YAMAHA
YAMAHA MOTOR CO., LTD.

YAMAHA ROBOT

Disk Handling Robot
(3, 4-axis specifications)

User's Manual

ENGLISH E

E41-Ver. 1.01

Before using the robot (Be sure to read the following notes.)

Thanks for your purchase of this YAMAHA disk handling robot.

1. Please be sure to perform the following tasks before using the robot.

Failing to perform the tasks below will require re-teaching of the robot since the origin position cannot be set to the same previous position. Robot malfunctions (vibration, noise) may also occur.

The origin positions of this robot are adjusted at the factory before shipment to the positions indicated in "3.3 Absolute reset" in Chapter 4.
The customer should perform the following absolute reset before any other job.

Absolute reset

This robot only requires the absolute reset to be performed once when the robot is introduced.
Once the absolute reset is performed, it does not need to be reperformed when the power is turned on next time.
Perform the absolute reset while referring to "3. Adjusting the origin" in Chapter 4 of this manual and "Absolute Reset" of the "YAMAHA Robot Controller RCX142 User's Manual".

⚠CAUTION

Never enter the robot movement range once the robot servo is turned on as this is extremely hazardous.

Affixing the origin position sticker

Set in emergency stop when absolute reset is complete, and immediately affix the origin position stickers according to instructions in "5. Affixing stickers for movement directions and axis names" in Chapter 4 of this manual.

Even though there is no problem with the robot, the following error messages are issued when the robot and controller are connected and power first turned on. (Actual error messages may differ according to how the robot and controller are connected.)

Error messages issued when robot and controller are connected (RCX142)

17.81: D?. ABS. battery wire breakage
17.83: D?. Backup position data error 1
17.85: D?. Backup position data error 2
17.92: D?. Resolver disconnected during power off
17.93: D?. Position backup counter overflow
etc.

2. If the X-axis or Y-axis rotation angle is small

If the X-axis or Y-axis rotation angle is smaller than 5° so that it always moves in the same position, an oil film is difficult to be formed on the joint support bearing, possibly leading to damage to the bearing. In this type of operation, add a movement so that the joint moves through 90° or more, about 5 times a day.

3. If the Z-axis or R-axis travel distance is short

If the Z-axis or R-axis travel distance is shorter than 5mm so that it always moves in the same position, an oil film is difficult to be formed on the linear motion bearing, possibly leading to damage to the bearing. In this type of operation, add a movement so that the axis moves more than 5mm, about 5 times a day.

Introduction

The disk handling robot arm is a two-joint manipulator comprising X and Y axes, with a tool attachment shaft at the manipulator tip. The robot also has a Z-axis that moves the arm up and down and an R-axis that serves as a travel axis. This configuration is ideal for handling DVD disks, etc. Please note that this robot is not completely designed for clean room use because the travel axis does not conform to clean room specifications.

This user's manual describes the safety measures, handling, adjustment, inspection and maintenance of the disk handling robots for correct, safe and effective use. Be sure to read this manual carefully before installing the robot. Even after reading this manual, keep it in a safe and convenient place for future reference. This user's manual should be used with the robot and considered an integral part of it. When the robot is moved, transferred or sold, be sure to send this manual to the new user along with the robot, and explain to the new user the need to read through this manual.
For robot operation and programming details, refer to the "YAMAHA Robot Controller RCX142 Series User's Manual".

NOTES

- The contents of this manual are subject to change without prior notice.
- Information furnished by YAMAHA in this manual is believed to be reliable. However, if you find any part unclear or inaccurate in this manual, please contact YAMAHA sales office or dealer.

YAMAHA MOTOR CO., LTD.
IM Operations

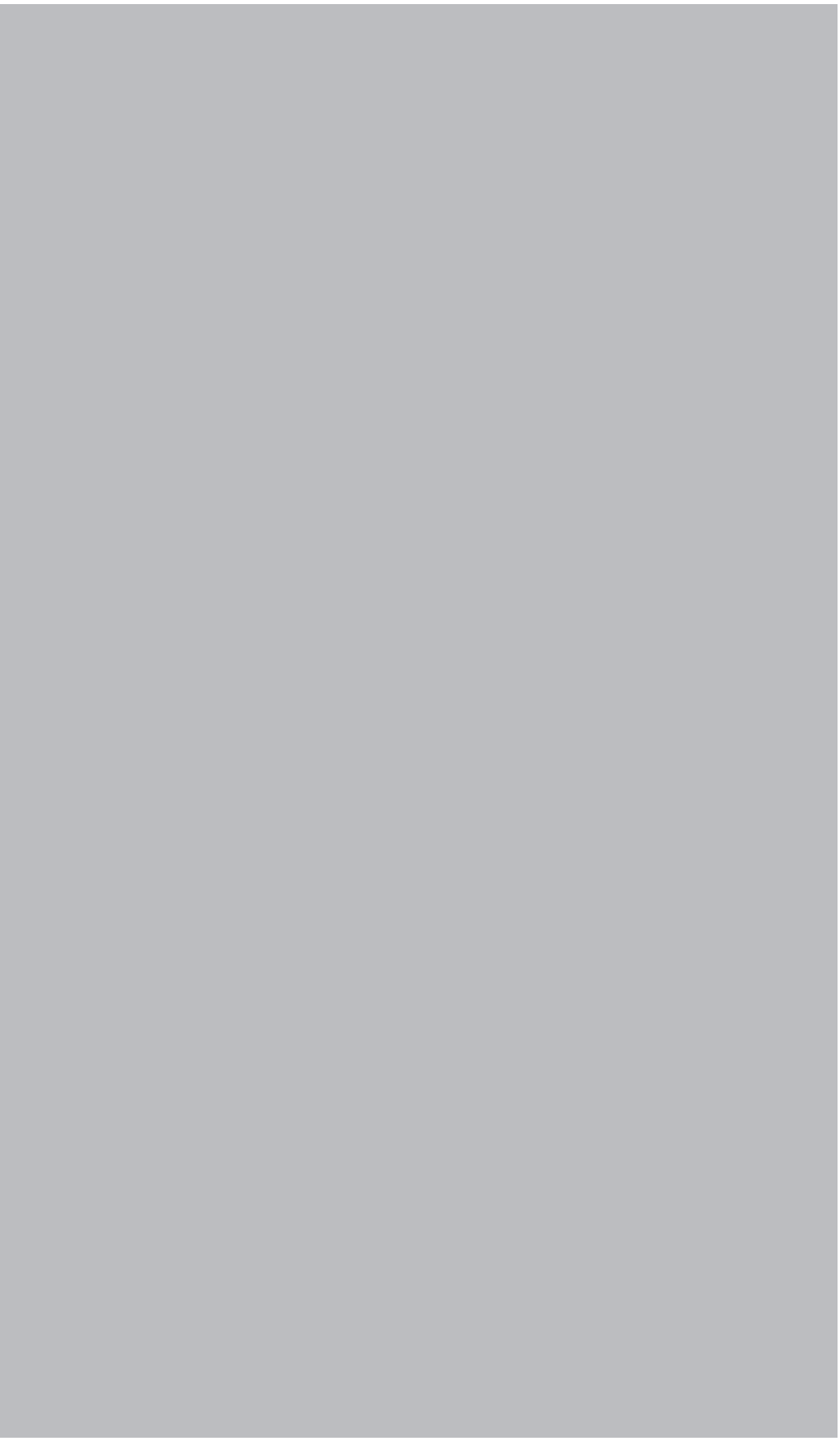
MEMO

General Contents

MEMO

Chapter 1 Using the Robot Safely

Contents



1. Safety information

Industrial robots are highly programmable, mechanical devices that provide a large degree of freedom when performing various manipulative tasks. To ensure correct and safe use of YAMAHA industrial robots, carefully read this manual and make yourself well acquainted with the contents. FOLLOW THE WARNINGS, CAUTIONS AND INSTRUCTIONS INCLUDED IN THIS MANUAL. Failure to take necessary safety measures or mishandling due to not following the instructions in this manual may result in trouble or damage to the robot and injury to personnel (robot operator or service personnel) including fatal accidents.

Warning information in this manual is classified by the following signal words.

⚠ DANGER

"DANGER" indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

"WARNING" indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

"CAUTION" indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury or damage to the equipment or software.

Refer to the user's manual by any of the following methods to operate or adjust the robot safely and correctly.

1. Operate or adjust the robot while referring to the printed version of the user's manual (available for an additional fee).
2. Operate or adjust the robot while viewing the CD-ROM version of the user's manual on your computer screen.
3. Operate or adjust the robot while referring to a printout of the necessary pages from the CD-ROM version of the user's manual.

It is not possible to detail all safety items within the limited space of this manual. So it is essential that the user have a full knowledge of basic safety rules and also that the operator makes correct judgments on safety procedures during operation. This manual and warning labels supplied with or affixed to the robot are written in English. If the robot operator or service personnel do not understand English, do not permit him/her to handle the robot.

2. Essential caution items

Particularly important cautions for handling or operating the robot are described below. In addition, safety information about installation, operation, inspection and maintenance is provided in each chapter. Be sure to comply with these instructions to ensure safe use of the robot.

(1)Observe the following cautions during automatic operation.

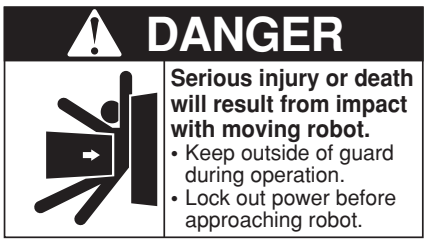
Warning labels 1 (Fig. 1-1) are affixed to the robot. See Fig. 2-2 for the locations of warning labels.

- Install a safety enclosure to keep any person from entering within the movement range of the robot and suffering injury due to being struck by moving parts.
- Install a safety interlock that triggers emergency stop when the door or panel is opened.
- Install safeguards so that no one can enter inside except from doors or panels equipped with safety interlocks.
- The warning labels shown in Fig. 1-1 are supplied with the robot and should be affixed to a conspicuous spot on doors or panels equipped with safety interlocks.

⚠DANGER

Serious injury or death will result from impact with moving robot.
• Keep outside of guard (safety enclosure) during operation.
• Lock out power or press emergency stop button before approaching robot.

■ **Fig. 1-1 Warning label 1**



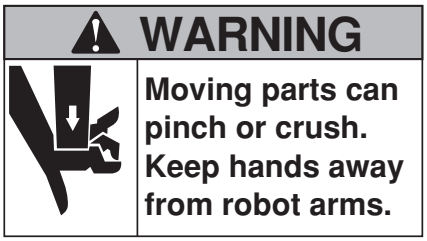
(2)Use caution to prevent hands or fingers from being pinched or crushed.

Warning labels 2 (Fig. 1-2) are affixed to the robot. See Fig. 2-2 for the locations of warning labels.
Be careful not to let hands or fingers be pinched or crushed by the moving parts of the robot during transportation or teaching.

⚠WARNING

Moving parts can pinch or crush hands. Keep hands away from robot arms.

■ Fig. 1-2 Warning label 2



(3)Follow the instructions on warning labels and in this manual.

Warning label 3 (Fig. 1-3) is affixed to the robot. See Fig. 2-2 for the locations of warning labels.

- Be sure to read the warning labels and this manual carefully and make sure you thoroughly understand their contents before attempting installation and operation of the robot.
- Before starting robot operation, even after you have read through this manual, read again the procedures and cautions relating to your work as well as the description in this chapter (Chapter 1, "Using the Robot Safely").
- Never install, adjust, inspect or service the robot in any manner that does not comply with the instructions in this manual.

⚠WARNING

Improper installation or operation can result in serious injury or death. Read user's manual and all warning labels before installation and operation.

■ Fig. 1-3 Warning label 3

(4)Do not use the robot in environments containing inflammable gas, etc.

⚠WARNING

- **This robot was not designed for operation in environments where inflammable or explosive substances are present.**
- **Do not use the robot in environments containing inflammable gas, dust or liquids. Explosions or fire may otherwise result.**

(5)Do not use the robot in locations possibly subject to electromagnetic interference, etc.

⚠WARNING

Avoid using the robot in locations subject to electromagnetic interference, electrostatic discharge or radio frequency interference. Malfunction may otherwise occur.

(6)Use caution when releasing the Z-axis (vertical axis) brake.

⚠WARNING

The Z-axis will slide down when the Z-axis brake is released, causing a hazardous situation.

- Press the emergency stop button and prop up the Z-axis with a support stand before releasing the brake.
- Use caution not to let your body get caught between the Z-axis and installation base when releasing the brake to perform direct teach.

(7)Provide safety measures for end effector (gripper, etc.).

⚠WARNING

- End effectors must be designed and manufactured so that they cause no hazards (for example, loosening of workpiece) even if power (electricity, air pressure, etc.) is shut off or power fluctuations occur.
- If there is a possible danger that the object gripped by the end effector may fly off or drop, then provide appropriate safety protection taking into account the object size, weight, temperature and chemical properties.

(8)Be cautious of possible Z-axis movement when the controller is turned off or emergency stop is triggered. (2-axis robots with air-driven Z-axis)

⚠WARNING

The Z-axis moves up when the power to the controller or PLC is turned off, the program is reset, emergency stop is triggered, or air is supplied to the solenoid valve for the Z-axis air cylinder.

- Do not let hands or fingers get caught and squeezed by moving parts of the Z-axis.
- Keep the usual robot position in mind so that the Z-axis will not interfere with obstacles during raising of the Z-axis, except in case of emergency stop.

(9) Use caution when the Z-axis is interfering with peripheral equipment.
(2-axis robots with air driven Z-axis)

⚠ WARNING

When the Z-axis comes to a stop due to obstructions from peripheral equipment, the Z-axis may move suddenly when the obstruction is removed, causing injury such as pinched or crushed hands.

- Turn off the controller and reduce the air pressure before attempting to remove the obstruction.
- Before reducing the air pressure, place a support stand under the Z-axis because it will drop under its own weight.

(10) Use caution on Z-axis movement when air supply is stopped.
(2-axis robots with air-driven Z-axis)

⚠ WARNING

The Z-axis may suddenly drop when the air pressure to the Z-axis air cylinder solenoid valve is reduced, creating a hazardous situation.
Turn off the controller and place a prop or support under the Z-axis before cutting off the air supply.

(11) Use caution when disassembling or replacing the pneumatic equipment.

⚠ WARNING

Air or parts may fly outwards if pneumatic equipment is disassembled or parts replaced while air is still supplied.

- Do service work after first turning off the controller and reducing the air pressure.
- Before reducing the air pressure, place a support stand under the Z-axis (2-axis robots with air-driven Z-axis) because it will drop under its own weight.

(12) Use caution when removing the Z-axis motor.

⚠ WARNING

The Z-axis will drop when the Z-axis motor is removed, causing a hazardous situation.

- Turn off the controller and set a support stand under the Z-axis before removing the motor.
- Use caution not to allow hands or body to be squeezed or crushed by moving parts on the Z-axis or between the Z-axis and the installation base.

(13) Use caution during inspection of controller.

⚠WARNING

- When you need to touch the terminals or connectors on the outside of the controller during inspection, always first turn off the controller power switch and also the power source in order to prevent possible electrical shock.
- Never touch any internal parts of the controller.

For precautions on handling the controller, refer to the "YAMAHA Robot Controller User's Manual".

(14) Consult us for corrective action when the robot is damaged or malfunction occurs.

⚠WARNING

If any part of the robot is damaged or any malfunction occurs, continuous operation may be very dangerous. Please consult YAMAHA sales office or dealer for corrective action.

Damage or Trouble	Possible Danger
Damage to machine harness or robot cable	Electrical shock, malfunction of robot
Damage to exterior of robot	Flying outwards of damaged parts during robot operation
Abnormal operation of robot (positioning error, excessive vibration, etc.)	Malfunction of robot
Z-axis brake trouble	Dropping of load

(15) Use caution not to touch the high temperature motor or speed reduction gear casing.

⚠WARNING

The motor and speed reduction gear casing are extremely hot after automatic operation, so burns may occur if these are touched.
Before touching these parts during inspections or servicing, turn off the controller, wait for a while and check that the temperature has cooled.

(16) Do not remove, alter or stain the warning labels.

⚠WARNING

If warning labels are removed or difficult to see, necessary cautions may not be taken, resulting in an accident.

- Do not remove, alter or stain the warning labels on the robot.
- Do not allow the warning labels to be hidden by the device installed to the robot by the user.
- Provide proper lighting so that the symbols and instructions on the warning labels can be clearly seen even from the outside of safety enclosure.

(17) Protective bonding

⚠WARNING

Be sure to ground the robot and controller to prevent electrical shock.

(18) Be sure to make correct parameter settings.

⚠CAUTION

The robot must be operated with an acceleration rate that is appropriate for the manipulator tip's weight and moment of inertia. If this is not observed, premature end to the life of the drive units, damage to the robot parts or residual vibration during positioning may result.

(19) Do not use the robot for tasks requiring motor thrust.

⚠CAUTION

Avoid using the disk handling robot for tasks which make use of motor thrust (press-fitting, burr removal, etc.). These tasks may cause malfunctions of the robot.

(20) If the X-axis or Y-axis rotation angle is small

⚠CAUTION

If the X-axis or Y-axis rotation angle is smaller than 5° so that it always moves in the same position, an oil film is difficult to be formed on the joint support bearing, possibly leading to damage to the bearing. In this type of operation, add a movement so that the joint moves through 90° or more, about 5 times a day.

(21) If the Z-axis or R-axis travel distance is short

⚠CAUTION

If the Z-axis or R-axis travel distance is shorter than 5mm so that it always moves in the same position, an oil film is difficult to be formed on the linear motion bearing, possibly leading to damage to the bearing. In this type of operation, add a movement so that the axis moves more than 5mm, about 5 times a day.

3. Special training for industrial robot operation

Companies or factories using industrial robots must make sure that every person, who handles the robot such as for teaching, programming, movement check, inspection, adjustment and repair, has received appropriate training and also has the skills needed to perform the job correctly and safely. Since the YAMAHA disk handling robots fall under the industrial robot category, the user must observe local regulations and safety standards for industrial robots, and provide special training for every person involved in robot-related tasks (teaching, programming, movement check, inspection, adjustment, repair, etc.).

4. Robot safety functions

(1) Overload detection

This function detects an overload applied to the motor and shuts off the servo power. If an overload error occurs, take the following measures.

1. Insert a timer in the program.
2. Reduce the acceleration coefficient.

(2) Overheat detection

This function detects an abnormal temperature rise in the driver inside the controller and shuts off the servo power. If an overheat error occurs, take the following measures.

1. Insert a timer in the program.
2. Reduce the acceleration coefficient.

(3) Soft limits

Soft limits can be set on each axis to limit the working envelope in manual operation after return-to-origin and during automatic operation. The working envelope is the area limited by soft limits.

(4) Mechanical stoppers

If the servo power is suddenly shut off during high-speed operation by emergency stop or safety functions, these mechanical stoppers prevent the axis from exceeding the movement range. The movement range is the area limited by mechanical stoppers.

- The X, Y, Z and R axes have fixed mechanical stoppers at their movement range limits in plus and minus directions.

⚠ WARNING

Axis movement will not stop immediately after the servo power supply is shut off by emergency stop or other safety functions, so use caution.

(5) Z-axis (vertical axis) brake

An electromagnetic brake is installed on the Z-axis to prevent the Z-axis from sliding down when servo power is turned off. This brake is working when the controller power is off or the Z-axis servo power is off even when the controller power is on. The Z-axis brake can be released by means of the programming unit or by a command in the program when the controller power is on.

⚠ WARNING

The Z-axis will slide down when the Z-axis brake is released, creating a hazardous situation.

- **Press the emergency stop button and prop the Z-axis with a support stand before releasing the brake.**
- **Use caution not to let your body get caught between the Z-axis and installation base when releasing the brake to perform direct teach.**

5. Safety measures for the system

Since the robot is commonly used in conjunction with an automated system, dangerous situations are more likely to occur from the automated system than from the robot itself. Accordingly, appropriate safety measures must be taken on the part of the system manufacturer according to the individual system. The system manufacturer should provide a proper instruction manual for safe, correct operation and servicing of the system.

6. Trial operation

After making installations, adjustments, inspections, maintenance or repairs to the robot, make a trial run using the following procedures.

(1) If a safety enclosure has not yet been provided right after installation of the robot, rope off or chain off around the movement area of the manipulator in place of the safety enclosure, and observe the following points.

1. Use sturdy, stable posts which will not fall over easily.
2. The rope or chain should be easily visible by everyone around the robot.
3. Place a sign to keep the operator or other personnel from entering the movement range of the manipulator.

(2) Check the following points before turning on the controller.

1. Is the robot securely and correctly installed?
2. Are the electrical connections to the robot correct?
3. Are items such as air pressure correctly supplied?
4. Is the robot correctly connected to peripheral equipment?
5. Have safety measures (safety enclosure, etc.) been taken?
6. Does the installation environment meet the specified standards?

(3) After the controller is turned on, check the following points from outside the safety enclosure.

1. Does the robot start and stop as intended? Can the operation mode be selected correctly?
2. Does each axis move as intended within the soft limits?
3. Does the end effector move as intended?
4. Are the signal transmissions to the end effector and peripheral equipment correct?
5. Does emergency stop work?
6. Are the teaching and playback functions normal?
7. Are the safety enclosure and interlock working as intended?
8. Does the robot move correctly during automatic operation?

7. Work within the safety enclosure

(1) When work is required inside the safety enclosure, always turn off the controller and place a sign indicating that the robot is being adjusted or serviced in order to keep any other person from touching the controller switch or operation panel, except for the following cases.

1) Origin position setting (See section 3 in Chapter 4.)
2) Soft limit setting (See section 4 in Chapter 4.)
3) X-axis and Y-axis arm alignment (See section 7 in Chapter 4.)
4) Teaching

For items 1), 2) and 3), follow the precautions and procedure described in each section. To perform item 4), refer to the description in (2) below.

(2) Teaching

When performing teaching within the safety enclosure, comply with the instructions listed below.

1) Check or perform the following points from outside the safety enclosure.
   1. Make sure that no hazards are present within the safety enclosure by a visual check.
   2. Check that the programming unit MPB operates correctly.
   3. Check that no failures are found in the robot.
   4. Check that emergency stop works correctly.
   5. Select teaching mode and prohibit automatic operation.

2) Never enter the movement range of the robot while within the safety enclosure.

8. Automatic operation

Automatic operation described here includes all operations in AUTO mode.

(1)Check the following before starting automatic operation.

1. No one is within the safety enclosure.
2. The programming unit and tools are in their specified locations.
3. The alarm or error lamps on the robot and peripheral equipment do not flash.
4. The safety enclosure is securely installed with safety interlocks actuated.

(2)Observe the following during automatic operation or in cases where an error occurs.

1) After automatic operation has started, check the operation status and warning lamp to ensure that the robot is in automatic operation.
2) Never enter the safety enclosure during automatic operation.
3) If an error occurs in the robot or peripheral equipment, observe the following procedure before entering the safety enclosure.
   1. Press the emergency stop button to set the robot to emergency stop.
   2. Place a sign on the start switch, indicating that the robot is being inspected in order to keep any other person from touching the start switch and restarting the robot.

9. Adjustment and inspection

Do not attempt any installation, adjustment, inspection or maintenance unless it is described in this manual.

10. Repair and modification

Do not attempt any repair, parts replacement and modification unless described in this manual. These works require technical knowledge and skill, and may also involve work hazards.

11. Warranty

The YAMAHA robot and/or related product you have purchased are warranted against the defects or malfunctions as described below.

Warranty description:

If a failure or breakdown occurs due to defects in materials or workmanship in the genuine parts constituting this YAMAHA robot and/or related product within the warranty period, then YAMAHA will repair or replace those parts free of charge (hereafter called "warranty repair").

Warranty Period:

The warranty period ends when any of the following applies:

1) After 18 months (one and a half year) have elapsed from the date of shipment
2) After one year has elapsed from the date of installation
3) After 2,400 hours of operation

Exceptions to the Warranty:

This warranty will not apply in the following cases:

1) Fatigue arising due to the passage of time, natural wear and tear occurring during operation (natural fading of painted or plated surfaces, deterioration of parts subject to wear, etc.)
2) Minor natural phenomena that do not affect the capabilities of the robot and/or related product (noise from computers, motors, etc.).
3) Programs, point data and other internal data that were changed or created by the user.

Failures resulting from the following causes are not covered by warranty repair.

1) Damage due to earthquakes, storms, floods, thunderbolt, fire or any other natural or man-made disasters.
2) Troubles caused by procedures prohibited in this manual.
3) Modifications to the robot and/or related product not approved by YAMAHA or YAMAHA sales representatives.
4) Use of any other than genuine parts and specified grease and lubricants.
5) Incorrect or inadequate maintenance and inspection.
6) Repairs by other than authorized dealers.

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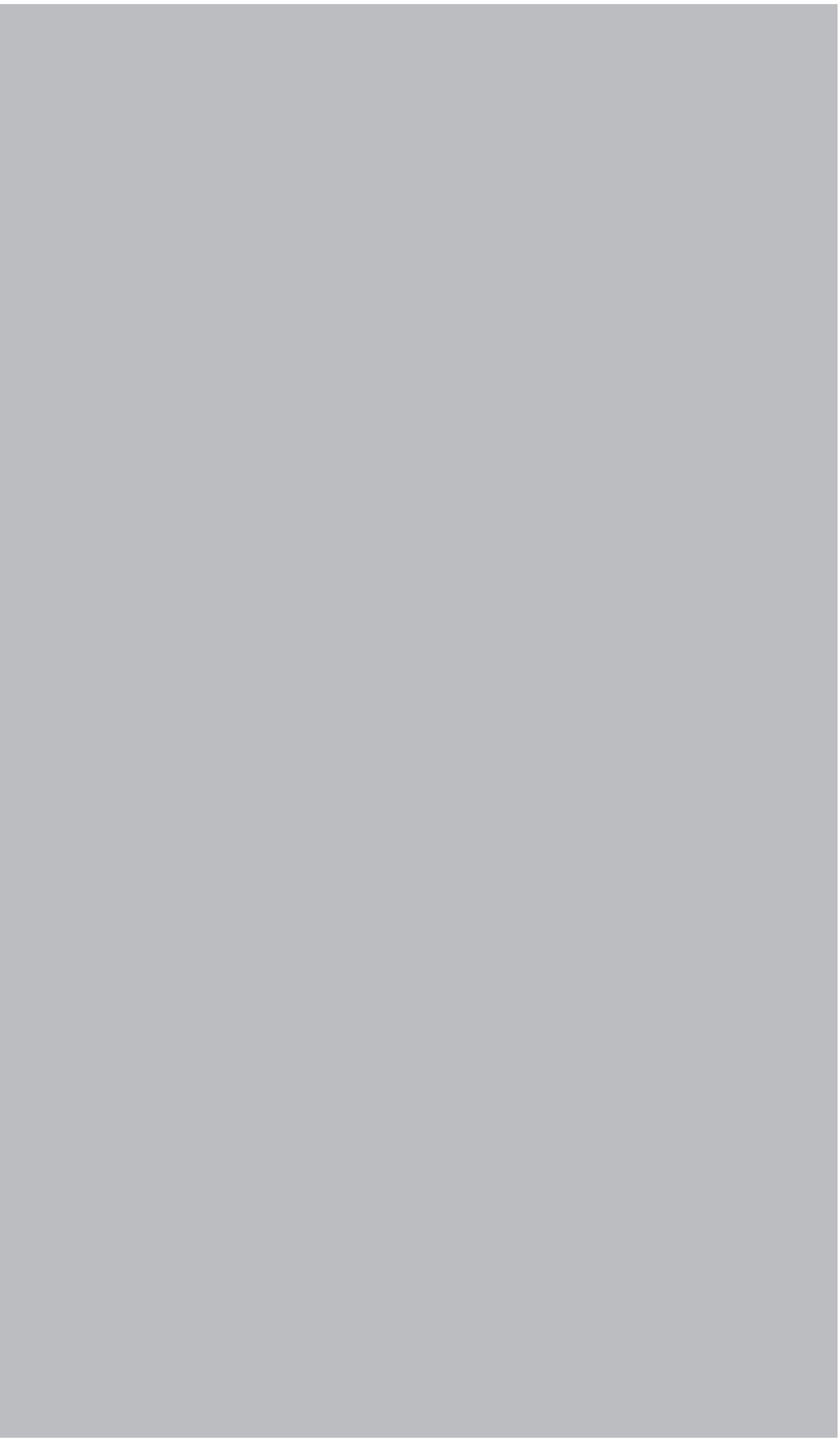
12. CE Marking

When the YAMAHA robots are exported to or used in EU (European Union) countries, refer to the separate "YAMAHA Robot Controller User's Manual" or "CE Marking Supporting Supplement Manual" for related information about CE marking.

Chapter 2 Functions

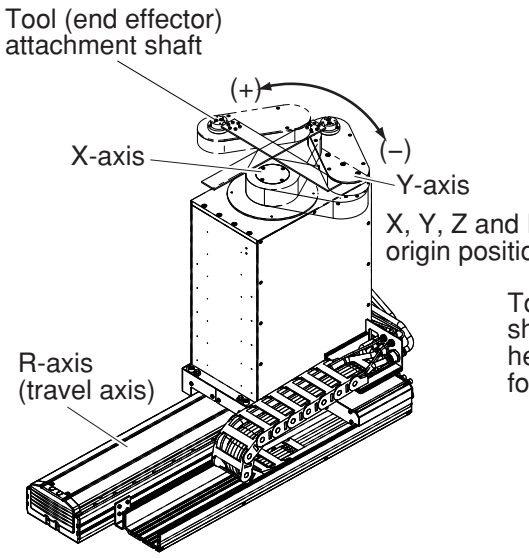
Contents



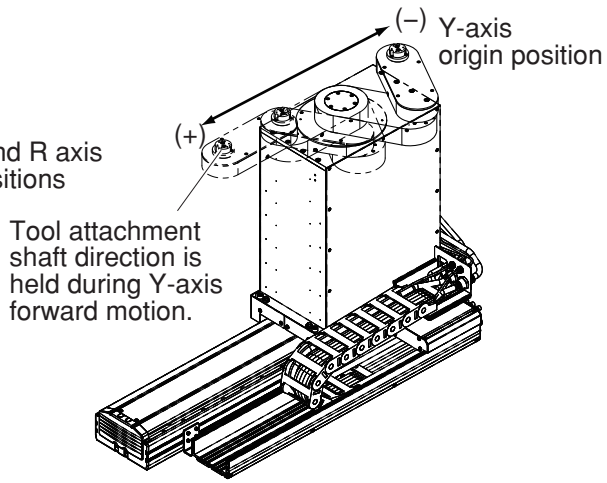
1. Robot manipulator

The disk handling robot can move as illustrated in Fig. 2-1 below. The (+) and (-) signs show the direction in which the robot moves when the jog keys on the programming unit are pressed (standard setting at the factory).

