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(54) **MOLDING SYSTEM PROVIDED WITH MOLDING MACHINE AND MOLDED ARTICLE REMOVAL DEVICE**

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B25J 9/16	(2006.01)

(52) **U.S. Cl.**

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(57) **ABSTRACT**

A molding system capable of performing highly accurate work on a molded article with a molded article removal device. The molding system includes a molding machine, a molded article removal device capable of removing a master work installed in a mold of the molding machine, a measurement section configured to measure a position of the master work when the master work is removed by the molded article removal device, a displacement calculation section configured to calculate a difference between a reference position and a detected position of the master work measured by the measurement section as a displacement, and a correction section configured to, on the basis of the displacement calculated by the displacement calculation section, correct a work position for when the molded article removal device performs work on a molded article.

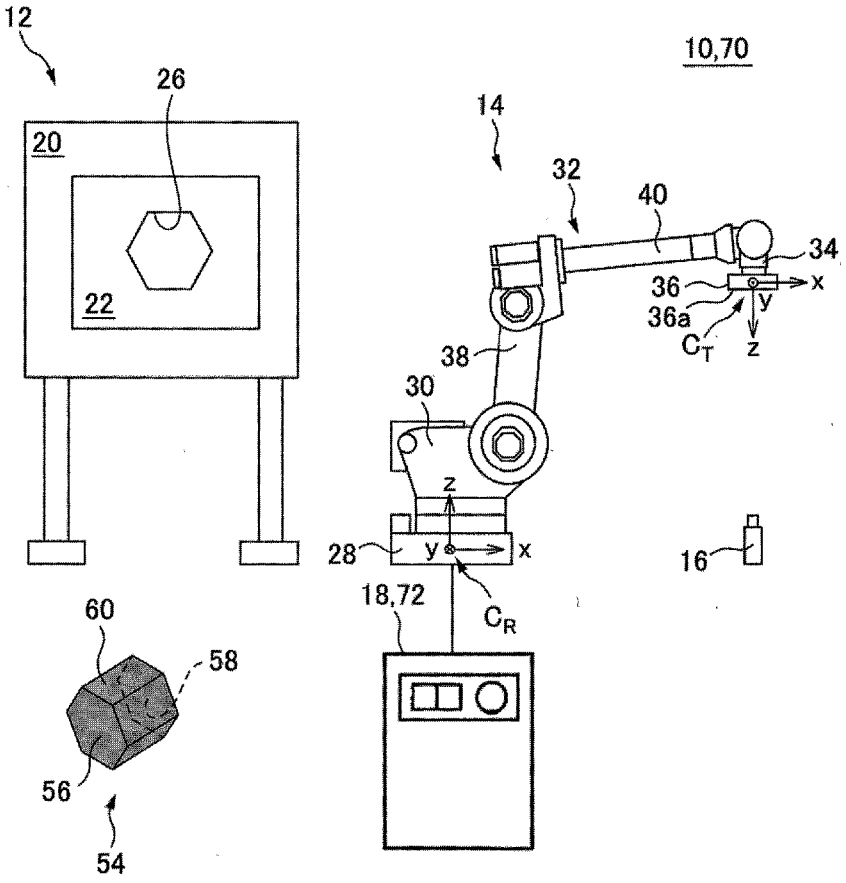


FIG. 1

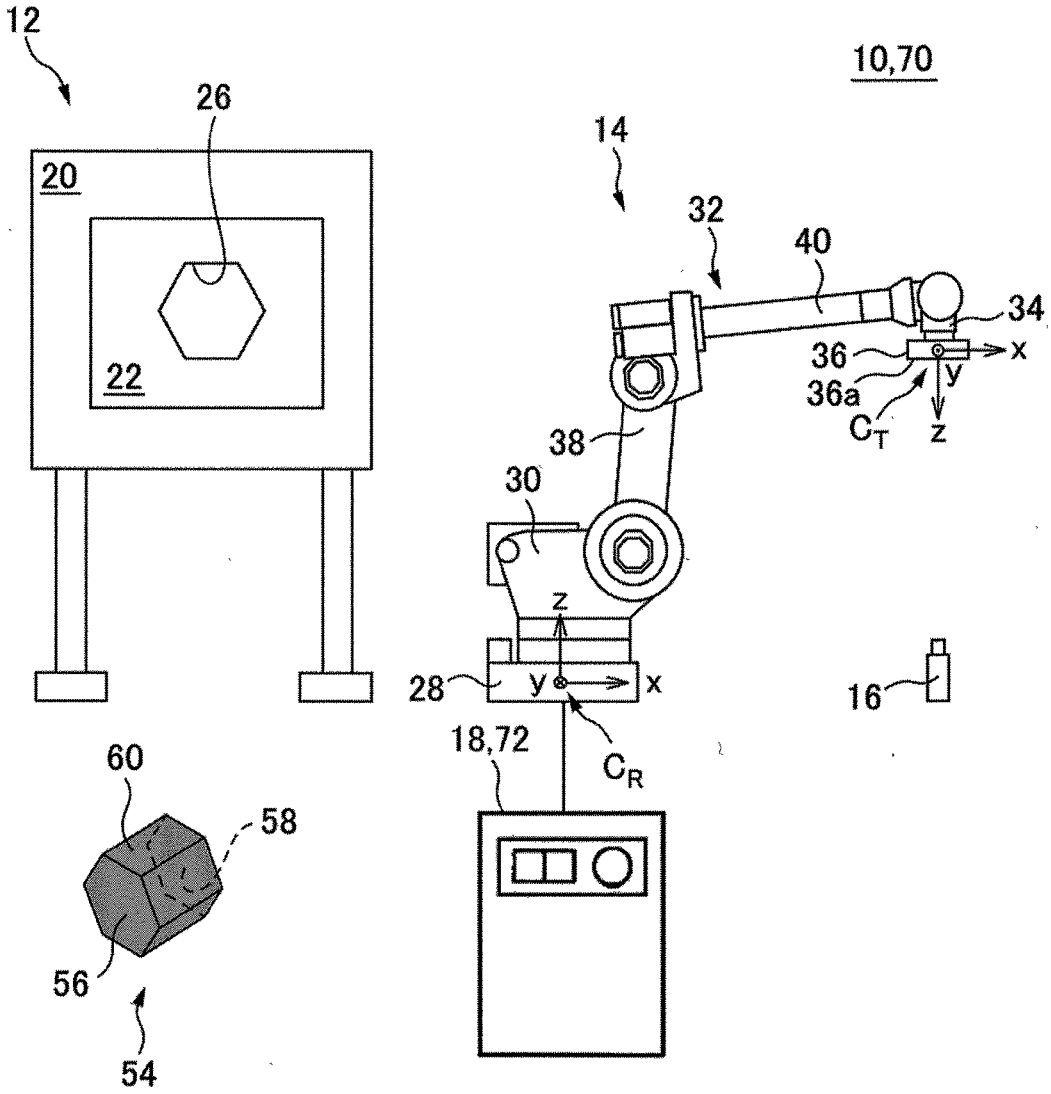

12
26
20
22
10,70
14
32
40
34
36
36a
x
y
z
C_T
38
30
z
28
y
x
16
18,72
C_R
60
58
56
54

FIG. 2

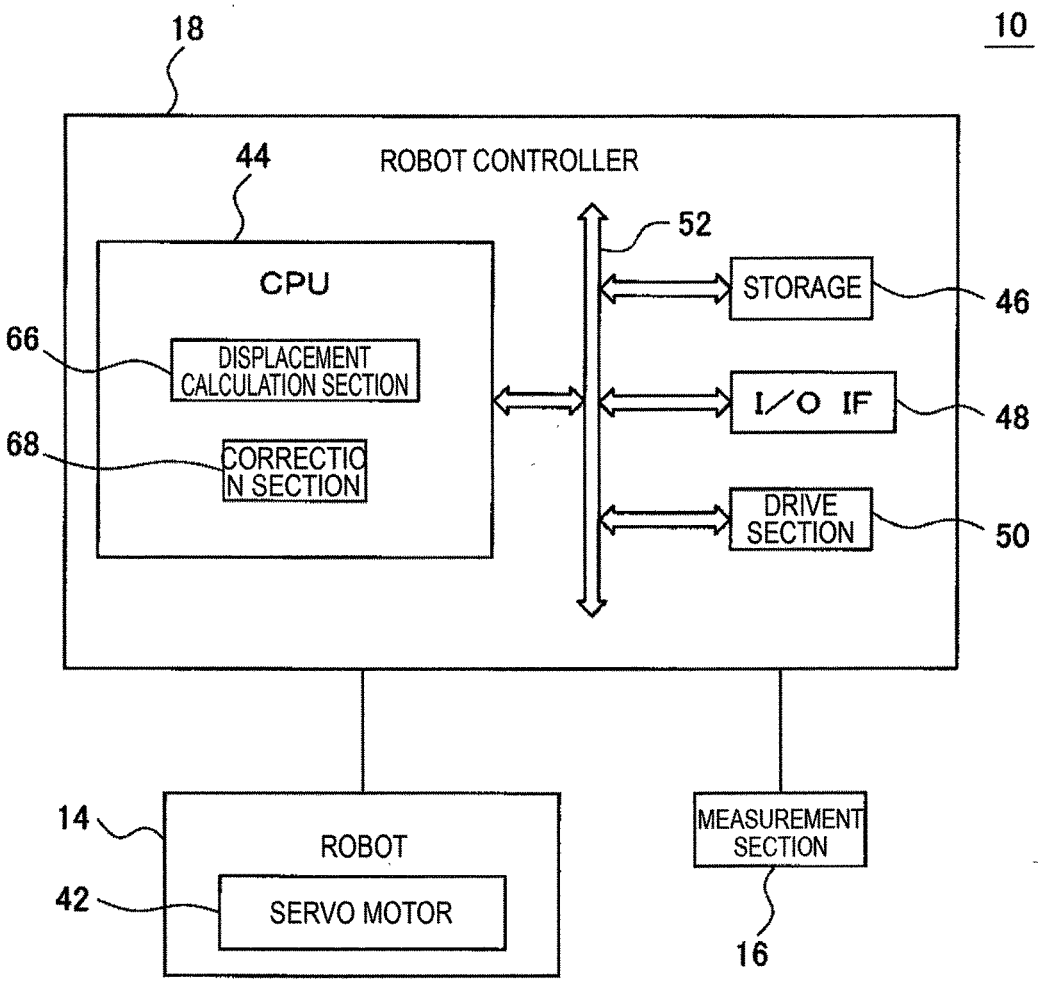

18
10
ROBOT CONTROLLER
44
CPU
66
DISPLACEMENT CALCULATION SECTION
68
CORRECTIO N SECTION
52
STORAGE
46
I/O IF
48
DRIVE SECTION
50
14
ROBOT
42
SERVO MOTOR
MEASUREMENT SECTION
16

FIG. 3

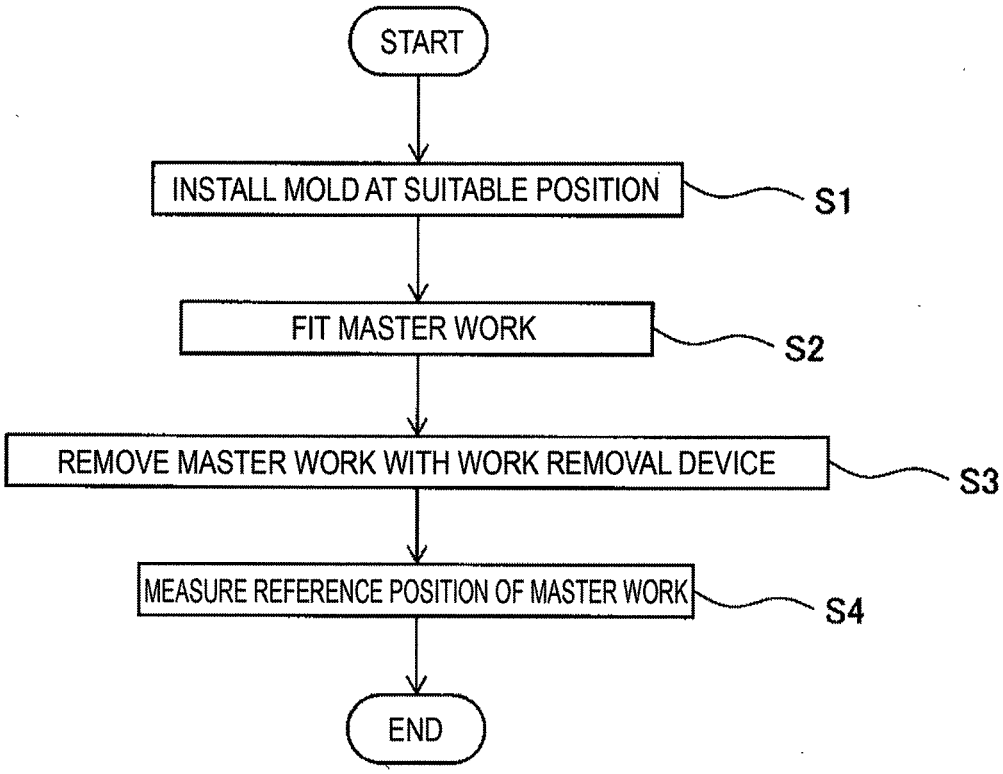

START
INSTALL MOLD AT SUITABLE POSITION
S1
FIT MASTER WORK
S2
REMOVE MASTER WORK WITH WORK REMOVAL DEVICE
S3
MEASURE REFERENCE POSITION OF MASTER WORK
S4
END

