of the target system to the numerical control device.

Effects of the Invention

[0012] According to the present disclosure, it is possible to provide a robot control device, a numerical control system, and a numerical control method capable of realizing interlocking control with a numerical control device having a plurality of control systems without complicating the control.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** is a schematic diagram of a numerical control system according to an embodiment of the present disclosure;

[0014] FIG. **2** is a functional block diagram of a robot control device and a numerical control device according to an embodiment of the present disclosure;

[0015] FIG. **3** is a diagram showing an example of a robot control program including a read command and a write command;

[0016] FIG. **4** is a diagram schematically showing a mechanical configuration of each of a system **1** and a system **2**;

[0017] FIG. **5** is a diagram showing an example of a robot control program of the robot control device;

[0018] FIG. **6** is a diagram showing an allotment example of custom macro variables of a numerical control program updated by the robot control device;

[0019] FIG. **7** is a diagram showing an example of a main program and a sub program of the system **1**;

[0020] FIG. **8** is a diagram showing an example of a main program and a sub program of the system **2**; and

[0021] FIG. **9** is a flowchart showing an example of processing of a numerical control system **1** according to an embodiment of the disclosure.

PREFERRED MODE FOR CARRYING OUT THE INVENTION

[0022] Hereinafter, an embodiment of the present disclosure will be described in detail with reference to the drawings.

[0023] FIG. **1** is a schematic diagram of a numerical control system **1** according to an embodiment of the present disclosure.

[0024] The numerical control system **1** includes a numerical control device (CNC) **2** that controls a machine tool **20**, and a robot control device **3** that is communicably connected to the numerical control device **2** and controls a robot **30** provided in the vicinity of the machine tool **20**. The numerical control system **1** according to the present embodiment interlinks to control the operations of the machine tool **20** and the robot **30** by using the numerical control device **2** and the robot control device **3** which are communicably connected to each other.

[0025] The numerical control device **2** generates machine tool command signals which are commands for the machine tool **20** according to a predetermined numerical control program, and transmits these signals to the machine tool **20**.

[0026] The machine tool **20** machines a workpiece (not shown) in accordance with machine tool command signals transmitted from the numerical control device **2**. The machine tool **20** is, for example, a composite machining device having a turret, a table, a tool post, a spindle, and the like. The machine tool **20** may be a composite machining device established by combining a lathe, a ball mill, a milling machine, a grinding machine, a laser processing machine, an injection molding machine, and the like as appropriate.

[0027] The robot **30** operates under control by the robot control device **3**, and executes predetermined work on the workpiece machined inside of the machine tool **20**, for example. The robot **30** is, for example, an articulated robot, and a tool **30***b* for gripping, processing, or inspecting a workpiece is attached to an arm tip portion **30***a* thereof. Hereinafter, a case establishing the robot **30** as a six-axis articulated robot will be described; however, the present invention is not limited thereto. Hereinafter, a case establishing the robot **30** as a six-axis articulated robot will be described; however, the present invention is not limited thereto.

[0028] FIG. **2** is a functional block diagram of the robot control device **3** and the numerical control device **2** according to an embodiment of the present disclosure.

[0029] The numerical control device **2** and the robot control device **3** are each computers respectively configured by hardware such as an arithmetic processing unit such as a CPU (Central Processing Unit), an auxiliary storage unit such as an HDD (Hard Disk Drive) or an SSD (Solid State Drive) storing various computer programs, a main storage unit such as RAM (Random Access Memory) for temporarily storing the data necessary for the arithmetic processing unit to execute the computer programs, an operation unit such as a keyboard on which an operator performs various operations, and a display unit such as a display for displaying various information to the operator. The numerical control device **2** and the robot control device **3** can transmit and receive various signals to and from each other by Ethernet (registered trademark), for example.