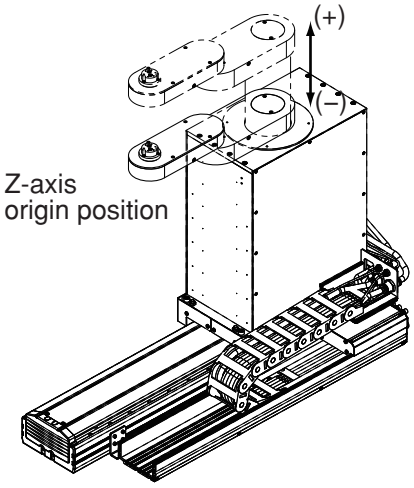
■ **Fig. 2-1 Robot motions**



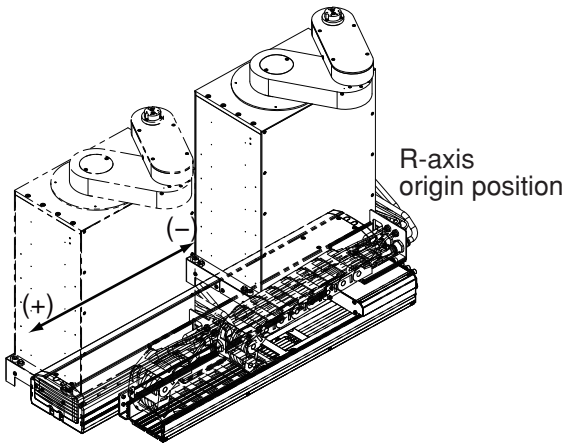
X-axis rotational motion



Y-axis forward motion (Direct forward motion of tool attachment shaft)



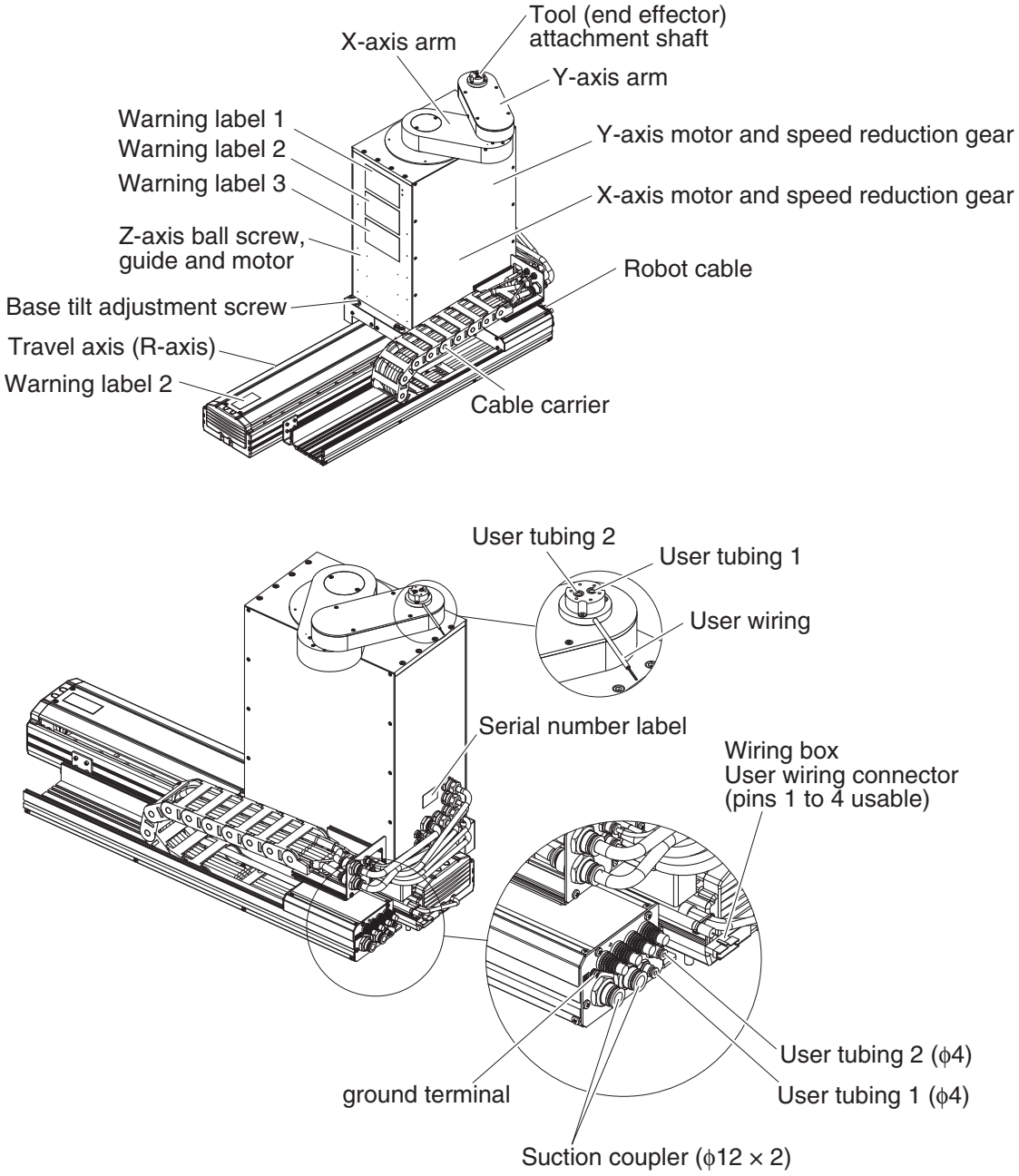
Z-axis up/down motion



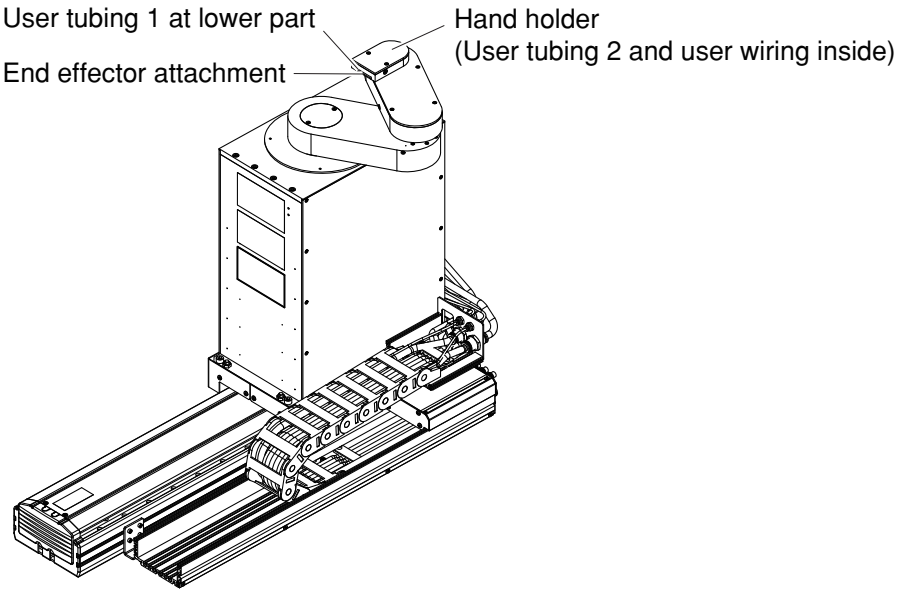
R-axis linear motion

Fig. 2-2 to Fig. 2-5 below show part names and functions of each robot model.

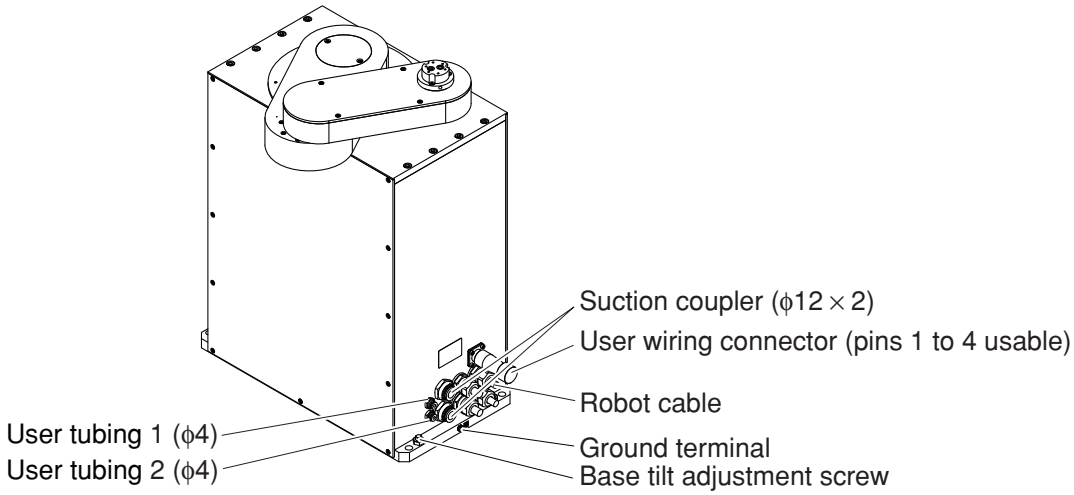
■ **Fig. 2-2 4-axis model (without hand holder)**



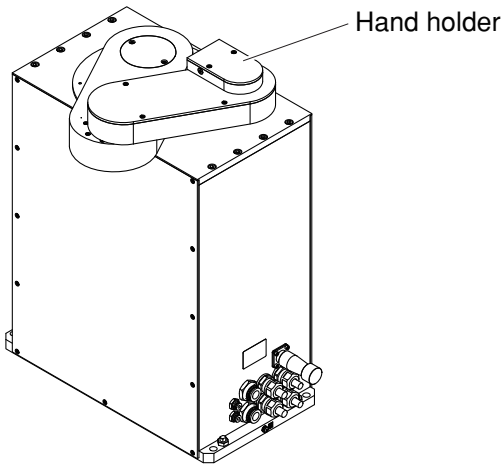
■ Fig. 2-3 4-axis model (with hand holder)



■ Fig. 2-4 3-axis model (without hand holder)



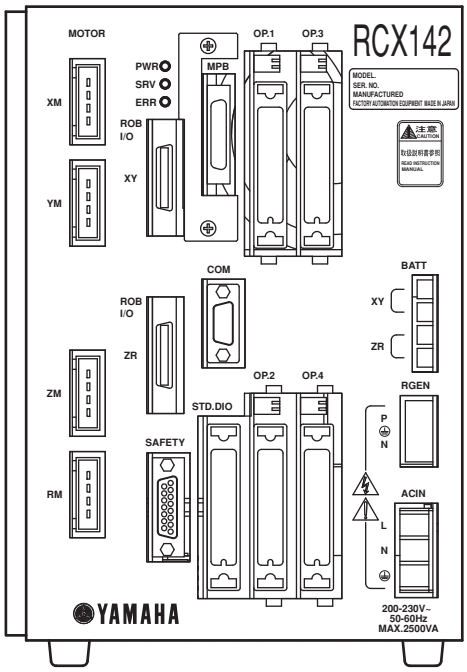
■ Fig. 2-5 3-axis model (with hand holder)



2. Robot controller

An RCX142 controller is used with the disk handling robot. For detailed information on the controller, refer to the separate "YAMAHA Robot Controller RCX142 Series User's Manual".

■ **Fig. 2-6 RCX142**



3. Parameter factory settings

This robot is a custom-order item, and therefore has customized parameters. Be sure to make a backup copy of the parameter factory settings. The parameter settings will be lost if the parameters are initialized. In that event, use the backup data to download the parameter settings again. The parameters are indicated on the custom parameter sheet attached to each robot.

Custom parameter sheet

To purchasers of this custom-made robot

Thank you for purchase of this YAMAHA robot.
This robot is a custom-order item, and therefore shipped with parameters customized by changing the standard robot settings. If this robot is used with parameter settings that differ from the "customized parameter settings", this may cause problems such as malfunctions. Do not change the customized parameter settings indicated on the custom parameter sheet.
The parameter settings will be lost if the robot parameters are initialized. In that event, set the parameters again.
Make a backup of the parameter settings before using the robot.
Please keep the custom parameter sheet carefully along with the user's manual, as it will be needed in cases where the parameters have to be set again.

Setting models

	Model	Serial No.	Date of manufacture (month/year)
Mechanical unit	Disk handling 3-axis robot + F17		
Controller	RCX142		

Customized parameter settings

Customized parameter settings are shown below. Boxes left blank indicate standard parameter settings.

Robot configuration

Configuration	Robot name	Robot No.
Main robot	MULTI	170

Axis configuration

Configuration	Axis name	Axis No.	Custom setting
M1	F14H-20	4060	
M2	F14-20	4050	
M3	F17-20V	4072	
M4	F17-10	4071	

Robot settings

Name	Changed value
Name	Changed value
Tip mass	0
Return-to-origin sequence	231456

* On the 3-axis model (X, Y and Z axes) using an RCX142 controller, only M1 to M3 settings are needed.

Axis settings (Blank boxes indicate default settings. Do not change them.)

Name	Changed value			
	M1	M2	M3	M4
+ soft limit	386844	269654	163840	
- soft limit	-386844	-4552		
Return-to-origin method	Sensor	Sensor		
Axis polarity	+	+	+	
Acceleration	1300	1200	3000	
Kvp	6000	3900	1500	
Kvi	4000	2600	1000	
Motor model	285	246	257	
Overload reference		2949		
Overload time		2548		
Id max	380			
Id limit	22			
Maximum torque command		1255		
Maximum motor revolution	5000	5000	2000	
Kip		48		
Kii		32		
Origin position return pulse			0	
Stroke-end origin position torque			80	

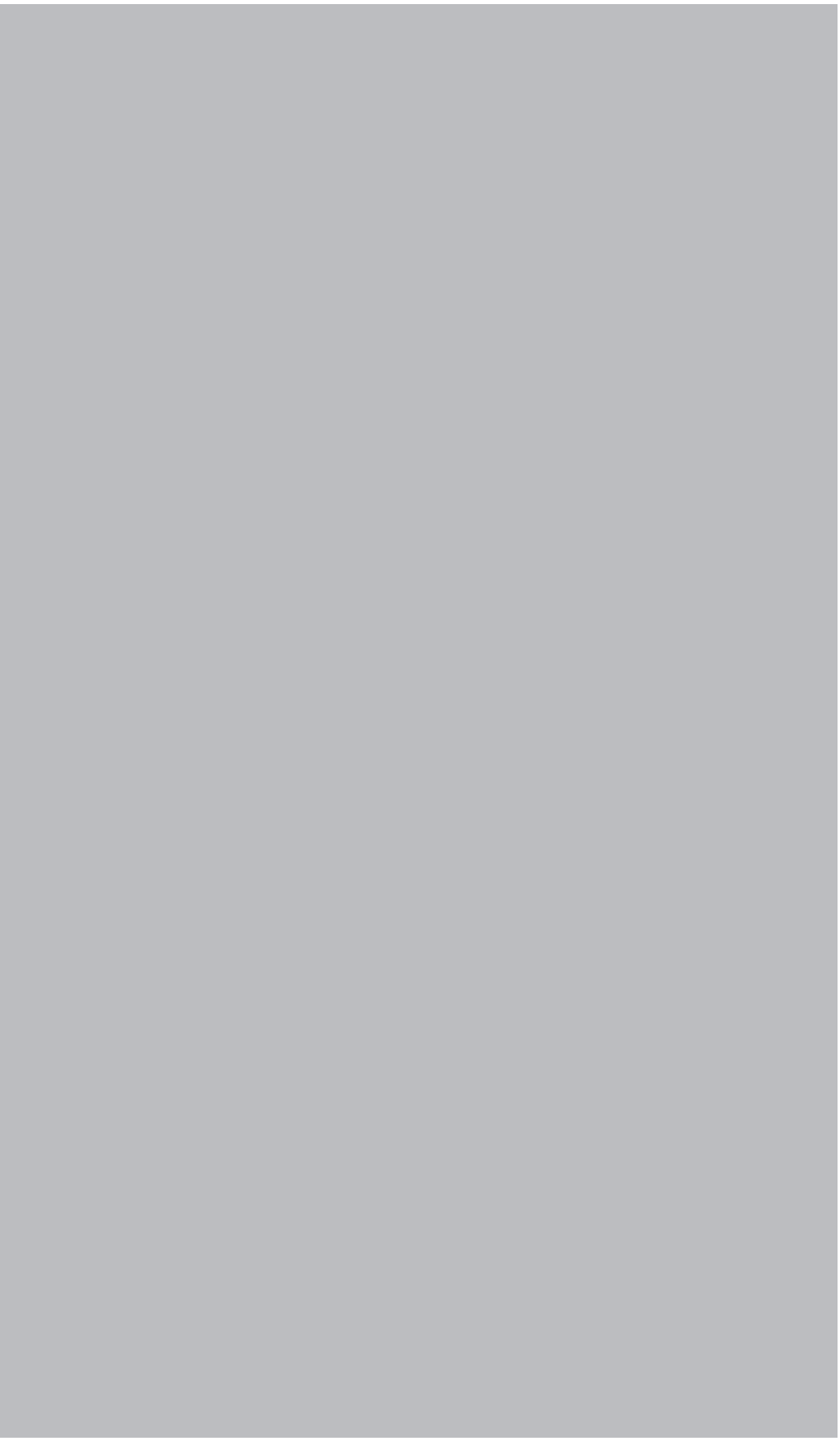
←**Never increase acceleration more than this level.**

←**Never change maximum motor revolution.**

* On the 3-axis model (X, Y and Z axes) using an RCX142 controller, only M1 to M3 settings are needed.

Chapter 3 Installation

Contents



1. Robot installation conditions

1.1 Installation environments

Be sure to install the robot in the following environments.

Items	Specifications
Allowable ambient temperature	0 to 40°C
Allowable ambient humidity	35 to 85% RH (non condensation)
Altitude	0 to 1000 meters above sea level
Ambient environments	Avoid installing near water, cutting water, oil, dust, metallic chips and organic solvent.
	Avoid installation near corrosive gas and corrosive materials.
	Avoid installation in atmosphere containing inflammable gas, dust or liquid.
	Avoid installation near objects causing electromagnetic interference, electrostatic discharge or radio frequency interference.
Vibration	Do not subject to impacts or vibrations.
Air supply pressure, etc.	Below 0.58MPa (6.0kgf/cm^2); clean dry air not containing deteriorated compressor oil; filtration 40μm or less
Working space	Allow sufficient space margin to perform jobs (teaching, inspection, repair, etc.)

For detailed information on how to install the robot controller, refer to the separate "YAMAHA Robot Controller User's Manual".

⚠ WARNING

- **Avoid installing the robot in locations where the ambient conditions may exceed the allowable temperature or humidity, or in environments where water, corrosive gases, metallic powder or dust are generated. Malfunction, failure or short circuits may otherwise result.**
- **This robot was not designed for operation in environments where inflammable or explosive substances are present. Do not use the robot in environments containing inflammable gas, dust or liquids. Explosions or fire could otherwise result.**
- **Avoid using the robot in locations subject to electromagnetic interference, electrostatic discharge or radio frequency interference. Malfunction may otherwise occur.**
- **Do not use the robot in locations subject to excessive vibration. Robot installation bolts may otherwise become loose causing the robot to fall over.**

1.2 Installation base

⚠WARNING

Always install the robot on a level surface, with the robot base mount facing downward. Grease may leak out from the speed reduction gear if the robot is installed in such a way that the base mount does not face downward.

⚠CAUTION

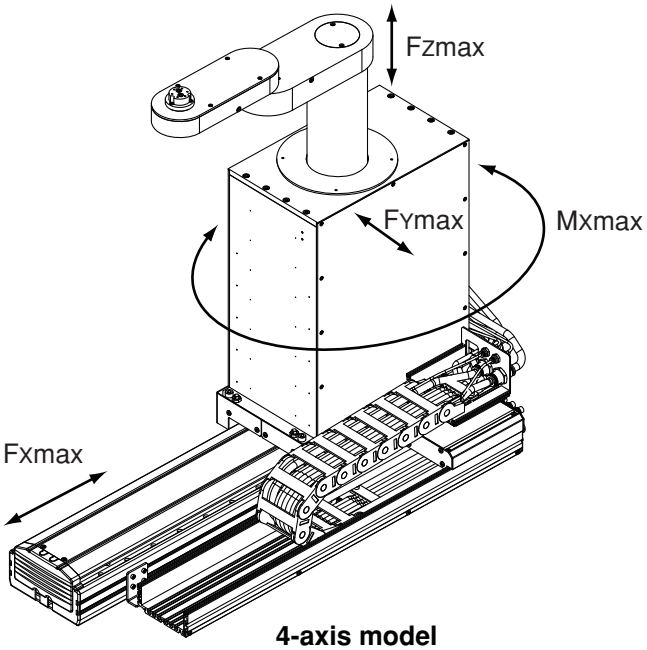
- **The manipulator positioning may decrease if the installation surface precision is insufficient.**
- **If the installation base is not sufficiently rigid and stable or a thin metallic plate is attached to the installation base, vibration (resonance) may occur during operation, causing detrimental effects on the manipulator work.**

1) Prepare a sufficiently rigid and stable installation base, taking account of the robot weight including the end effector (gripper), workpiece and reaction force while the robot is operating.
The maximum reaction force (see Fig.3-1) applied to the robot is as shown below.
These values are an instantaneous force applied to the robot during operation and do not indicate the maximum load capacity.

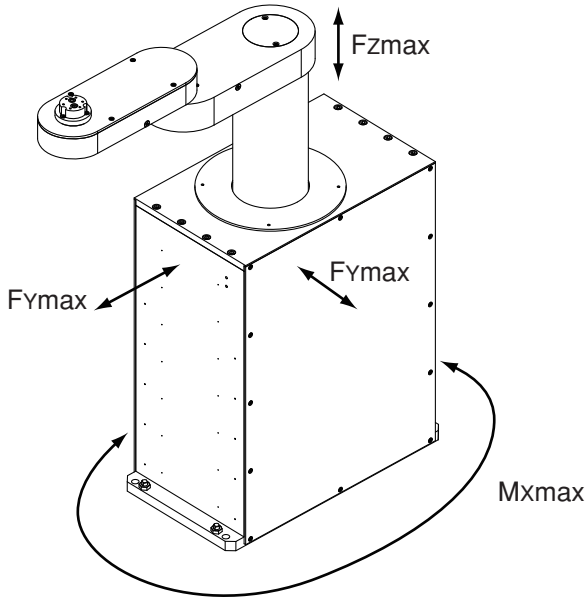
Maximum reaction force during robot operation

Fxmax		Fymax		Mxmax		Fzmax	
N	kgf	N	Kgf	Nm	kgfm	N	Kgf
1019	104	686	70	56	6	294	30

■ **Fig. 3-1 Maximum reaction force applied during operation**



4-axis model



3-axis model

2) The installation base surface must be machined within a flatness of ±0.05mm/500mm. The robot base mount must be installed facing down and in a level position.

3) Tap holes into the surface of the installation base. Refer to "2. External view and dimensions" in Chapter 7 for machining dimensions and positions.

4) Securely fix the installation base on the floor with anchor bolts.

2. Installation

2.1 Unpacking

⚠WARNING

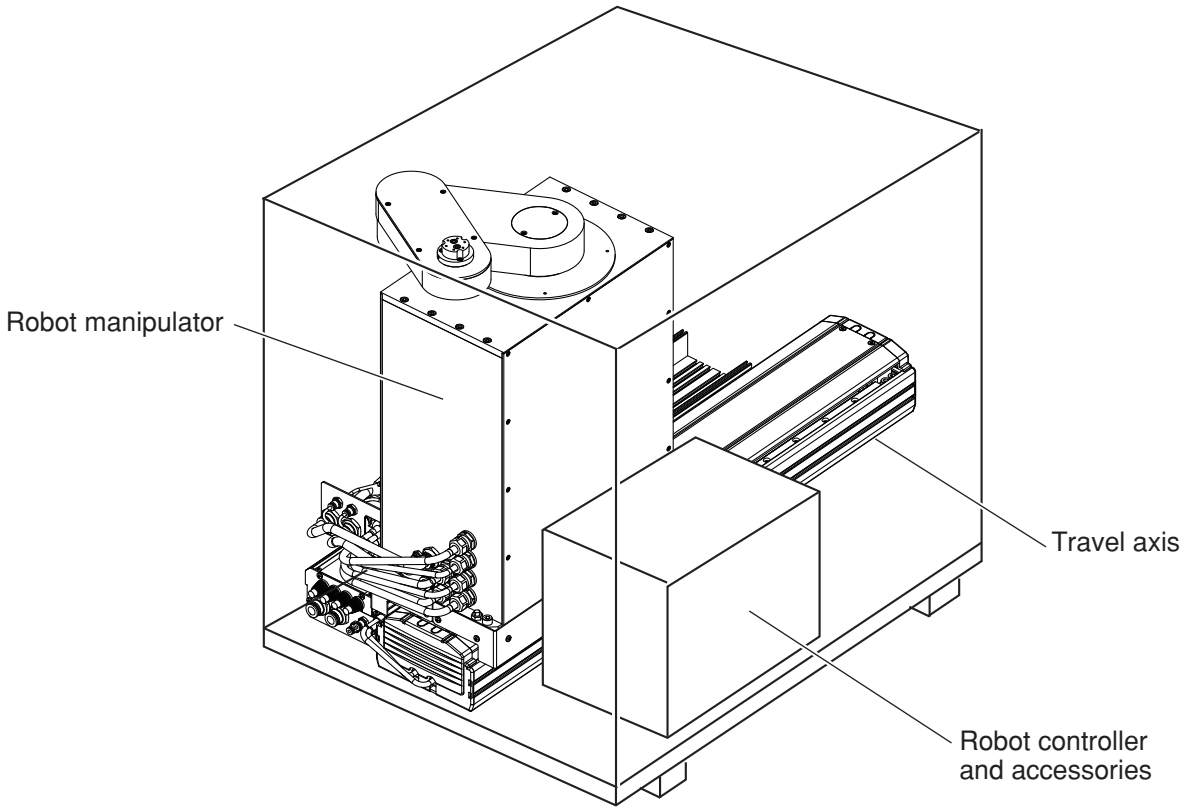
The robot and controller are heavy. Take sufficient care not to drop them during moving or unpacking as this may damage the equipment or cause bodily injury.

⚠CAUTION

Allow only properly qualified personnel to operate equipment such as forklifts that require a license to use. Equipment and tools used for moving the robot should be serviced daily.

The disk handling robot comes packed with a robot controller and accessories, according to the order specifications. Using a carrying cart (dolly) or forklift, move the package to near the installation base. Take sufficient care not to apply shocks to the equipment when unpacking it.

■ **Fig. 3-2 Packed state**



4-axis model (3-axis model does not have travel axis.)

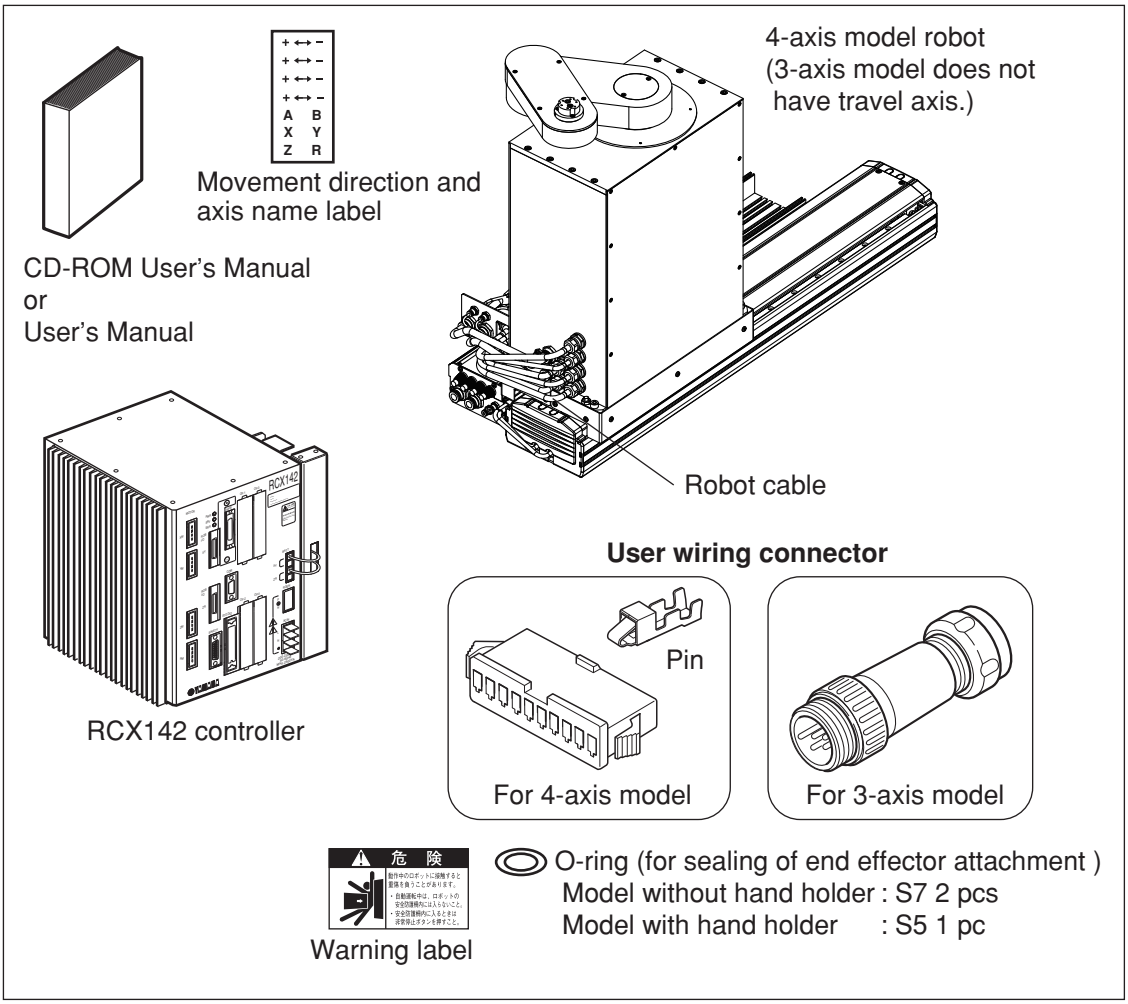
2.2 Checking the product

After unpacking, check the product configuration and conditions.

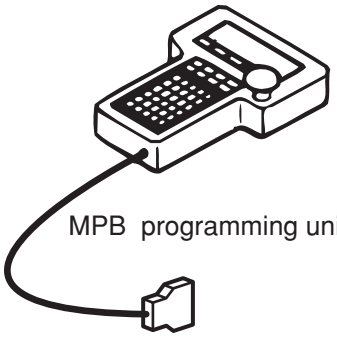
⚠CAUTION

If there is any damage due to transportation or insufficient parts, please notify your YAMAHA sales office or dealer immediately.