FIG. 4

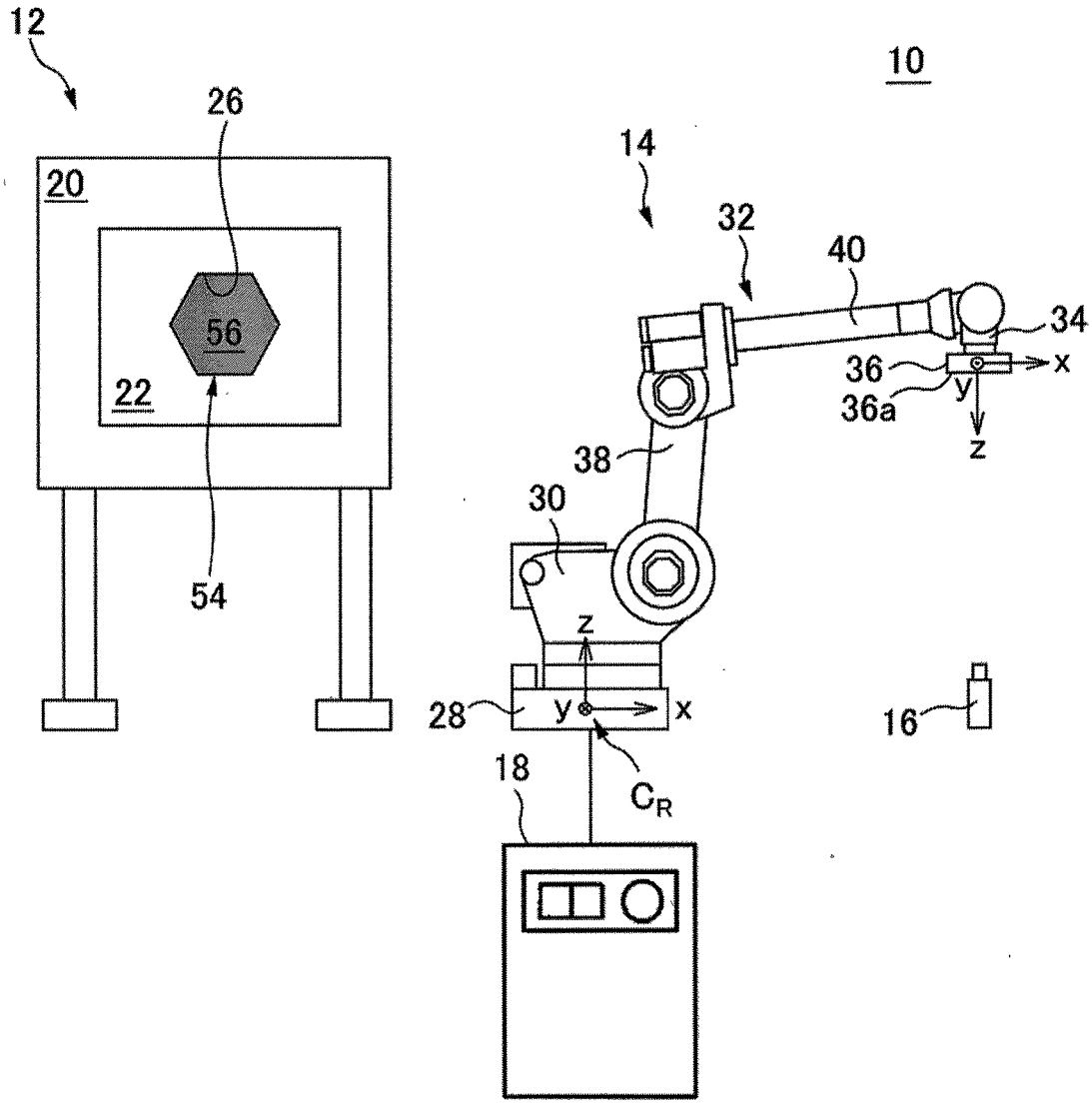


FIG. 5

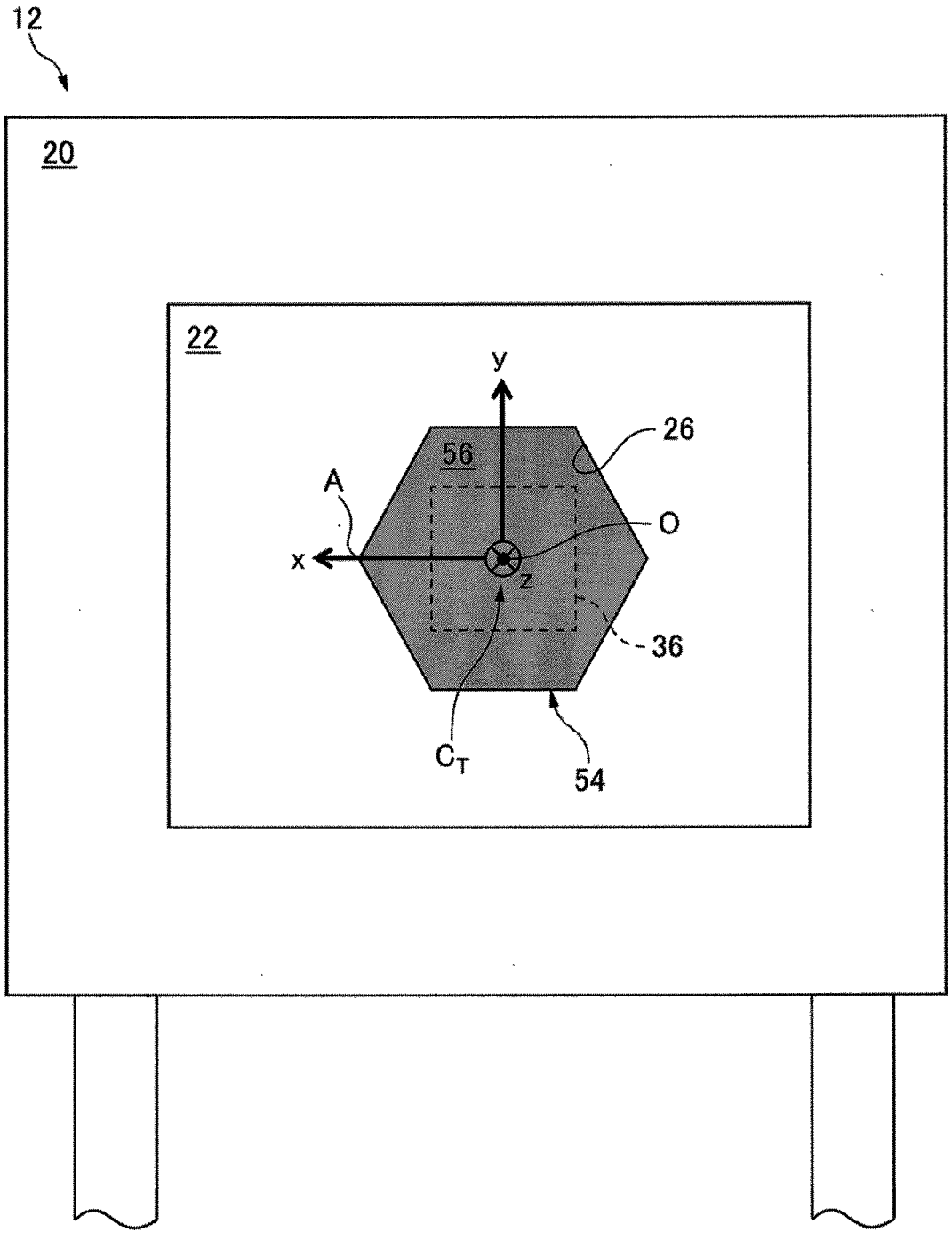


FIG. 6

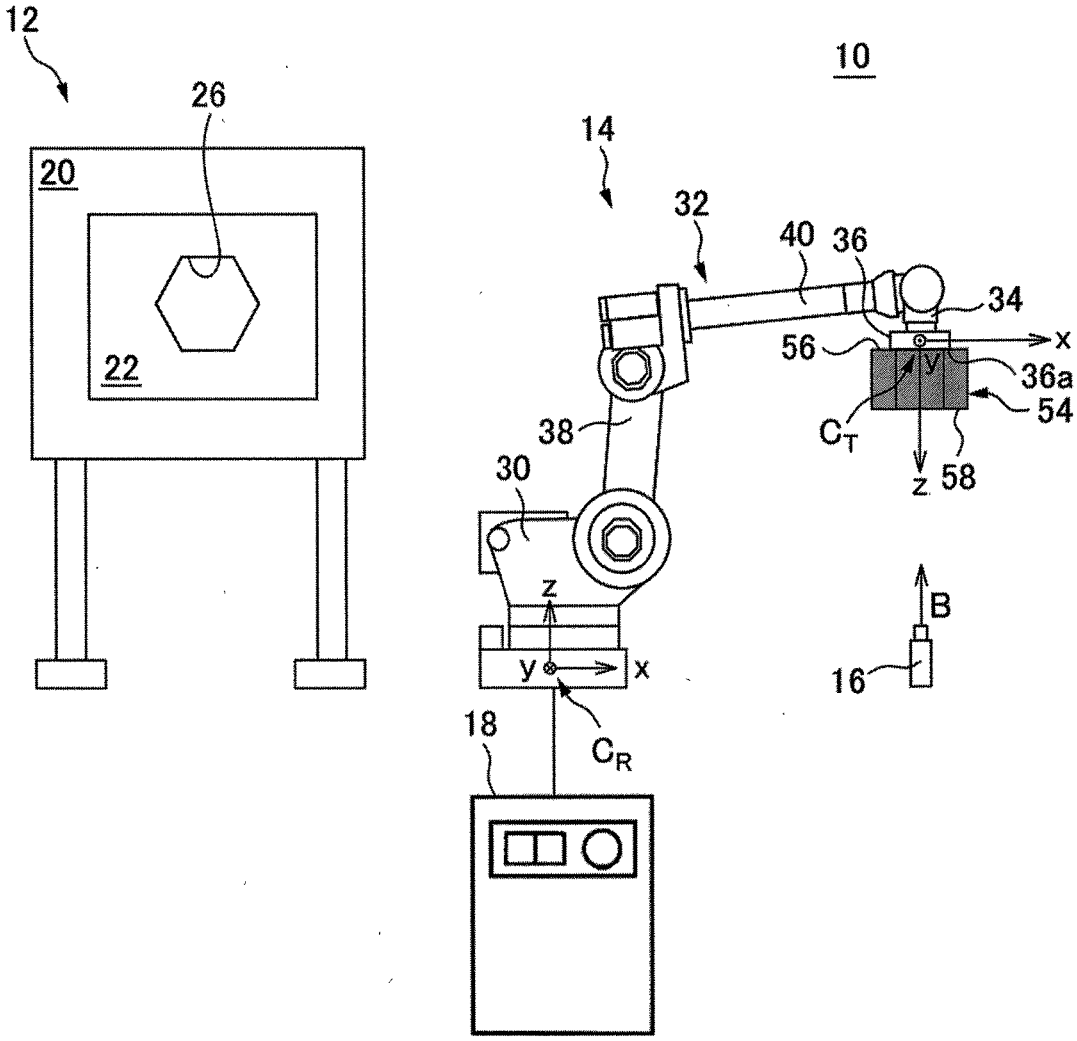


FIG. 7

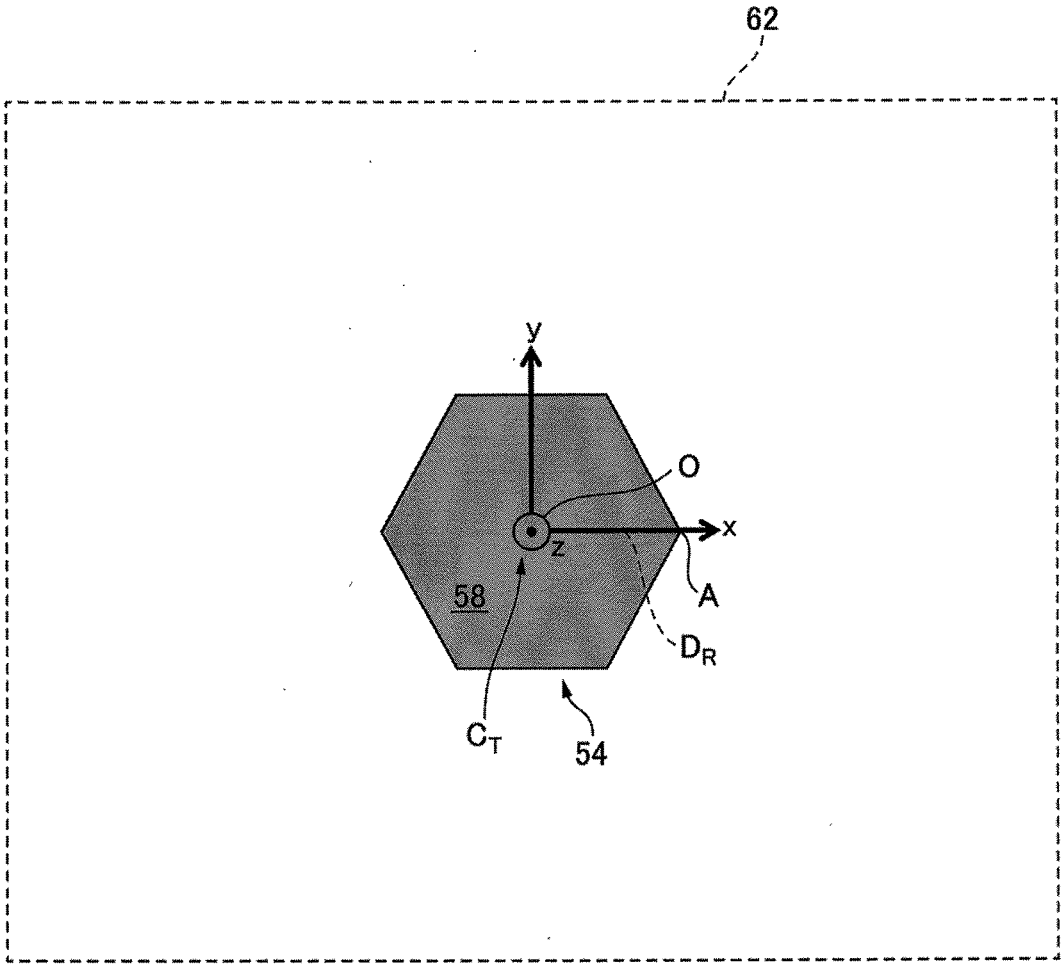


FIG. 8

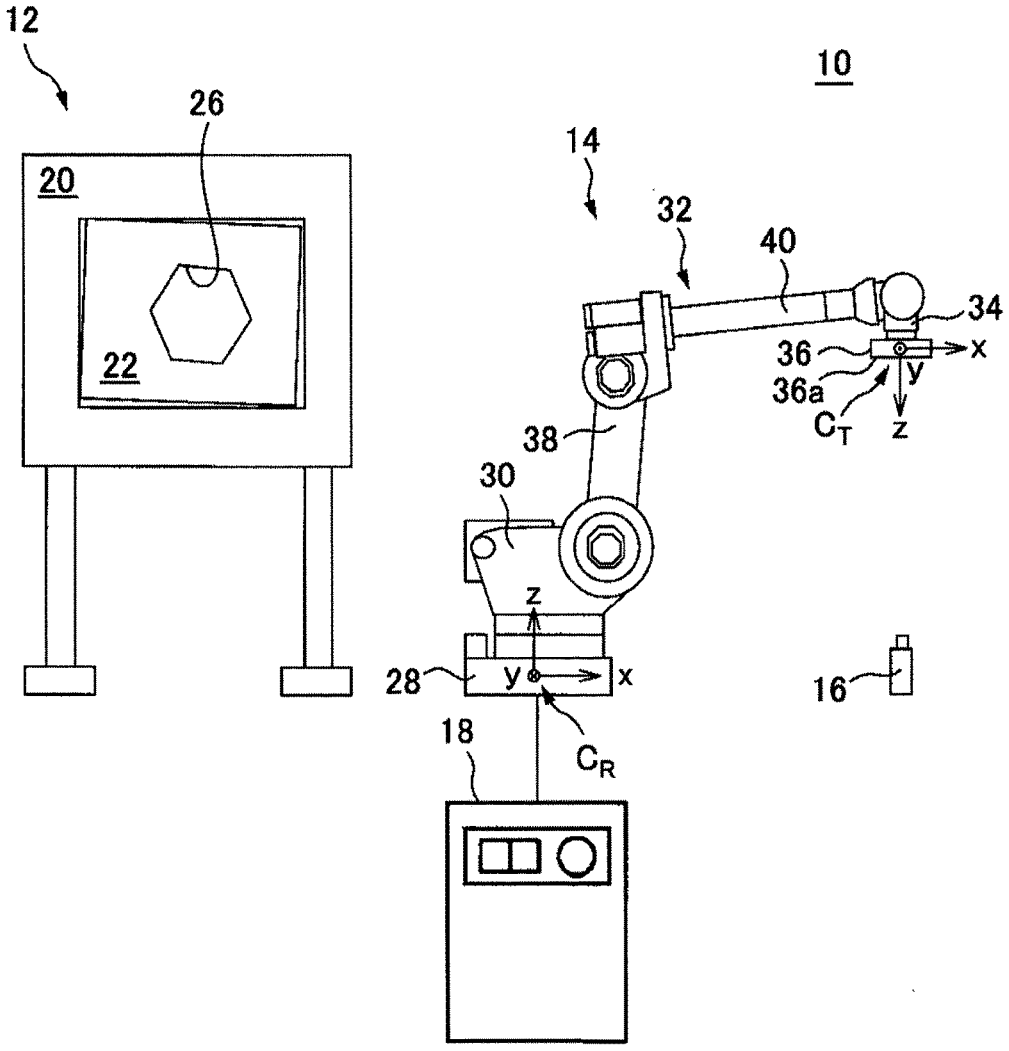


FIG. 9

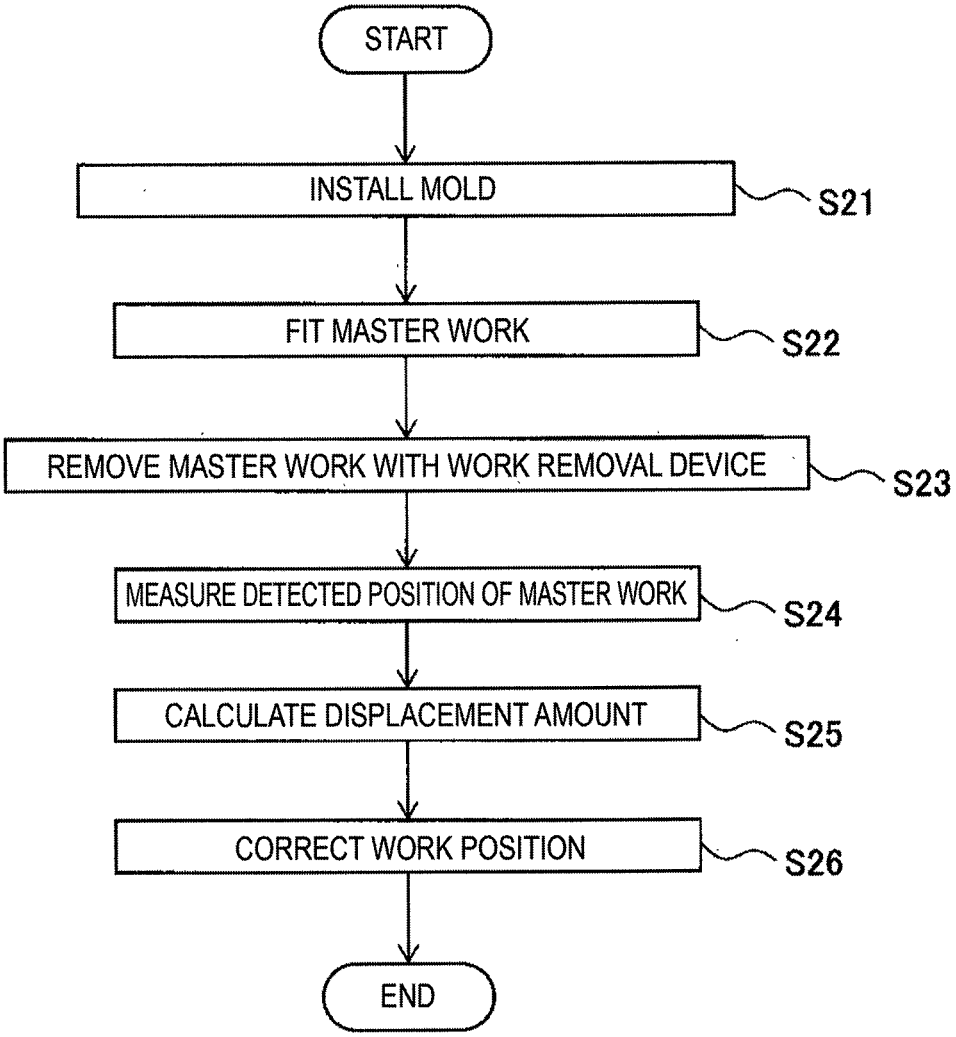

START
INSTALL MOLD
S21
FIT MASTER WORK
S22
REMOVE MASTER WORK WITH WORK REMOVAL DEVICE
S23
MEASURE DETECTED POSITION OF MASTER WORK
S24
CALCULATE DISPLACEMENT AMOUNT
S25
CORRECT WORK POSITION
S26
END