[0030] First, the configuration of the numerical control device **2** will be described. The numerical control device **2** realizes a machine tool control function of controlling the operation of the machine tool **20** to be interlocked with the operation of the control axis of the robot **30** by the above-described hardware configuration. More specifically, in order to realize these functions, the numerical control device **2** includes a storage unit **21**, a program input unit **22**, an analysis unit **23**, a robot control variable unit **26**, an I/O control unit **25**, an interpolation control unit **24**, a servo control unit **27**, a data communication unit **28**, and the like.

[0031] The storage unit **21** stores numerical control programs. The numerical control program is created based on operations by an operator, for example. The numerical control program is configured by a plurality of command blocks, etc. related to the machine tool **20** for controlling operation of the machine tool **20**. The numerical control program is written in a known program language such as G code or M code.

[0032] It should be noted that various kinds of information other than the numerical control programs are also stored in the storage unit **21**. The various kinds of information include, for example, machine coordinate values, robot coordinate values, and robot teaching positions.

[0033] The machine coordinate values are values indicating positions of various axes of the machine tool **20** operated under the numerical control program (that is, positions of a tool post, table, etc. of the machine tool **20**). The machine coordinate values are defined under a machine tool coordinate system having a reference point defined at an arbitrary position on the machine tool **20** or in the vicinity of the machine tool **20** as an origin. The latest values of the machine coordinate values, which sequentially change under the numerical control program, are sequentially updated by processing (not shown) so as to be stored in the storage unit **21**.

[0034] The robot coordinate values are values indicating the position and posture of a control point of the robot **30** (for example, the arm tip portion **30***a* of the robot **30**) operated under the control of the robot control device **3**, in other words, the position of each control axis of the robot **30**. The robot coordinate values are defined under a robot coordinate system which differs from the machine tool coordinate system, as described above. The robot coordinate system is a coordinate system having a reference point defined at an arbitrary position on the robot **30** or in the vicinity of the robot **30** as an origin. Hereinafter, a case where the robot coordinate system is different from the machine tool coordinate system will be described. The robot coordinate system may coincide with the machine tool coordinate system. In other words, the origin or the coordinate axis direction of the robot coordinate system may coincide with the origin or the coordinate axis direction of the machine tool coordinate system. In addition, the robot coordinate system can be switched between two or more coordinate formats having different control axes. More specifically, in the numerical control program, the position and posture of the control points of the robot **30** can be specified by Cartesian coordinate format or respective axis coordinate formats.

[0035] The latest values of the robot coordinate values that sequentially change under the numerical control program are sequentially updated by the robot coordinate values acquired from the robot control device **3** by processing (not shown), so as to be stored in the storage unit **21**.

[0036] The robot teaching positions are teaching positions such as a start point and an end point of the robot **30** input by an operator, specifically, a teaching position of the robot **30** input from a teach pendant or the like, a teaching position input such as from a keyboard, or the like. The teaching positions of the robot **30** include robot coordinate values indicating the positions of each control axes of the robot **30**.

[0037] The program input unit **22** reads the numerical control program from the storage unit **21**, and sequentially inputs this to the analysis unit **23**. In addition, the program input unit **22** reads various kinds of information such as the machine coordinate values, the robot coordinate values, and the robot teaching positions stored in the storage unit **21**, and inputs the information to the analysis unit **23**.

[0038] The analysis unit **23** analyzes the command classification based on the numerical control program input from the program input unit **22** for each command block, and acquires information on the custom macro variable from the robot control variable unit **26**. The analysis unit **23** outputs, to the interpolation control unit **24** and the I/O control unit **25**, a command for controlling the machine tool **20** based on the analysis result of the numerical control program and the custom macro variable. Hereinafter, the custom macro variable will be described as a variable.

[0039] In the present embodiment, when the robot control variable is updated, the analysis unit **23** outputs, to the interpolation control unit **24** and the I/O control unit **25**, a command for operating the target system, based on the information specifying the system.

[0040] The interpolation control unit **24** is connected to the servo control unit **27**, and performs interpolation control for linear interpolation, arc interpolation, helical interpolation, etc. through the servo control unit **27**. The servo control unit **27** generates machine tool control signals for controlling the operation of the machine tool **20**, and inputs the machine tool control signals to the actuators that drive various axes of the machine tool **20**. The machine tool **20** operates in accordance with machine tool control signals to machine a workpiece (not shown). After controlling the operation of the machine tool **20** according to the numerical control program, the aforementioned machine coordinate values are updated with the latest machine coordinate values.