■ **Fig. 3-3 Product configuration**



Options



2.3 Moving the robot

⚠WARNING

Serious injury may occur if the robot falls and pins someone underneath it.
- **Do not allow any part of your body within the area beneath the robot during work.**
- **Always wear a helmet, safety shoes and gloves during work.**

⚠CAUTION

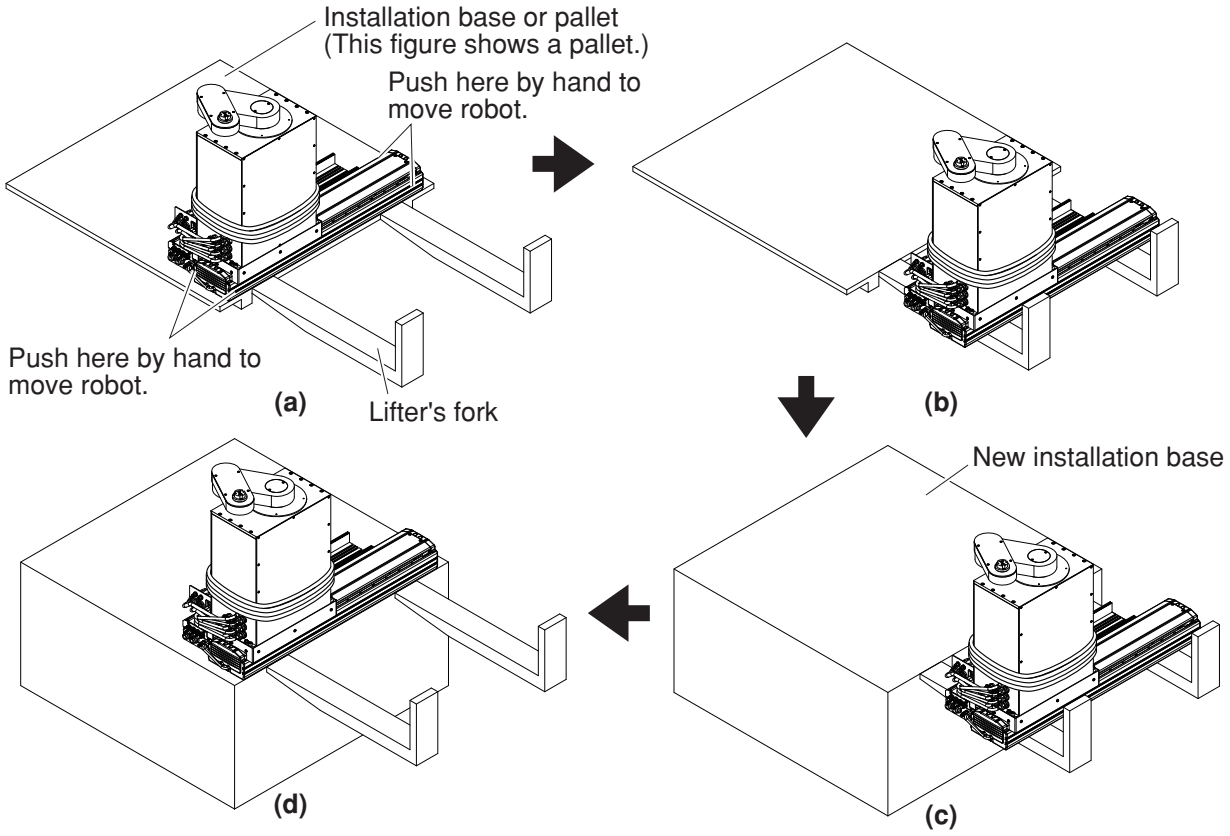
- **Allow only properly qualified personnel to operate equipment such as cranes that require a license to use.**
- **Equipment and tools used for moving the robot should be serviced daily.**

2.3.1 4-axis model

The robot weighs more than 70kg so take suitable precautions when carrying the robot. Use 3 or more people for the following work.

1) Move each axis to its origin position, and then turn off the controller and disconnect the robot cable from the controller. (The robot is bolted to a pallet at the time of shipment.)

■ **Fig. 3-4**



2) Wind the robot cable around the robot base and fasten the robot cable with adhesive tape. (See Fig. 3-4 (a).)

3) In the following work, hold the robot being careful to keep it balanced so it will not fall over.
Remove the R-axis (travel axis) mounting bolts. (See "2.4 Installing the robot".)

4) Move the robot to one edge of the installation base (or pallet), by pushing the robot toward the edge with two people, one each at the ends of the R-axis (travel axis).

5) Have another person use a lifter to position it against the edge of the installation base (or pallet). Use a lifter with a maximum payload capacity sufficient to support the robot mass.

6) Shift the robot onto the forks of the lifter with two people. (See Fig. 3-4 (b).) Hold the robot while the lifter is moving up or down to ensure the robot will not fall over.

7) Move the robot on the lifter to the new installation base and then position the lifter against the edge of the installation base. At this point, hold the robot to ensure it will not fall over. (See Fig. 3-4 (c).)

8) Shift the robot onto the installation base with two people. Make sure the robot is stably placed on the installation base. (See Fig. 3-4 (d).)

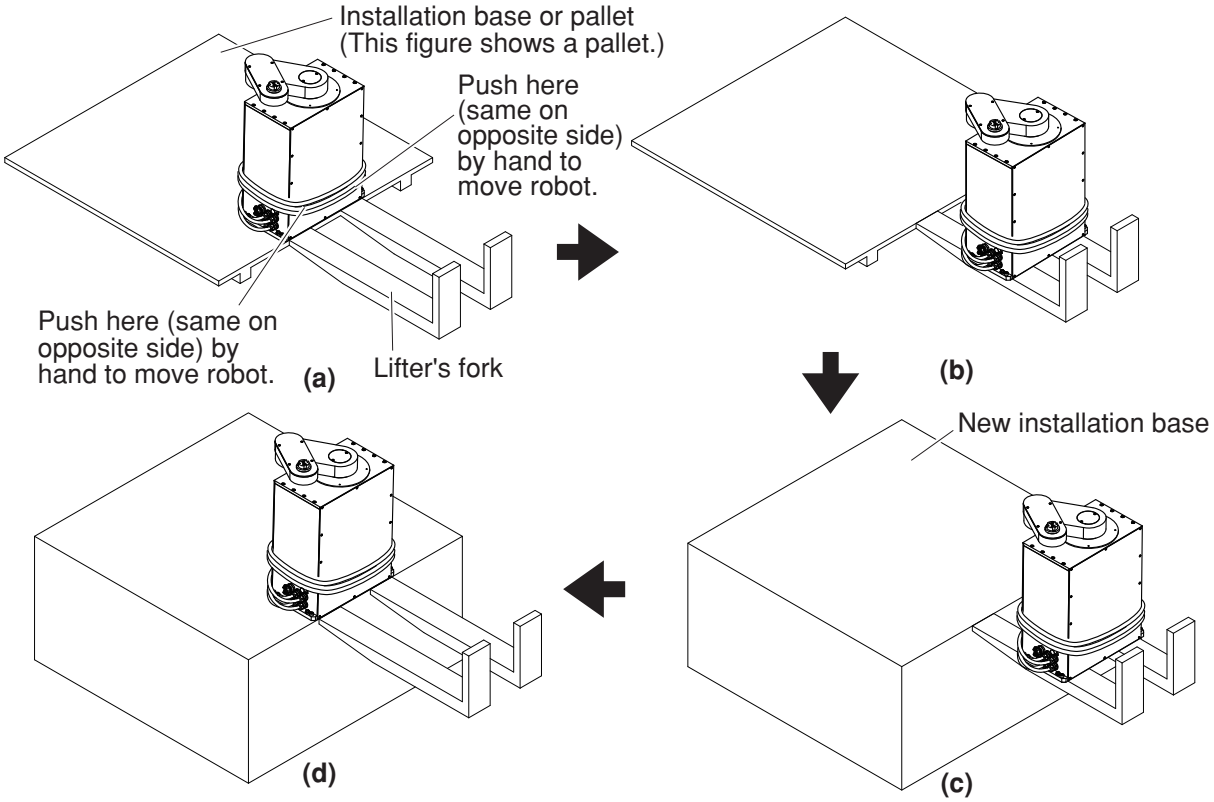
9) Bolt the robot promptly by referring to the description in "2.4 Installing the robot".

2.3.2 3-axis model

The robot weighs more than 40kg so take suitable precautions when carrying the robot. Use 3 or more people for the following work.

1) Move each axis to its origin position, and then turn off the controller and disconnect the robot cable from the controller. (The robot is bolted to a pallet at the time of shipment.)

■ **Fig. 3-5**



2) Wind the robot cable around the robot base and fasten the robot cable with adhesive tape. (See Fig. 3-5 (a).)

3) In the following work, hold the robot being careful to keep it balanced so it will not fall over.
Remove the robot base mounting bolts. (See "2.4 Installing the robot".)

4) Move the robot to one edge of the installation base (or pallet), by pushing the robot toward the edge with two people, one at each end of the robot base.

5) Have another person use a lifter to position it against the edge of the installation base (or pallet). Use a lifter with a maximum payload capacity sufficient to support the robot weight.

6) Shift the robot onto the forks of the lifter with two people. (See Fig. 3-5 (b).) Hold the robot while the lifter is moving up or down to ensure the robot will not fall over.

7) Move the robot on the lifter to the new installation base and then position the lifter against the edge of the installation base. At this point, hold the robot to ensure it will not fall over. (See Fig. 3-5 (c).)

8) Shift the robot onto the installation base with two people. Make sure the robot is stably placed on the installation base. (See Fig. 3-5 (d).)

9) Bolt the robot promptly by referring to the description in "2.4 Installing the robot".

2.4 Installing the robot

⚠WARNING

- **When installing the robot, use the specified size and number of bolts that match the depth of tapped holes in the installation base, and securely tighten the bolts to the correct torque. If this is not observed, the robot might fall over during operation causing a serious accident.**
- **Make sure that the bolts do not reach the bottom of the tapped holes.**

2.4.1 4-axis model

The method for installing the robot is described below.

1) Tap holes into the surface of the installation base where the robot is to be installed. Refer to "2. External view and dimensions" in Chapter 7 for machining positions.

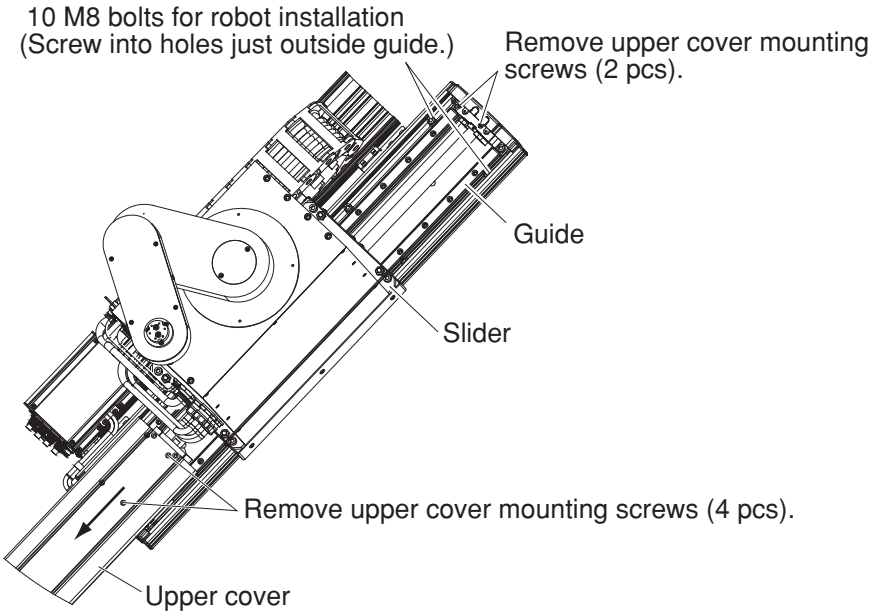
2) Remove the screws holding the upper cover of the robot and remove the upper cover. Move the slider to a position where the mounting holes in the bottom of the robot are seen.

3) Fix the robot to the installation base with the specified bolts.

Bolt size	Tightening torque	Number of bolts
M8	37Nm (380Kgfcm)	10

Depth of tapped holes in installation base:
Iron installation base 15mm or more (bolt length 40mm or more)
Aluminum installation base 25mm or more (bolt length 50mm or more)
Recommended bolt : JIS B 1176 hex socket head bolt, or equivalent
Strength class JIS B 1051 12.9, or equivalent

■ **Fig. 3-6 Installing the robot**



4) Reattach the upper cover.

2.4.2 3-axis model

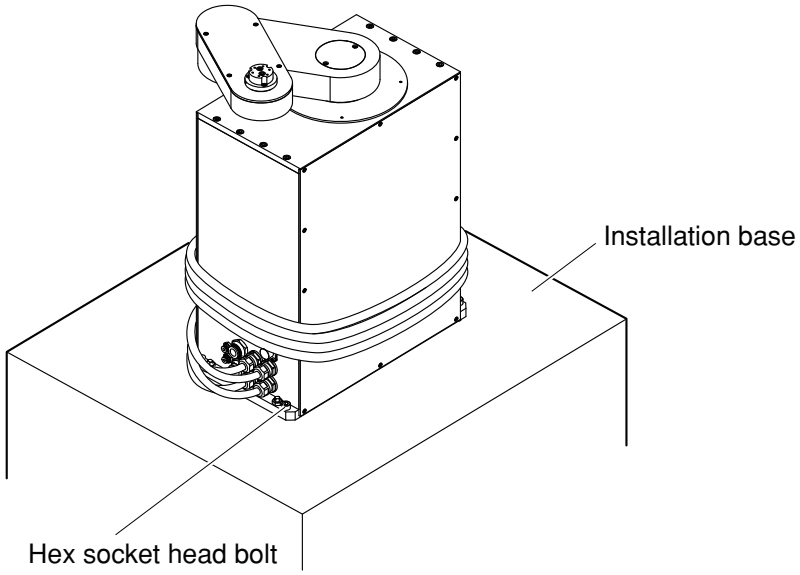
Fix the robot securely with 4 hex socket head bolts as shown in Fig. 3-7.

Tightening torque

Bolt size	Tightening torque	Number of bolts
M8	37Nm (380Kgfcm)	4

Depth of tapped holes in installation base:
Iron installation base 17mm or more (bolt length 30mm or more)
Aluminum installation base 27mm or more (bolt length 40mm or more)
Recommended bolt :JIS B 1176 hex socket head bolt, or equivalent
Strength class JIS B 1051 12.9 or higher, or equivalent

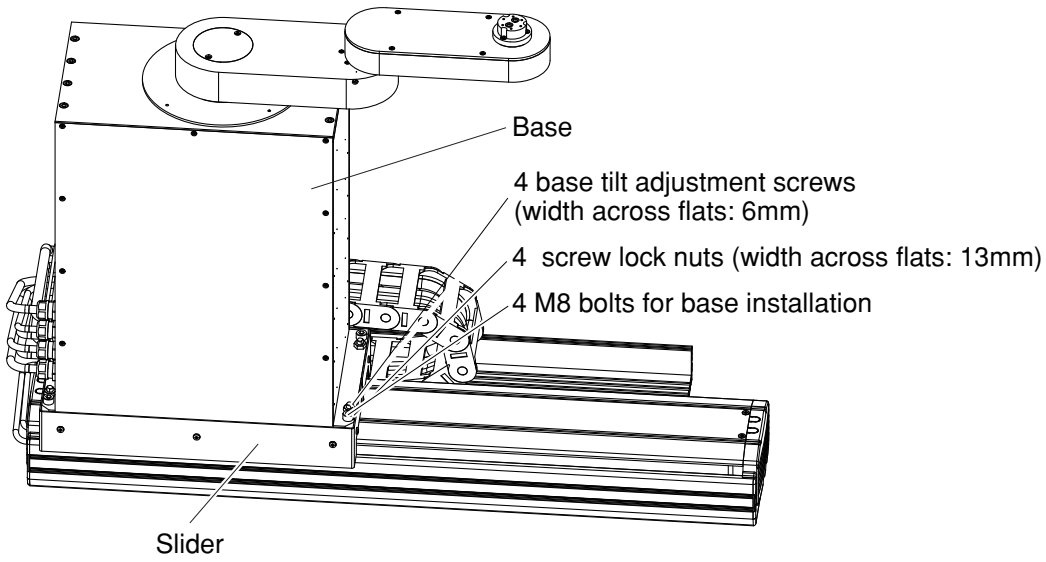
■ **Fig. 3-7 Installing the robot**



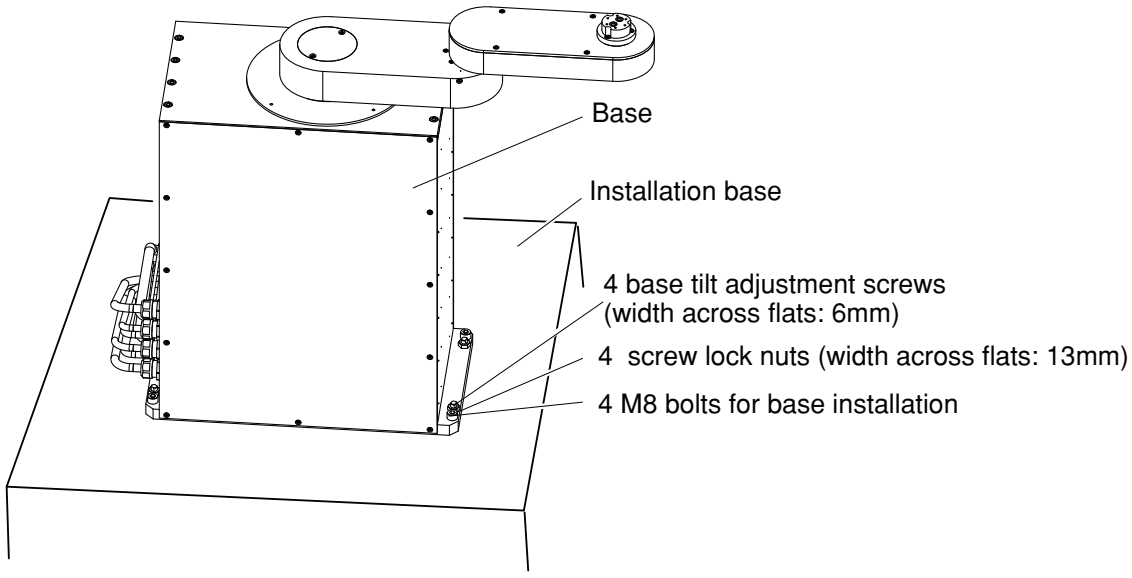
2.5 Adjusting the robot base tilt

Use the following method to adjust the robot base tilt versus the slider (4-axis model) or installation base (3-axis model). (See Fig. 3-8.) Making this adjustment also affects the robot base alignment that was made at the factory prior to shipment, so do not attempt this adjustment unless necessary.

■ **Fig. 3-8 4-axis model**



■**Fig. 3-8 3-axis model**



1) Loosen the M8 bolts securing the robot base.
2) Loosen the nuts securing the robot base tilt adjustment screws.
3) Tighten the robot base tilt adjustment screws to adjust the tilt as needed.
4) When finished, retighten the M8 bolts to a torque of 37Nm (380Kgfcm) to secure the robot base.
5) Retighten the nuts to secure the robot base tilt adjustment screws.

3. Protective bonding

⚠WARNING

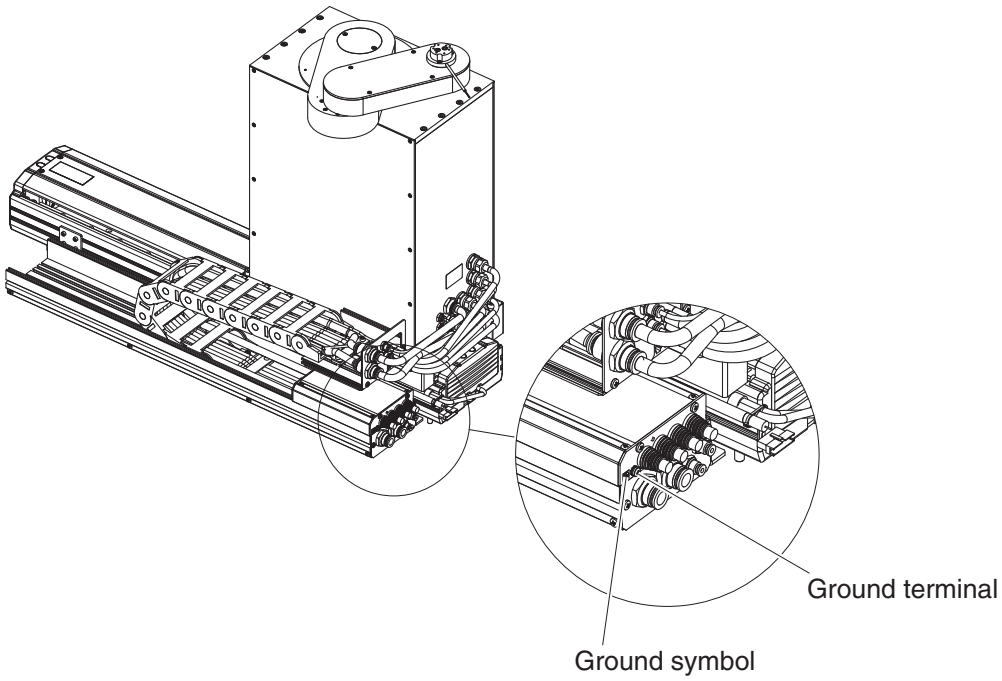
- **Be sure to ground the robot and controller to prevent electrical shock.**
- **Turn off the controller before grounding the robot.**

The robot must be grounded as follows:

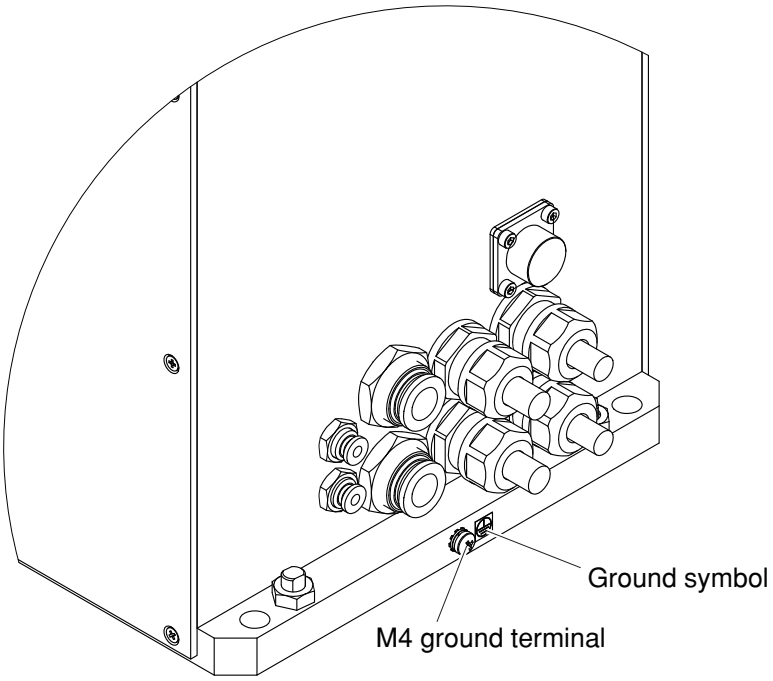
1) Provide a terminal marked "PE" for the protective conductor of the entire system and connect it to an external protective conductor. In addition, securely connect the ground terminal on the robot to the same protective conductor. (See Fig. 3-9.)

(Symbol 417-IEC-5019)

■ **Fig. 3-9 4-axis model**

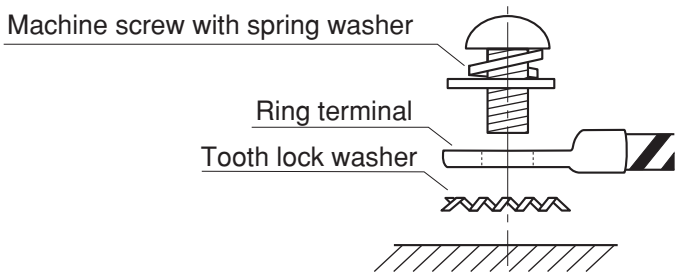


■ **Fig. 3-9 3-axis model**



2) An M4 machine screw with a spring washer and a tooth lock washer is attached to the ground terminal. Tighten the M4 machine screw by inserting it through the tooth lock washer, ring terminal and spring washer. (See Fig. 3-10.)

■ **Fig. 3-10**



3) When the tool (end effector) uses an electrical device which, if it malfunctions, might make contact with the power supply, ground the end effector properly on your responsibility since no ground terminal is provided for such a device on the robot body.

4) For protective bonding on the robot body to comply with CE marking, follow the instructions on controller protective bonding explained in the "YAMAMA Robot Controller User's Manual or "CE Marking Supporting Supplement Manual".

5) Use a ground cable with a conductor wire cross section of at least 2.0mm^2 and a length within 1 meter.
On the 4-axis model, take out the ground cable through the cutout in the wiring box so that it will not interfere with the movable parts.

4. Robot cable connection

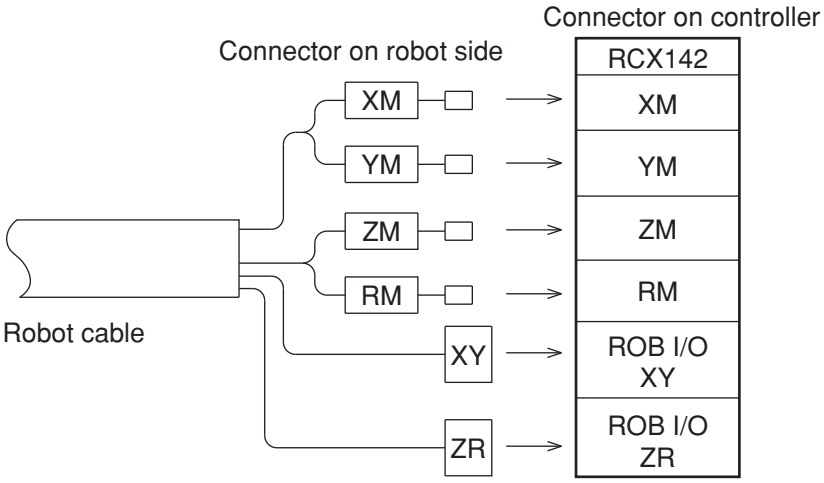
For details on connecting the robot cable to the controller, refer to Fig. 3-11 and the "YAMAHA Robot Controller User's Manual". After making connections, check the operation while referring to "6. Trial operation" in Chapter 1.

⚠WARNING

- **Before connecting the cables, check that there are no bends or breaks in the connector pins of the robot cable and that the cables are not damaged. Bent or broken pins or cable damage may cause malfunction of the robot.**
- **Ensure that the controller is off before connecting the robot cable to the controller.**
- **In the RCX142 controller, the MOTOR connectors XM and ZM, and YM and RM each have identical shapes. In addition, the PI connectors XY and ZR have identical shapes. Do not confuse these connectors when making connections. Wrong connections may result in malfunction and hazardous situations.**
- **If the connector installation is inadequate or if there are contact failures in the pins, the robot may malfunction causing a hazardous situation. Reconfirm that each connector is securely installed before turning on the controller.**
- **To attach the PI connector securely, tighten the screws supplied with the robot.**
- **Take caution not to apply an excessive load to the connectors due to stress or tension on the cables.**
- **Lay out the cables so that they do not obstruct robot motion.**
  Determine the robot work area in which the robot cables will not interfere with the load or workpiece picked up by the manipulator tip. If the robot cables interfere with the movable parts of the robot, the cables may be damaged causing malfunction and hazardous situations.
- **Lay out the robot cables so as to keep the operator or any other person from tripping on them. Bodily injury may result if someone trips on the cables.**

Connect the robot cable to the controller as shown below.

■ **Fig. 3-11 Robot cable connections**



*On the 3-axis (X, Y and Z axes) model, it is not necessary to connect the RM connector, but always connect the ZR connector.

5. User wiring connector and user tubing

⚠WARNING

- **Always turn off the controller and shut off air supply before attempting wiring or tubing work.**
  If air or power is supplied during this work, the robot may move erroneously causing a hazardous situation.
- **Be sure that user wiring and tubing installed utilizing the user wiring connectors and user tubing bulkhead unions do not interfere with robot motion, and do not become entangled with the robot, or swing about freely, as such conditions can damage the wiring or tubing and possibly cause malfunctions.**
- **User wiring and tubing installed utilizing the user wiring connector and tubing bulkhead unions should be positioned so that they will not be in the way of the operator and other workers. Tripping over the wiring or tubing could result in falls and possible injury.**

The disk handling robots are equipped with user signal wires and air tubes in the robot's machine harness. The table below shows the number of signal wires and air tubes available to users.

User wiring	User tubing
4 wires	ϕ4, 2 tubes

The specifications of user signal wires and air tubes are shown below. Always observe these specifications.

User Wiring

Rated voltage	30V
Allowable current	1.5A
Nominal cross-section area of conductor	0.1mm^2
Shield	None

User Tubing

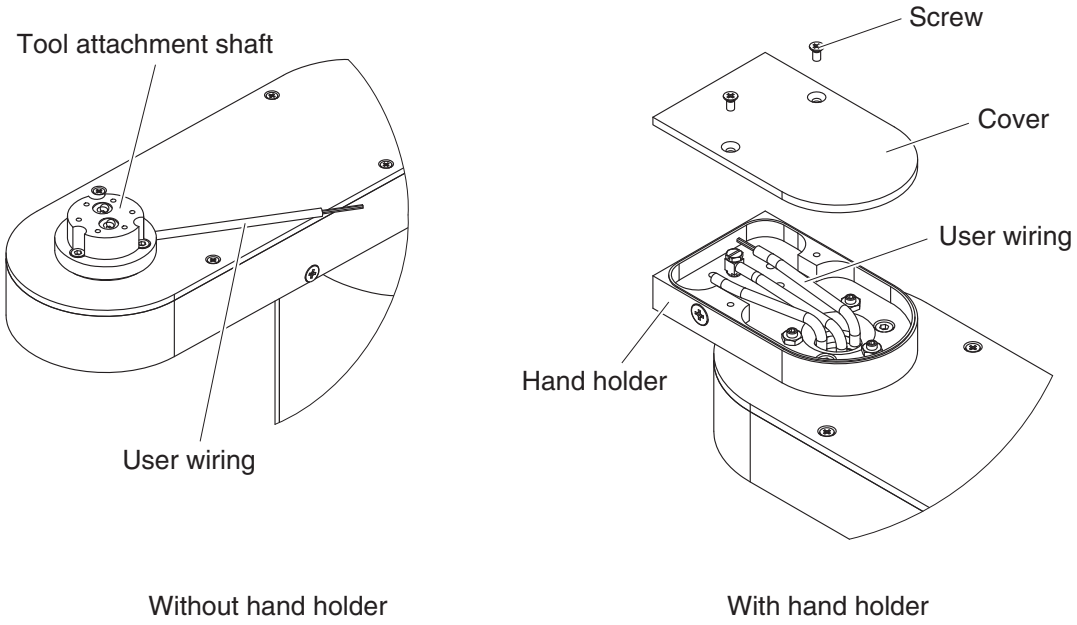
Maximum pressure	0.58MPa (6Kgf/cm^2)
Outer diameter × inner diameter	ϕ4mm × ϕ2.5mm
Fluid	Dry clean air not containing deteriorated compressor oil; air filter filtration 40μm or less

5.1 User wiring

1) User wiring is provided on the arm side. (See Fig. 3-12.)
Make wiring to the end effector. When taking the user wires out of the hand holder (if provided), drill an additional hole in the cover of the hand holder.

2) A user wiring connector is provided on the controller side of the robot. (See Fig. 3-12.)
On the 4-axis model, the user wiring connecter is located inside the wiring box.
On the 3-axis model, the user wiring connector is located on the rear of the robot base.