FIG. 10

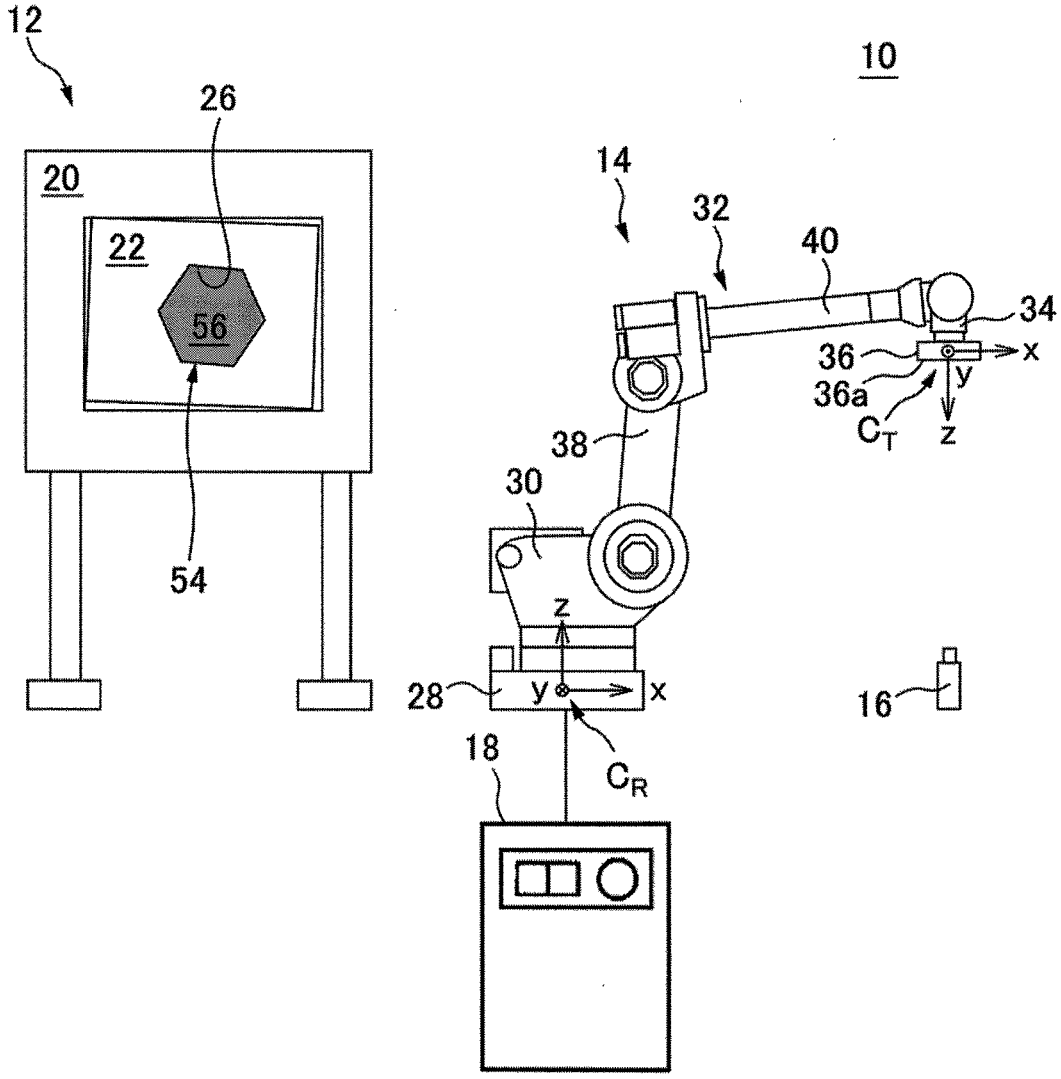


FIG. 11

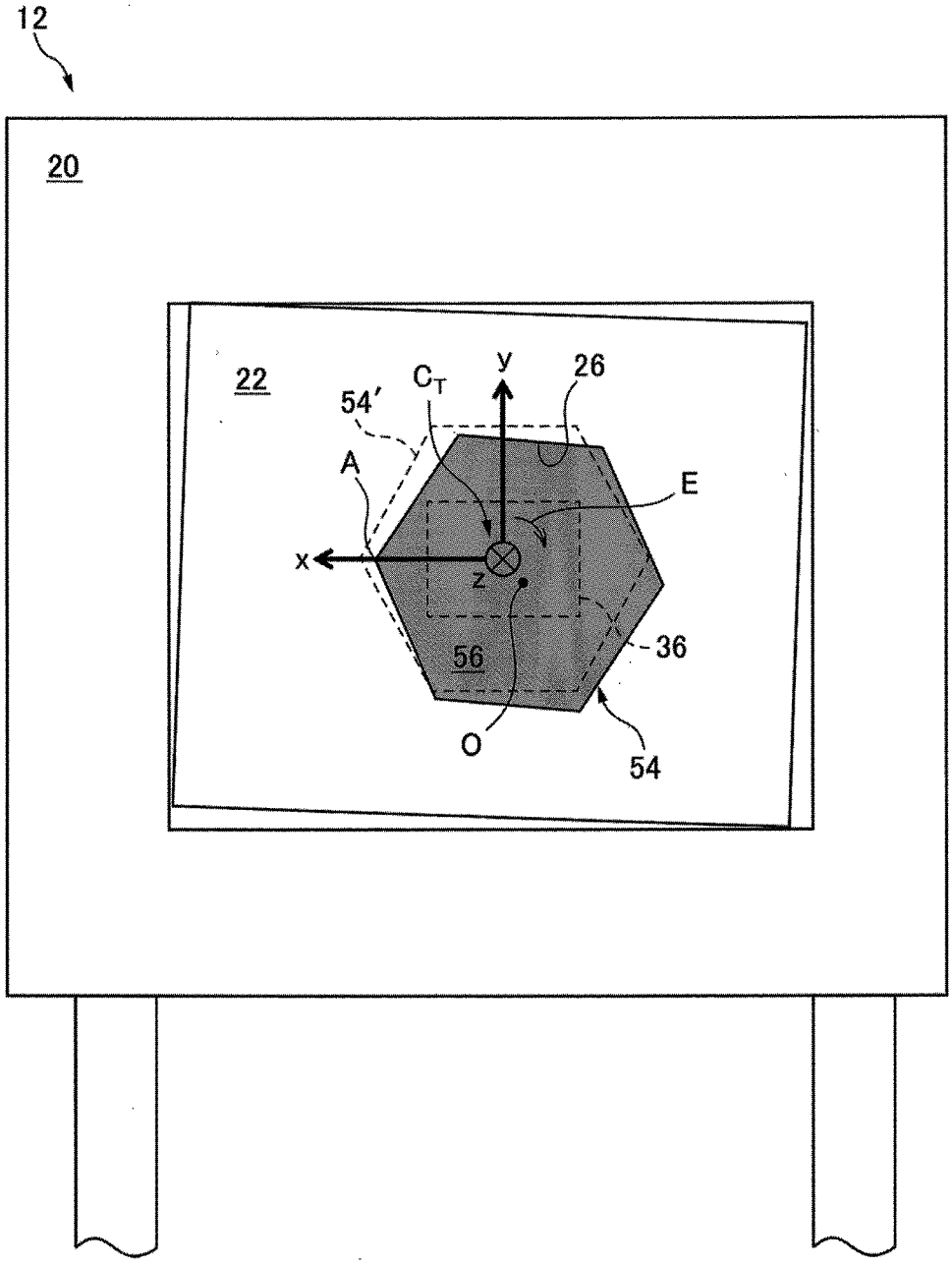


FIG. 12

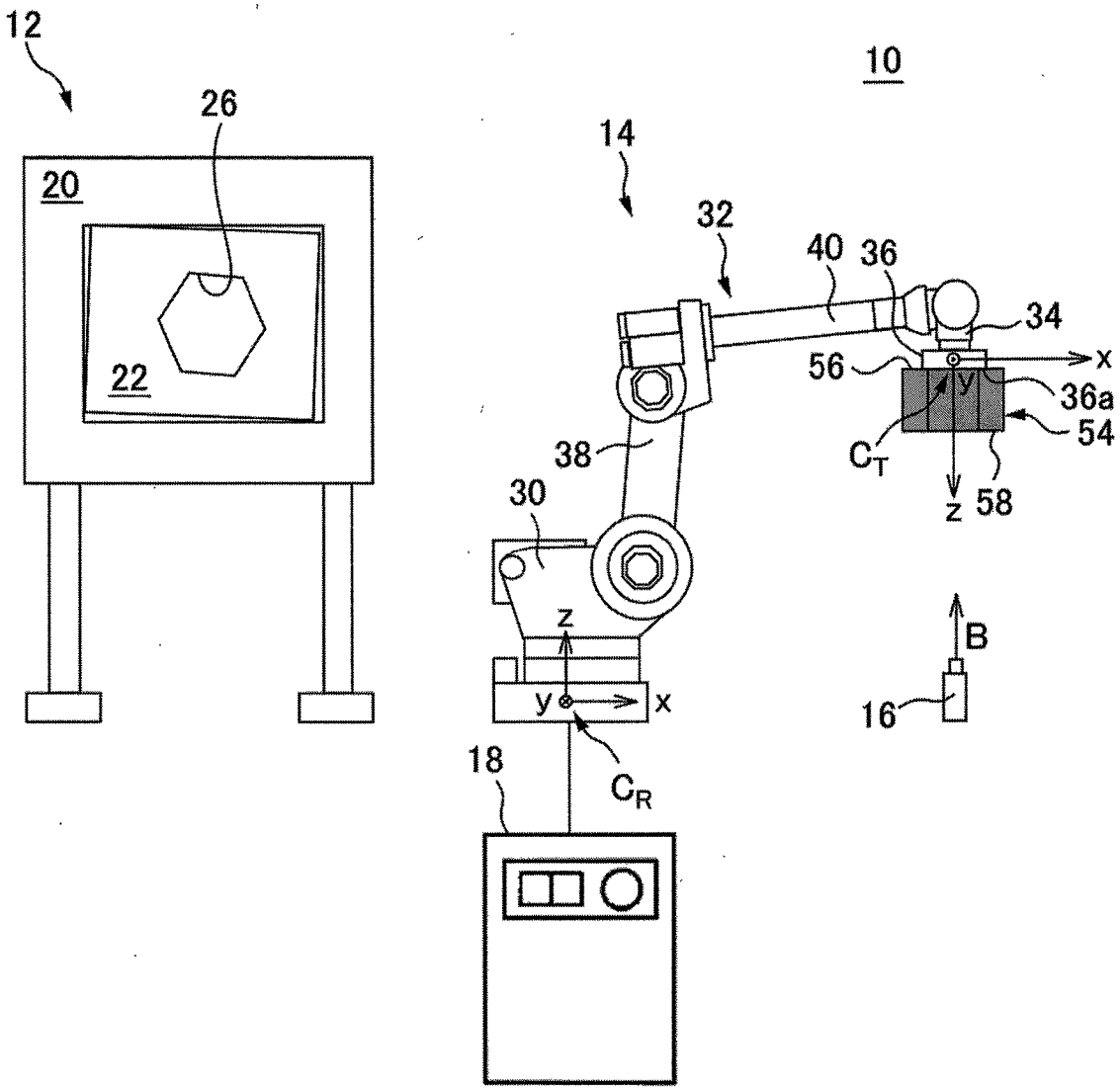


FIG. 13

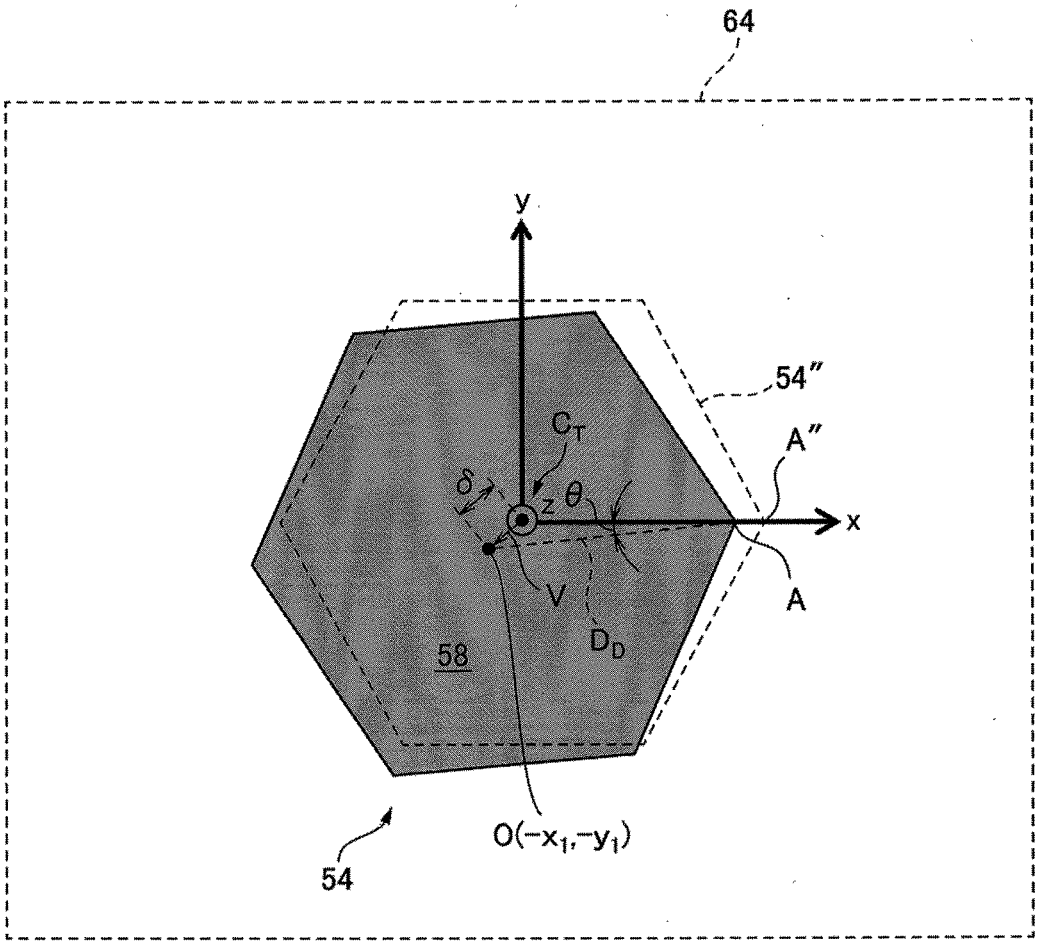


FIG. 14

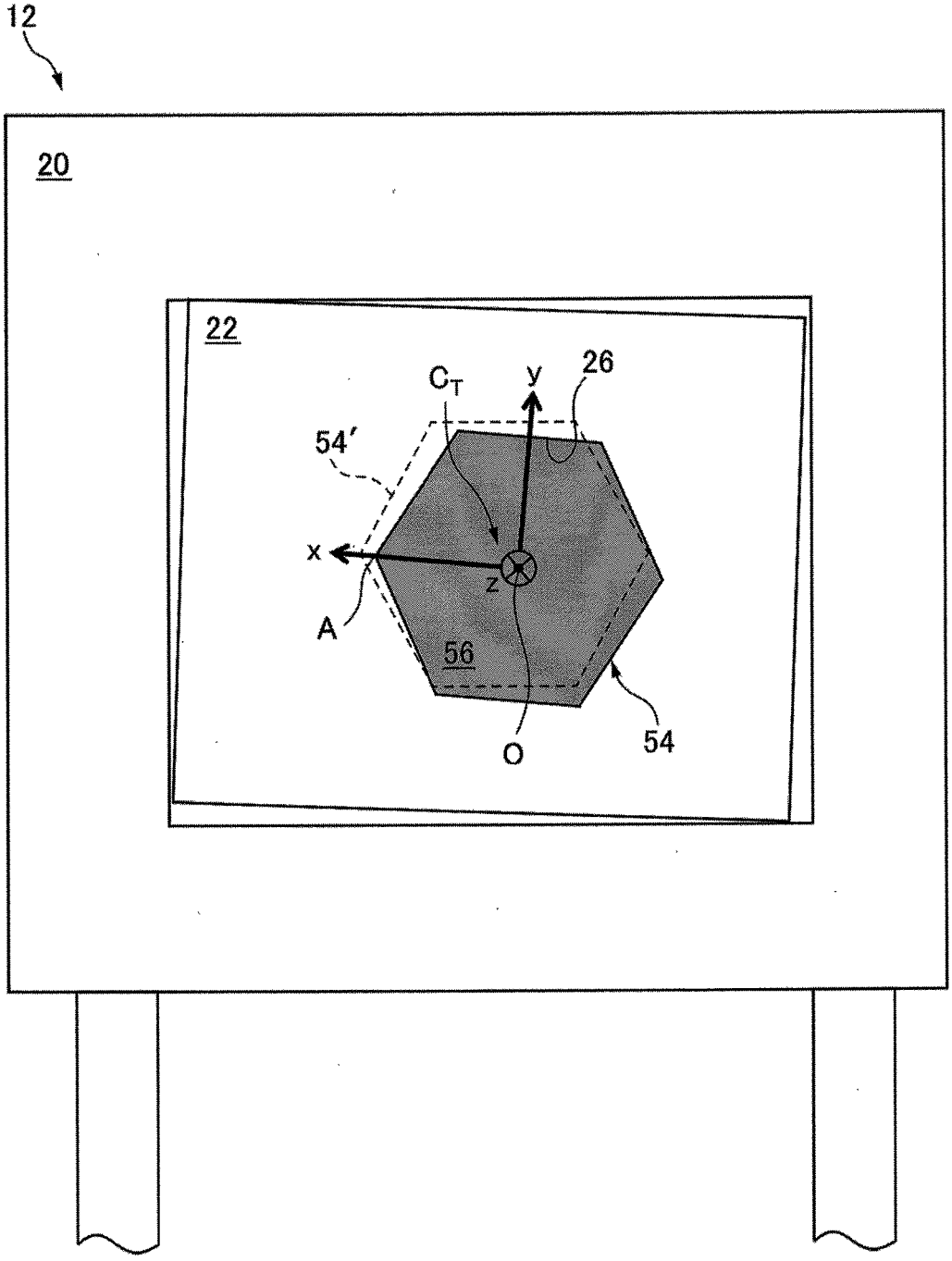


FIG. 15

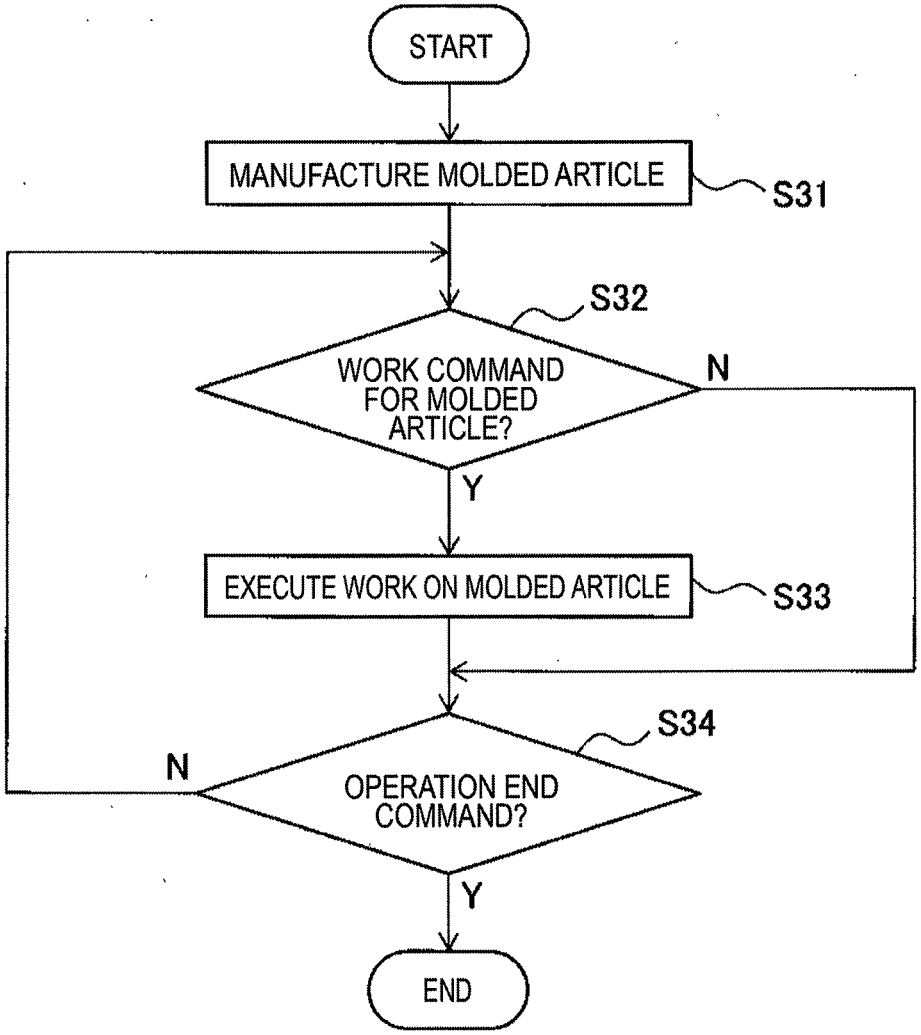

START
MANUFACTURE MOLDED ARTICLE
S31
S32
WORK COMMAND FOR MOLDED ARTICLE?