[0041] The robot control variable unit **26** analyzes the commands in the machining program read and written from the robot control device **3**, and updates the variable.

[0042] The data communication unit **28** transmits and receives various commands and data to and from the data communication unit **39** of the robot control device **3**.

[0043] Next, the configuration of the robot control device **3** will be described in detail. As illustrated in FIG. **2**, in order to control the operation of the robot **30**, the robot control device **3** includes a storage unit **31**, a program input unit **32**, an analysis unit **33**, a path control unit **34**, a kinematics control unit **35**, a servo control unit **36**, a system setting unit **37**, a robot control variable unit **38**, a data communication unit **39**, and the like.

[0044] The storage unit **31** stores various kinds of information such as the robot control program. The robot control program is created based on operations by an operator, for example. The robot control program is configured by a plurality of command blocks, etc. for the robot **30** for controlling the operation of the robot **30**. The various kinds of information include, for example, machine coordinate values, robot coordinate values, and robot teaching positions.

[0045] The program input unit **32** reads the robot control program from the storage unit **31**, and inputs the robot control program to the analysis unit **33**.

[0046] The analysis unit **33** determines a command classification of the robot control program inputted. The analysis unit **33** transmits commands of an operation plan based on the analysis results to the path control unit **34**.

[0047] When the commands of the operation plan are input from the analysis unit **33**, the path control unit **34** calculates time-series data of control points of the robot **30**, and outputs the time-series data to the kinematics control unit **35**.

[0048] The kinematics control unit **35** calculates a target angle of each joint of the robot **30** by inverse kinematics calculation based on the time-series data inputted, and outputs the target angles to the servo control unit **36**. Herein, the inverse kinematics calculation of the robot **30** is a calculation method of calculating the angle of each joint from the implement position and posture of the robot **30**.

[0049] The servo control unit **36** generates robot control signals for the robot **30** by feedback-controlling each servo motor of the robot **30** so that the target angles inputted from the kinematics control unit **35** are realized, and inputs the robot control signals to the servo motor of the robot **30**.

[0050] In addition, in the analysis unit **33** of the present embodiment, when the command classification of the inputted robot control program is analyzed as the read/write command of the variable of the numerical control device **2**, the target system included in the read/write command is notified from the analysis unit **33**.

[0051] The read/write command includes a read command and a write command. FIG. **3** is a diagram illustrating an example of a robot control program including read commands **60** and write commands **70**. Each read command **60** has the four parameters of a first argument **61**, a second argument **62**, a third argument **63**, and a fourth argument **64**. The first argument **61** indicates a machine to be a target of the read command **60**, and is "MACHINE1" in this example. The second argument **62** is a system number (system information) for specifying which system from among a plurality of systems, and is "**1**" in this example. The third argument **63** is a macro variable number for specifying a target macro variable, and is "**100**" in this example. The fourth argument **64** indicates an address for storing the read value, and is "1" in this example.

[0052] Similarly, each write command **70** also has the four parameters of a first argument **71**, a second argument **72**, a third argument **73**, and a fourth argument **74**. The first argument **71** indicates a machine that is a target of the write command **70**, and is "MACHINE1" in this example. The second argument **72** is a system number (system information) for specifying which system from among a plurality of systems, and is "1" in this example. The third argument **73** is a macro variable number for specifying a target macro variable, and is "100" in this example. The fourth argument **74** indicates a value to be written to the target macro variable, and is "1" in this example.

[0053] The system setting unit **37** transmits commands for reading and writing variables of a target system to the robot control variable unit **38**, based on the robot control program including the read command **60** and the write command **70**.