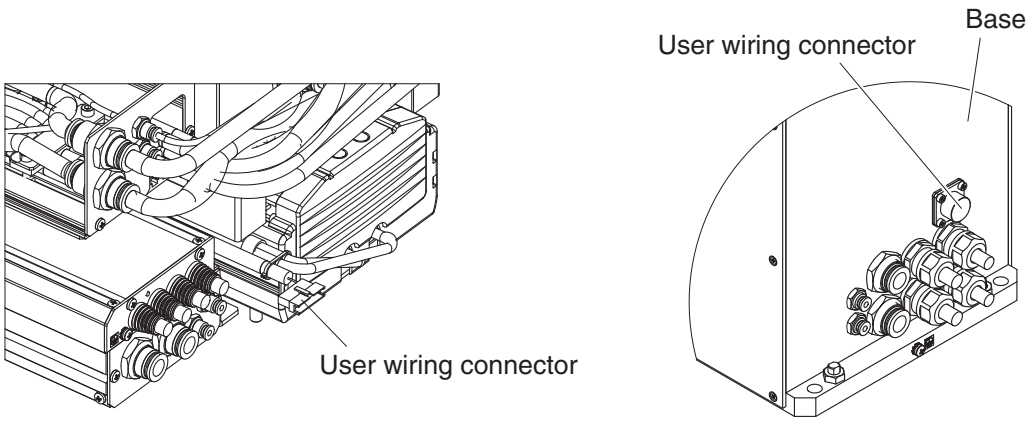
■ **Fig. 3-12**



Without hand holder

With hand holder

Arm side



4-axis model

3-axis model

Controller side

3) Signal wire connections in machine harness
Pins 1 to 4 in the user wiring connector can be used.

4-axis model

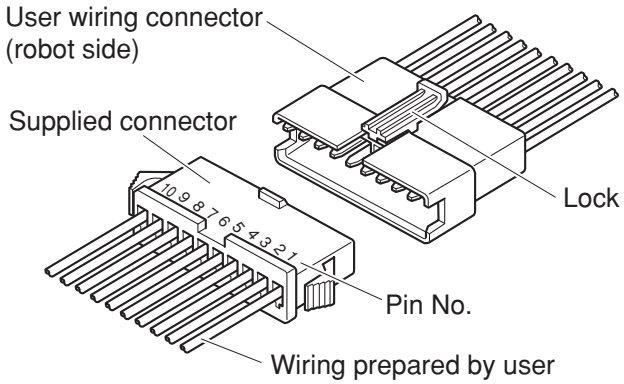
Signal		No.	Color	Connection	No.	Color	Connector
User signal wire	(Arm side)	1	Red		1	Red	I/O (Controller side)
		2	White		2	White	
		3	Yellow		3	Green	
		4	Blue		4	White	
					5 6 7 8 9 10	Cannot be used.	

3-axis model

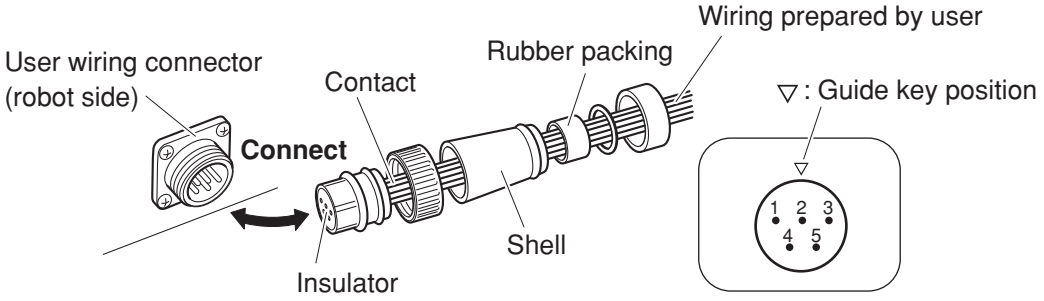
Signal		No.	Color	Connection	No.	Color	Connector
User signal wire	(Arm side)	1	Red		1	Red	I/O (Controller side)
		2	White		2	White	
		3	Yellow		3	Yellow	
		4	Blue		4	Blue	
					5	Cannot be used.	

4) On the 4-axis model, as shown in Fig. 3-13, crimp the wires (prepared by user) to the pins (supplied) using a crimping tool, and insert the pins into the connector (supplied). Then plug that connector into the user wiring connector. Take out the user wires through the cutout in the wiring box so that they will not interfere with the movable parts.
On the 3-axis model, solder the user wires to the connector pins.

■ **Fig. 3-13**



For 4-axis model



For 3-axis model

⚠WARNING

Securely attach the supplied connector into the user wiring connector on the robot side. If this connector comes loose or comes off, malfunction may result. The connector for the 4-axis model has lock tabs.

⚠CAUTION

Always use the pins and connector supplied with the robot. Using other types may result in contact failure.

For 4-axis model

Supplied connector for user wiring : SMR-10-V-B
Supplied pins for user wiring : SYM-001T-0.6
Manufacturer : JST Mfg. Co., Ltd.

For 3-axis model

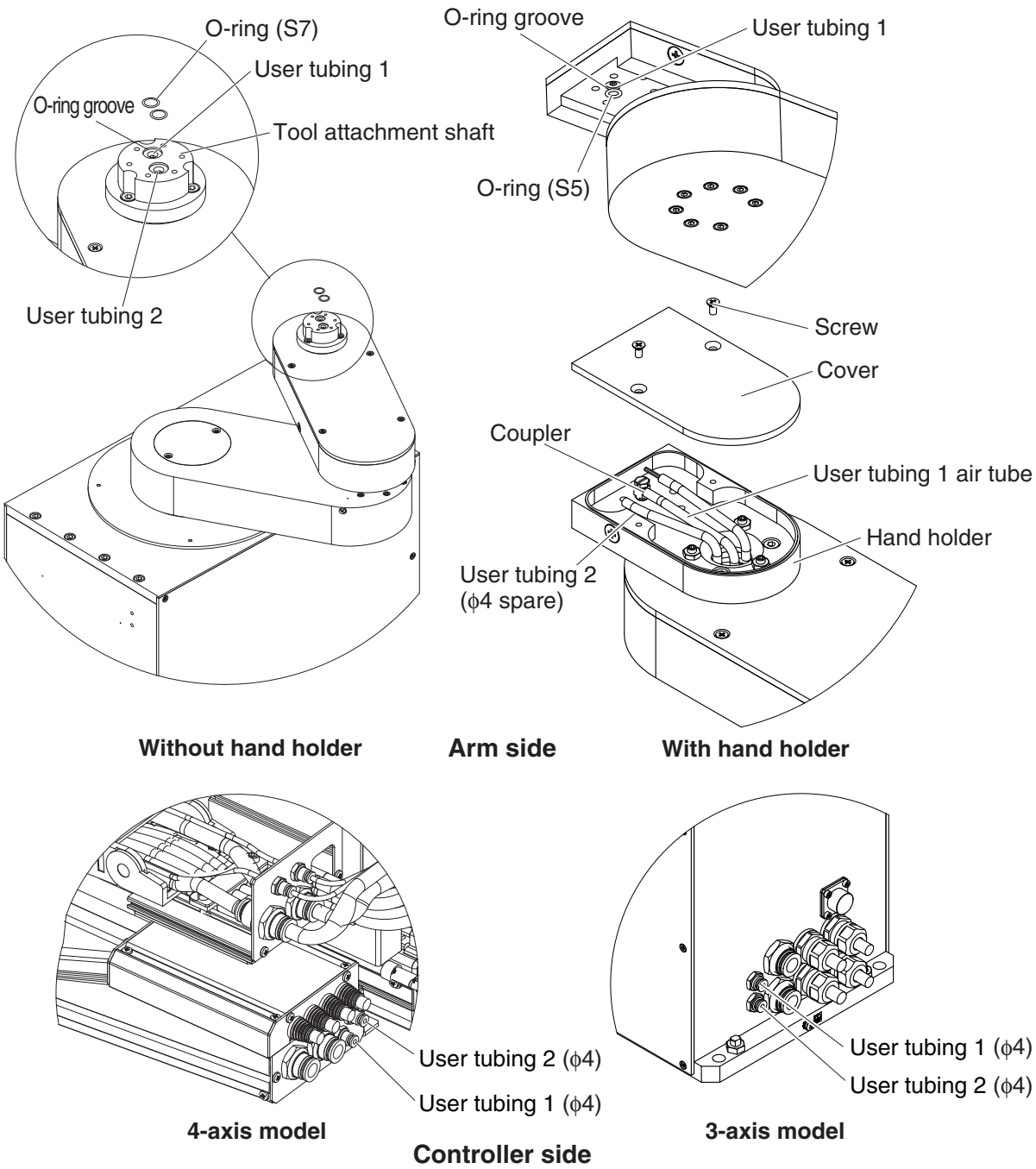
Supplied connector for user wiring : NJW-16-5-PF-9
Manufacturer : MISUMI Corporation

5.2 User tubing

1) Air tubes are installed in the arm side, and an O-ring groove formed at the port of each air tube to allow direct attachment of a suction hand or gripper. Fit the supplied O-ring in this O-ring groove when using the air tube. When taking the user tubing 2 out of the hand holder (if provided), drill an additional hole in the cover of the hand holder and provide sealing, etc.

2) There are bulkhead unions for user tubing on the controller side of the robot.

■ **Fig. 3-14 User tubing**



3) To check the signal exchange and operation between the end effector and the controller or peripheral equipment after making user wiring and tubing connections, refer to "6. Trial Operation" in Chapter 1.

6. Attaching the end effector

6.1 Acceleration

The disk handling robot has a maximum load mass capacity of 200g (tool attachment shaft rotation's moment of inertia: 0.040kgf·cm·sec^2). Therefore a mass and moment of inertia exceeding this level should never be applied to the tool attachment shaft. An excessive end effector moment of inertia can cause vibration and overload during operation of the X or Y axis or tool attachment shaft. This may also produce residual vibration during positioning.

⚠CAUTION

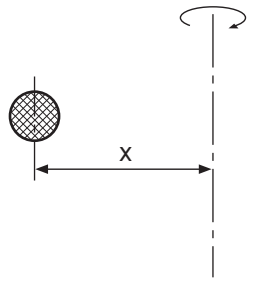
An excessive end effector moment of inertia can cause vibration and overload. Failure to comply with the maximum load mass capacity and moment of inertia will shorten the drive system life, and may result in damage and residual vibration during positioning.

6.2 Equation for moment of inertia calculation

Usually the load on the tool attachment shaft is not a simple form, and the calculation of the moment of inertia is not easy.
As a method, the load is replaced with several factors that resemble a simple form for which the moment of inertia can be calculated. The total of the moment of inertia for these factors is then obtained.
The objects and equations often used for the calculation of the moment of inertia are shown below.
There is the following relation: J (kgf·cm·sec^2) = I (kgm^2) × 10.2.

1) Moment of inertia for material particle
The equation for the moment of inertia for a material particle that has a rotation center such as shown in Fig. 3-15 is as follows:
This is used as an approximate equation when x is sufficiently larger than the object size.

■ **Fig. 3-15**



$$I = mx^2 \ (kgm^2)$$

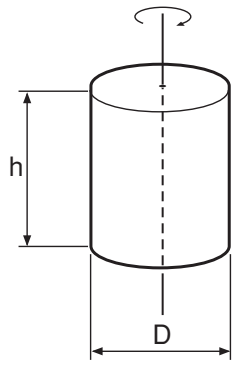
$$J = \frac{Wx^2}{g} \ (kgfcmsec^2)$$

... (Eq. 3.1)

g : Gravitational acceleration (cm/sec^2)
m : Mass of material particle (kg)
W : Weight of material particle (kgf)

2) Moment of inertia for cylinder (part 1)
The equation for the moment of inertia for a cylinder that has a rotation center such as shown in Fig. 3-16 is given below.

■ **Fig. 3-16**



$$I = \frac{\rho\pi D^4 h}{32} = \frac{mD^2}{8} \ (kgm^2)$$

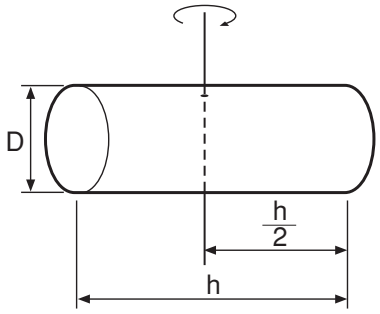
$$J = \frac{\rho\pi D^4 h}{32g} = \frac{WD^2}{8g} \ (kgfcmsec^2)$$

... (Eq. 3.2)

ρ : Density (kg/m^3, kg/cm^3)
g : Gravitational acceleration (cm/sec^2)
m : Mass of cylinder (kg)
W : Weight of cylinder (kgf)

3) Moment of inertia for cylinder (part 2)
The equation for the moment of inertia for a cylinder that has a rotation center such as shown in Fig. 3-17 is given below.

■ **Fig. 3-17**



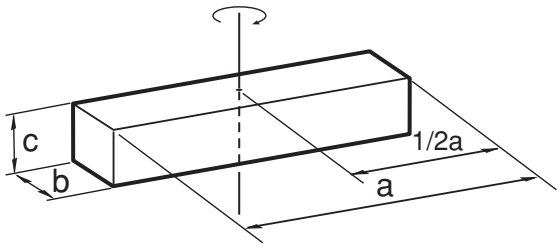
$$I = \frac{\rho\pi\ D^2 h}{16}\left(\frac{D^2}{4}+\frac{h^2}{3}\right) = \frac{m}{4}\left(\frac{D^2}{4}+\frac{h^2}{3}\right)\ (kgm^2)$$

$$J = \frac{\rho\pi\ D^2 h}{16g}\left(\frac{D^2}{4}+\frac{h^2}{3}\right) = \frac{W}{4g}\left(\frac{D^2}{4}+\frac{h^2}{3}\right)\ (kgfcmsec^2) \quad \text{... (Eq. 3.3)}$$

ρ : Density (kg/m^3, kg/cm^3)
g : Gravitational acceleration (cm/sec^2)
m : Mass of cylinder (kg)
W : Weight of cylinder (kgf)

4) Moment of inertia for prism
The equation for the moment of inertia for a prism that has a rotation center as shown in Fig. 3-18 is given as follows.

■ **Fig. 3-18**



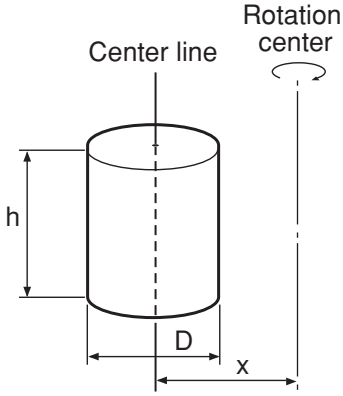
$$I = \frac{\rho\ abc(a^2+b^2)}{12} = \frac{m(a^2+b^2)}{12}\ (kgm^2)$$

$$J = \frac{\rho\ abc(a^2+b^2)}{12g} = \frac{W(a^2+b^2)}{12g}\ (kgfcmsec^2) \quad \text{... (Eq. 3.4)}$$

ρ : Density (kg/m^3, kg/cm^3)
g : Gravitational acceleration (cm/sec^2)
m : Mass of prism (kg)
W : Weight of prism (kgf)

5) When the object's center line is offset from the rotation center.
The equation for the moment of inertia, when the center of the cylinder is offset by the distance "x" from the rotation center as shown in Fig. 3-19, is given as follows.

■ **Fig. 3-19**



$$I = \frac{\rho\pi D^4 h}{32} + \frac{\rho\pi D^2 h x^2}{4} = \frac{mD^2}{8} + mx^2\ (kgm^2)$$

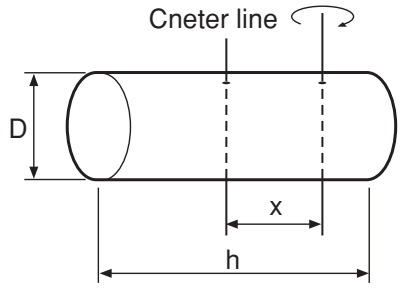
$$J = \frac{\rho\pi D^4 h}{32g} + \frac{\rho\pi D^2 h x^2}{4g}$$

$$= \frac{WD^2}{8g} + \frac{Wx^2}{g}\ (kgfcmsec^2) \quad \text{... (Eq. 3.5)}$$

ρ : Density (kg/m^3, kg/cm^3)
g : Gravitational acceleration (cm/sec^2)
m : Mass of cylinder (kg)
W : Weight of cylinder (kgf)

In the same manner, the moment of inertia of a cylinder as shown in Fig. 3-20 is given as follows:

■ **Fig. 3-20**



$$I = \frac{\rho\pi D^2 h}{16}\left(\frac{D^2}{4} + \frac{h^2}{3}\right) + \frac{\rho\pi D^2 h x^2}{4} = \frac{m}{4}\left(\frac{D^2}{4} + \frac{h^2}{3}\right) + mx^2 \quad (kgm^2)$$

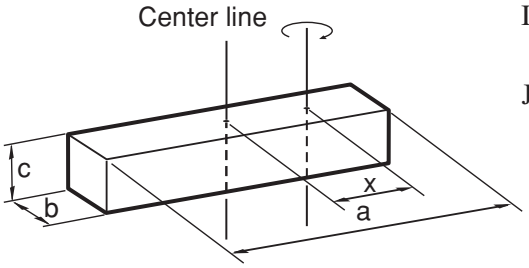
$$J = \frac{\rho\pi D^2 h}{16g}\left(\frac{D^2}{4} + \frac{h^2}{3}\right) + \frac{\rho\pi D^2 h x^2}{4g}$$

$$= \frac{W}{4g}\left(\frac{D^2}{4} + \frac{h^2}{3}\right) + \frac{Wx^2}{g} \quad (kgfcmsec^2)$$

... (Eq. 3.6)

In the same manner, the moment of inertia of a prism as shown in Fig. 3-21 is given as follows:

■ **Fig. 3-21**



$$I = \frac{\rho abc(a^2 + b^2)}{12} + \rho abcx^2 = \frac{m(a^2 + b^2)}{12} + mx^2 \quad (kgm^2)$$

$$J = \frac{\rho abc(a^2 + b^2)}{12g} + \frac{\rho abcx^2}{g}$$

$$= \frac{W(a^2 + b^2)}{12g} + \frac{Wx^2}{g} \quad (kgfcmsec^2)$$

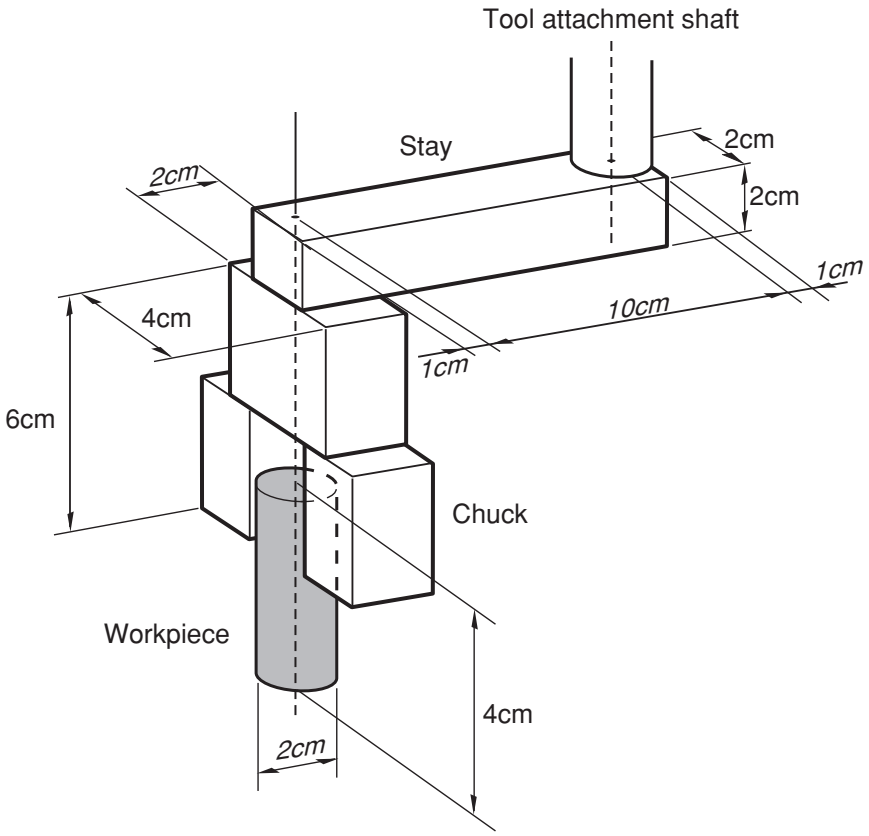
... (Eq. 3.7)

m : Mass of prism (kg)
W : Weight of prism (kgf)

6.3 Example of moment of inertia calculation

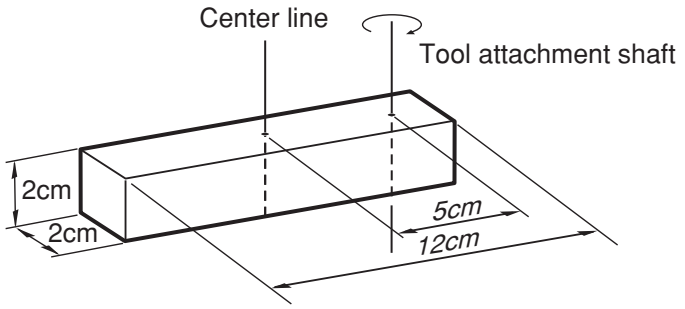
Let's discuss an example in which the chuck and workpiece are at a position offset by 10cm from the tool attachment shaft by a stay, as shown in Fig. 3-22.
The moment of inertia is calculated with the following three factors, assuming that the load material is steel and its density ρ is 0.0078kg/cm^3.

■ **Fig. 3-22**



1) Moment of inertia of the stay

■ **Fig. 3-23**



From Fig. 3-23, the weight of the stay (Ws) is given as follows:

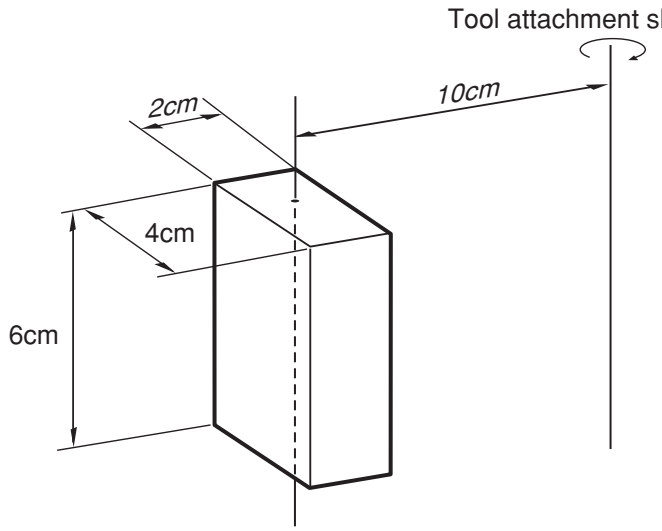
$Ws = \rho abc = 0.0078 \times 12 \times 2 \times 2 = 0.37$ (kgf)

The moment of inertia of the stay (Js) is then calculated from Eq. 3-7.

$$Js = \frac{0.37 \times (12^2+2^2)}{12 \times 980} + \frac{0.37 \times 5^2}{980} = 0.014 \text{ (kgfcmsec}^2\text{)}$$

2) Moment of inertia of the chuck
When the chuck form resembles that shown in Fig. 3-24, the weight of the chuck (Wc) is

■ **Fig. 3-24**



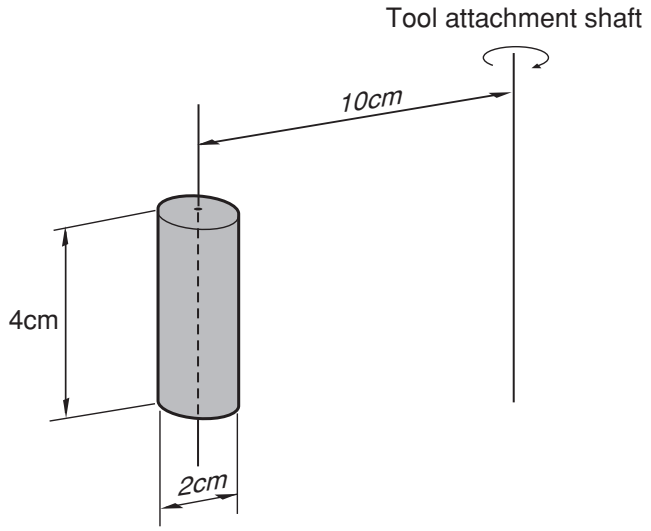
$$Wc = 0.0078 \times 2 \times 4 \times 6$$
$$= 0.37 \text{ (kgf)}$$

The moment of inertia of the chuck (Jc) is then calculated from Eq. 3-7.

$$Jc = \frac{0.37 \times (2^2+4^2)}{12 \times 980} + \frac{0.37 \times 10^2}{980}$$
$$= 0.038 \text{ (kgfcmsec}^2\text{)}$$

3) Moment of inertia of workpiece
When the workpiece form resembles that shown in Fig. 3-25, the weight of the workpiece (Ww) is

■ **Fig. 3-25**



$$Ww = \frac{\rho\pi D^2 h}{4} = \frac{0.0078\pi \times 2^2 \times 4}{4}$$
$$= 0.098 \text{ (kgf)}$$

The moment of inertia of the workpiece (Jw) is then calculated from Eq. 3-5.

$$Jw = \frac{0.097 \times 2^2}{8 \times 980} + \frac{0.097 \times 10^2}{980}$$
$$= 0.010 \text{ (kgfcmsec}^2\text{)}$$

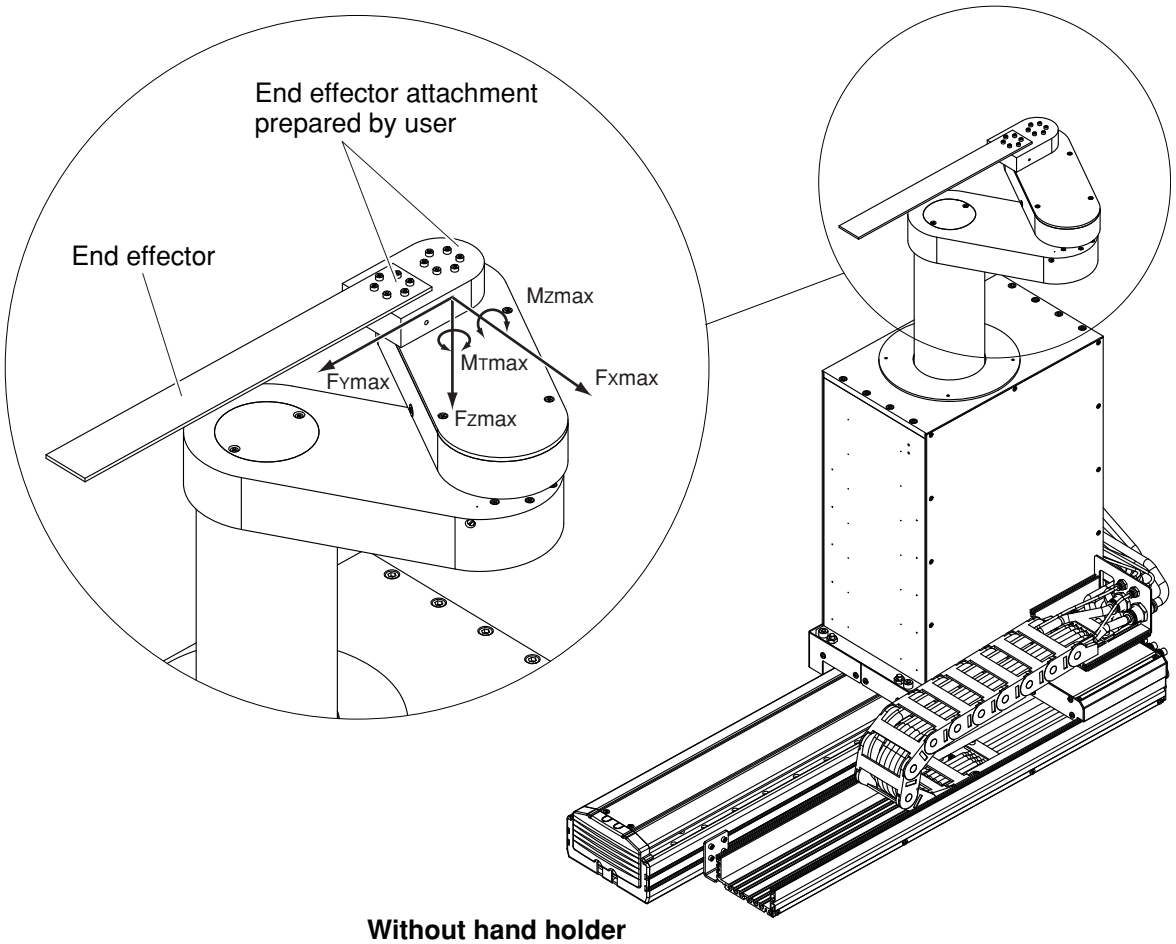
4) Total weight
The total weight (W) is calculated as follows:
W = Ws + Wc + Ww = 0.84 (kgf)

5) Total moment of inertia
The total moment of inertia (J) is then obtained as follows:
J = Js + Jc + Jw = 0.062 (kgfcmsec^2)

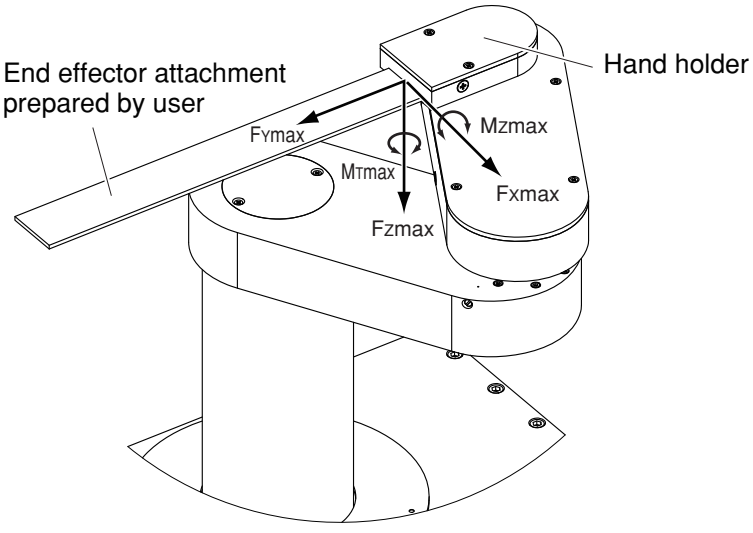
6.4 End effector attachment strength and rigidity

The end effector attachment must have adequate strength and rigidity, as well as gripping force to prevent positioning errors. Table 3-1 and Fig. 3-26 show the maximum load that can be applied to the end effector attachment during operation.

■ **Fig. 3-26**



Without hand holder



With hand holder

■ Table 3-1

Fxmax		Fzmax		Fymax		MTmax		Mzmax	
N	kgf	N	kgf	N	kgf	Nm	kgfm	Nm	kgfm
24.5	2.5	9.8	1	24.5	2.5	12.7	1.3	1.4	0.14

⚠WARNING

- Be sure that the end effector mounting area has an adequate strength versus the loads in Table 3-1. If the strength is inadequate, the attachment may break during robot operation and the end effector may fly off causing a hazardous situation.
- Be sure that the end effector mounting area has an adequate rigidity versus the loads in Table 3-1. If this rigidity is inadequate, the end effector may vibrate during robot operation causing bad effects on the manipulation tasks.