N
Y
EXECUTE WORK ON MOLDED ARTICLE
S33
S34
N
OPERATION END COMMAND?
Y
END

FIG. 16

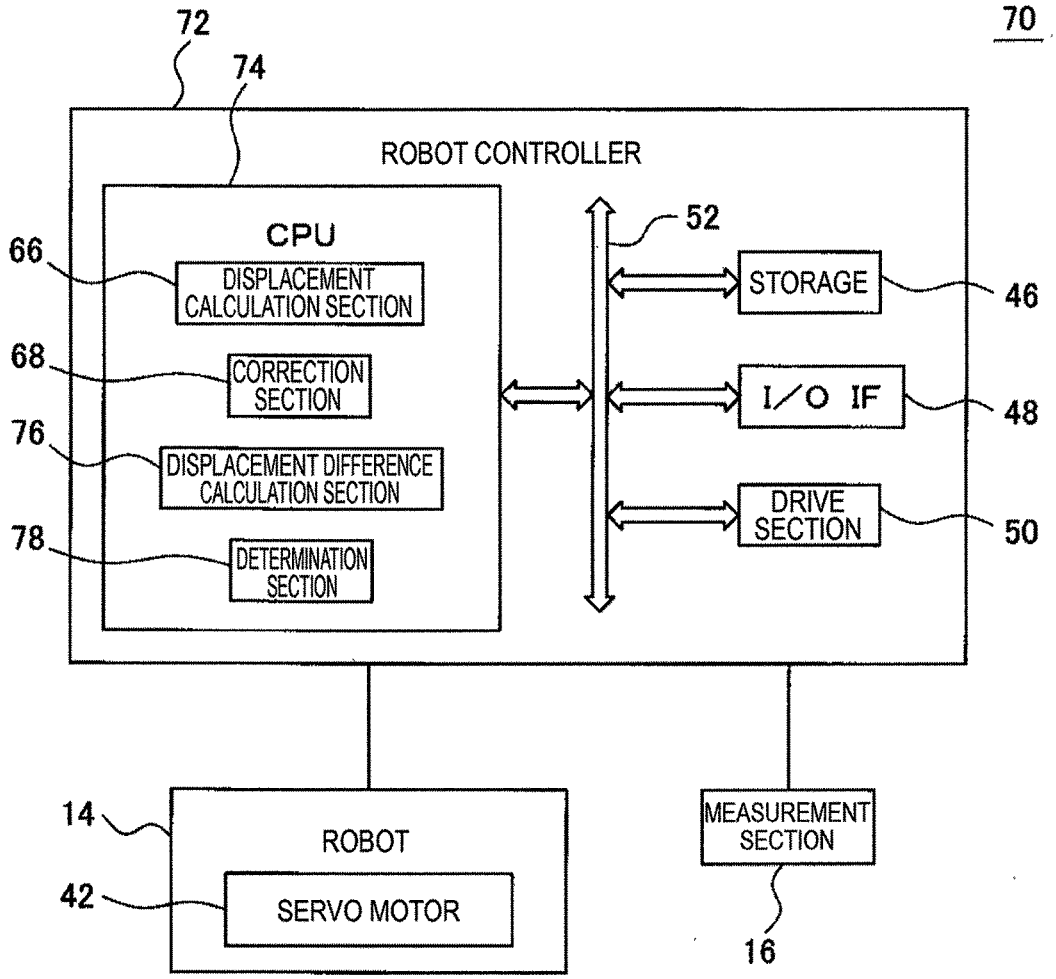

72
74
70
ROBOT CONTROLLER
CPU
66
DISPLACEMENT CALCULATION SECTION
68
CORRECTION SECTION
76
DISPLACEMENT DIFFERENCE CALCULATION SECTION
78
DETERMINATION SECTION
52
STORAGE
46
I/O IF
48
DRIVE SECTION
50
14
ROBOT
42
SERVO MOTOR
MEASUREMENT SECTION
16