[0054] The robot control variable unit **38** transmits commands for reading and writing variables to the data communication unit **39**, based on the commands notified from the system setting unit **37**. The data communication unit **39** transmits and receives command signals to and from the data communication unit **28**. The commands for reading and writing the variables are transmitted to the robot control variable unit **26** via the data communication unit **28**.

[0055] Next, specific examples of controlling the system **1** and the system **2** will be described with reference to FIGS. **4** to **8**. FIG. **4** is a diagram schematically showing the mechanical configurations of each of the system **1** and the system **2**. FIG. **4** shows a system **1** which performs machining by a second turret **52** on a workpiece W1 set on the table **53**, and a system **2** which performs machining by a first turret **51** on a workpiece W2 set on the table **54**.

[0056] In FIG. **4**, **21** of the system **1** indicates the z-axis direction, and corresponds to a variable indicating the coordinates in the z-axis direction of the system **1**. X**2** indicates the x-axis direction, and corresponds to a variable indicating the coordinates in the x-axis direction of the system **1**. Similarly, Z**2** of the system **2** indicates the z-axis direction, and corresponds to a variable indicating the coordinates in the z-axis direction of the system **2**. X1 indicates the x-axis direction, and corresponds to a variable indicating the coordinates in the x-axis direction of the system **2**.

[0057] FIG. **5** is a diagram illustrating an example of a robot control program input from the program input unit **32** to the analysis unit **33**. As shown in FIG. **5**, the label [1] is written in the first row. In the second row, "CALL WR CNC_MACRO ('MACHINE1', 1, 101, 1)" is a read command of the system **1**, and read processing of the machining start request of the system **1** is performed. In the third row, "CALL WR CNC_MACRO ('MACHINE1', 2, 101, 1)" is a read command of the system **2**, and read processing of the machining start request of the system **2** is performed.

[0058] In the fourth line, a label [2] is written. In the fifth row of "WAIT 10.0 sec", standby processing for 10 seconds is performed. In the sixth line, "CALL RD_CNC MACRO ('MACHINE1', 1, 101, 1)" is a write command of the system **1**. "IF REGISTER [1]=ON, Jump Label 2" is processing of confirming machining completion of the system **1**, and when the condition of "IF REGISTER [1]=ON" is satisfied, the processing transitions to "label 2".

[0059] In the seventh line, a label [3] is written. In the eighth line of "WAIT 10.0 sec", standby processing for 10 seconds is performed. In the ninth line, "CALL RD_CNC MACRO ('MACHINE1', 2, 101, 2)" is a write command of the system **2**. "IF REGISTER [2]=ON, Jump Label 3" is processing of confirming the machining completion of the system **2**, and when the condition of "IF REGISTER [2]=ON" is satisfied, the processing transitions to the label 3.

[0060] As illustrated in FIG. **5**, in the robot control program, the systems are distinguished from each other, and the processing of reading and writing variables is performed by the robot control device **3**. FIG. **6** is a diagram showing an allocation example of custom macro variables of the numerical control program read and written by the robot control device **3**. In the example of FIG. **6**, the variable #100 is a variable indicating a program stop request, and #100=0 indicates request OFF, and #100=1 indicates request ON. Furthermore, a variable #101 indicates a processing request, a variable #102 indicates a door opening request, a variable #103 indicates a door closing request, a variable #104 indicates a chuck opening request, and a variable #105 indicates a chuck closing request. In any of the variables #101 to #105, 0 indicates request OFF, and 1 indicates request ON.

[0061] Next, with reference to FIGS. **7** and **8**, control of the system **1** and the system **2** in a situation in which the variables shown in the example of FIG. **7** are set will be described.

[0062] FIG. **7** is a diagram showing an example of a main program and a sub program of the system **1**. FIG. **7** shows a program of the system **1** called by the robot control program of FIG. **5**.

[0063] First, control of the system **1** will be described. A conditional branch is set to the sequence number "N10". In the first "IF[#101 EQ 1]GOTO20", when the variable #101=1 is established, the processing transitions to the sequence number "N20". In the sequence number "N20", the sub program O1000 corresponding to the program number 1000 is called and executed by "M98P1000".