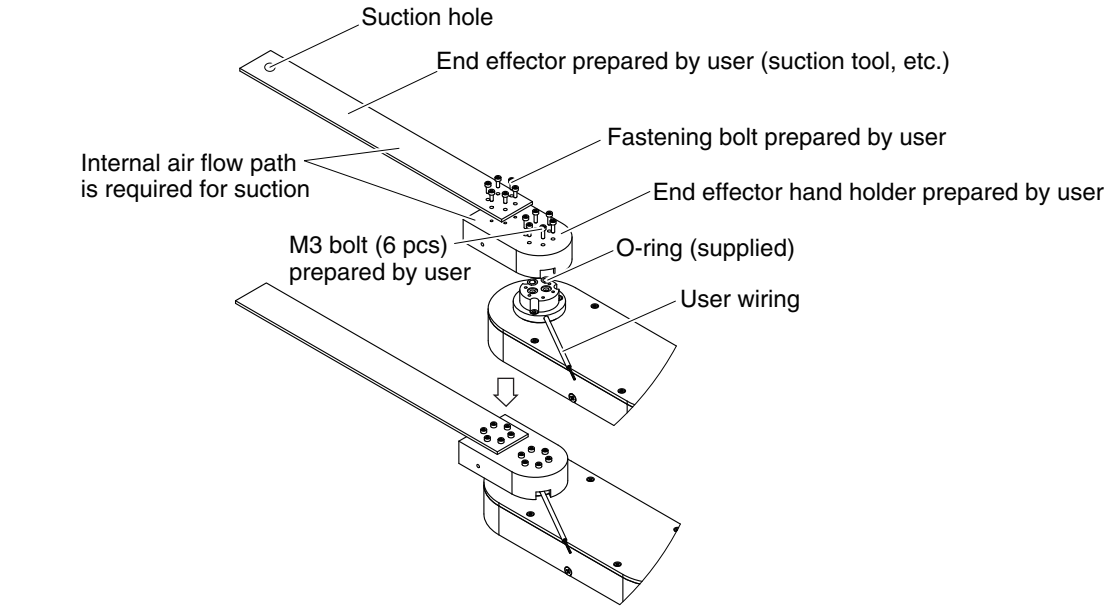
6.5 Attaching the end effector

⚠WARNING

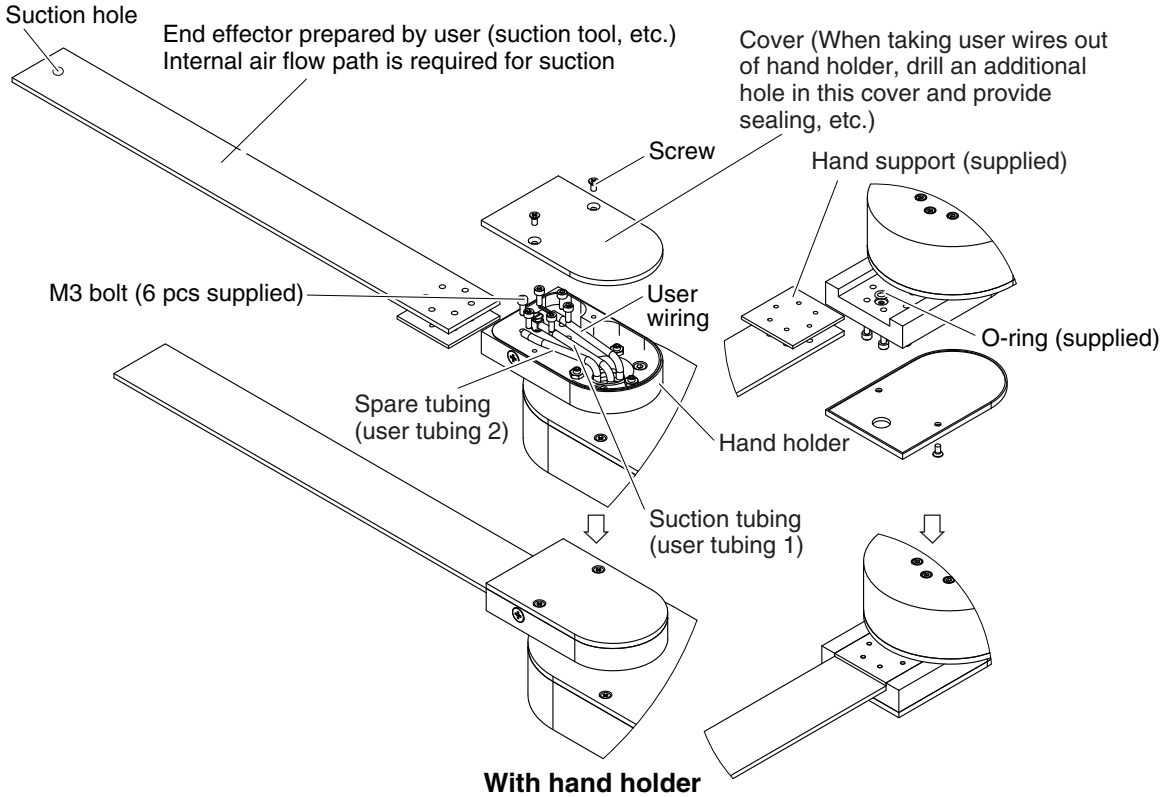
Before attaching the end effector, be sure to turn off the controller.

1) Recommended methods for attaching the end effector are shown in Fig. 3-27 and Table 3-2 below.

■ **Fig. 3-27**



Without hand holder



With hand holder

■ **Table 3-2**

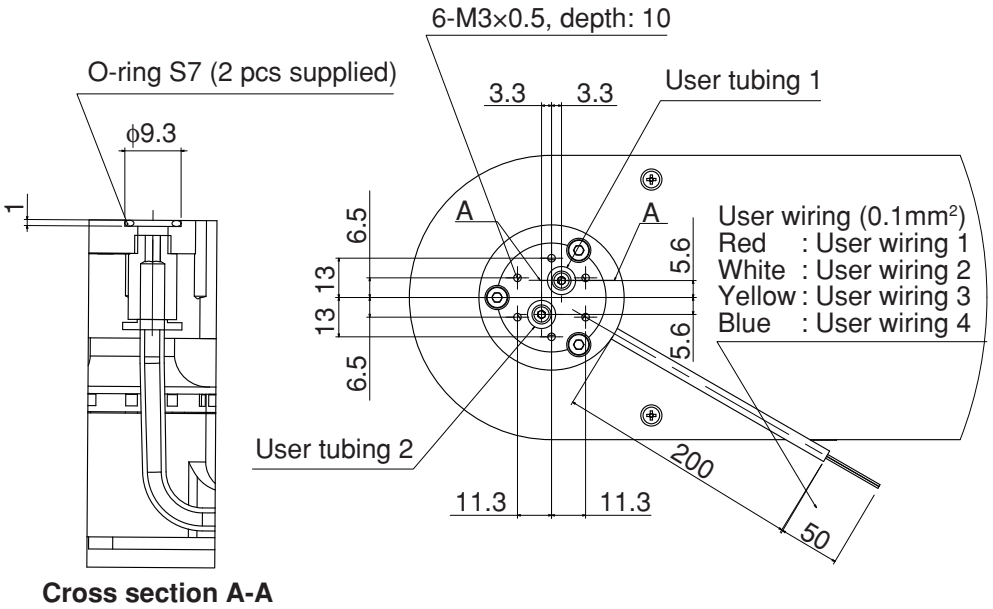
Bolt size	Number of bolts	Tightening torque	
		Nm	kgf • cm
M3	6	2.0	20

Recommended bolt : JIS B 1176, or equivalent
Hex socket head bolt
Strength class JIS B 1051 12.9, or equivalent

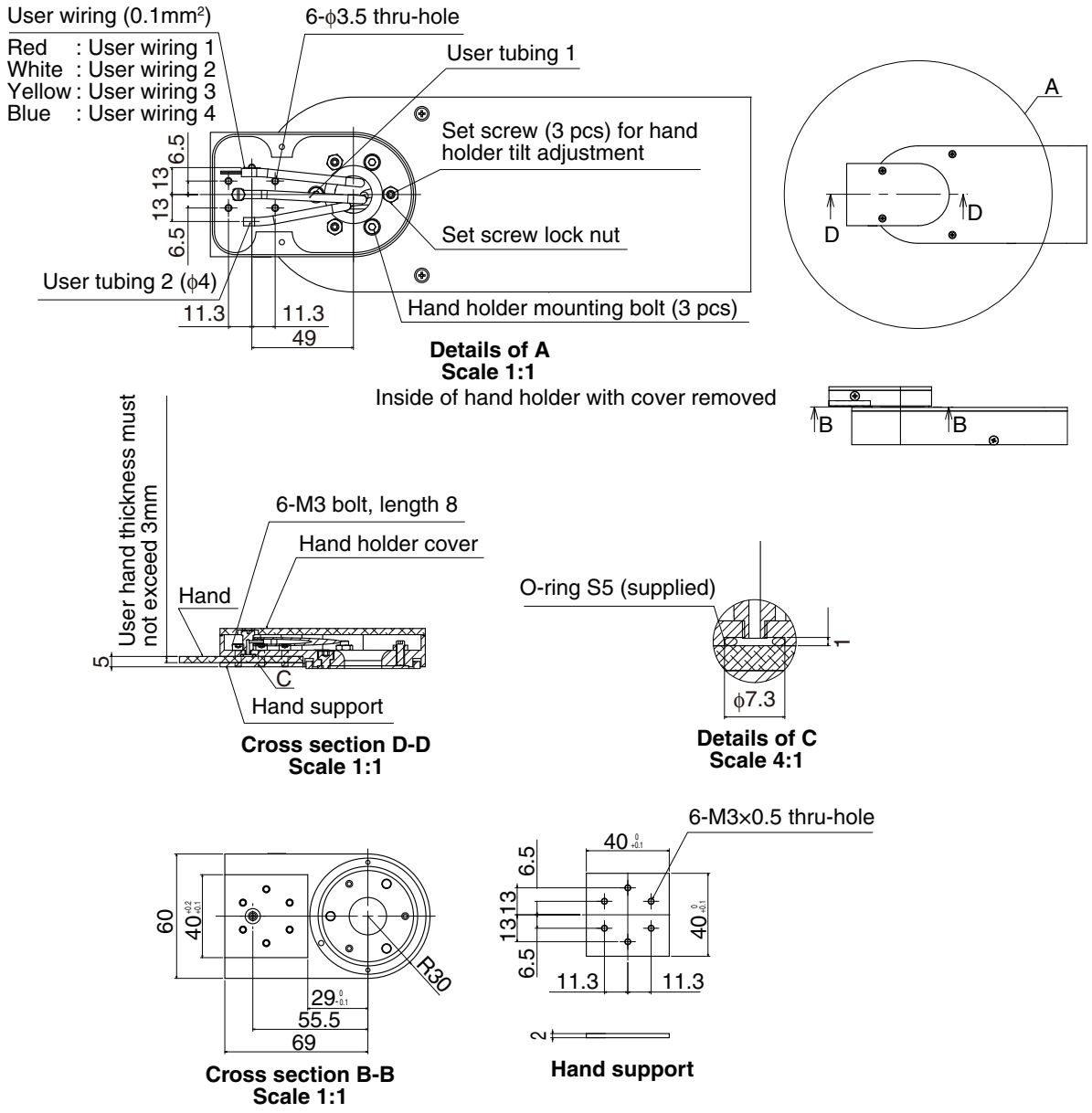
* In cases where the end effector cannot withstand the tightening torque for M3 bolts, reduce the tightening torque as needed. Use care, however, to avoid reducing the tightening torque to the point where the end effector may shift or fall off.

2) Refer to Fig. 3-28 for details on the end effector attachment section of the robot.

■ **Fig. 3-28 Without hand holder**



■ Fig. 3-28 With hand holder

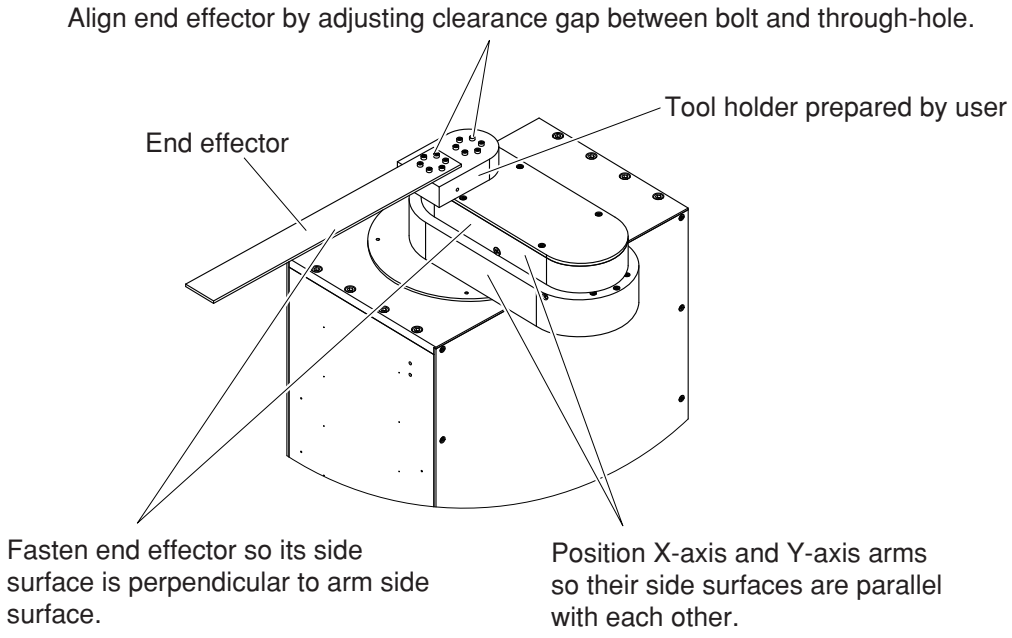


⚠WARNING

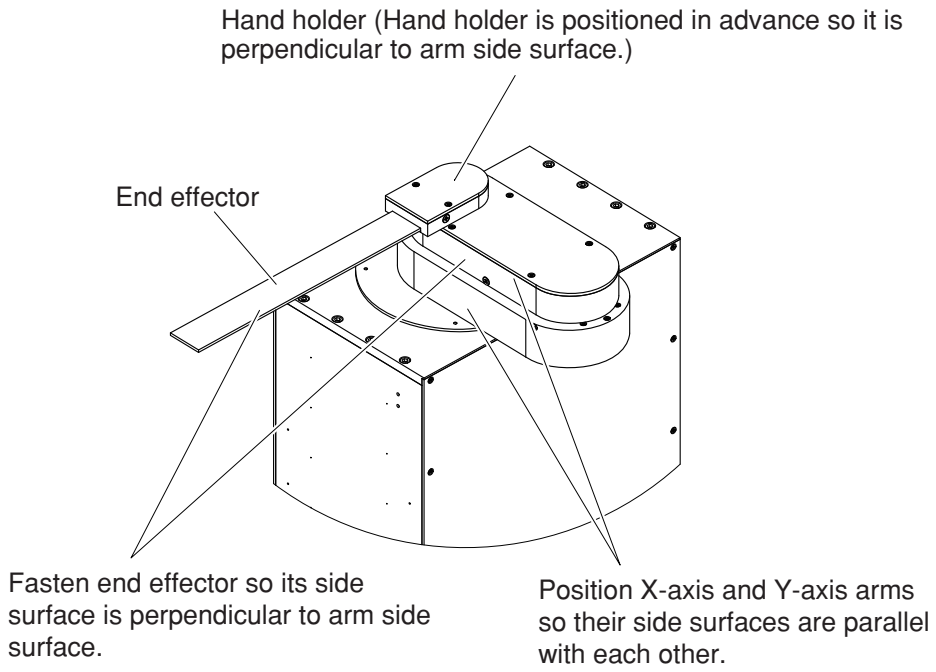
- When the end effector is mounted using the M3 bolts shown in Fig.3-28, be sure that the bolts are adequately tightened. If loose, the end effector could fly off during robot operation, causing a hazardous situation.
- Do not mount by any method other than that described above.

3) If the end effector is attached in a way that it is not aligned with the straight forward direction of the tool attachment shaft, it moves along a path deviating from the straight forward direction. With the X-axis and Y-axis arms positioned as shown in Fig. 3-29, attach the end effector so its side surface is perpendicular to the arm side surface.

■ **Fig. 3-29 Without hand holder**



■ **Fig. 3-29 With hand holder**

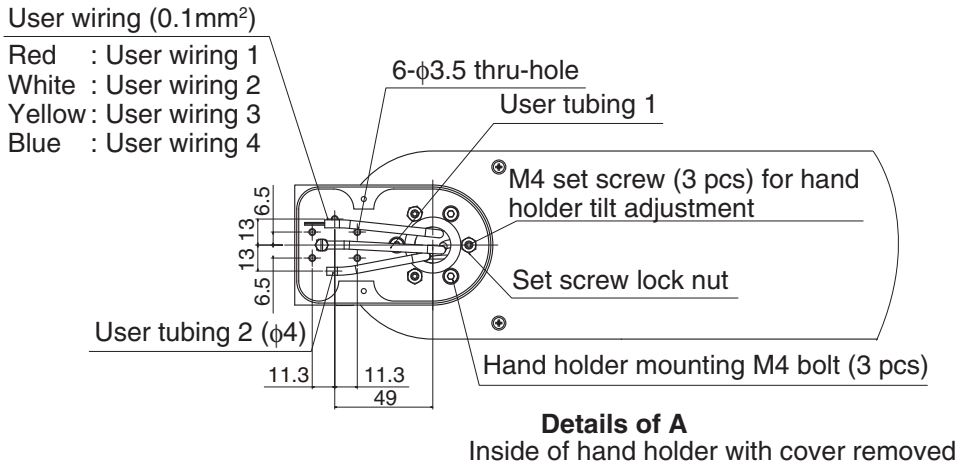


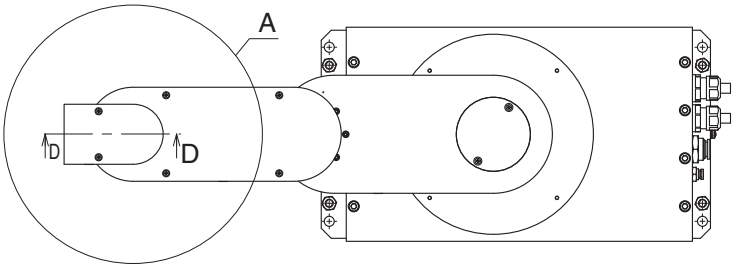
4) Refer to "6. Trial operation" in Chapter 1 to check the end effector motion.

6.6 Adjusting the end effector tilt (when equipped with hand holder)

Fig. 3-30 shows details of the hand holder section. The hand holder is fastened to the tool attachment shaft with three M4 bolts. To adjust the tilt of the hand attached to the hand holder, loosen those M4 bolts and then adjust the tightening of the M4 bolts and three M4 set screws. Do not tighten the set screws more than 1/2 turn after they reach the bottom of the screw holes. Doing so may cause the hand holder to come off the tool attachment shaft.
After the adjustment is finished, tighten the M4 bolts to a torque of 4.5Nm (46Kgfcm) and lock the set screws with the nuts. Making this adjustment affects the hand holder's horizontal alignment that was made at the factory prior to shipment, so do not attempt this adjustment unless necessary.

■ **Fig. 3-30 External view**





6.7 Gripping force of end effector

The gripping force of the end effector must have a sufficient extra margin of strength versus the workpiece mass and reaction force applied to the workpiece during robot operation.
The reaction force applied to the workpiece during operation can be calculated from the maximum acceleration applied to the workpiece.

$$\text{(Reaction force (Kgf))} = \text{(Workpiece mass (Kg))} \times \frac{\text{Maximum acceleration}}{9.8}$$

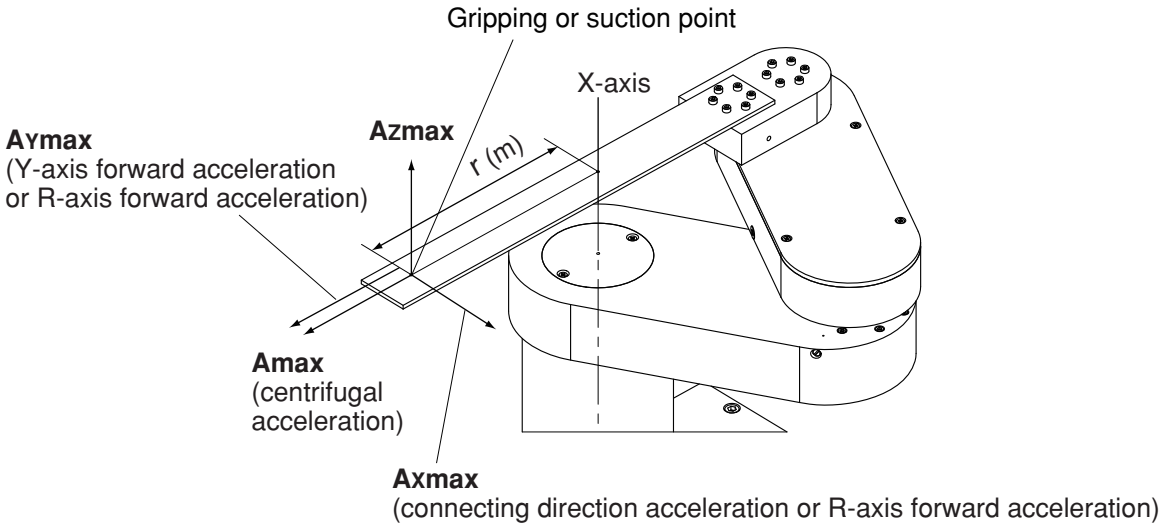
$$\text{(Reaction force (N))} = \text{(Workpiece mass (Kg))} \times \text{Maximum acceleration}$$

The maximum acceleration applied to a workpiece during operation is shown in the table below.

■ **Table 3-3 Maximum acceleration during robot operation**

Amax (m/sec^2)	Axmax (m/sec^2)	Aymax (m/sec^2)	Azmax (m/sec^2)
110r	26.0	26.0	9.6

■ **Fig. 3-31 Maximum acceleration on end effector attachment**



Since simultaneous X, Y and R axis operations are prohibited (see "2. Operating the robot" in Chapter 5), Amax, Axmax and Aymax are not applied at the same time.

⚠WARNING

Allow an adequate gripping force margin to ensure that the workpiece gripped by the end effector is held in a secure manner. An insufficient gripping force could cause the workpiece to fly off, causing a hazardous situation.

7. Working envelope and mechanical stopper positions for maximum working envelope

For details concerning the robot's working envelope and the operation limit mechanical stopper positions, see "2. External View and Dimensions" in Chapter 7.

1) X-axis and Y-axis
Do not attempt operation outside the working envelope.
Due to origin adjustments, the origin positions may differ slightly from those shown in the external view. The mechanical stopper positions may vary somewhat depending on the parts machining accuracy, etc.

2) Tool attachment shaft
The tool attachment shaft movement is indirectly restricted by the Y-axis mechanical stoppers.

3) Z-axis
The Z-axis has mechanical stoppers at the upper and lower ends.
The manipulator lowers approximately 3mm from near the origin position during return to origin by stroke end detection.

4) R-axis
The R-axis has a mechanical stopper at its stroke end.
The manipulator moves approximately 5mm to the mechanical stopper from near the origin position during return to origin by stroke end detection.

5) Others
Depending on the parts machining accuracy and assembly condition, the X and Y axis arms and tool attachment shaft may not be completely aligned in a straight line even when the arms are fully extended.

6) A urethane damper is installed to absorb the shock when an impact occurs with the mechanical stopper, so a certain amount of overrun occurs when the robot strikes the mechanical stopper. Use caution and take overrun into account since the end effector may interfere with the robot body and peripheral equipment or the robot body may interfere with the peripheral equipment.
Maximum overrun amounts are listed below (normal operation at maximum speed).
When the robot strikes the X-axis or Y-axis mechanical stopper or another object, or when the end effector collides with an object, the X-axis or Y-axis speed reduction gears might be locked while being meshed if the collision impact is large. Belt slippage could also occur inside the robot arms. If this occurs, please contact a YAMAHA sales office or dealer.

■ **Table 3-4**

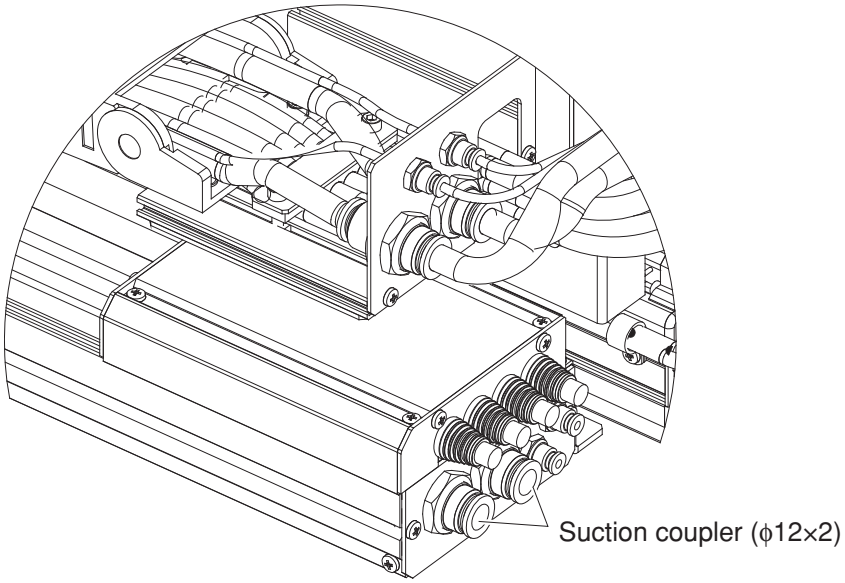
X-axis	Y-axis		Z-axis		R-axis	
	Forward end	Backward end	Upper end	Lower end	Forward end	Backward end
2.5°	2mm	2mm	2mm	2mm	2mm	2mm

Note: Here, ° (deg.) is the overrun angle at the X-axis joint.

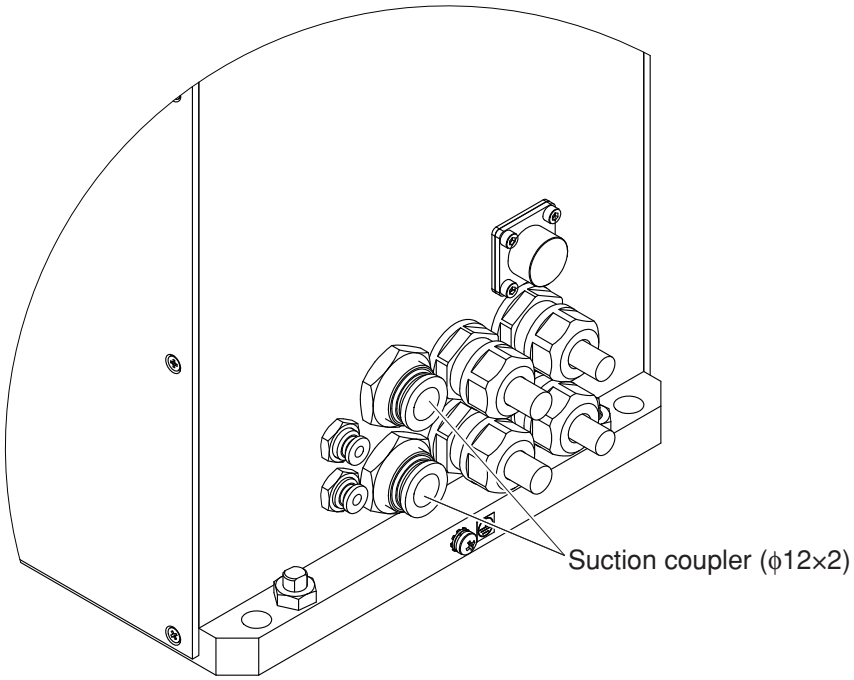
8. Base suction tube

Couplers for suction in the robot base and arms are located on the rear of the robot base. A suction rate of 60 Nl/min is required. Refer to "1. Basic specifications" in Chapter 7 for information about the cleanliness degree during suction.

■ **Fig. 3-32 4-axis model**

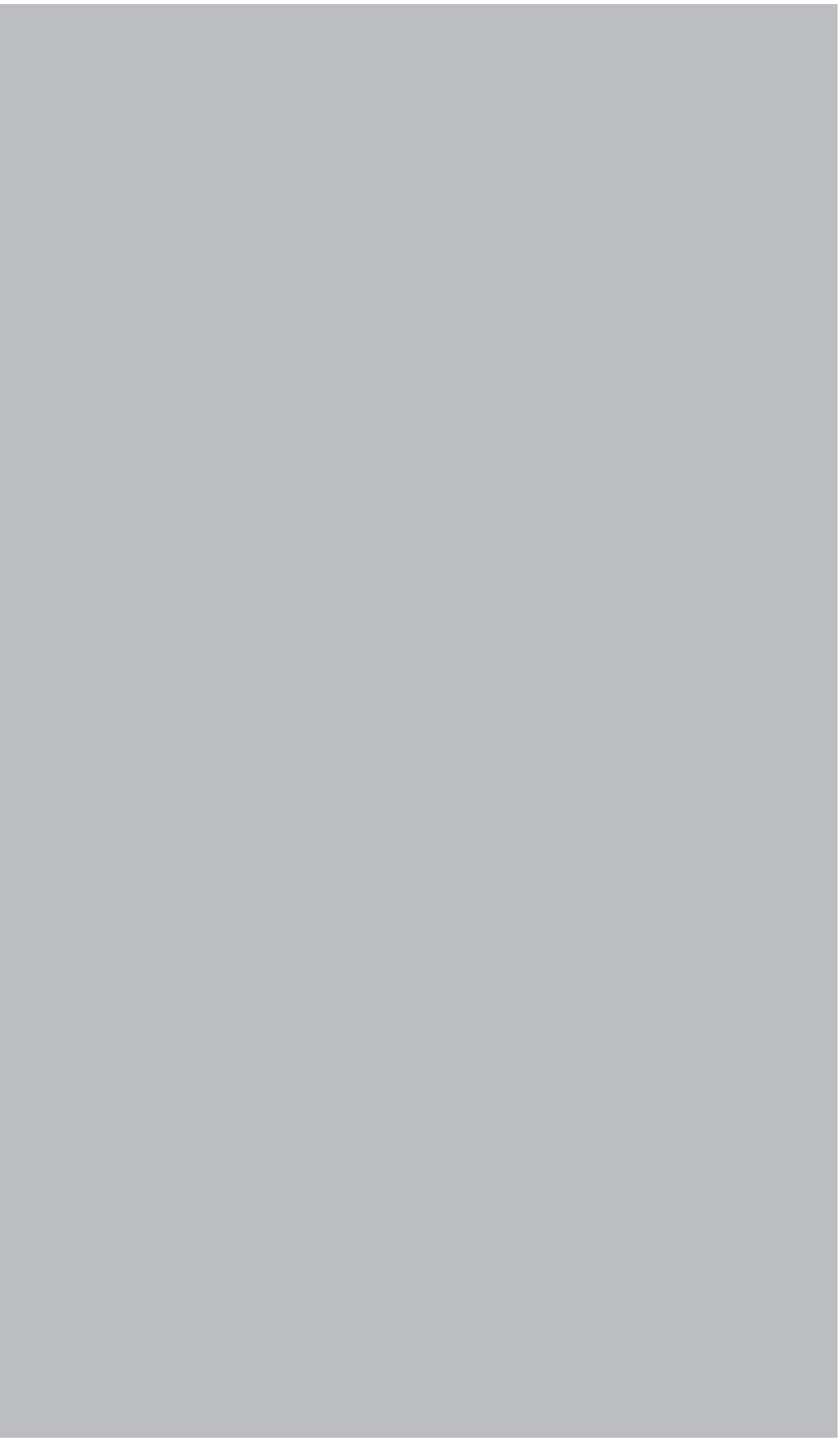


■**Fig. 3-32 3-axis model**



Chapter 4 Adjustment

Contents



1. Overview

YAMAHA robots have been completely adjusted at the factory or by the sales representative before shipment, including the origin position adjustment. If the operating conditions are changed and the robot must be adjusted, then follow the procedures described in this chapter.