FIG. 17

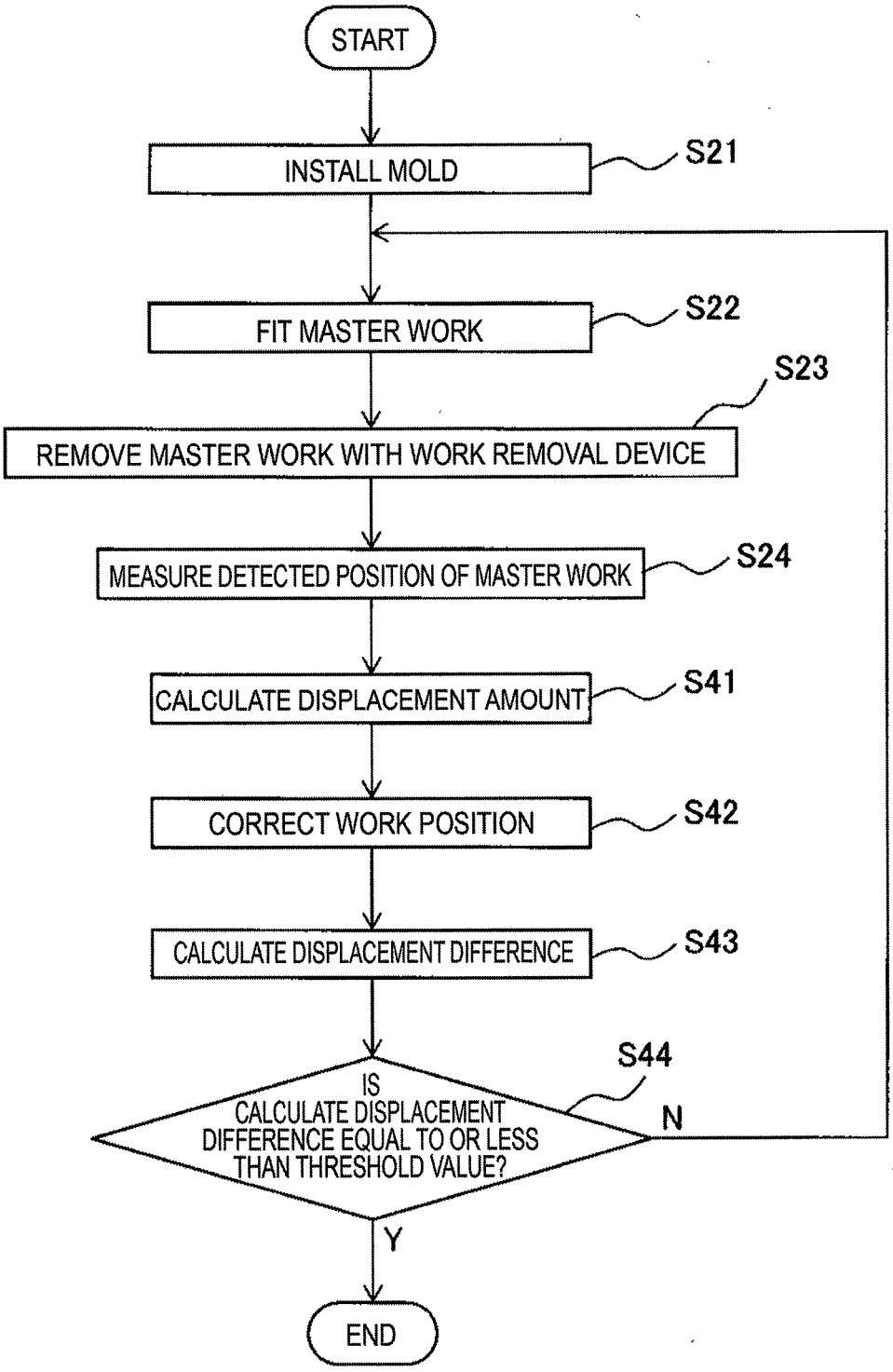

START
INSTALL MOLD
S21
FIT MASTER WORK
S22
S23
REMOVE MASTER WORK WITH WORK REMOVAL DEVICE
MEASURE DETECTED POSITION OF MASTER WORK
S24
CALCULATE DISPLACEMENT AMOUNT
S41
CORRECT WORK POSITION
S42
CALCULATE DISPLACEMENT DIFFERENCE
S43
S44
IS CALCULATE DISPLACEMENT DIFFERENCE EQUAL TO OR LESS THAN THRESHOLD VALUE?
N
Y
END

FIG. 18

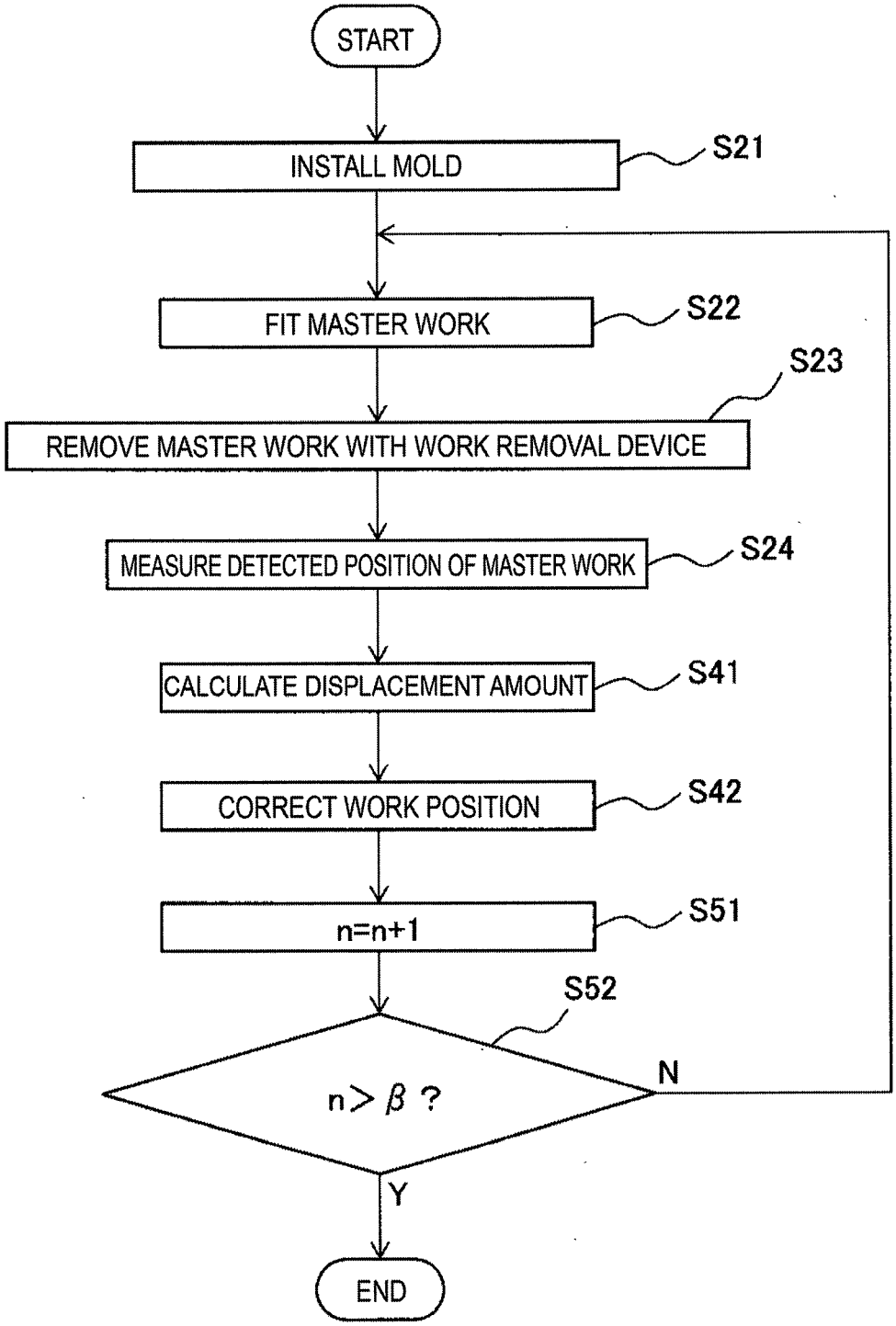

START
INSTALL MOLD
S21
FIT MASTER WORK
S22
S23
REMOVE MASTER WORK WITH WORK REMOVAL DEVICE
MEASURE DETECTED POSITION OF MASTER WORK
S24
CALCULATE DISPLACEMENT AMOUNT
S41
CORRECT WORK POSITION
S42
n=n+1
S51
S52
n> β ?
N
Y
END

FIG. 19

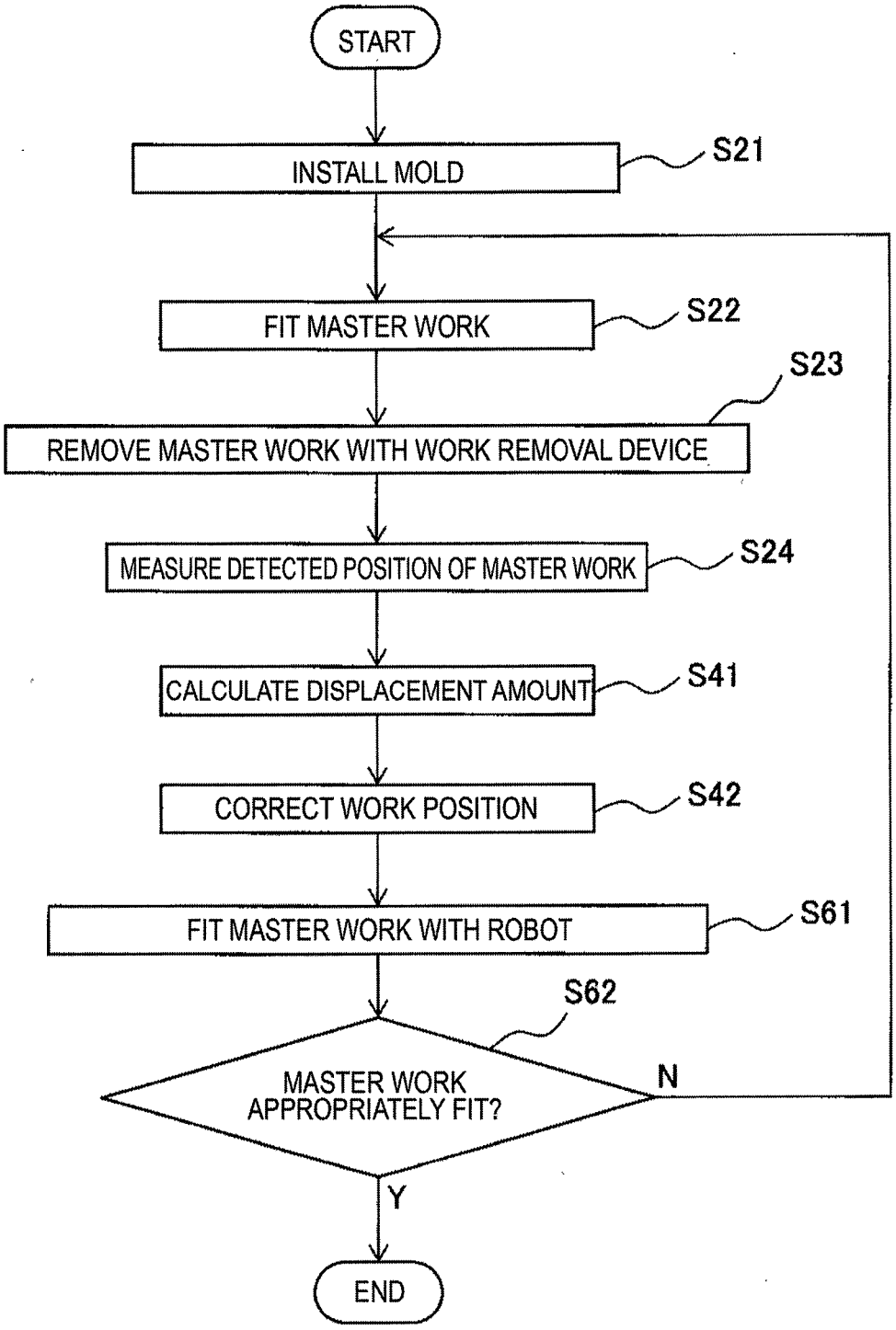

START
INSTALL MOLD
S21
FIT MASTER WORK
S22
S23
REMOVE MASTER WORK WITH WORK REMOVAL DEVICE
MEASURE DETECTED POSITION OF MASTER WORK
S24
CALCULATE DISPLACEMENT AMOUNT
S41
CORRECT WORK POSITION
S42
FIT MASTER WORK WITH ROBOT
S61
S62
MASTER WORK APPROPRIATELY FIT?
N
Y
END

FIG. 20A

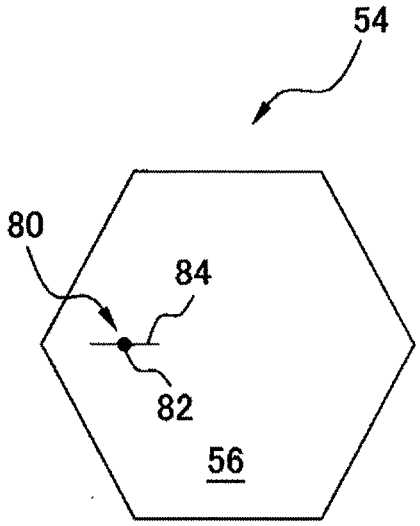
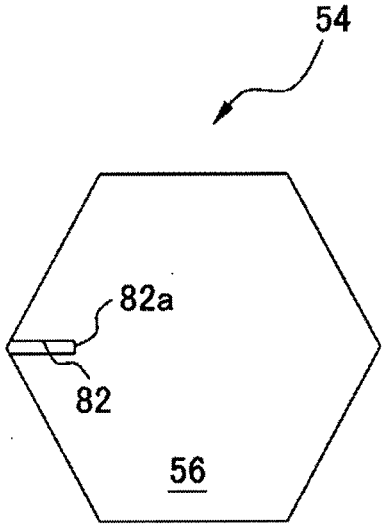


FIG. 20B



MOLDING SYSTEM PROVIDED WITH MOLDING MACHINE AND MOLDED ARTICLE REMOVAL DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a molding system provided with a molding machine and a molded article removal device.

2. Description of the Related Art

[0002] A technology for positioning a mold at a fixed position with respect to a molding machine when replacing the mold of the molding machine is known (i.e., JP-A-2000-317949).

[0003] There is currently a demand for technology that employs a molded article removal device composed of a robot and the like to perform highly accurate operations (e.g. inserting an insert in the molded article) on a molded article formed by the mold of the molding machine.

SUMMARY OF THE INVENTION

[0004] A molding system includes a molding machine in which a mold is installed; a molded article removal device capable of removing a master work attached to the mold; and a measurement section configured to measure a position of the master work held by the molded article removal device when the molded article removal device removes the master work attached to the mold, as a reference position.

[0005] The measurement section is configured to measure a position of the master work held by the molded article removal device when the molded article removal device removes the master work attached to the mold after measuring the reference position, as a detected position.

[0006] The molding system includes a displacement calculation section configured to calculate a difference between the reference position and the detected position measured by the measurement section, as a displacement amount; and a correction section configured to correct a work position in a molded article molded by the molding machine with the mold, based on the displacement amount calculated by the displacement calculation section, wherein the work position is a position where the molded article removal device carries out a work on the molded article.

[0007] The molded article removal device may repeatedly carry out removing the master work attached to the mold, after the measurement section measures the reference position. The measurement section may measure the detected position each time the molded article removal device removes the master work attached to the mold. The displacement calculation section may calculate the displacement amount each time the measurement section measures the detected position.

[0008] The molding system may further include a displacement difference calculation section configured to calculate a displacement difference which is a difference between a first displacement amount calculated by the displacement calculation section and a second displacement amount calculated by the displacement calculation section prior to the first displacement amount.

[0009] The molding system may further include a determination section configured to determine whether the displacement difference calculated by the displacement difference calculation section is equal to or less than a predetermined threshold value. The correction section may correct a removal position as the work position where the molded article removal device removes the molded article in the mold, based on the displacement amount.