[0064] In the sub program 01000, the positioning processing is performed based on the coordinates of X**2**=100 and Z**1**=100 in "G00". In the positioning processing, processing for linearly moving at a feed speed based on F=1000 to the coordinate of Z**1**=0 by "G01" is performed. Next, 0 indicating request OFF is input to "#101", and the sub program ends at "M99". After the sub program O1000 ends, the processing returns to the sequence number "N10" at "GOTO10", and the conditional branch processing is repeated.

[0065] When #101=1 is not established in the first "IF [#101 EQ 1]GOTO20", the processing transitions to "IF [#102 EQ 1]GOTO30". When #102=1 is established in this "IF[#102 EQ 1]GOTO30", the processing transitions to the sequence number "N30" (not shown), and in the sequence number "N30", although the specific processing is omitted, processing related to the operation of opening the door is executed. When #102=1 is not established in "IF[#102 EQ 1]GOTO30", the processing transitions to "IF[#103 EQ 1]GOTO40". When #103=1 is established in this "IF[#103 EQ 1]GOTO40", the processing transitions to the sequence number "N40" (not shown), and in the sequence number "N40", although the specific processing is omitted, processing related to the operation of closing the door is executed. When #103=1 is not established in "IF[#103 EQ 1]GOTO40", the processing transitions to "IF[#104 EQ 1]GOTO50". When #104=1 is established in "IF[#104 EQ 1]GOTO50", the processing transitions to the sequence number "N50" (not shown), and in the sequence number "N50", although the specific processing is omitted, processing related to the operation of opening the chuck is executed. When #104=1 is not established in "IF[#104 EQ 1]GOTO50", the processing transitions to "IF[#105 EQ 1]GOTO60". When #105=1 is established in "IF[#105 EQ 1]GOTO60", the processing transitions to the sequence number "N60" (not shown), and in the sequence number "N60", although the specific processing is omitted, processing related to the operation of closing the chuck is executed.

[0066] When the determination condition of "IF[#105 EQ 1]GOTO 60" is not satisfied, the determination of "IF[#100 EQ 1]GOTO 100" is performed. When the condition of the determination of "IF[#100 EQ 1]GOTO100" is satisfied, the program is ended by "M30" in the sequence number "N100".

[0067] FIG. **8** is a diagram showing an example of a main program and a sub program of the system **2**. FIG. **8** shows a program of the system **2** called by the robot control program of FIG. **5**. Also in FIG. **8**, the same processing as in the example shown in FIG. **7** is performed. The example of FIG. **8** is different in that the subprogram O2000 corresponding to the program number 2000 is called by "M98P2000" in the sequence number "N20".

[0068] In the sub program O2000, the positioning processing is performed based on the coordinates of X**1**=200 and Z**2**=0 in "G00". In the positioning processing, processing for linearly moving at a feed speed based on F=1000 to the coordinate of Z**2**=1000 in "G01" is performed. Next, 0 indicating request OFF is input to "#101", and the sub program ends at "M99". After the sub program O2000 ends, the processing returns to the sequence number "N10" at "GOTO10", and the conditional branch processing is repeated.

[0069] In the example described with reference to FIGS. **8** and **9**, the variables #100 to #105 are shared between the system **1** and the system **2**. In the configuration of the present embodiment, since the system **1** and the system **2** are distinguished from each other by the command output from the robot control device **3**, the system can be specified on the numerical control device **2** side.

[0070] Next, the flow of the system selection processing of the numerical control system **1** will be described with reference to FIG. **9**. FIG. **9** is a flowchart illustrating an example of processing of the numerical control system **1** according to the embodiment of the present disclosure. FIG. **9** illustrates only an example of the flow of the system selection processing, and other parallel processing shall be omitted.

[0071] First, the program input unit **32** of the robot control device **3** reads the robot control program from the storage unit **31**, and then executes input processing of inputting the robot control program to the analysis unit **33** (Step S**1**).