2. Safety precautions

(1) Read and understand the contents of this chapter completely before attempting to adjust the robot.

(2) Place a conspicuous sign indicating the robot is being adjusted, to prevent others from touching the controller switch, programming unit or operation panel.

(3) If a safety enclosure has not yet been provided right after installation of the robot, rope off or chain off the movement area around the manipulator in place of a safety enclosure, and observe the following points.

① Use stable posts which will not fall over easily.

② The rope or chain should be easily visible by everyone around the robot.

③ Place a conspicuous sign prohibiting the operator or other personnel from entering the movement area of the manipulator.

(4) To check operation after adjustment, see "6. Trial operation" in Chapter 1.

3. Adjusting the origin

The disk handling robot uses absolute position sensors. The origin position (zero-pulse position) is set by performing an absolute reset (return to origin).
Once an absolute reset has been performed, it need not be performed again at the next power ON. An absolute reset is required, however, under the conditions shown below. Note that the robot is in condition "c" when shipped from the factory, and an absolute reset is therefore required after installation. For details regarding absolute resets, refer to "11.8 Absolute reset" in Chapter 4 of the "YAMAHA Robot Controller RCX142 Series User's Manual".

a. After an absolute-related error occurs at an axis.
b. After a low-voltage condition is detected in the absolute battery installed outside the controller.
c. After the cable that connects the controller to the robot is disconnected. (Shipping status).
d. After robot generation is changed.
e. After parameters are initialized.
f. After "Origin shift", "Origin method", "Origin direction" or " "Motor Direction" of the axis parameter data is changed.
g. After motor replacement (after disconnecting the motor cable).
h. After writing all data files (data with "ALL" extension name) or parameter files (data with "PRM" extension name) to the controller via the RS-232C interface.

This chapter explains the absolute reset procedures.

⚠CAUTION

- **If any of the above cases (a to h) occur after installing the robot, absolute reset must be performed again. The robot must be moved to its origin position in order to perform an absolute reset. Install the robot in a location where there is no interference with peripheral equipment, etc., after the origin position (fixed) setup is completed.**
- **After performing an absolute reset, move the robot to a known point to check whether the origin position is correctly set. When doing this check, move the robot at the slowest possible speed.**

The X-axis and Y-axis use a "search method (sensor method)" to detect the origin positions, while the Z-axis uses a "stroke end method" that allows the mechanical unit to strike the lower-end mechanical stopper to detect the origin position. The R-axis (travel axis) also uses the same "stroke end" method to detect the origin position. For the R-axis details, refer to the F17 single-axis robot described in the "FLIP-X Series User's Manual".

3.1 Absolute reset method

3.1.1 Sensor method (X-axis and Y-axis)

In the sensor method, the target axis is automatically operated for absolute reset, and the absolute reset is performed at the position where the proximity sensor provided on the target axis detects the detection point (dog). The absolute reset in the sensor method can be executed with the teaching pendant (MPB), RS-232C communication, and dedicated input.

⚠WARNING

Serious injury might occur from physical contact with the robot during operation. Never enter within the robot movement range during absolute reset.

⚠CAUTION

The origin cannot be detected in any axis which is not positioned on the plus side from the origin (See Fig. 4-3 (a) to (d).) before starting the return-to-origin operation. (Factory setting at shipment.)
In this case, press the STOP key to interrupt the return-to-origin operation, move the target axis to the plus side of the origin, and reperform the return-to-origin operation. If the return-to-origin operation is not interrupted, the robot will continue the operation and may collide with the mechanical stopper or a peripheral device.

3.1.2 Stroke end method (Z-axis and R-axis)

In the stroke end method, absolute reset is performed at a position slightly backed off from the stroke end, after the mechanical unit contacts the mechanical stopper and stroke end is detected.

⚠WARNING

Serious injury might occur from physical contact with the robot during operation. Never enter within the robot movement range during absolute reset.

3.2 Machine reference

The disk handling robot uses a resolver as the position sensor. The resolver provides 4 absolute reset positions per motor turn. When performing an absolute reset by the sensor method, the origin position is set at one of those absolute reset positions located just after the point where the origin sensor reacts to the dog (origin signal detected). The machine reference means the position relationship of the position where the robot detects the origin signal to the position where the absolute reset can be performed soon after detection. (See Fig. 4-1.) The machine reference is expressed in the ratio of interval A to interval B shown in Fig. 4-1. Interval A is the minimum distance between the positions where absolute reset can be performed and interval B is the distance between the position where the origin signal is detected and the position where absolute reset can be performed soon after the origin signal detection. The machine reference value is displayed on the optional MPB screen (unit: %).

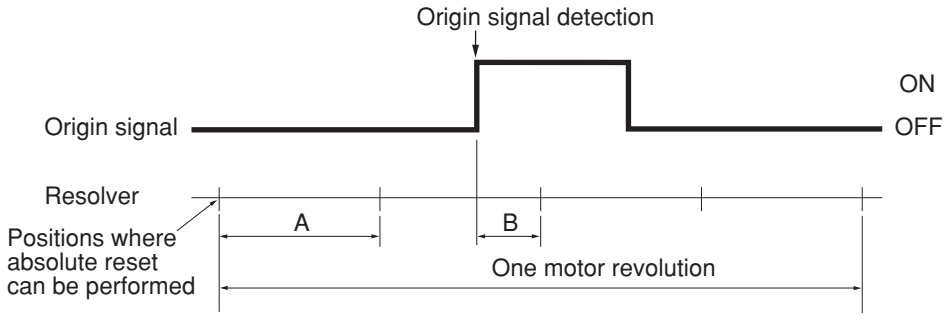
Machine reference value = B/A × 100 (%)

⚠CAUTION

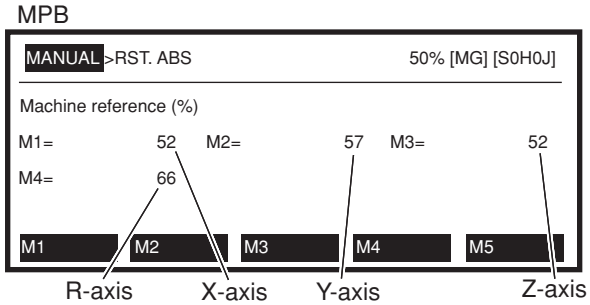
The machine reference must be adjusted within a specified range to keep the repeatability precision of the absolute reset position. (The machine reference is factory-adjusted, and does not normally require further adjustment.) If the origin position is changed, the machine reference must be readjusted.
For information on how to adjust the machine reference, see "3.4 Adjusting the machine reference" in Chapter 4. When the temperature of the robot joint sections is high immediately after the robot has been operated, the machine reference value might be outside the specified range (40 to 60%). When checking or adjusting the machine reference value, always make sure that the temperature of the robot joint sections has returned to room temperature.

Recommended machine reference value: 40 to 60%

■ **Fig. 4-1 Machine reference**



■ **Fig. 4-2 Machine reference value display on MPB screen**



3.3 Absolute reset procedures

3.3.1 Sensor method (X-axis and Y-axis)

⚠WARNING

Serious injury might occur from physical contact with the robot during operation. Never enter within the robot movement range during absolute reset.

The operation procedure using the MPB is described below. (Press the ESC key on the MPB if you want to return to the preceding step.) Refer to the "YAMAHA Robot Controller User's Manual" for how to operate the robot controller.

1) Check that no one is inside the safeguard enclosure and then turn on the controller.

2) Place a sign indicating the robot is being adjusted, to keep others from touching the controller switch or operation panel.

3) Set the controller to MANUAL mode, if not in MANUAL mode.

4) Press the F13 (LOWER + F3) key to select "RST. ABS".

5) Select the axis for absolute reset. (X-axis: M1, Y-axis: M2)
To perform absolute reset on all axes, select "ALL" with the F11 (LOWER+F1) key.

⚠CAUTION

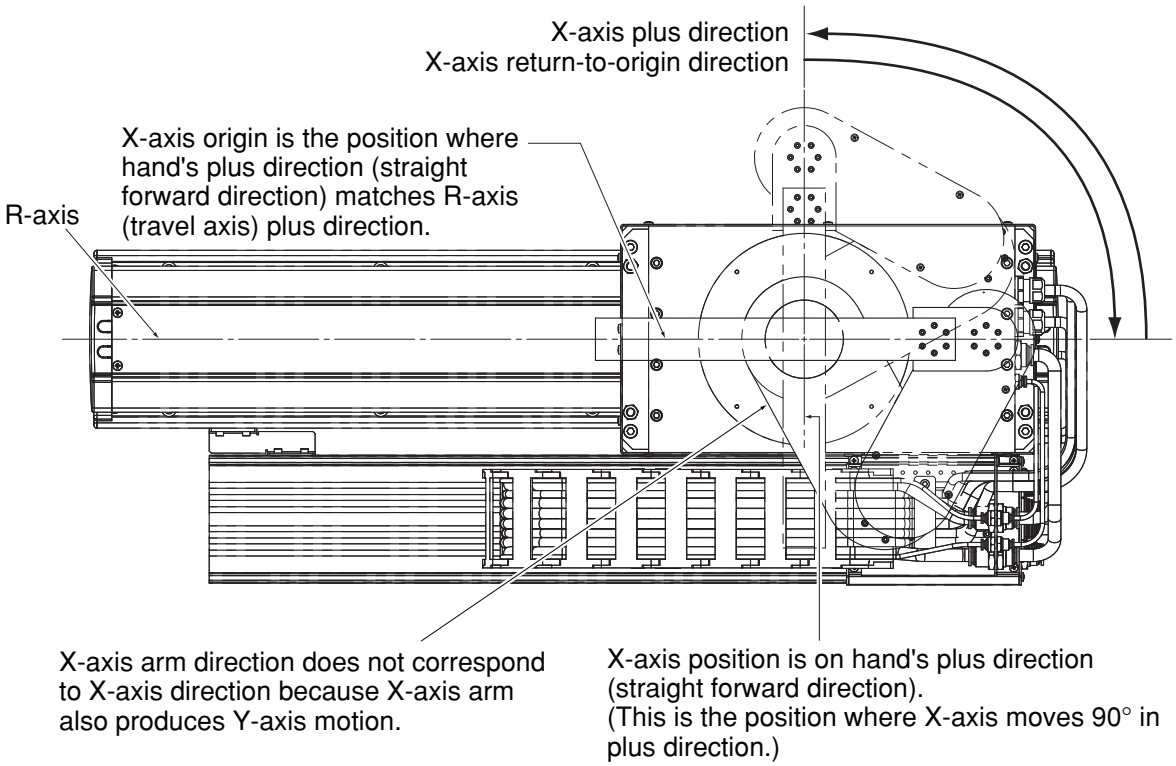
When performing absolute reset on all axes, the Z-axis of the stroke end method lowers following the Y-axis absolute reset, and then the R-axis of the stroke end method detects the origin following the X-axis absolute reset (default setting). Be careful that your fingers do not get pinched or crushed by axis movement.

6) Check that the X and Y axes for absolute reset are positioned at the plus side of the origin. (See Fig. 4-3 (a) to (d).)
If it is not at the plus side, then press the jog key to move the target axis to the plus side.

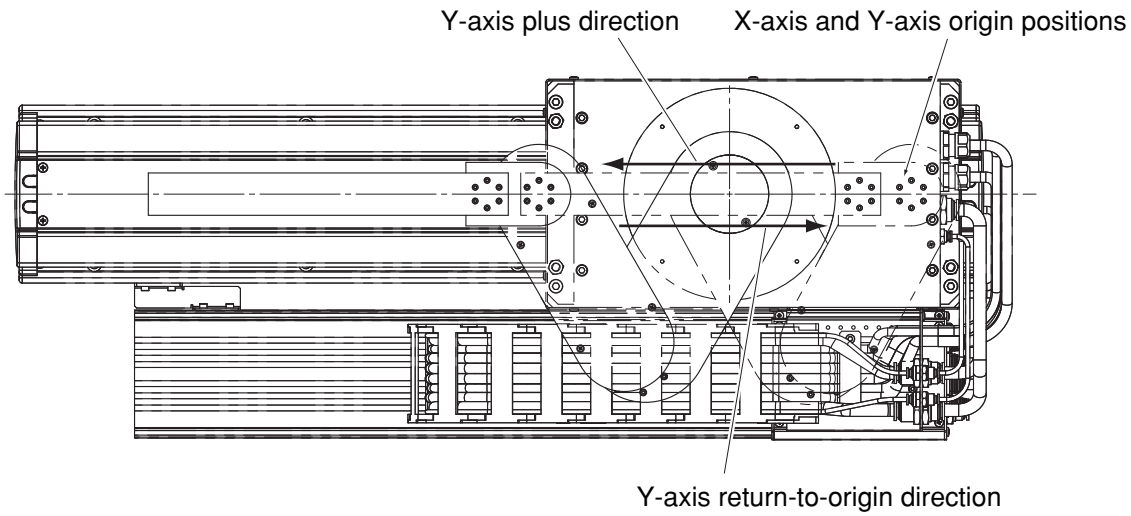
7) Since the message "Reset ABS encoder OK?" appears, check that there are not any obstacles in the robot movement range, and press the F4 (YES) key.

8) After the absolute reset is completed, check that the machine reference value displayed on the MPB is between 40 and 60 (recommended range).
If the machine reference value is outside the recommended range, then the next absolute reset may not be properly performed. In this case, adjust the machine reference by referring to "3.5 Adjusting the machine reference".

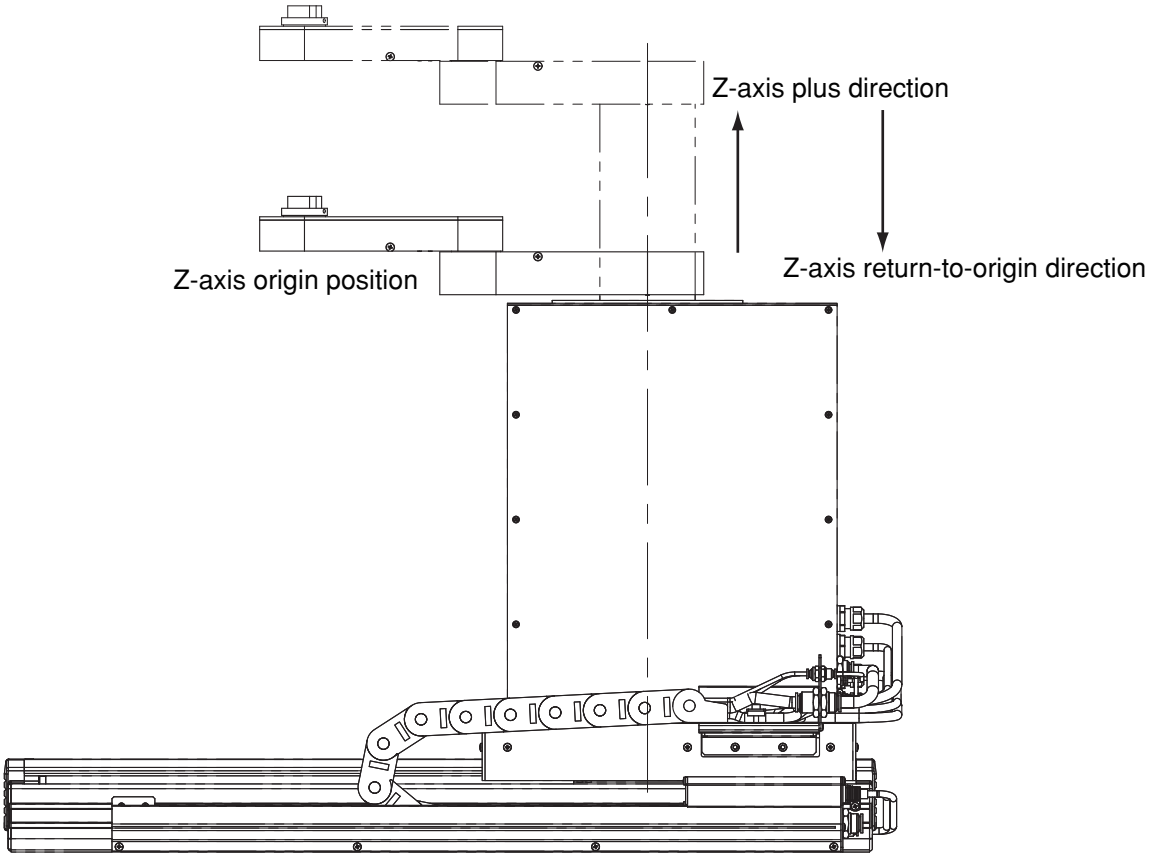
■ Fig. 4-3 (a)



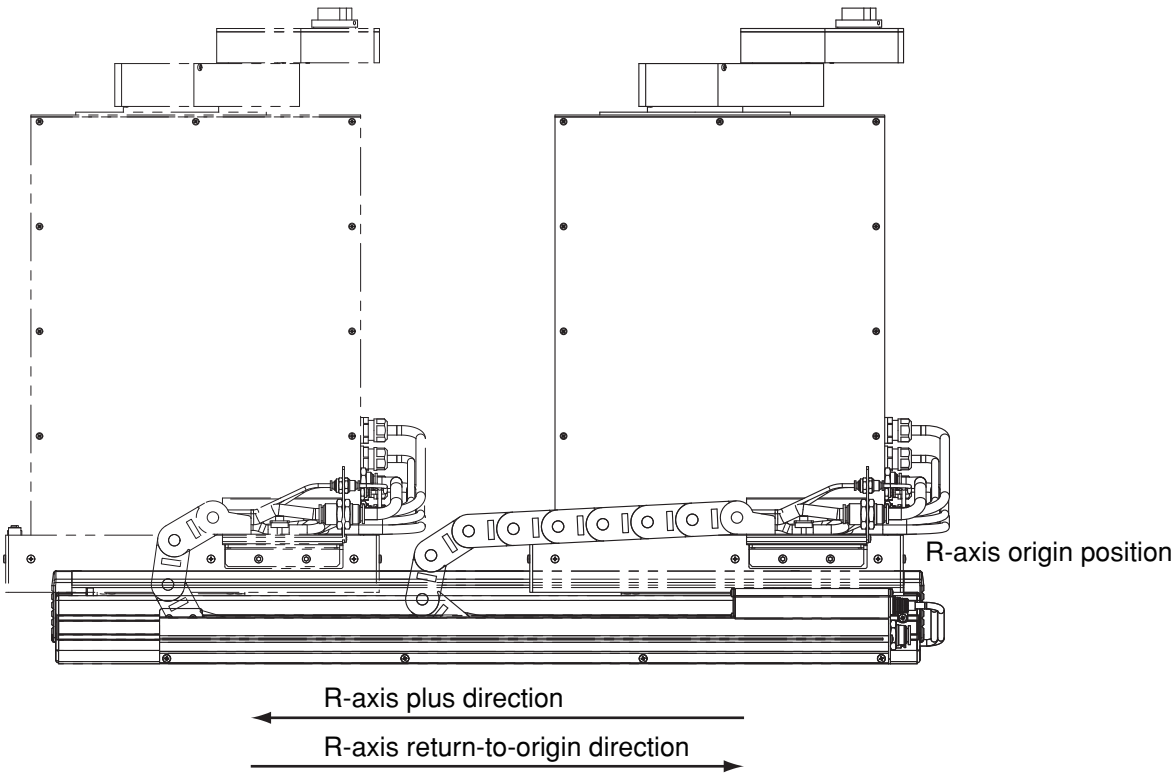
■ Fig. 4-3 (b)



■ Fig. 4-3 (c)



■ Fig. 4-3 (d)



3.3.2 Strike end method (Z-axis and R-axis)

⚠WARNING

Serious injury might occur from physical contact with the robot during operation. Never enter within the robot movement range during absolute reset.

The operation procedure using the MPB is described below. (Press the ESC key on the MPB if you want to return to the preceding step.) Refer to the "YAMAHA Robot Controller User's Manual" for how to the robot controller. For the R-axis (travel axis) details, refer to the F17 single-axis robot described in the "FLIP-X Series User's Manual".

1) Check that no one is inside the safeguard enclosure and then turn on the controller.

2) Place a sign indicating the robot is being adjusted, to keep others from touching the controller switch or operation panel.

3) Set the controller to MANUAL mode, if not in MANUAL mode.

4) Press the F13 (LOWER + F3) key to select "RST. ABS".

5) Select the axis for absolute reset. (Z-axis: M3, R-axis: M4)

6) Since the message "Reset ABS encoder OK?" appears, check that there are not any obstacles in the robot movement range, and press the F4 (YES) key.

7) After the absolute reset is completed, check that the **machine reference value for stroke-end method adjustment** displayed on the MPB is within the allowable absolute reset range (40 to 60).

⚠CAUTION

Use the following procedure to display the machine reference value for stroke-end method adjustment. When adjusting the machine reference, always use this procedure to check the machine reference value for adjustment.

① Press the MODE key.
② Press the F3 key to enter MANUAL mode.
③ Press the F13 (LOWER + F3) key to select "RST.ABS".
④ After the Z-axis absolute reset is completed, press the F10 (UPPER + F5). The **machine reference value for adjustment** is then displayed in percent (%).

If the machine reference value is outside the allowable absolute reset range, then the next absolute reset may not be properly performed. In this case, adjust the machine reference by referring to "3.5 Adjusting the machine reference".

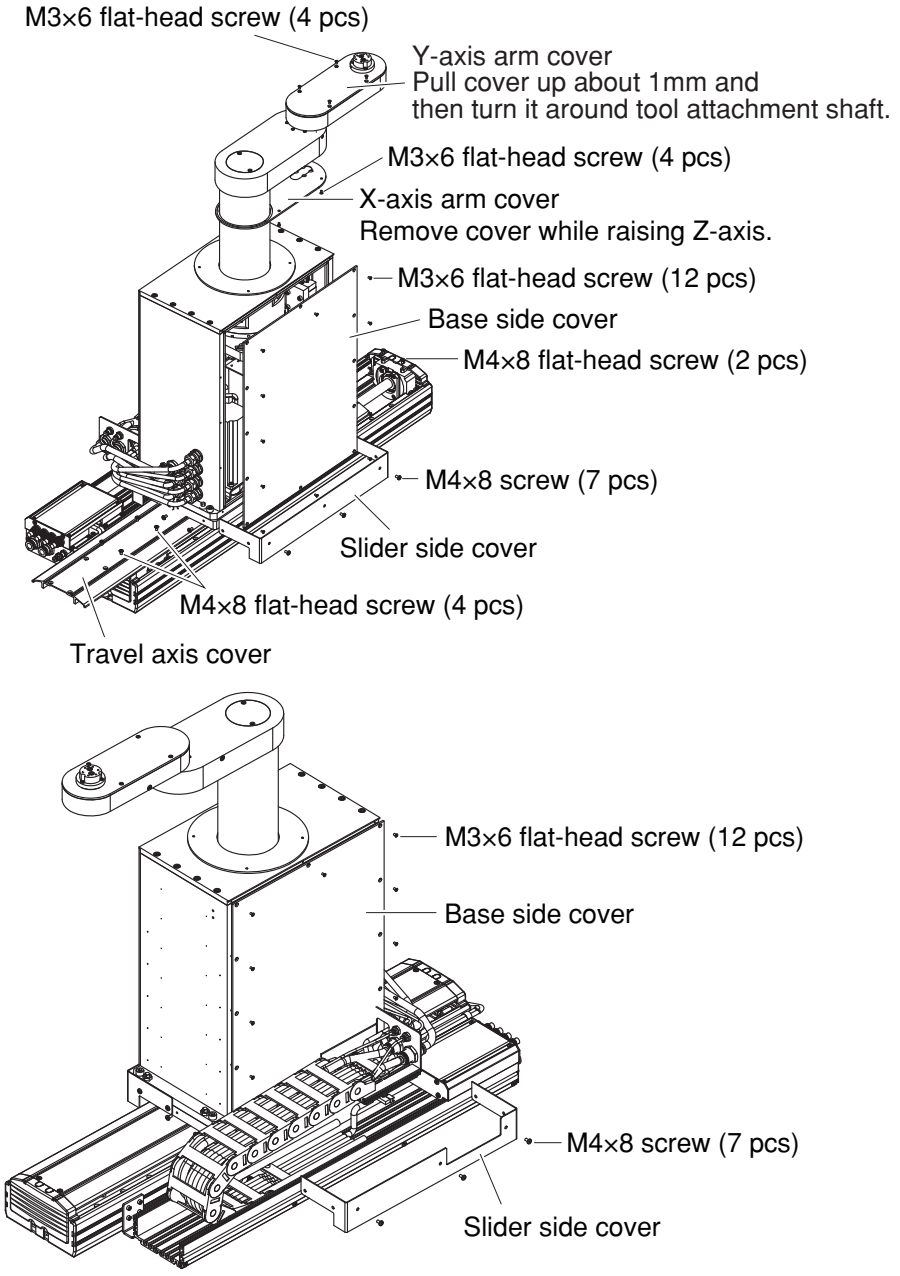
3.4 Removing the robot covers

⚠WARNING

Before removing the robot covers, be sure to turn off the controller power.

Refer to the figures below when removing the covers to adjust soft limits or belt tension. For the R-axis (travel axis) details, refer to the F17 single-axis robot described in the "FLIP-X Series User's Manual".

■ **Fig. 4-4 Removing the robot covers**



3.5 Adjusting the machine reference

⚠CAUTION

If any machine reference is adjusted, the origin position may change. Before the adjustment, mark off the reference mark at the current origin position on the robot body. After the machine reference is adjusted, be sure to check that the origin position has not deviated. The point data must be set again if the origin position is changed after machine reference adjustment.

3.5.1 Adjusting the X-axis machine reference

The adjustment method for the X-axis machine reference is as follows.

1) Prepare the necessary tools.
   - Hex wrench set
   - Phillips screwdrivers

2) Check that no one is inside the safety enclosure and then turn on the controller.

3) Perform an absolute reset from outside the safety enclosure. See "3.3.1 Sensor method (X-axis and Y-axis)" about the absolute reset method.

4) The following adjustment is required if a machine reference outside the 40 to 60 range (recommended range) is displayed on the MPB after absolute reset. For details on machine reference, see "3.2 Machine reference".

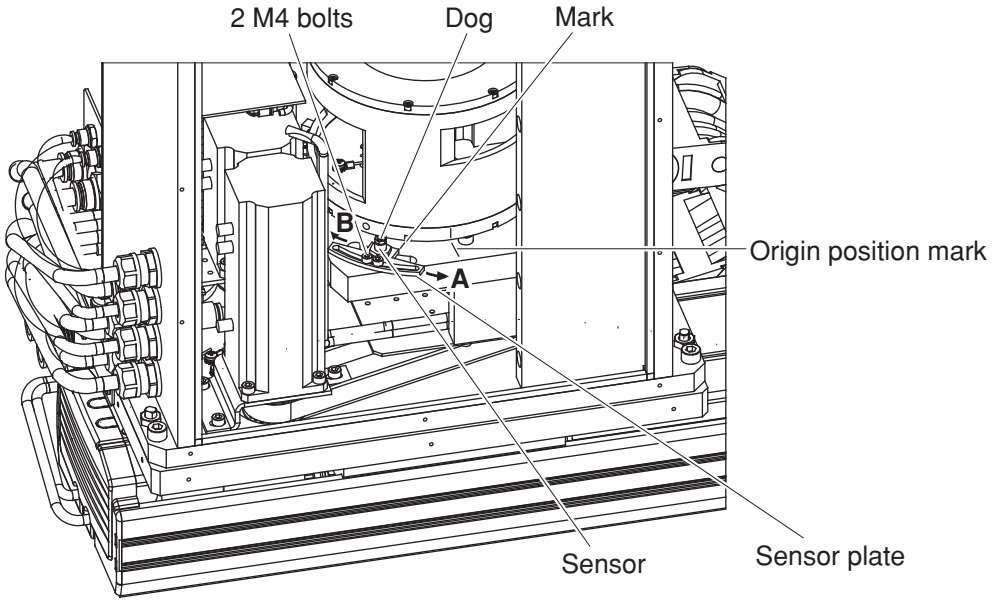
5) Place a sign indicating that the robot is being adjusted in order to keep others from operating the controller or operation panel.

6) Turn off the controller and enter the safety enclosure.

7) Remove the base cover.
   See "3.4 Removing the robot covers" for this procedure.
   At this time, avoid touching the X-axis arm to prevent the origin position from deviating.

8) Mark off the reference mark at the current origin position on the X-axis joint area of the robot. (See Fig. 4-4.) At this time, avoid touching the X-axis arm to prevent the origin position from deviating.

■ **Fig. 4-4**



9) Make a reference mark at the sensor plate position.

10) Loosen the M4 bolts and move the sensor plate as described below, then tighten the bolts.
When "machine reference" < 40%: Move sensor plate in direction "A".
When "machine reference" > 60%: Move sensor plate in direction "B".
As an approximate guide, a 2.4mm movement equals 100%.

11) Go out of the safety enclosure, and check that no one is inside the safety enclosure. Then turn on the controller.

12) Perform an absolute reset from outside the safety enclosure.

13) After the absolute reset is completed, read the machine reference value displayed on the MPB.

14) The machine reference adjustment is complete when the machine reference is within the 40 to 60 range (recommended range). Turn off the controller and then reattach the base cover.
If the machine reference is still outside the recommended range, readjust it by repeating the procedure from step 9).

3.5.2 Adjusting the Y-axis machine reference

The adjustment method for the Y-axis machine reference is as follows.

1) Prepare the necessary tools.
   - Hex wrench set
   - Phillips screwdrivers

2) Check that no one is inside the safety enclosure and then turn on the controller.

3) Perform an absolute reset from outside the safety enclosure. See "3.3.1 Sensor method (X-axis and Y-axis)" about the absolute reset method.