[0010] The correction section may correct an insertion position as the work position where the molded article removal device inserts an insert part into the molded article in the mold, based on the displacement amount. The molded article removal device may be a robot. The measurement section may include an imaging section configured to image the master work.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The above-described or other objects, features and advantages of the invention will become more apparent from the following description of the embodiments in connection with the accompanying drawings, in which:

[0012] FIG. **1** is a view of a molding system according to an embodiment;

[0013] FIG. **2** is a block diagram of the molding system illustrated in FIG. **1**;

[0014] FIG. **3** is a flowchart illustrating an example of an operation flow of the molding system illustrated in FIG. **1**;

[0015] FIG. **4** is a view of a state when step S**2** in FIG. **3** has ended;

[0016] FIG. **5** is a view illustrating an example of a tool coordinate system established in step S**3** in FIG. **3**;

[0017] FIG. **6** is a view of a state when step S**3** in FIG. **3** has ended;

[0018] FIG. **7** is a view illustrating an example of an image imaged by the measurement section in step S**4** in FIG. **3**;

[0019] FIG. **8** is a view illustrating a state in which the molding machine is installed with a mold after replacing the mold;

[0020] FIG. **9** is a flowchart illustrating an example of an operation flow of the molding system illustrated in FIG. **1**;

[0021] FIG. **10** is a view of a state when step S**22** in FIG. **9** has ended;

[0022] FIG. **11** is a view illustrating an example of a tool coordinate system established in step S**23** in FIG. **9**;

[0023] FIG. **12** is a view of a state when step S**23** in FIG. **9** has ended;

[0024] FIG. **13** is a view illustrating an example of an image imaged by the measurement section in step S**24** in FIG. **9**;

[0025] FIG. **14** is a view illustrating an example of a tool coordinate system established in step S**33** in FIG. **15**;

[0026] FIG. **15** is a flowchart illustrating an example of an operation flow of the molding system illustrated in FIG. **1**;

[0027] FIG. **16** is a block diagram of a molding system according to another embodiment;

[0028] FIG. **17** is a flowchart illustrating an example of an operation flow of the molding system illustrated in FIG. **16**;

[0029] FIG. **18** is a flowchart illustrating an alternative example of the flow illustrated in FIG. **17**;

[0030] FIG. **19** is a flowchart illustrating another alternative example of the flow illustrated in FIG. **17**;

[0031] FIG. **20**A is a view of a master work according to another embodiment; and

[0032] FIG. **20**B is a view of a master work according to yet another embodiment.

DETAILED DESCRIPTION

[0033] Below, embodiments of the invention are described in detail with reference to the drawings. Note that, in the various embodiments described below, similar elements are assigned the same reference numerals, and repetitive descriptions thereof will be omitted. Herein, the robot coordinate system C_R in FIG. **1** is used as a standard for directions, and for the sake of convenience, the x-axis positive direction of the robot coordinate system C_R is referred to as to rightward, the y-axis positive direction is referred to as rearward, and the z-axis positive direction is referred to as upward.

[0034] First, a molding system **10** according to an embodiment will be described with reference to FIGS. **1** and **2**. The molding system **10** includes a molding machine **12**, a robot **14**, a measurement section **16**, and a robot controller **18**.

[0035] The molding machine **12** is e.g. an injection molding machine or a die cast molding machine, and includes a mold installation portion **20** and a mold **22**.

[0036] The mold **22** is formed with a cavity **26** into which material such as resin is injected. The molding machine **12** fills the cavity **26** of the mold **22** with the material, and molds a molded article. In this embodiment, the cavity **26** is a space having a hexagonal prism shape.

[0037] The robot **14** is a vertical articulated robot, and includes a robot base **28**, a revolving drum **30**, a robot arm **32**, a wrist **34**, and an end effector **36**. The robot base **28** is fixed on a floor of a work cell. The revolving drum **30** is mounted on the robot base **28** so as to be able to revolve about a vertical axis.

[0038] The robot arm **32** includes an upper arm **38** rotatably coupled to the revolving drum **30** and a forearm **40** rotatably coupled to a distal end of the upper arm **38**. The wrist **34** is attached to a distal end of the forearm **40**, and supports the end effector **36** so as to be rotatable about three axes.

[0039] In this embodiment, the end effector **36** includes an adsorption surface **36***a* (not illustrated), and is able to adsorb and hold a master work **54** and a molded article described below by the adsorption surface **36***a*.

[0040] The adsorption surface **36***a* is composed of e.g. an air suction device, an electromagnet, or a sucker. Alternatively, the end effector **36** may include a gripper (not illustrated) able to grip an insert part described below, wherein the gripper may be a robot hand including openable and closeable fingers.

[0041] The robot **14** includes a plurality of servomotors **42** (FIG. **2**). The servo motors **42** are built in the revolving drum **30**, the robot arm **32**, and the wrist **34**, respectively, and rotate these components about the respective rotation axes in accordance with commands from the robot controller **18**.

[0042] The robot coordinate system C_R is set as an automatic control-coordinate system for controlling the components of the robot **14**. The robot controller **18** operates the components of the robot **12** with reference to the robot coordinate system C_R. For example, the z-axis of the robot coordinate system C_R is arranged parallel with the vertical direction of real space, and the revolving drum **30** is rotated about the z-axis of the robot coordinate system C_R.

[0043] On the other hand, a tool coordinate system C_T is set for the end effector **36**. The tool coordinate system C_T is an automatic control-coordinate system which defines the position and orientation of the end effector **36** in the robot coordinate system C_R.

[0044] For example, the tool coordinate system C_T is set such that the origin of the tool coordinate system C_T is arranged at the center of the adsorption surface **36***a* of the end effector **36**, and the z-axis of the tool coordinate system C_T is orthogonal to the adsorption surface **36***a*.

[0045] The robot controller **18** operates the revolving drum **30**, the robot arm **32**, and the wrist **34** in the robot coordinate system C_R so as to match the position and orientation of the end effector **36** with those defined by the tool coordinate system C_T. In this way, the end effector **36** is positioned at any position and orientation in the robot coordinate system C_R.

[0046] The measurement section **16** is e.g. a vision sensor, and includes an imaging section capable of imaging an article. The imaging section includes an imaging element such as a charge-coupled device (CCD) or complementary metal oxide semiconductor (CMOS) sensor. The measurement section **16** images an article and sends the image data thereof to the robot controller **18** in accordance with a command from the robot controller **18**. Note that, the function of the measurement section **16** will be described below.

[0047] The robot controller **18** directly or indirectly controls each component of the robot **14**. Specifically, as illustrated in FIG. **2**, the robot controller **18** includes a CPU **44**, a storage **46**, an input/output interface (I/O interface) **48**, and a drive section **50**.

[0048] The CPU **44** is communicably connected to the storage **46**, the I/O interface **48**, and the drive section **50** via a bus **52**, and carries out various processes described below while communicating with these components.

[0049] The storage **46** includes an electrically erasable/recordable nonvolatile memory such as EEPROM (registered trademark), and stores constants, variables, setting values, programs, and the like necessary for the CPU **44** to execute the various processes such that these data are not lost when the molding system **10** is shut down.

[0050] Additionally, the storage **46** includes a RAM such as DRAM or SRAM capable of high-speed reading/writing, and temporarily stores data necessary for the CPU **44** to execute the various processes. Further, the constants, variables, setting values, parameters, programs, and the like stored in the nonvolatile memory are appropriately loaded onto the RAM, and the CPU **44** uses the data loaded onto the RAM to execute the various processes.

[0051] The I/O interface **48** is communicably connected to the measurement section **16**, and receives data from the measurement section **16** in accordance with a command from the CPU **44**. The I/O interface **48** may be constituted by e.g. an ethernet port or a USB port, and communicate with the measurement section **16** via wired communication. Alternatively, the I/O interface **48** may communicate with the measurement section **16** via Wi-Fi or wireless LAN by wireless communication.

[0052] The drive section **50** drives each servomotor **42** built in the robot **14** in accordance with a command from the CPU **44**. Specifically, the drive section **50** includes e.g. an inverter or servo amplifier, and sends a command (speed command, torque command, etc.) to each servomotor **42** so as to drive the servo motor **42**.

[0053] The molding system **10** evaluates a displacement amount of the position of the mold **22** installed in the mold installation portion **20** from a suitable position, with using the master work **54** (FIG. **1**). The master work **54** has a shape

of a hexagonal prism coinciding with the cavity **26** formed at the mold **22**, and can be fit into the cavity **26** without gap.

[0054] More specifically, the master work **54** includes a front surface **56**, a rear surface **58** opposite the front surface **56**, and a side surface **60** extending between the front surface **56** and the rear surface **58**. Each of the front surface **56** and the rear surface **58** has a shape of a hexagon coinciding with the cavity **26**. The side surface **60** is a tubular surface of hexagonal prism shape, and extends over the circumference of the master work **54**.

[0055] Next, the operation of the molding system **10** will be described. When the molding system **10** is operated, a reference position measuring flow illustrated in FIG. **3** is firstly carried out. In step S**1**, the user sets the mold **22** in the mold installation portion **20** at a suitable position with respect to the mold installation portion **20**. The suitable position is determined by that the user adjusts the position of the mold **22** in the rotation direction with using a level gauge such that the upper surface of the mold **22** is horizontal.

[0056] For example, the suitable position is determined as a position of the mold **22** with respect to the mold installation portion **20** in which the upper surface of the mold **22** is horizontal when the mold **22** is installed in the mold installation portion **20**. FIG. **1** illustrates a state in which the mold **22** is arranged at the suitable position.

[0057] In step S**2**, the user or the robot **14** fits the master work **54** into the cavity **26** of the mold **22** installed at the suitable position. At this time, the master work **54** is fit into the cavity **26** such that the rear surface **58** of the master work **54** faces a bottom surface of the cavity **26**, and the front surface **56** of the master work **54** faces the outside. This state is illustrated in FIG. **4**.

[0058] In this embodiment, when the master work **54** is fit into the cavity **26** as illustrated in FIG. **4**, the front surface **56** of the master work **54** is disposed substantially parallel with the x-z plane of the robot coordinate system C_R.

[0059] In step S**3**, the CPU **44** of the robot controller **18** carries out a master work removal operation of removing the master work **54** from the mold **22**. Specifically, the CPU **44** operates the robot **14** as described below in accordance with a robot program.

[0060] First, the CPU **44** sets the tool coordinate system C_T as illustrated in FIG. **5**. In the example illustrated in FIG. **5**, the origin (or the z-axis) of the tool coordinate system C_T is arranged frontward of the center O of the master work **54**.

[0061] Further, the z-axis of the tool coordinate system C_T is orthogonal to the front surface **56** of the master work **54** (i.e., the x-z plane of the robot coordinate system C_R). Further, a projection point of one corner A of the master work **54** when the corner A is projected on the x-y plane of the tool coordinate system C_T is arranged on the x-axis of the tool coordinate system C_T.

[0062] Then, the CPU **44** sends a command to each servomotor **42** built in the robot **14** through the drive section **50** so as to arrange the end effector **36** at a position and orientation defined by the tool coordinate system C_T illustrated in FIG. **5**.

[0063] When the end effector **36** is arranged at the position and orientation defined by the tool coordinate system C_T illustrated in FIG. **5**, the end effector **36** is positioned relative to the master work **54** as indicated by the dotted line **36** in FIG. **5**, and the adsorption surface **36***a* of the end effector **36** contacts the front surface **56** of the master work **54**.

[0064] Then, the CPU **44** operates the end effector **36** so as to adsorb the front surface **56** of the master work **54** by the adsorption surface **36***a*. Then, the CPU **44** sets the tool coordinate system C_T as illustrated in FIG. **6**.

[0065] In the example illustrated in FIG. **6**, the position in the horizontal plane (i.e., the x-y plane of the robot coordinate system C_R) of a visual-line direction B of the imaging section of the measurement section **16** coincides with that of the z-axis of the tool coordinate system C_T.

[0066] Then, the CPU **44** sends a command to each servomotor **42** through the drive section **50** so as to arrange the end effector **36** at a position and orientation defined by the tool coordinate system C_T illustrated in FIG. **6**.

[0067] As a result, the end effector **36** and the master work **54** are disposed upward of the measurement section **16**, as illustrated in FIG. **6**. In this way, the CPU **44** carries out the master work removal operation in accordance with the robot program.

[0068] The robot program is constructed by teaching the above-mentioned master work removal operation to the robot **14**, and is pre-stored in the storage **46**. The robot program includes a command to be sent to each servomotor **42** from the CPU **44** in order to carry out the master work removal operation.

[0069] Thus, in this embodiment, the robot **14** functions as a molded article removal device configured to remove the master work **54** attached to the mold **22**.

[0070] In step S**4**, the CPU **44** operates the measurement section **16** so as to measure a reference position of the master work **54**. Specifically, the CPU **44** sends a position-measurement command to the measurement section **16**. The measurement section **16** images the master work **54** in the state illustrated in FIG. **6** when receiving the position-measurement command from the CPU **44**.

[0071] An example of the image imaged by the measurement section **16** is illustrated in FIG. **7**. Note that, in the image **62** illustrated in FIG. **7**, the tool coordinate system C_T of FIG. **6** is shown for the sake of easy understanding. The measurement section **16** sends the imaged image **62** to the I/O interface **48**.

[0072] The CPU **44** receives the image **62** via the I/O interface **48**, and stores in the storage **46** the position of the master work **54** in the image **62** as the reference position. In this way, the measurement section **16** measures the reference position of the master work **54** by imaging the master work **54** held by the robot **14**.

[0073] After the flow illustrated in FIG. **3** is ended, the user replaces the mold **22** with another mold (not illustrated), and then installs the mold **22** in the mold installation portion **20** again. At this time, the mold **22** may be skewed or displaced with respect to the mold installation portion **20**, as illustrated in FIG. **8**.

[0074] In order to address this, the molding system **10** according to this embodiment calculates such a displacement amount from the suitable position by comparing the position of the mold **22** with the reference position of the master work **54** acquired in the above-described step S**4**.

[0075] Then, on the basis of the calculated displacement amount, the molding system **10** corrects the work position in the molded article where the robot **14** carries out a work on the molded article molded by the molding machine **12** with the mold **22**.

[0076] The work position correction operation will be described below with reference to FIG. **9**. The flow illus-

trated in FIG. **9** is started after the flow illustrated in FIG. **3** is ended and the mold **22** illustrated in FIG. **1** is replaced.

[0077] In step S**21**, the user fixes the mold **22** in the mold installation portion **20**. Below, a case is described where the mold **22** is fixed in the mold installation portion **20** in a skewed manner as illustrated in FIG. **8** in step S**21**.

[0078] In step S**22**, the user or the robot **14** fits the master work **54** into the cavity **26** of the mold **22** illustrated in FIG. **8**. At this time, the master work **54** is fit into the cavity **26** such that the rear surface **58** of the master work **54** faces the bottom surface of the cavity **26**, and the front surface **56** of the master work **54** faces the outside. This state is illustrated in FIG. **10**. In step S**23**, the CPU **44** of the robot controller **18** causes the robot **14** to carry out the above-mentioned master work removal operation so as to remove the master work **54** illustrated in FIG. **10** from the mold **22**, in accordance with the robot program.

[0079] Specifically, the CPU **44** sets the tool coordinate system C_T such that the position of the origin and the axial directions thereof are the same as those illustrated in FIG. **5**. This state is illustrated in FIG. **11**. Note that, in FIG. **11**, the position of the master work **54** in FIG. **5** is indicated by the dotted line **54'** for the sake of easy understanding.

[0080] As illustrated in FIG. **11**, if the mold **22** is installed in the mold installation portion **20** in a skewed manner, the center O of the master work **54** is disposed from the origin of the tool coordinate system C_T (i.e., the z-axis) in the x-y plane of the tool coordinate system C_T.