[0072] Next, the analysis unit **33** determines a command classification of the input robot control program, acquires system information specifying the system and variables belonging to the system when the command classification is analyzed as a variable read/write command of the numerical control device **2**, and executes analysis processing of notifying of the target system to the system setting unit **37** (Step S**2**).

[0073] The system setting unit **37** notified of the target system in Step S**2** executes setting processing of outputting, to the robot control variable unit **38**, the target system notified from the analysis unit **33** and the variables belonging to the target system (Step S**3**).

[0074] The robot control variable unit **38** transmits the target system and the variables belonging thereto to the data communication unit **28** of the numerical control device **2** by the data communication unit **39**, and executes update processing of updating the target system and the variables belonging thereto of the robot control variable unit **26** of the numerical control device **2** (Step S**4**).

[0075] The robot control device **3** executes machining request processing for commanding a target system of the machine tool **20** to perform machining, and the target system of the machine tool **20** performs machining on a workpiece (Step S**5**). Thus, the present processing is ended.

[0076] As described above, the numerical control system **1** of the present embodiment includes the numerical control device **2** having a plurality of control systems, and the robot control device **3** that interlocks with the numerical control device **2** to control the robot **30**. Then, the robot control device **3** includes: a program input unit **32** that acquires a robot control program for controlling the robot **30** from the storage unit **31**; an analysis unit **33** that analyzes the robot control program input by the program input unit **32**, and acquires a read command and a write command in which a variable of the numerical control program for controlling the numerical control device **2** and system information (system number) specifying a target system from a plurality of control systems included in the numerical control device are set; a system setting unit **37** that outputs a command for reading and writing a variable of the target system based on the information acquired by the analysis unit **33**; and a data communication unit **39** that causes the numerical control device **2** to update the variable of the target system, by transmitting a command for reading and writing a variable of the target system to the numerical control device **2**.

[0077] In addition, a numerical control method for controlling the robot control device **3** and the numerical control device **2** to be interlocked with each other according to the present embodiment includes: a program input step of acquiring a robot control program for controlling the robot **30** from the storage unit **31**; an analysis step of analyzing the robot control program inputted in the program input step, and acquiring a read command and a write command in which variables of a numerical control program for controlling the numerical control device **2** and system information (system number) specifying a target system from a plurality of control systems included in the numerical control device **2** are set; a system setting step of outputting a command for reading and writing the variable of the target system on the basis of the information acquired in the analysis step; and an update step of the robot control device **3** transmitting a command for reading and writing the variable of the target system to the numerical control device **2**, to cause update of the variable of the target system to be executed in the numerical control device **2**.

[0078] The robot control device **3**, the numerical control system **1**, and the numerical control method according to the present embodiment exert the following such effects. That is, even in the case of the numerical control device **2** having a plurality of control systems and the variables being shared between each of the control systems, it is possible to distinguish the systems by the robot control device **3**, and read and write the variables of the numerical control device **2**. Therefore, update of the variables of the target system can be appropriately updated without setting the variables of different systems on the numerical control device **2** side, and the interlocking control of the numerical control device **2** having a plurality of control systems and the robot control device **3** can be appropriately realized without complicating the interlocking control.

[0079] In addition, the analysis unit **33** of the robot control device **3** according to the present embodiment outputs a command to perform robot control so as to interlock with a plurality of control systems controlled by the numerical control device **2** based on the updated variables of the target system.

[0080] It is thereby possible to appropriately perform interlocking of the numerical control device **2** having a plurality of control systems and the robot control device **3**.

[0081] Furthermore, in the present embodiment, each of the plurality of control systems (system **1** and system **2**) controls at least one of the tool post, the turret, the table, and the spindle so as to machine a workpiece, and at least one of the tool post, the turret, the table, and the spindle is controlled based on the variables of the target system updated by the numerical control device **2**. In the present embodiment, the first turret **51**, the second turret, the table **53**, and the table **54** are control targets.

[0082] Accordingly, since each of the plurality of control systems includes at least one of the tool post, the turret, the table, and the spindle, it is possible to realize efficient creation of a control program using variables, even in a case where various controls are set.