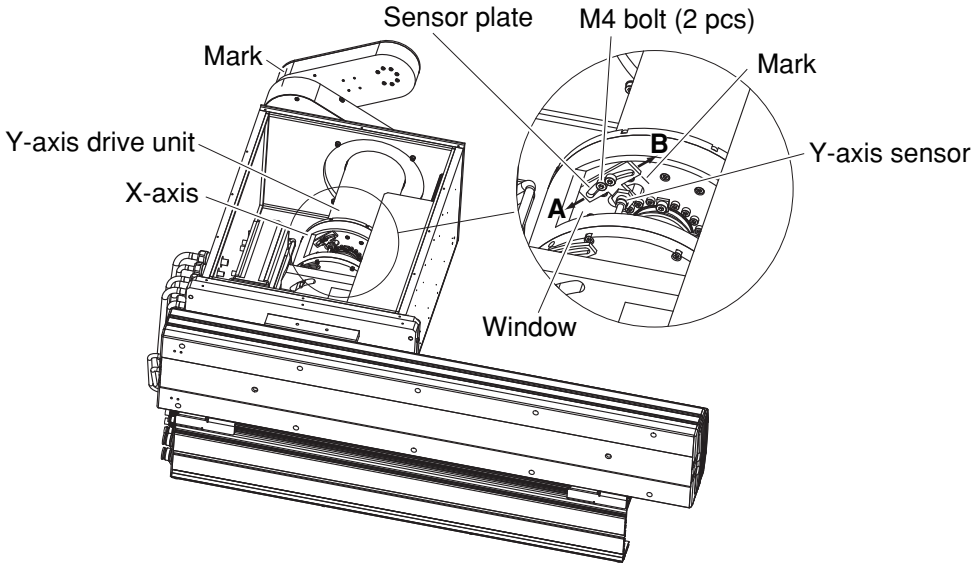
4) The following adjustment is required if a machine reference outside the 40 to 60 range (recommended range) is displayed on the MPB after absolute reset. For machine reference details, see "3.2 Machine reference".

5) Place a sign indicating that the robot is being adjusted in order to keep others from operating the controller or operation panel.

6) Turn off the controller and enter the safety enclosure.

7) Mark off the reference mark at the current origin position on the Y-axis joint area of the robot. (See Fig. 4-5.) At this time, avoid touching the Y-axis arm to prevent the origin position from deviating.

■ **Fig. 4-5**



8) Remove the base cover.
   See "3.4 Removing the robot covers" for this procedure.

9) Make a reference mark at the sensor plate position.

10) Loosen the M4 bolts and move the sensor plate as described below, then tighten the bolts.
When "machine reference" < 40%: Move sensor plate in direction "A".
When "machine reference" > 60%: Move sensor plate in direction "B".
As an approximate guide, a 1.7mm movement equals 100%.

11) Go out of the safety enclosure, and check that no one is inside the safety enclosure. Then turn on the controller.

12) Perform an absolute reset from outside the safety enclosure.

13) After the absolute reset is completed, read the machine reference value displayed on the MPB.

14) The machine reference adjustment is complete when the machine reference is within the 40 to 60 range (recommended range). Turn off the controller and then reattach the base cover.
If the machine reference is still outside the recommended range, readjust it by repeating the procedure from step 9).

3.5.3 Adjusting the Z-axis machine reference

The Z-axis origin position is fixed at the lower end of the Z-axis stroke and cannot be changed. The Z-axis machine reference value is preadjusted before shipment and does not need to be adjusted in normal operation.
However, if for some reason the machine reference value goes outside the allowable absolute reset range (40 to 60), adjust with the procedure below.
To check the machine reference value, refer to step 13).

⚠WARNING

Fingers may get caught between the drive pulley and belt, causing injury. Before touching those parts, always turn off the controller and perform the work carefully.

⚠CAUTION

Adjusting the machine reference will usually change the origin position. The point data must be set again after the machine reference adjustment.

1) Check that no one is inside the safety enclosure and then turn on the controller.

2) Place a sign indicating that the robot is being adjusted in order to keep others from operating the controller or operation panel.

3) Before beginning the following steps, always perform a Z-axis absolute reset. The Z-axis may otherwise slide down.
Perform an absolute reset on the Z-axis.
See "3.3.2 Stroke end method (Z-axis and R-axis)" about the Z-axis absolute reset method.

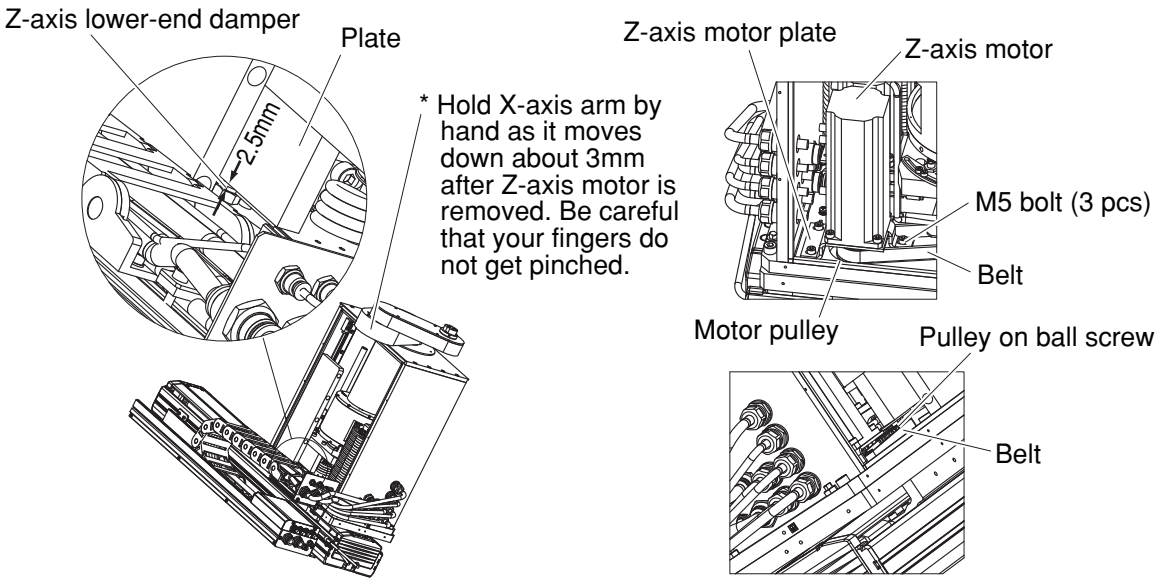
4) Turn off the controller.

5) Enter the safety enclosure.

6) Remove the base cover.
See "3.4 Removing the robot covers" for this procedure.

7) Hold the X-axis arm by hand as it moves down about 3mm after the Z-axis motor is removed.
Be careful that your fingers do not get pinched. (See Fig. 4-6.)

■ **Fig. 4-6**



8) Remove the M5 bolts securing the Z-axis motor plate and then remove the Z-axis motor.

9) While holding the arms, install the Z-axis motor plate so the distance from the Z-axis lower-end damper to the bottom of the plate is 2.5mm. At this point, make sure that the belt is properly engaged with the motor pulley and ball screw pulley.

10) After reassembling the Z-axis motor, adjust the timing belt tension.
To adjust the timing belt tension, see "6.1 Adjusting the X-axis, Y-axis, and Z-axis motor belt tension".

11) Go out of the safety enclosure.

12) Check that no one is inside the safety enclosure. Then turn on the controller.

13) Perform an absolute reset on the Z-axis.
After the absolute reset is completed, check that the **machine reference value for stroke-end method adjustment** is within the allowable absolute reset range (40 to 60).

⚠CAUTION

Use the following procedure to display the machine reference value for stroke-end method adjustment. When adjusting the machine reference, always use this procedure to check the machine reference value for adjustment.

① Press the MODE key.
② Press the F3 key to enter MANUAL mode.
③ Press the F13 (LOWER + F3) key to select "RST.ABS".
④ After the Z-axis absolute reset is completed, press the F10 (UPPER + F5). The **machine reference value for adjustment** is then displayed in percent (%).

If the **machine reference value for adjustment** is still outside the allowable absolute reset range (40 to 60), repeat from step 7) onward so it is within the allowable range.

14) Reattach the cover.

4. Setting the soft limits

In the disk handling robot, the working envelope during manual and automatic operation can be limited by setting the plus soft limit [pulses] and minus soft limit [pulses] on each axis. The origin point (0 [pulses]) is used as the reference to set the soft limits. The working envelope can be limited by specifying the number of pulses from the 0 pulse position. Refer to the "YAMAHA Robot Controller RCX142 Series User's Manual" for further details. Also refer to "2. External view and dimensions" in Chapter 7 for the robot's working envelope. When performing actual checks of the soft limit settings, operate the robot manually from outside the safety enclosure.

Soft limit settings on each axis

The factory-set soft limits are for the maximum working envelope. Follow the procedure below to set soft limits that prevent interference with peripheral equipment (but are within the maximum working envelope).
When the servo power is off, it is difficult to move the X and Y axes because of their structures and the Z-axis because of its weight. Manually move each axis with the following procedure. See "3. Creating point data, direct teaching, and external forces to arms" in Chapter 5 for more details.

1) Place a sign indicating that the robot is being adjusted in order to keep others from operating the controller or operation panel.

2) Check that no one is inside the safety enclosure, and then turn on the controller.

3) Enter the safety enclosure while holding the MPB. Keep clear of the robot's working envelope.

4) Manually move each axis to positions just prior to interference with peripheral equipment, then make a note of the plus-direction and minus-direction pulses for each axis displayed on the MPB screen.

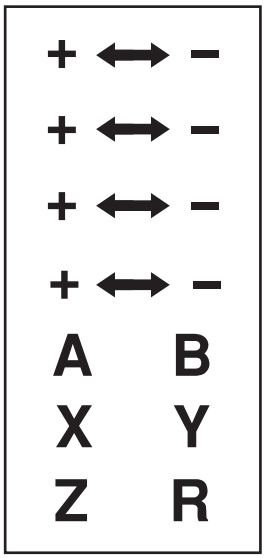
5) Set the soft limits using the pulses for each axis that were noted in step 3) above. This software limit setting must be made from outside the safety enclosure. Refer to the "YAMAHA Robot Controller RCX142 Series User's Manual" for further details on soft limit settings.

6) Unlike the SCARA robots, the soft limits cannot be set on an orthogonal coordinate system. Point displays based on an orthogonal coordinate have no meaning, and such a coordinate system should not be used.

5. Affixing stickers for movement directions and axis names

The robot comes packed with stickers (self-adhesive labels) showing movement directions and axis names as shown in Fig. 4-7. Using the following procedure, attach these stickers in conspicuous points on the robot after installing peripheral equipment.

■ **Fig. 4-7**



Movement direction and axis name stickers

1) Turn off the controller.

2) Place a sign indicating the robot is being adjusted, to keep others from operating the controller switch.

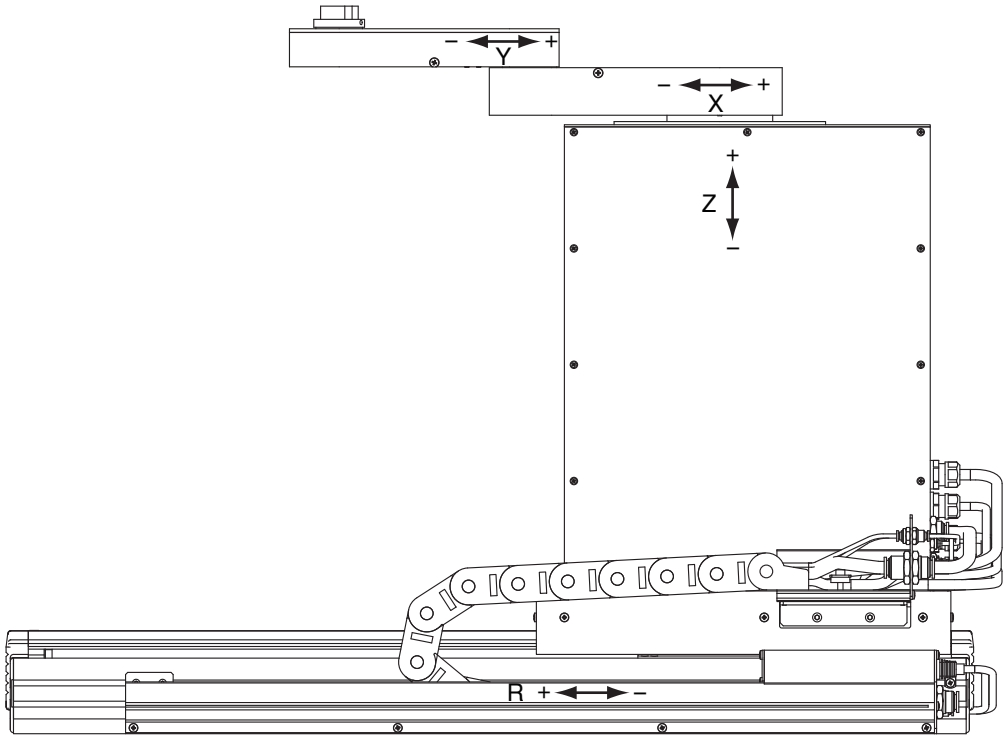
3) Enter the safety enclosure.

4) Affix the axis name stickers and movement direction stickers in prominent positions on each of the robot arms. Use a cloth moistened with alcohol to remove grease from the surface where you will affix the stickers. After the surface is completely dry, affix the stickers securely. (See Fig. 4-8)
The direction in which the Y-axis joint rotates to move the tool attachment shaft straight forward (plus direction) is the plus direction. (Example 1)
Please note that the X-axis also rotates while the tool attachment shaft moves straight forward.
When the end effector is long as shown in example 2, you may affix stickers to it along the straight forward direction of the tool attachment shaft.

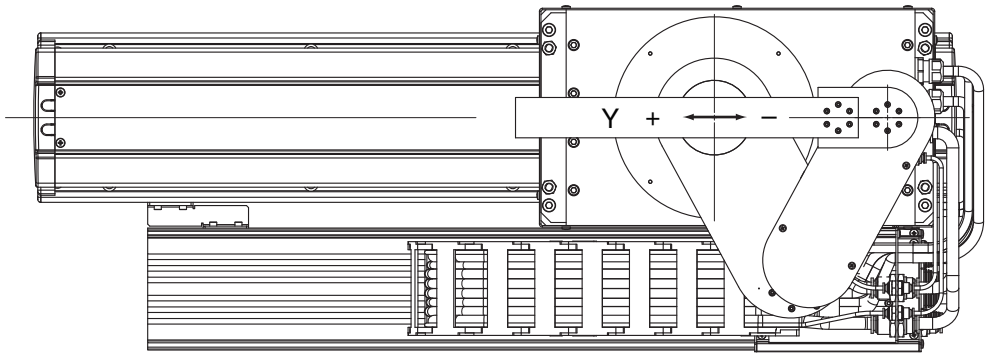
⚠WARNING

Align the direction of movement stickers with the jog direction and affix them correctly. Affix each axis name sticker on the correct axis. Affixing the sticker at a wrong location may cause faulty operation and hazardous situations.

■ Fig. 4-8 Example 1



■ Fig. 4-8 Example 2



6. Adjusting the timing belt tension

If the timing belt becomes slack, use the following procedure to give proper tension to the belt.

⚠WARNING

- **The motor and speed reduction gear casing are extremely hot after automatic operation, so burns may occur if these are touched. Before touching these parts, turn off the controller, wait for a while and check that the temperature has cooled.**
- **Injury can occur if hands or fingers are squeezed between the drive pulley and belt. Always turn off the controller and use caution when handling these parts.**

⚠CAUTION

Since a positional shift occurs after adjusting the belt tension, it is necessary to make absolute reset and point data setting again.

6.1 Adjusting the X-axis, Y-axis, and Z-axis motor belt tension

1) Prepare the necessary tools.
   - Push-pull scale
   - Stay (See Fig. 4-10. This stay should be prepared by the user.)
   - Hex wrench set
   - Phillips screwdrivers
   - Scale

2) When adjusting the X-axis or Y-axis belt tension, position the X-axis at the front base and the Z-axis at a stroke position of 130mm (106496 pulses). When adjusting the Z-axis belt tension, move the Z-axis to its origin position. If adjustment is made with the Z-axis not at the origin position, the Z-axis may slides down causing a hazardous situation.
   Then turn off the controller.

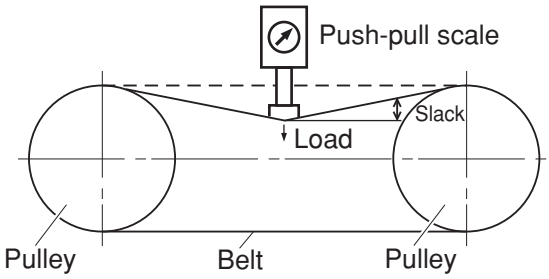
3) Place a sign indicating the robot is being adjusted, to keep others from operating the controller switch.

4) Enter the safety enclosure.

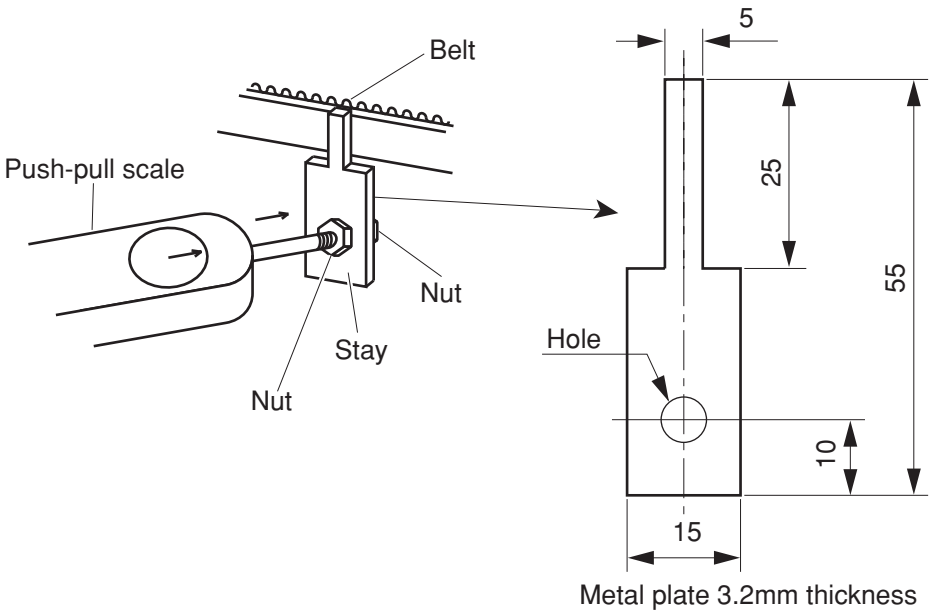
5) Remove the base cover.
   See "3.4 Removing the robot covers" for this procedure.

6) Adjust the belt tension by two people as follows.
   Using the push-pull scale, one person applies a load perpendicular to the middle of the belt. The other person checks the slack of the belt. (See Fig. 4-9, Fig. 4-10, Fig. 4-11, Fig. 4-12 and Fig. 4-13.)
   At the Y-axis belt, the Fig. 4-12 "part 1" must be removed from "part 2" in order to use the push-pull scale to measure the tension.
   An easy way to check the belt tension is to press a finger against the belt through the inspection window. There should be some give in the belt when pressed. If there is no give in the belt, the belt is too tight. Use this as a reference for belt tension.

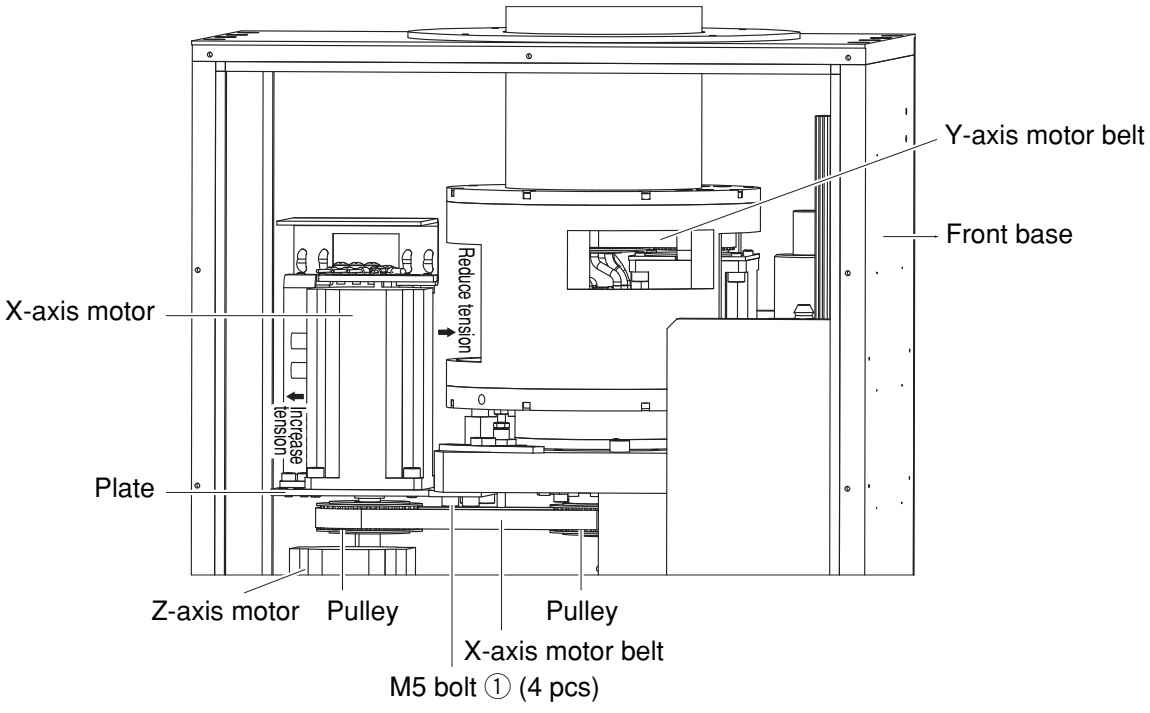
■ Fig. 4-9 Belt tension adjustment



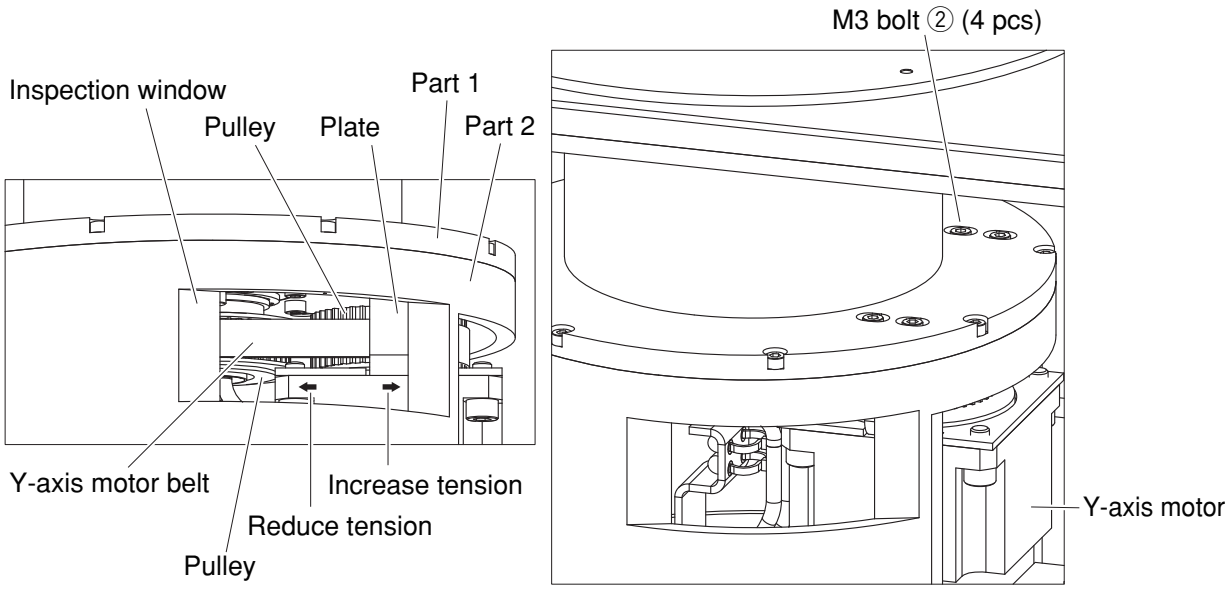
■ Fig. 4-10 Stay (example)



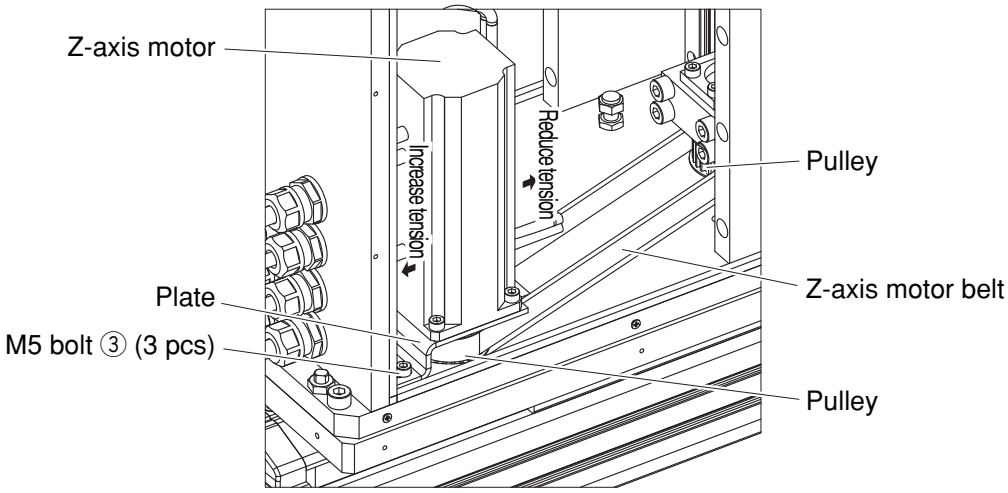
■ Fig. 4-11 X-axis



■ Fig.4-12 Y-axis



■ Fig. 4-13 Z-axis



7) Belt tension adjustment is not required if the load producing the Table 4-1 "Slack" is within the "Load" range in Table 4-1. If outside the load range, adjust using the procedure described below.

■ **Table 4-1**

Location	Load (N)	Load (kgf)	Slack (mm)
X-axis Belt	6.1 to 7.4	0.62 to 0.75	1.92
Y-axis Belt	2.7 to 4.1	0.28 to 0.42	0.74
Z-axis Belt	5.7 to 6.3	0.58 to 0.64	4.4

■ **Table 4-2 Tightening torque**

Axis	Bolt size	Tightening torque (kgf·cm)	Tightening torque (N·m)
X	M5	92	9.0
Y	M3	20	2.0
Z	M5	92	9.0

(1)X-axis belt adjustment

1. Loosen the bolt ① shown in Fig. 4-11. Never remove it.
2. If the load producing the slack specified in Table 4-1 (step 6) above) is smaller than the specified range, move the X-axis motor plate in the direction increasing the tension. If the load is greater than that range, move it in the direction reducing the tension. Then, retighten the bolt.
3. Recheck the belt tension using the same procedure in step 6).
   When the load applied to produce the specified slack is within the specified load range of Table 4-1, the adjustment is okay. If not, repeat the above procedure from steps 1 to 3.

(2)Y-axis belt adjustment

1. Loosen the bolts ② shown in Fig. 4-11 and Fig. 4-12. Never remove them.
2. If the load producing the slack specified in Table 4-1 (step 6) above) is smaller than the specified range, move the Y-axis motor plate in the direction increasing the tension. If the load is greater than that range, move it in the direction reducing the tension. Then, retighten the bolts.
3. Recheck the belt tension using the same procedure in step 6).
   When the load applied to produce the specified slack is within the specified load range of Table 4-1, the adjustment is okay. If not, repeat the above procedure from steps 1 to 3.

(3)Z-axis belt adjustment

1. Loosen the bolts ③ shown in Fig. 4-13. Never remove them.
2. If the load producing the slack specified in Table 4-1 (step 6) above) is smaller than the specified range, move the Z-axis motor plate in the direction increasing the tension. If the load is greater than that range, move it in the direction reducing the tension. Then, retighten the bolts.
3. Recheck the belt tension using the same procedure in step 6).
   When the load applied to produce the specified slack is within the specified load range of Table 4-1, the adjustment is okay. If not, repeat the above procedure from steps 1 to 3.

8) After adjustment is complete, tighten the bolts ①, ② or ③ to the torque specified in Table 4-2.

9) Attach the base cover.

10) Go outside the safety enclosure.

11) Check that no one is inside the safety enclosure, and then turn on the controller.

6.2 Adjusting the timing belt tension for the X-axis and Y-axis arms

The timing belts used in the X and Y axis arms have almost no stretch. Therefore, the belt tension will be appropriate as long as the tensioners (See Fig. 4-14 and Fig. 4-15) are not moved. If for some reason their positions have moved, adjust the belt tension with the following procedure.

6.2.1 Adjusting the X-axis arm belt

1) Prepare the necessary tools.
   - Hex wrench set
   - Phillips screwdrivers
   - 7mm wrench

2) Turn off the controller.

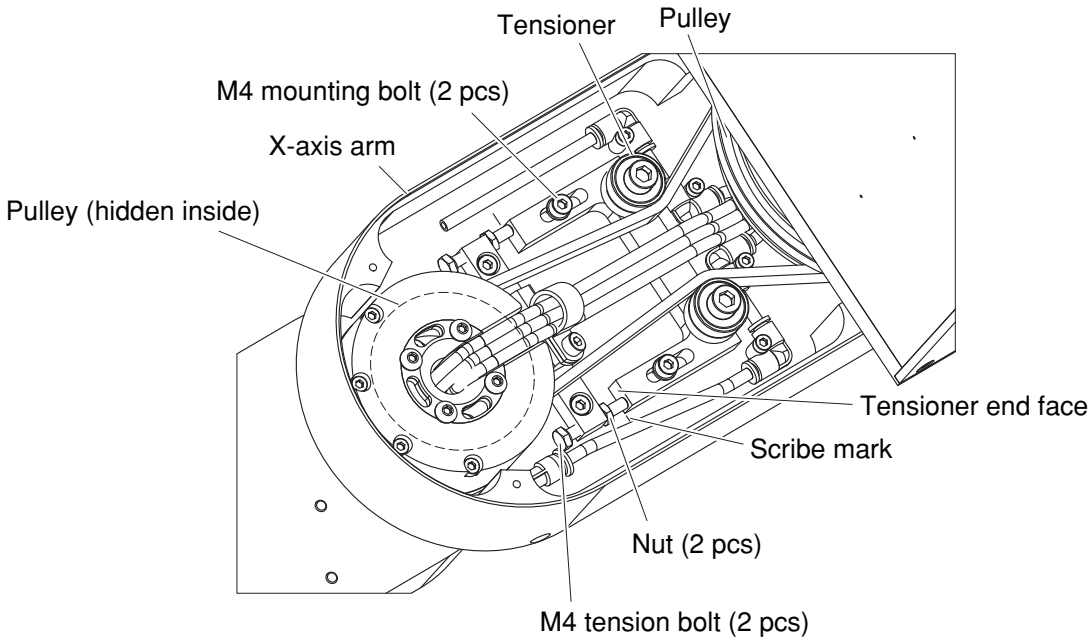
3) Place a sign indicating the robot is being adjusted, to keep others from operating the controller switch.

4) Enter the safety enclosure.

5) Remove the X-axis arm cover.
   See "3.4 Removing the robot covers" for this procedure.

6) No adjustment is necessary if the tensioner end face is aligned with the scribe mark (Fig.4-14). If not aligned, adjust using the procedure described below.

■ **Fig. 4-14 Bottom view of X-axis arm**



7) Slightly loosen the two tensioner mounting M4 bolts. Do not loosen to the degree that play occurs at the tensioner and the X-axis arm.