[0081] Then, the CPU **44** sends a command to each servomotor **42** built in the robot **14** through the drive section **50** so as to arrange the end effector **36** at a position and orientation defined by the tool coordinate system C_T illustrated in FIG. **11**.

[0082] When the end effector **36** is arranged at the position and orientation defined by the tool coordinate system C_T illustrated in FIG. **11**, the end effector **36** is positioned with respect to the master work **54** as indicated by the dotted line **36** in FIG. **11**, and the adsorption surface **36***a* of the end effector **36** contacts the front surface **56** of the master work **54**.

[0083] Then, the CPU **44** operates the end effector **36** so as to adsorb the front surface **56** of the master work **54** by the adsorption surface **36***a*. Then, the CPU **44** sets the tool coordinate system C_T such that the position of the origin and the axial directions thereof are the same as those illustrated in FIG. **6**.

[0084] Then, the CPU **44** sends a command to each servomotor **42** through the drive section **50** so as to arrange the end effector **36** at a position and orientation defined by the set tool coordinate system C_T.

[0085] As a result, as illustrated in FIG. **12**, the end effector **36** and the master work **54** are disposed upward of the measurement section **16**. In this way, the CPU **44** executes the master work removal operation on the master work **54** illustrated in FIG. **10**.

[0086] In step S**24**, the CPU **44** operates the measurement section **16** so as to measure the position of the master work **54**. Specifically, the CPU **44** sends a position-measurement command to the measurement section **16**. When receiving the position-measurement command from the CPU **44**, the measurement section **16** images the master work **54** held by the end effector **36** as illustrated in FIG. **12**.

[0087] An example of the image imaged by the measurement section **16** at this time is illustrated in FIG. **13**. Note that, in the image **64** illustrated in FIG. **13**, the tool coordinate system C_T is shown, and the reference position of the master work **54** illustrated in FIG. **7** is indicated by the dotted line **54"**, for the sake of easy understanding.

[0088] As illustrated in FIG. **13**, in the image **64**, the center O of the master work **54** is displaced from the origin of the tool coordinate system C_T (i.e., the center of the reference position **54"**) by the distance δ in the x-y plane of the tool coordinate system C_T.

[0089] For example, if the image **64** is represented as coordinates in the x-y plane of the tool coordinate system C_T, the center of the reference position **54"** is defined as the origin (0, 0). On the other hand, the coordinates of the center O of the master work **54** are $(-x_1, -y_1)$. Accordingly, the distance δ is $(x_1^2+y_1^2)^{1/2}$.

[0090] Further, an angle θ about the z-axis of the tool coordinate system C_T is formed between an imaginary line D_D, which connects the center O and the corner A of the master work **54**, and the x-axis of the tool coordinate system C_T (i.e., the imaginary line that connects the center and the corner A" of the reference position **54"**).

[0091] The measurement section **16** sends the captured image **64** to the I/O interface **48**. The CPU **44** receives the image **64** via the I/O interface **48**, and stores in the storage **46** the position of the master work **54** in the image **64** as a detected position.

[0092] In step S**25**, the CPU **44** calculates the difference between the reference position and the detected position as the displacement amount. Specifically, the CPU **44** reads out from the storage **46** the reference position of the master work **54** in the image **62** stored in step S**4** and the detected position of the master work **54** in the image **64** stored in step S**24**.

[0093] As an example, the CPU **44** analyses the image **62** illustrated in FIG. **7** and detects the center of the master work **54** in the image **62** (i.e., the center of the reference position **54"** in FIG. **13**). Then, the CPU **44** calculates the coordinates P_R (0, 0) in the x-y plane of the tool coordinate system C_T of the detected center of the reference position **54"**.

[0094] On the other hand, the CPU **44** analyses the image **64** illustrated in FIG. **13** and detects the center O of the master work **54** in the image **64**. Then, the CPU **44** calculates the coordinates P_D $(-x_1, -y_1)$ in the x-y plane of the tool coordinate system C_T of the detected center O in the image **64**. Then, the CPU **44** calculates the vector V $(-x_1, -y_1)$ from the coordinates P_R to the coordinates P_D as the displacement amount indicative of the difference in the x-y plane between the reference position and the detected position.

[0095] In addition, the CPU **44** analyses the image **62** illustrated in FIG. **7** and calculates an imaginary line D_R(FIG. **7**) that connects the center O and the corner A of the master work **54** in the image **62**. In this embodiment, the imaginary line D_R coincides with the x-axis of the tool coordinate system C_T.

[0096] On the other hand, the CPU **44** analyses the image **64** illustrated in FIG. **13** and calculates the imaginary line D_D that connects the center O and the corner A of the master work **54** in the image **64**. Then, the CPU **44** calculates the angle θ between the imaginary line D_R (i.e., the x-axis of the tool coordinate system C_T) and the imaginary line D_D as the displacement amount indicative of the difference between the reference position and the detected position about the z-axis.

[0097] Then, the CPU **44** stores the calculated vector V $(-x_1, -y_1)$ and the angle θ in the storage **46**. Thus, in this embodiment, the CPU **44** functions as a displacement calculation section **66** (FIG. **2**) configured to calculate the displacement amount.

[0098] In step S**26**, the CPU **44** corrects the work position in the molded article where the robot **14** carries out a work (e.g., removing the molded article, or inserting an insert part into the molded article) on the molded article in step **33** described below.

[0099] As an example, the CPU **44** corrects the robot program such that the position of the tool coordinate system C_T to be set when carrying out the work on the molded article in following step S**33** is moved by the displacement amount calculated in step S**25**.

[0100] Here, it is assumed that the CPU **44** sets the tool coordinate system C_T when the robot **14** carries out the work on the molded article in the following step S**33** as illustrated in FIG. **11**.

[0101] In this case, the CPU **44** moves the origin (i.e., the z-axis) of the tool coordinate system C_T to be set in the following step S**33** from the position illustrated in FIG. **11** by the vector V $(-x_1, -y_1)$ in the x-y plane of the tool coordinate system C_T (i.e., moves the origin by x_1 in the x-axis negative direction and y_1 in the y-axis negative direction).

[0102] Additionally, the CPU **44** rotates the tool coordinate system C_T to be set in the following step S**33** from the position illustrated in FIG. **11** about the z-axis by the angle θ in the direction indicated by an arrow E in FIG. **11**. As a result, the tool coordinate system C_T to be set in step S**33** is changed to the position illustrated in FIG. **14**. In this way, the CPU **44** corrects the robot program so as to change the setting of the tool coordinate system C_T when executing step S**33**.

[0103] As another example, the CPU **44** may arrange the end effector **36** at the position and orientation defined by the tool coordinate system C_T set as illustrated in FIG. **11** in the following step S**33**, and after that, further move the end effector **36** by the displacement amount calculated in step S**25**.

[0104] In this case, the CPU **44** moves the end effector **36** arranged at the tool coordinate system C_T illustrated in FIG. **11** by the vector V $(-x_1, -y_1)$ in the x-y plane of the tool coordinate system C_T.

[0105] Together with this, the CPU **44** rotates the end effector **36** about the z-axis by the angle θ in the direction of the arrow E in FIG. **11**. The CPU **44** corrects the robot program so as to carry out such operations.

[0106] After the execution of the flow illustrated in FIG. **9**, the CPU **44** carries out the flow illustrated in FIG. **15**. In step S**31**, the molding machine **12** molds the molded article with the mold **22**. Specifically, the material such as resin is injected into the cavity **26** of the mold **22**. The molding machine **12** fills up the cavity **26** of the mold **22** with the material and molds the molded article.

[0107] In step S**32**, the CPU **44** determines whether or not it receives a work command for carrying out the work on the molded article from the user, host controller, or a molding program. The work command includes a command for causing the robot **14** to carry out the work of removing the molded article from the mold **22**, or inserting an insert part into the molded article in the mold **22**, for example.

[0108] When the CPU **44** determines that it receives the work command (i.e., determines YES), the CPU **44** proceeds to step S**33**. On the other hand, when the CPU **44** determines that it does not receive the work command (i.e., determines NO), the CPU **44** proceeds to step S**34**.

[0109] In step S**33**, the CPU **44** carries out the work on the molded article. As an example, if the robot program is corrected so as to change the setting of the tool coordinate system C_T in the above-mentioned step S**26**, the CPU **44** sets the tool coordinate system C_T as illustrated in FIG. **14**.

[0110] Then, the CPU **44** arranges the end effector **36** at the position and orientation defined by the tool coordinate system C_T, and adsorbs the front surface of the molded article by the adsorption surface **36***a* of the end effector **36**. Then, the CPU **44** operates the robot **14** so as to remove the molded article held by the end effector **36** from the mold **22**.

[0111] Here, the position (removal position) in the molded article where the adsorption surface **36***a* adsorbs the molded article is corrected in accordance with the displacement amount calculated in step S**25**. Accordingly, even if the mold **22** is installed in a skewed manner as illustrated in FIG. **8** upon the replacement of the mold **22**, it is possible to arrange the end effector **36** at the same position and orientation with respect to the molded article. Therefore, the molded article can be reliably removed.

[0112] Alternatively, the CPU **44** arranges the end effector **36** at the position and orientation defined by the tool coordinate system C_T illustrated in FIG. **14**, and inserts the insert part gripped by the gripper provided at the end effector **36** at the insertion position formed in the molded article.

[0113] Here, the insertion position where the end effector **36** inserts the insert part into the molded article is corrected in accordance with the displacement amount calculated in step S**25**. Accordingly, even if the mold **22** is installed in a skewed manner as illustrated in FIG. **8** upon the replacement of the mold **22**, it is possible to arrange the end effector **36** at the same position and orientation with respect to the molded article. Therefore, the insert part can be reliably inserted at the given insertion position.

[0114] As another example, if the robot program is corrected so as to move the end effector **36** in the above-mentioned step S**26**, the CPU **44** sets the tool coordinate system C_T as illustrated in FIG. **11**, and arranges the end effector **36** at the position and orientation defined by the tool coordinate system C_T.

[0115] Then, the CPU **44** operates the robot **14** so as to move the end effector **36** by the vector V $(-x_1, -y_1)$ in the x-y plane of the tool coordinate system C_T and rotate the end effector **36** about the z-axis by the angle θ in the direction of the arrow E in FIG. **11**.

[0116] Thereby, since the work position where the end effector **36** works on the molded article in this step S**33** can be corrected in accordance with the displacement amount calculated in step S**25**, it is possible to arrange the end effector **36** at the same position and orientation with respect to the molded article, even if the mold **22** is installed in a skewed manner.

[0117] In step S**34**, the CPU **44** determines whether or not it receives an operation end command from the user, host controller, or molding program. If the CPU **44** determines that it receives the operation end command (i.e. determines YES), the CPU **44** stops the robot **14** and ends the flow illustrated in FIG. **15**. On the other hand, if the CPU **44**

determines that it does not receive the operation end command (i.e. determines NO), the CPU **44** returns to step S**32**.

[0118] As described above, in this embodiment, the CPU **44** calculates the displacement amount (vector V, angle θ) between the reference position measured when the master work **54** installed at the suitable position is removed and the detected position measured when the master work **54** installed after the measurement of the reference position is removed (step S**25**).

[0119] Then, on the basis of the calculated displacement amount, CPU **44** corrects the work position (the removal position, the insertion position) where the robot **14** carries out the work (removing the molded article, inserting the insert part) on the molded article in step S**33** (step S**26**).

[0120] According to this configuration, it is possible to automatically correct the work position of the robot **14** in accordance with the displacement amount from the suitable position of the mold **22**, without repeatedly teaching the robot **14** the operation of step S**33** each time the mold **22** is installed in the mold installation portion **20**. Therefore, it is possible to cause the robot **14** to carry out the work on the work position with high accuracy.

[0121] Further, according to this embodiment, since the work position of the robot **14** can be corrected with the measurement section **16** and the robot **14** which functions as the molded article removal device, the configuration of the molding system **10** can be made compact.

[0122] Furthermore, if an existing mold is used, it is not necessary to machine the mold for correcting the work position. Further, since the measurement section **16** is arranged outside of the mold, this embodiment can be used for a mold in which sufficient space for the focal point of the measurement section **16** cannot be taken.

[0123] Next, a molding system **70** according to another embodiment will be described below with reference to FIGS. **1** and **16**. The molding system **70** includes the molding machine **12**, the robot **14**, the measurement section **16**, and a robot controller **72**. The robot controller **72** includes a CPU **74**, the storage **46**, the I/O interface **48**, and the drive section **50**.

[0124] Similarly to the above-mentioned CPU **44**, the CPU **74** is communicably connected to the storage **46**, the I/O interface **48**, and the drive section **50** via the bus **52**. The CPU **44** carries out the various processes described below while communicating with these components.

[0125] Next, the operation of the molding system **70** will be described with reference to FIG. **17**. At first, the molding system **70** executes the reference position measuring flow illustrated in FIG. **3**, similarly to the above-mentioned molding system **10**. Then, the molding system **70** executes the work position correction operation illustrated in FIG. **17**.

[0126] Note that, in the flow illustrated in FIG. **17**, processes similar to those in the flow illustrated in FIG. **3** are assigned the same step number, and repetitive descriptions thereof will be omitted. The flow illustrated in FIG. **17** is started after the flow illustrated in FIG. **3** is ended and the mold **22** illustrated in FIG. **1** is replaced.

[0127] Here, in the flow illustrated in FIG. **17**, a loop of steps S**22** to S**44** is repeated until it is determined YES in step S**44** described below. Below, the execution of the n-th time of loop will be described below.

[0128] After the n-th time of steps S**22** and S**23** is executed, in step S**41**, the CPU **74** functions as the displacement calculation section **66** (FIG. **16**) so as to calculate the displacement amount.

[0129] Specifically, by the method similar to the above-mentioned embodiment, the CPU **74** calculate the vector V_n (x_n, y_n) and the angle θ_n as the displacement amount, from the reference position included in the image (e.g., image **62**) obtained in the above-mentioned step S**4** and the detected position included in the image (e.g., image **64**) obtained in step S**24** of the n-th time.

[0130] Additionally, the CPU **44** calculates the distance $\delta_n=(x_n^2+y_n^2)^{1/2}$ between the reference position and the detected position from the calculated vector V_n (x_n, y_n). The CPU **74** stores the calculated vector V_n (x_n, y_n), angle θ_n, and distance δ_n in the storage **46**.

[0131] In step S**42**, the CPU **74** functioning as the correction section **68** (FIG. **16**) so as to correct the work position where the robot **14** works on the molded article in step S**33**, on the basis of the displacement amount calculated in the most-recent step S**41**, in a similar manner to step S**26** described above.

[0132] In step S**43**, the CPU **74** calculates a displacement difference. Specifically, the CPU **74** reads out from the storage **46** the distance $\delta_{n-1}=(x_{n-1}^2+y_{n-1}^2)^{1/2}$ stored in step S**41** executed the (n−1)-th time and the distance $\delta_n=(x_n^2+y_n^2)^{1/2}$ stored in step S**41** executed the n-th time.

[0133] Then, the CPU **74** calculates the difference Δ_n between the distance δ_{n-1} and the distance Δ_n as the displacement difference Δ_n (i.e., $\Delta_n=|\delta_n-\delta_{n-1}|=|(x_n^2+y_n^2)^{1/2}-(x_{n-1}^2+y_{n-1}^2)^{1/2}|$). Thus, in this embodiment, the CPU **74** functions as a displacement difference calculation section **76** (FIG. **16**) configured to calculate the displacement difference Δ_n.