[0083] The present disclosure is not limited to the above embodiment, and various modifications and variations are possible.

EXPLANATION OF REFERENCE NUMERALS

[0084] **1** numerical control system
[0085] **2** numerical control device
[0086] **3** robot control device
[0087] **20** machine tool
[0088] **30** robot
[0089] **31** storage unit
[0090] **32** program input unit
[0091] **33** analysis unit
[0092] **37** system setting unit
[0093] **39** data communication unit

1. A robot control device comprising:

a program input unit which acquires a robot control program for controlling a robot from a storage unit;

an analysis unit which analyzes the robot control program inputted from the program input unit, and acquires a read command and a write command in which a variable of a numerical control program controlling a numerical control device and system information specifying a target system from a plurality of control systems possessed by the numerical control device are set;

a system setting unit which outputs a command for reading and writing a variable of the target system based on information acquired by the analysis unit; and

a data communication unit which causes update of the variable of the target system to be executed in the numerical control device, by transmitting a command for reading and writing the variable of the target system to the numerical control device.

2. The robot control device according to claim **1**, wherein the analysis unit outputs a command to perform robot control so as to interlock with the plurality of control systems controlled by the numerical control device based on the variable of the target system which has been updated.

3. The robot control device according to claim **1**, wherein each of the plurality of control systems machines a workpiece by controlling at least one among a tool post, a turret, a table and a spindle, and

wherein at least one among of the tool post, the turret, the table and the spindle is controlled based on the variable of the target system updated by the numerical control device.

4. A numerical control system comprising:

a numerical control device having a plurality of control systems; and

a robot control device which interlocks with the numerical control device to controls a robot,

wherein the robot control device includes:

a program input unit which acquires a robot control program for controlling a robot from a storage unit;

an analysis unit which analyzes the robot control program inputted from the program input unit, and acquires a read command and a write command in which a variable of a numerical control program controlling the numerical control device and system information specifying a target system from a plurality of control systems possessed by the numerical control device are set;

a system setting unit which outputs a command for reading and writing a variable of the target system based on information acquired by the analysis unit; and

a data communication unit which transmits a command for reading and writing a variable of the target system to the numerical control device, and

wherein the numerical control device executes update of the variable of the target system based on a command for reading and writing a variable of the target system received from the robot control device.

5. The numerical control system according to claim **4**, wherein the analysis unit outputs a command to perform robot control so as to interlock with the plurality of control systems controlled by the numerical control device based on the variable of the target system which has been updated.

6. The numerical control system according to claim **4**, wherein each of the plurality of control systems machines a workpiece by controlling at least one among a tool post, a turret, a table and a spindle, and

wherein at least one among the tool post, the turret, the table and the spindle is controlled based on the variable of the target system updated by the numerical control device.

7. A numerical control method for interlock controlling a robot control device and a numerical control device with each other, the numerical control method comprising:

a program input step of acquiring a robot control program for controlling a robot from a storage unit;

an analysis step of analyzing the robot control program inputted in the program input step, and acquiring a read command and a write command in which a variable of a numerical control program controlling the numerical control device and system information specifying a target system from a plurality of control systems possessed by the numerical control device are set;

a system setting step of outputting a command for reading and writing a variable of the target system based on information acquired in the analysis step; and

an updating step of the robot control device causing update of a variable of the target system to be executed in the numerical control device, by transmitting a command for reading and writing the variable of the target system to the numerical control device.

8. The robot control device according to claim **2**, wherein each of the plurality of control systems machines a workpiece by controlling at least one among a tool post, a turret, a table and a spindle, and

wherein at least one among of the tool post, the turret, the table and the spindle is controlled based on the variable of the target system updated by the numerical control device.

9. The numerical control system according to claim **5**, wherein each of the plurality of control systems machines a workpiece by controlling at least one among a tool post, a turret, a table and a spindle, and

wherein at least one among the tool post, the turret, the table and the spindle is controlled based on the variable of the target system updated by the numerical control device.

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