[0134] In step S**44**, the CPU **74** determines whether or not the displacement difference Δ_n calculated in the most-recent step S**43** is equal to or less than a predetermined threshold value α ($\Delta_n \leq \alpha$). The threshold value α is predetermined for the displacement difference Δ_n, and stored in the storage **46**.

[0135] If the displacement difference Δ_n calculated in the most-recent step S**43** is equal to or less than the predetermined threshold value α ($\Delta_n \leq \alpha$), the CPU **74** determines YES, and ends the flow illustrated in FIG. **17**. On the other hand, if the displacement difference Δ_n is greater than the threshold value α ($\Delta_n > \alpha$), the CPU **74** determines NO, and returns to step S**22**.

[0136] Thus, in this embodiment, the CPU **74** functions as a determination section **78** (FIG. **16**) configured to determine whether or not the displacement difference Δ_n is equal to or less than the predetermined threshold value α. After the execution of the flow illustrated in FIG. **17**, the CPU **74** carries out the flow illustrated in FIG. **15**, similarly to the above-mentioned embodiment.

[0137] As stated above, in this embodiment, the CPU **74** repeats a loop of steps S**22** to S**44** until the displacement difference Δ_n calculated in step S**43** is equal to or less than the predetermined threshold value α. The technical significance of this operation will be described below.

[0138] A molded article, which has a curved front surface that faces the outside of the mold **22**, may be molded. In this case, the front surface **56** of the master work **54** corresponding to such a molded article is also a curved surface. If the end effector **36** of the robot **14** adsorbs thus-curved front surface **56** of the master work **54**, the position where the end

effector **36** adsorbs the front surface **56** may change due to the curved shape of the front surface **56**, each time step S**23** in FIG. **17** is repeatedly carried out.

[0139] By such a change in the adsorption position, an error due to the curved shape of the front surface **56** may be included in the displacement amount calculated in step S**41**.

[0140] As a result of thorough research, the inventors discovered that such an error can be gradually reduced by repeatedly carry out a series of operations of removing the master work (step S**23**), measuring the detected position (step S**24**), and calculating the displacement (step S**41**).

[0141] In this embodiment, the CPU **74** repeatedly carries out a loop of steps S**22** to S**44** in FIG. **17**, in order to calculate the displacement amount after reducing the above-mentioned error to be within an allowable range.

[0142] Thereby, the error in the displacement amount caused by the shape of the molded article can be reduced, and the displacement amount can be calculated with higher accuracy. Accordingly, it is possible to cause the robot **14** to carry out the work on the work position with highly accuracy in step S**33**, irrespective of the shape of the molded article.

[0143] Note that, in the flow illustrated in FIG. **17**, when the displacement difference Δ_n calculated in step S**43** is equal to or less than the threshold value α, the CPU **74** judges that the error in the displacement amount calculated in step S**41** is reduced to be within an allowable range, and ends the flow illustrated in FIG. **17**.

[0144] However, the CPU **74** may judge that the error in the displacement amount is reduced to be within an allowable range when the number of times the CPU **74** carries out steps S**22** to S**42** reaches a predetermined number.

[0145] Below, an alternative example of the work position correction operation illustrated in FIG. **17** will be described with reference to FIG. **18**. In the flow of the work position correction operation illustrated in FIG. **18**, the CPU **74** repeatedly carries out a loop of steps S**22** to S**52** until it determines YES in step S**52** described below. The flow illustrated in FIG. **18** differs from the flow illustrated in FIG. **17** in steps S**51** and S**52**.

[0146] After step S**42**, in step S**51**, the CPU **74** increments the execution number "n", which indicates the number of times the CPU **74** executes steps S**22** to S**42**, by "1" (i.e., n=n+1).

[0147] For example, when the CPU **74** executes the first loop of step S**22** to S**52**, the CPU **74** increments the execution number "n" from "0" to "1" in this step S**51**. The CPU **74** stores the incremented execution number "n" in the storage **46**.

[0148] In step S**52**, the CPU **74** determines whether or not the execution number "n" is greater than a predetermined threshold value β. The threshold value β is predetermined by the user as an integer greater than 1 (e.g., β=10), and stored in the storage **46**.

[0149] In this step S**52**, the CPU **74** reads out from the storage **46** the threshold value β and the execution number "n" currently stored in the storage **46**. Then, the CPU **74** compares the execution number "n" with the threshold value β, and determines whether or not the execution number "n" is greater than the threshold value β.

[0150] If the execution number "n" is greater than the threshold value β ($n>\beta$), the CPU **74** determines YES and ends the flow illustrated in FIG. **18**. On the other hand, if the execution number "n" is equal to or less than the threshold value β ($n\leq\beta$), the CPU **74** determines NO and returns to step S**22**.

[0151] Thus, in the flow illustrated in FIG. **18**, the CPU **74** judges that the error in the displacement amount is reduced to be within an allowable range when the number of times a loop of steps S**22** to S**42** is executed reaches a predetermined number, and ends the work position correction operation.

[0152] According to this configuration, similarly to the flow illustrated in FIG. **17**, the error in the displacement amount caused by the shape of the molded article can be reduced, and the displacement amount can be calculated with higher accuracy. Accordingly, it is possible to cause the robot **14** to work on the work position with highly accuracy in step S**33**, irrespective of the shape of the molded article.

[0153] Next, another alternative example of the work position correction operation illustrated in FIG. **17** will be described with reference to FIG. **19**. For example, the flow of the work position correction operation illustrated in FIG. **19** is applied to a case where the robot **14** removes the molded article in step S**33** shown in FIG. **15**.

[0154] After step S**42**, in step S**61**, the CPU **74** operates the robot **14** so as to fit the master work **54**, which has been removed in step S**23**, into the cavity **26** again.

[0155] For example, if the robot program is corrected to change the setting of the tool coordinate system C_T in the above-mentioned step S**42**, the CPU **74** sets the post-change tool coordinate system C_T (FIG. **14**) with respect to the mold installation portion **20**.

[0156] Next, the CPU **74** sends a command to each servomotor **42** built in the robot **14** via the drive section **50** so as to arrange the end effector **36** at a position and orientation defined by the post-change tool coordinate system C_T, and fits the master work **54** into the cavity **26**.

[0157] In step S**62**, the CPU **74** determines whether or not the master work **54** is appropriately fit into the cavity **26**. If the error in the displacement amount calculated in the most-recent step S**41** is sufficiently small, it is possible to appropriately fit the master work **54** into the cavity **26** when carrying out step S**61** in accordance with the work position (i.e., the post-change tool coordinate system C_T) corrected in step S**42**.

[0158] On the other hand, if the error in the displacement amount calculated in the most-recent step S**41** is large, the master work **54** can not be appropriately fit into the cavity **26** even when carrying out step S**61** in accordance with the corrected work position (i.e., the post-change tool coordinate system C_T).

[0159] In the flow illustrated in FIG. **19**, in order to determine whether or not the error in the displacement amount calculated in step S**41** is reduced to be within an allowable range, the CPU **74** executes step S**61** in accordance with the work position corrected in step S**42**, and determines whether or not the master work **54** is appropriately fit into the cavity **26** in step S**62**.

[0160] As an example, the CPU **74** monitors feedback from each servomotor **42** (e.g., feedback current, load torque, etc.) during the execution of step S**61**. In this step S**62**, the CPU **74** determines whether or not the feedback is within a predetermined allowable range.

[0161] If the master work **54** can not be appropriately fit into the cavity **26** during the execution of step S**61**, the master work **54** engages the front surface of the mold **22**,

thereby the master work **54** can not smoothly be pushed into the cavity **26**. In this case, the load torque acting on each servomotor **42** increases, thereby the feedback from each servomotor **42** abnormally fluctuates.

[0162] The CPU **74** can determine whether or not the master work **54** is appropriately fit into the cavity **26** during the execution of step S**61**, by determining whether the feedback from each servomotor **42** is within a predetermined allowable range.

[0163] If the feedback is within the allowable range until the end of step S**61**, the CPU **74** determines YES, and ends the flow illustrated in FIG. **19**. On the other hand, if the feedback is out of the allowable range, the CPU **74** determines NO, and returns to step S**22**. Then, in step S**22**, the user fits the master work **54** into the cavity **26** of the mold **22**. In this way, the CPU **74** repeatedly carries out a loop of steps S**22** to S**62** until it determines YES in step **62**.

[0164] Thus, in the flow illustrated in FIG. **19**, the CPU **74** operates the robot **14** in accordance with the work position corrected in step S**42** so as to fit the master work **54** into the cavity **26**. Then, the CPU **74** judges that the error in the displacement amount calculated in step S**41** is reduced to be within an allowable range and ends the work position correction operation, when the master work **54** is appropriately fit into the cavity **26**.

[0165] According to this configuration, similarly to the flow illustrated in FIG. **17**, the error in the displacement amount caused by the shape of the molded article can be reduced, thereby the displacement amount can be calculated with higher accuracy. Accordingly, it is possible to cause the robot **14** to carry out the work (i.e., removing the molded article) on the work position in step S**33** with highly accuracy, irrespective of the shape of the molded article.

[0166] Note that, in step S**4** described above, the CPU **44** may analyze the image **62** illustrated in FIG. **7** so as to detect any characteristic point (e.g., the corner A) of the master work **54** in the image **62**, and calculate the coordinates P_R (x_R, y_R) of the tool coordinate system C_T of the detected characteristic point.

[0167] In this case, in step S**25**, the CPU **44** may analyze the image **64** illustrated in FIG. **13** so as to detects a characteristic point (e.g., the corner A) of the master work **54** in the image **64**, which corresponds to the characteristic point of the reference position, and calculate the coordinates P_D (x_D, y_D) of the tool coordinate system C_T of the detected characteristic point.

[0168] Then, the CPU **44** may calculate the vector V (x_R-x_D, y_R-y_D) from the coordinates P_R to the coordinates P_D as the displacement mount indicative of the difference in the x-y plane between the reference position and the detected position.

[0169] Further, in step S**25** described above, the CPU **44** may calculate the displacement mount on the basis of a mark or shape provided on the master work **54**, instead of the corner A or the imaginary line D.

[0170] Such an embodiment will be described with reference to FIGS. **20**A and **20**B. In the master work **54** shown in FIG. **20**A, a mark **80** is provided on the front surface **56** of the master work **54**. The mark **80** includes a point **82** and a straight line **84**.

[0171] In the above-mentioned step S**25**, the CPU **44** may detect the point **82** instead of the above-mentioned corner A, and calculate the coordinates P (x, y) of the tool coordinate system C_T of the detected point **82**. Further, in the above-mentioned step S**25**, the CPU **44** may detect the straight line **84** instead of the above-mentioned imaginary lines D_R, D_D, and calculate the angle θ between the straight line **84** of the reference position and the straight line **84** of the detected position, as the displacement amount.

[0172] On the other hand, in the master work **54** illustrated in FIG. **20**B, a linear notch **82** is formed on the front surface **56** of the master work **54**. In the above-mentioned step S**25**, the CPU **44** may detect an end **82***a* of the notch **82** instead of the above-mentioned corner A, and calculate the coordinates P (x, y) of the tool coordinate system C_T of the detected end **82***a*.

[0173] Further, in step S**25**, the CPU **44** may detect the notch **82** instead of the above-mentioned imaginary lines D_R, D_D, and calculate the angle θ between the extension direction of the notch **82** of the reference position and the extension direction of the notch **82** of the detected position, as the displacement amount.

[0174] Note that, a sensor coordinate system may be set for the measurement section **16**, and in step S**4** described above, the CPU **44** may detect a characteristic point (e.g., the center or the corner A) of the master work **54** in the image **62** illustrated in FIG. **7**, and calculate the coordinates P_R (x_R, y_R) of the sensor coordinate system of the detected characteristic point.

[0175] In this embodiment, in step S**25**, the CPU **44** analyzes the image **64** illustrated in FIG. **13**, detects a characteristic point (e.g., the corner A) of the master work **54** in the image **64**, which corresponds to the characteristic point of the reference position, and calculates the coordinates P_D (x_D, y_D) of the sensor coordinate system of the detected characteristic point.

[0176] Then, the CPU **44** may calculate the vector V (x_R-x_D, y_R-y_D) from the coordinates P_R to the coordinates P_D as the displacement amount indicative of the difference between the reference position and the detected position in the x-y plane of the sensor coordinate system. For example, the sensor coordinate system may be set similarly as the tool coordinate system C_T illustrated in FIG. **7**.

[0177] Further, the measurement section **16** is not limited to an imaging section, but may include any sensor able to detect the shape of the master work **54**, such as a laser displacement sensor. Further, the end effector **36** may be a robot hand including fingers capable of opening and closing.

[0178] Further, instead of the robot **14**, a loader may be applied so as to constitute the molded article removal device, for example. Further, the cavity **26** and the master work **54** are not limited to a hexagonal prism shape, but may be of any shape.

[0179] The invention has been described above using embodiments of the invention. However, the embodiments described above are not intended to limit the scope of the claims of the invention. Combinations of the configurations described in the embodiments of the invention are included in the technical scope of the invention. However, not all such combinations are imperative for solving the problem of the invention. As will be apparent to one skilled in the art, various changes and modifications can be made to the embodiments described above.

[0180] Also, it should be understood that the order of execution of the processing including the operations, procedures, steps, processes, and stages of the devices, systems, programs, and methods described in the claims, specification, and drawings may be performed in any order unless

"before" or "prior to" and other such expressions are used or the output of a prior process is used in the following process. In describing the operation flow in the claims, specification, and drawings, for convenience, "first", "next", "then", and other such expressions are used; however, this does not mean that the order of execution has to be carried out in such a specific order.

1. A molding system, comprising:

a molding machine in which a mold is installed;

a molded article removal device capable of removing a master work attached to the mold;

a measurement section configured to:

measure a position of the master work held by the molded article removal device when the molded article removal device removes the master work attached to the mold, as a reference position; and

measure a position of the master work held by the molded article removal device when the molded article removal device removes the master work attached to the mold after measuring the reference position, as a detected position;

a displacement calculation section configured to calculate a difference between the reference position and the detected position measured by the measurement section, as a displacement amount; and

a correction section configured to correct a work position in a molded article molded by the molding machine with the mold based on the displacement amount calculated by the displacement calculation section, the work position being a position where the molded article removal device carries out a work on the molded article.

2. The molding system of claim **1**, wherein the molded article removal device repeatedly carries out removing the master work attached to the mold, after the measurement section measures the reference position,

wherein the measurement section measures the detected position each time the molded article removal device removes the master work attached to the mold,

wherein the displacement calculation section calculates the displacement amount each time the measurement section measures the detected position,

wherein the molding system further comprising:

a displacement difference calculation section configured to calculate a displacement difference which is a difference between a first displacement amount calculated by the displacement calculation section and a second displacement amount calculated by the displacement calculation section prior to the first displacement amount; and

a determination section configured to determine whether the displacement difference calculated by the displacement difference calculation section is equal to or less than a predetermined threshold value.

3. The molding system of claim **1**, wherein the correction section corrects a removal position as the work position where the molded article removal device removes the molded article in the mold, based on the displacement amount.

4. The molding system of claim **1**, wherein the correction section corrects an insertion position as the work position where the molded article removal device inserts an insert part into the molded article in the mold, based on the displacement amount.

5. The molding system of claim **1**, wherein the molded article removal device is a robot.

6. The molding system of claim **1**, wherein the measurement section includes an imaging section capable of imaging the master work.

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