8) Verify that the belt is securely in place on the pulley.

9) Loosen the tension bolt nut, turn the tension bolt until the tensioner end face is aligned with the scribe mark, then tighten the tensioner mounting bolt and secure the tension bolt nut. The tightening torque for the tensioner mounting bolt is 4.5Nm (46kgf·cm).

⚠CAUTION

Belt slippage will occur if the tensioner end face shifts to a position in front of the scribe mark, and a shift beyond the scribe mark will reduce the durability of the Y-axis drive system. Therefore, be sure that the tensioner end face is aligned with the scribe mark.

10)Reattach the covers.

6.2.2 Adjusting the Y-axis arm belt

1) Prepare the necessary tools.
   - Hex wrench set
   - Phillips screwdrivers
   - 7mm wrench

2) Turn off the controller.

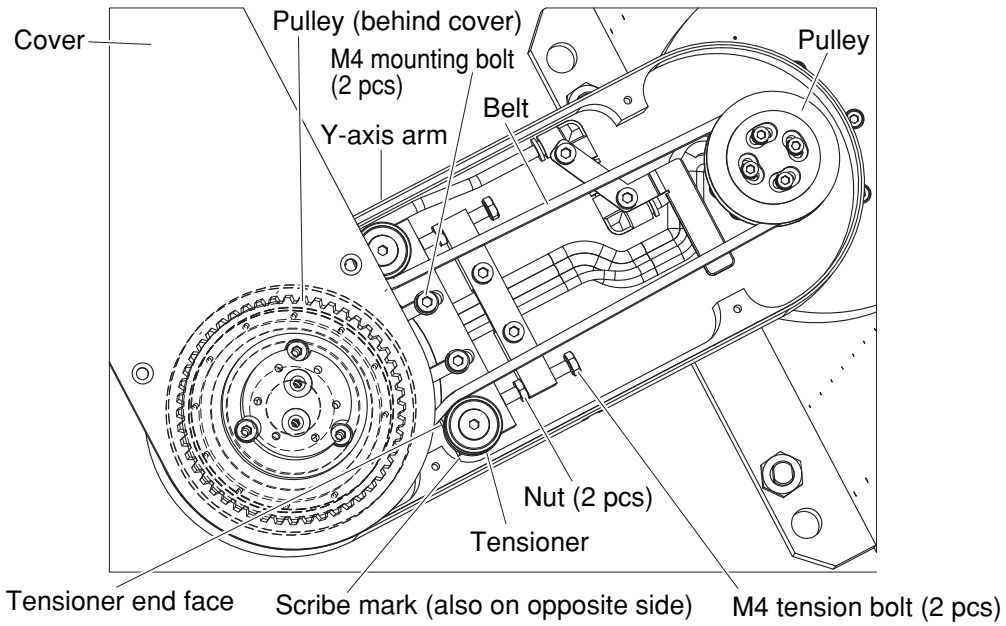
3) Place a sign indicating the robot is being adjusted, to keep others from operating the controller switch.

4) Enter the safety enclosure.

5) Remove the Y-axis arm cover.
   See "3.4 Removing the robot covers" for this procedure.

6) No adjustment is necessary if the tensioner end face is aligned with the scribe mark (Fig.4-15). If not aligned, adjust using the procedure described below.

■ **Fig. 4-15**



7) Slightly loosen the two tensioner mounting M4 bolts. Do not loosen to the degree that play occurs at the tensioner and the Y-axis arm.

8) Verify that the belt is securely in place on the pulley.

9) Loosen the tension bolt nut, turn the tension bolt until the tensioner end face is aligned with the scribe mark, then tighten the tensioner mounting bolt. The tightening torque for the tensioner mounting bolt is 4.5Nm (46kgf·cm). Finally, secure the tension bolt nut.

⚠CAUTION

Belt slippage will occur if the tensioner end face shifts to a position in front of the scribe mark, and a shift beyond the scribe mark will reduce the durability of the R-axis drive system. Therefore, be sure that the tensioner end face is aligned with the scribe mark.

10)Reattach the covers.

7. X-axis and Y-axis arm alignment

If the X or Y axis arm strikes the peripheral hardware with a harsh impact, the belt inside the arm will jump from the gear teeth, so that the X and Y axis arms might no longer fully extend during Y-axis forward movement. If that happens, realign the X and Y axis arms using the jigs like those shown below. The alignment jigs must be made by the customer. The arms can be approximately aligned even without the jigs.
The arm alignment procedure is described below.

1) Prepare the following tools.
   - Hex wrench set
   - Phillips screwdrivers

2) Place a sign indicating that the robot is being adjusted in order to keep others from operating the controller or operation panel.

3) Check that no one is inside the safety enclosure, and then turn on the controller.

4) Enter the safety enclosure while holding the MPB.

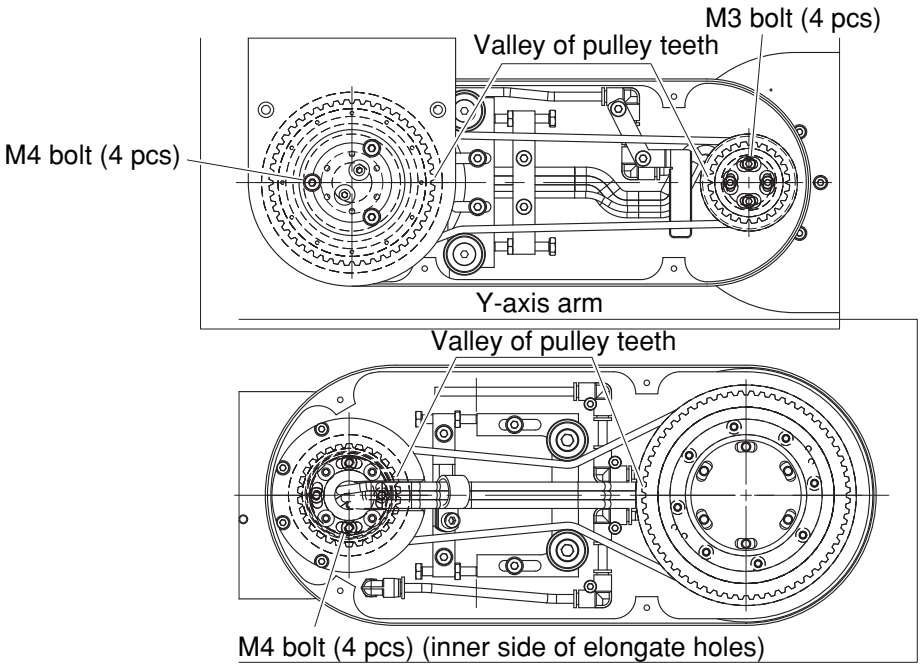
5) Check whether the X and Y axis arms are aligned in a line at the front base position when they are extended. Be careful not to enter within the robot movement range at this time.

6) Make a visual check and if the arms are not aligned then perform the following steps. However, please note that even when the arms are fully extended, the X and Y axis arms and tool attachment shaft are not completely aligned in a line due to parts machining accuracy and assembly condition.

7) Turn off the controller power.

8) Refer to "6.2 Adjusting the X and Y axis timing belt tension".
   Loosen the tensioner nut and tension bolt, and re-adjust the belt tension so the relative positions of the bolts and the valleys of the pulley teeth are approximately as shown in Fig. 4-16. Then retighten the tensioner nut and tension bolt.

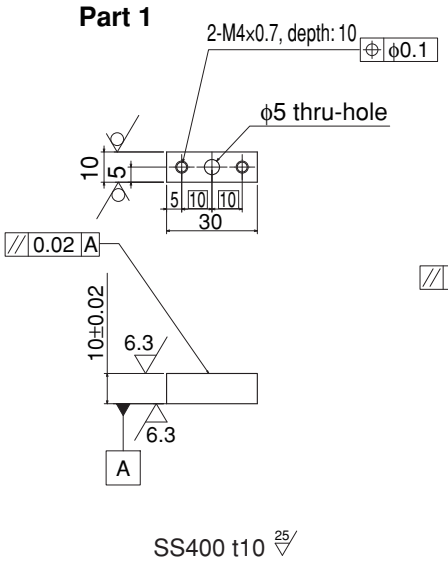
■ **Fig. 4-16 X-axis arm (bottom view)**



9) Prepare the jigs as shown in Fig. 4-17, Fig. 4-18 and Fig. 4-19.

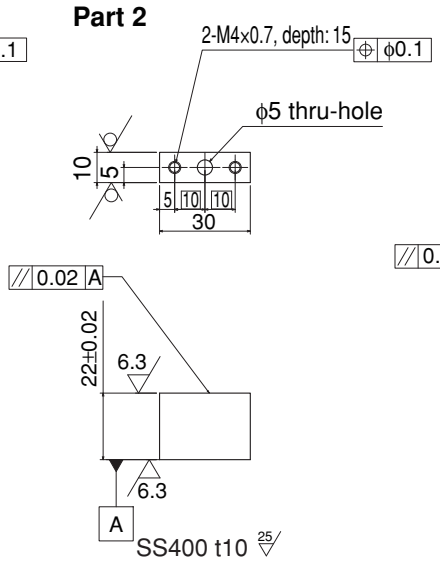
■ **Fig. 4-17**

Part 1



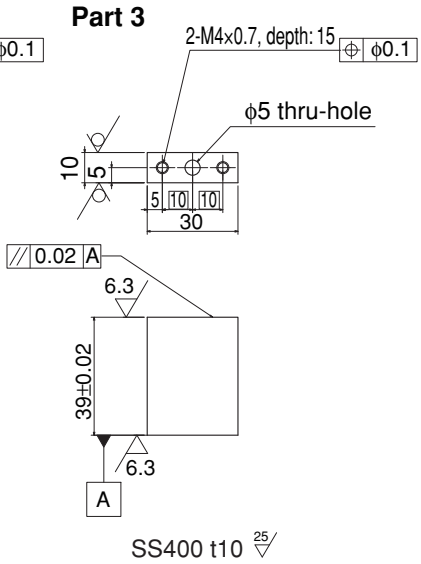
Note:
1. Corner chamfer is C0.5 unless otherwise indicated.

Part 2



Note:
1. Corner chamfer is C0.5 unless otherwise indicated.

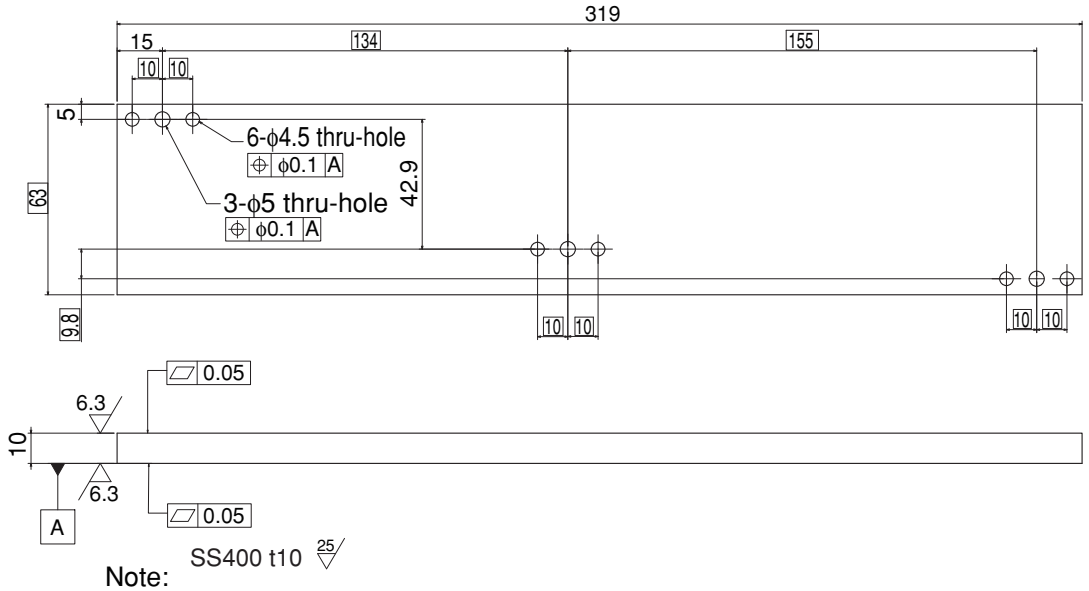
Part 3



Note:
1. Corner chamfer is C0.5 unless otherwise indicated.

■ Fig. 4-18

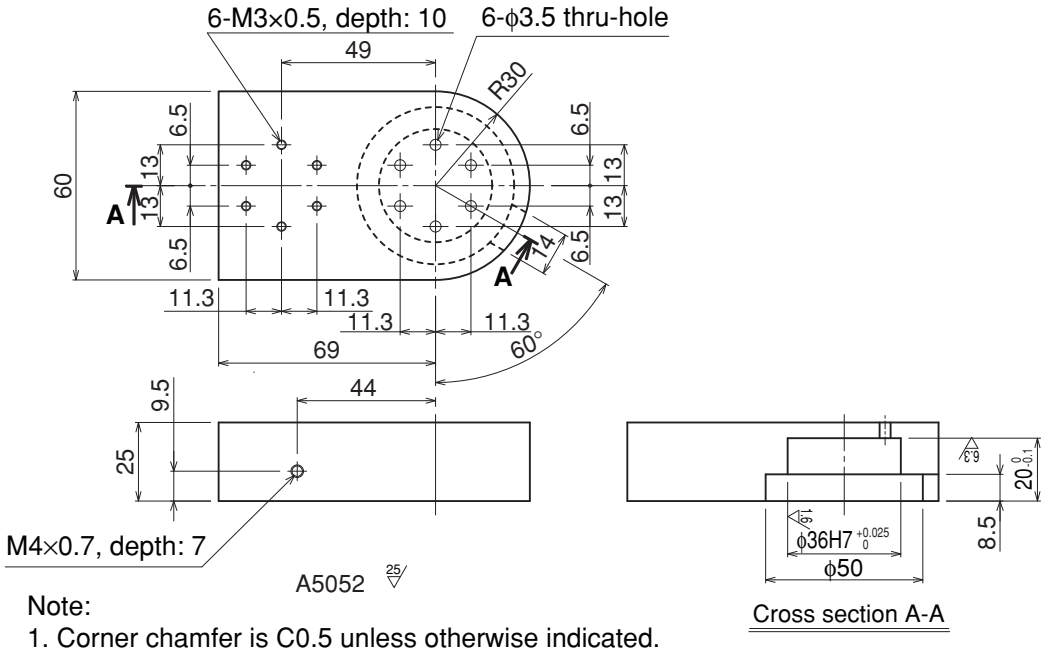
Part 4



Note:
1. Corner chamfer is C0.5 unless otherwise indicated.

■ Fig. 4-19

Part 5



Note:
1. Corner chamfer is C0.5 unless otherwise indicated.

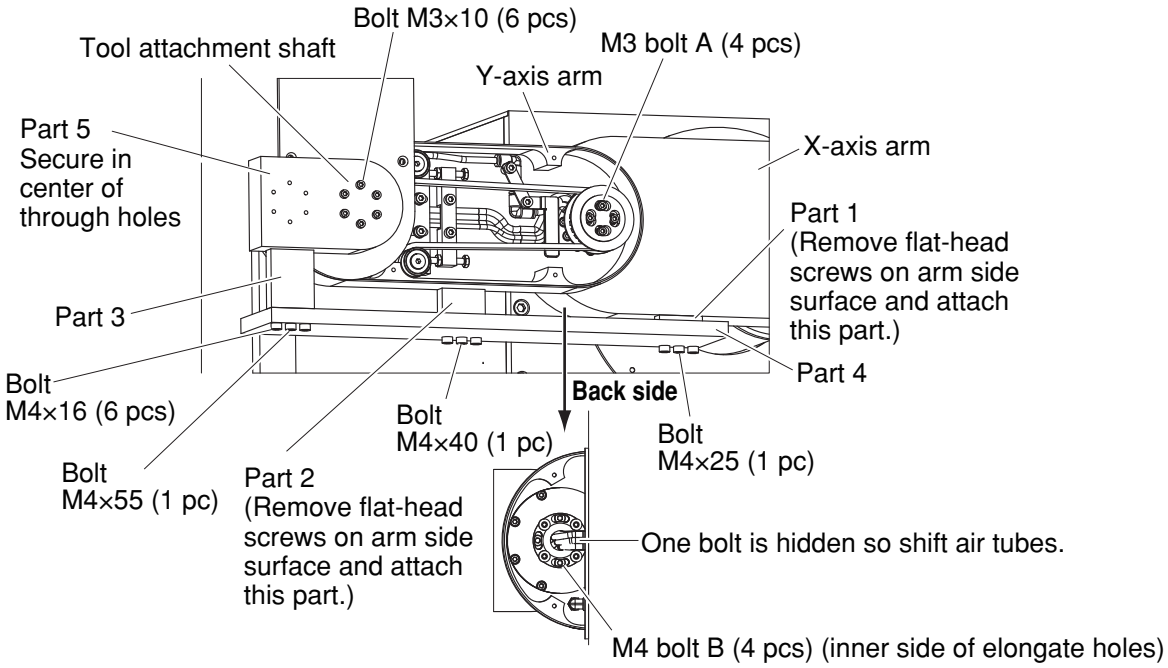
Cross section A-A

(This jig is not required if equipped with a hand holder.)

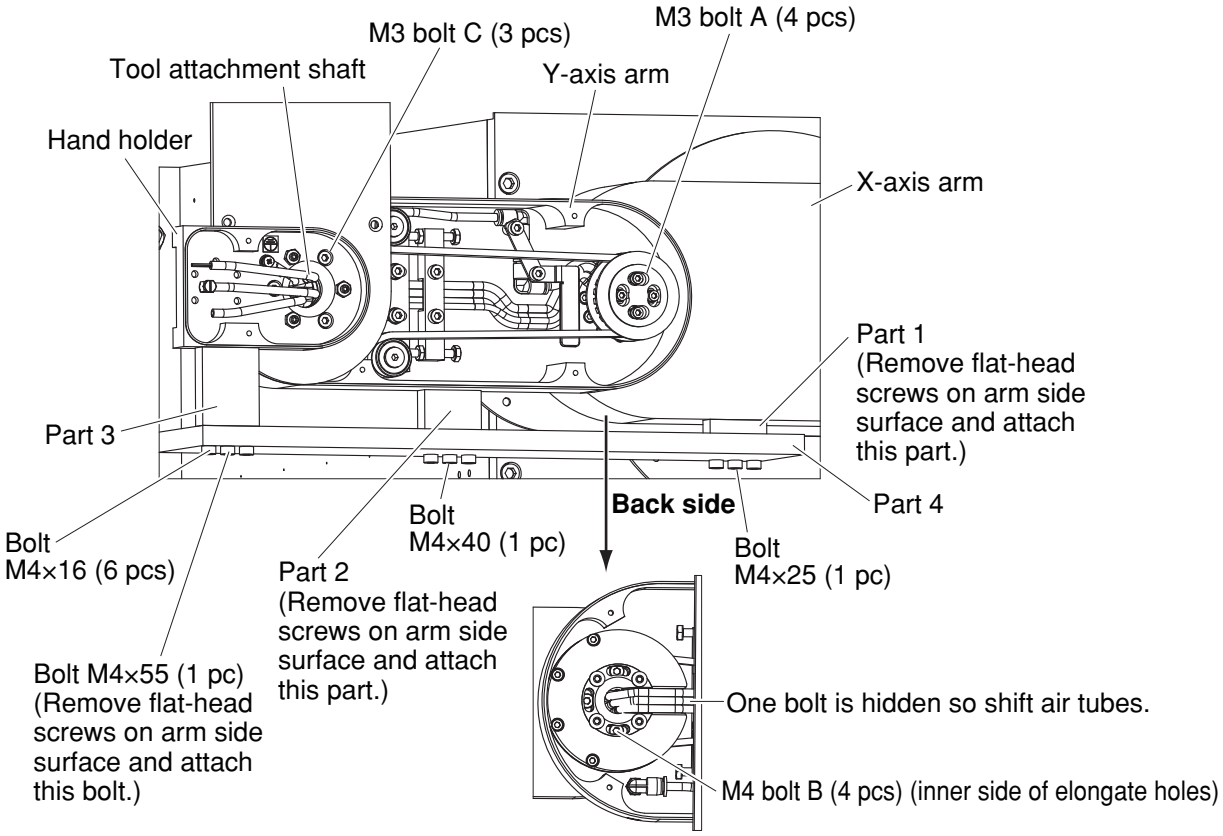
10)Set the X and Y axis arms and tool attachment shaft in roughly a straight line.

11)Loosen the bolts A and B, remove the flat-head screws on the arm side surface, and set the jigs as shown in Fig. 4-20. If equipped with a hand holder then loosen the bolt C.

■ Fig. 4-20 No hand holder



■ Fig. 4-20 Equipped with hand holder



12) Gradually tighten the bolts A and B. If equipped with a hand holder then tighten the bolt C.
The jigs are heavy so be careful not to drop them and cause injuries. Suddenly tightening the bolts may prevent the arms from extending straight after removing the jigs, so use caution.

13)Remove the jigs.

14)Turn on the controller power and make the tool attachment shaft move straight forward. When the arms are fully extended, check that the X and Y axis arms and tool attachment shaft are aligned in a straight line. Be careful not to enter within the robot movement range at this time.

15)Even if no jigs are available, you can make a visual check to see that the X and Y axis arms and tool attachment shaft approximately form a straight line, and then tighten the bolts A, B, and C.

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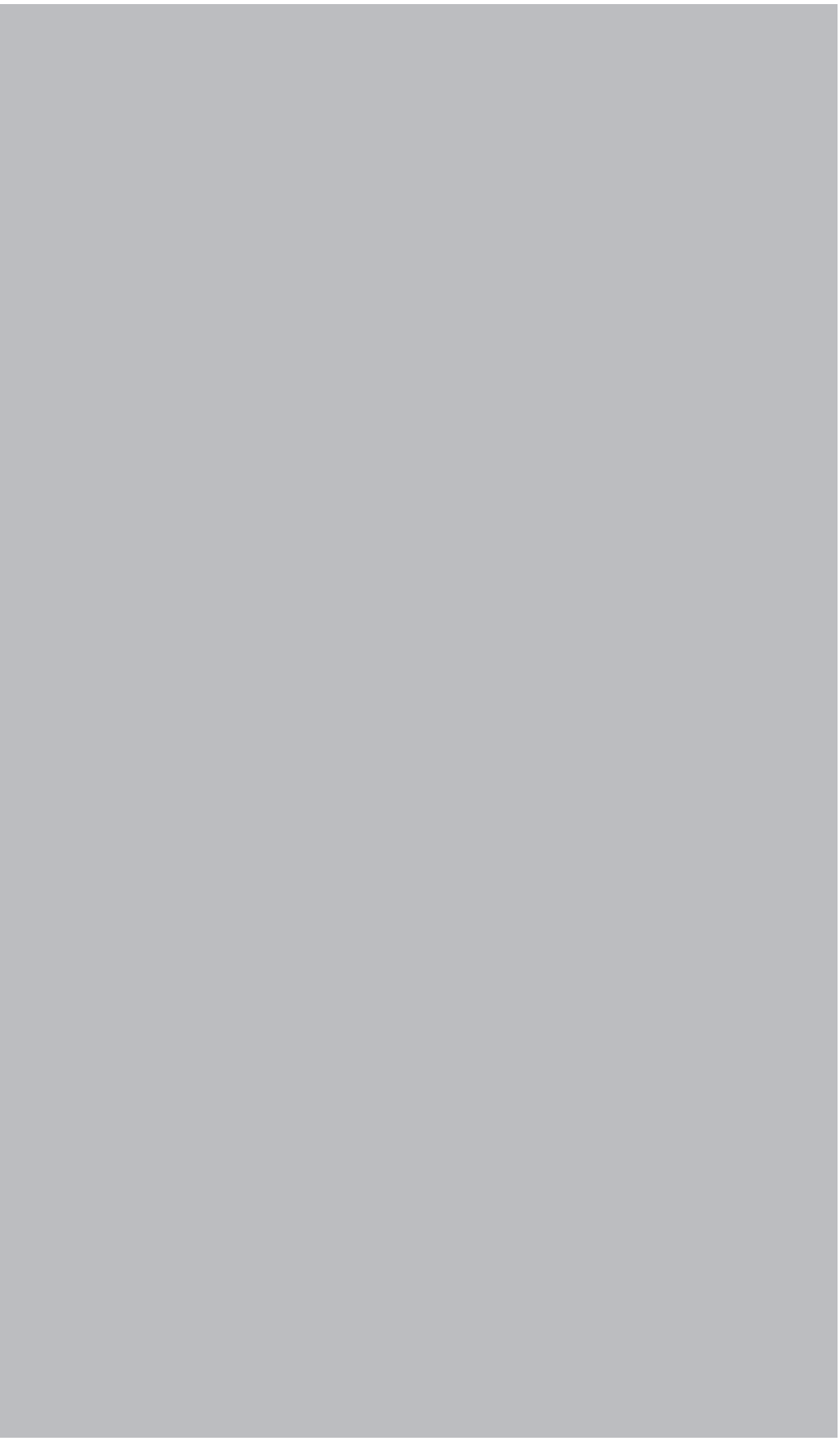
Chapter 5 Operating the Robot

Contents



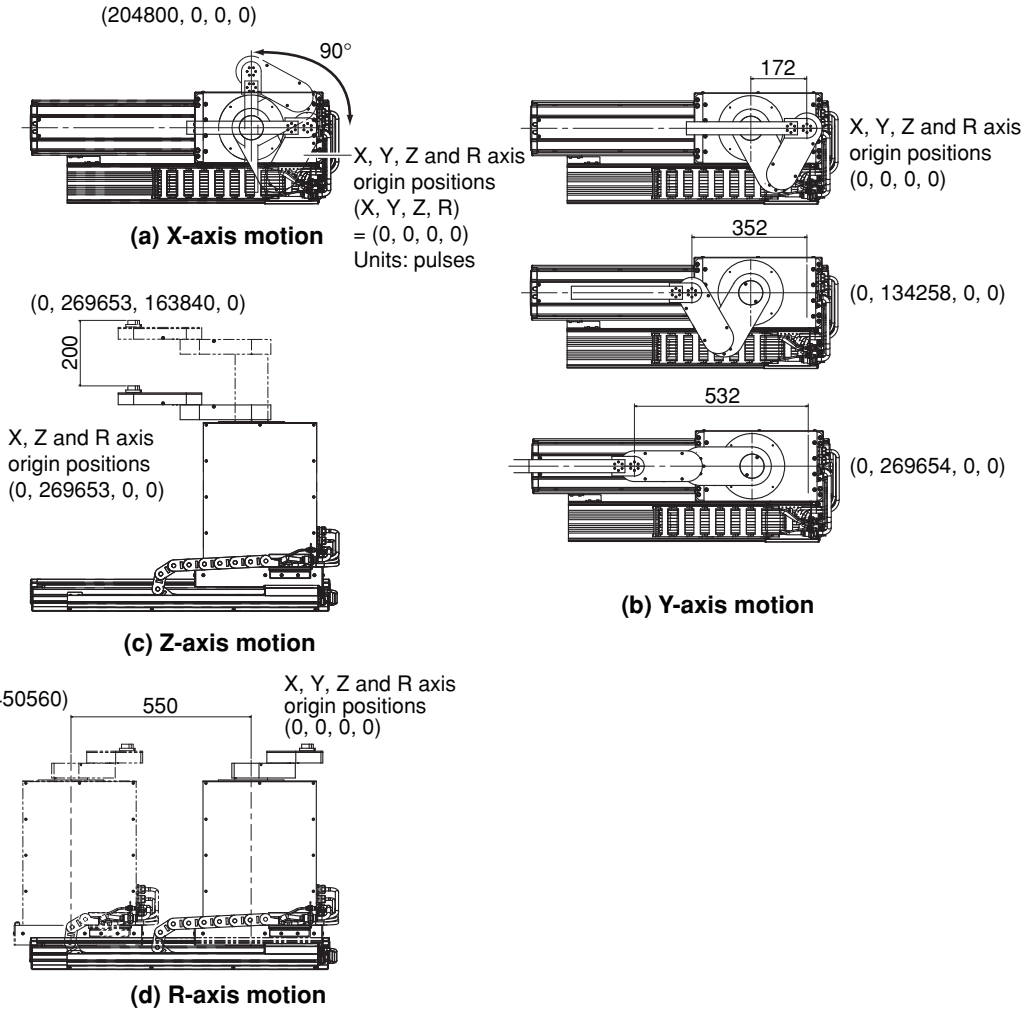
1. Robot motion

Before operating the disk handling robot, be aware that its motion differs from that of the SCARA robots.
Unlike the SCARA robots, the reference coordinates cannot be set for this robot. Point displays based on an orthogonal coordinate system have no meaning, and such a coordinate system should not be used.
As shown in Fig. 5-1, the Y-axis performs a straight forward motion, while the X-axis rotates the straight forward direction of the Y-axis. The Z-axis moves the X and Y axes up and down together. The R-axis moves the X, Y and Z axes together.
Since the RCX142 controller is used, the coordinates are displayed in pulses.
The table below shows axis travel distances and corresponding pulse counts.

Axis	Travel distance	Pulse count
X-axis	360°	819200 pulses
Y-axis	532mm	Approx. 269654 pulses
Z-axis	200mm	163840 pulses
R-axis	550mm	450560 pulses

The Y-axis travel distance is not proportional to the pulse count.
For motion programming details, refer to the "YAMAHA Robot Controller RCX142 Series User's Manual".

■ **Fig. 5-1 Robot motions**



2. Operating the robot

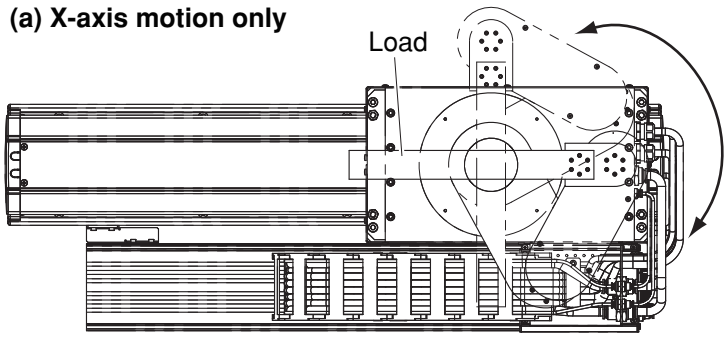
The robot's X-axis and Y-axis acceleration is determined by the "X-axis motion only" or "Y-axis motion only" operations shown in Fig. 5-2 below. Therefore, when the X-axis and Y-axis are operated simultaneously or the X-axis rotates while the Y-axis is far from its origin position, this will shorten the drive system life, and could result in mechanical damage, overload conditions, and residual vibration during positioning.
The Y-axis should always be near its origin position when the X-axis rotates, and the X and Y axes should not be operated simultaneously.
The R-axis (travel axis) is located beneath the disk handling robot. Do not attempt to move the X, Y and Z axes while the travel axis is moving. If attempted, an inertia force will be applied to the X and Y axes by the travel axis motion. This will shorten the drive system life and could result in mechanical damage, overload conditions, and residual vibration during positioning. If the Z-axis is moved while the travel axis is moving, the Z-axis harness may interfere with the Z-axis drive section, causing the harness wires to break.

A sample robot motion program is shown below. (See also Fig. 5-3.)

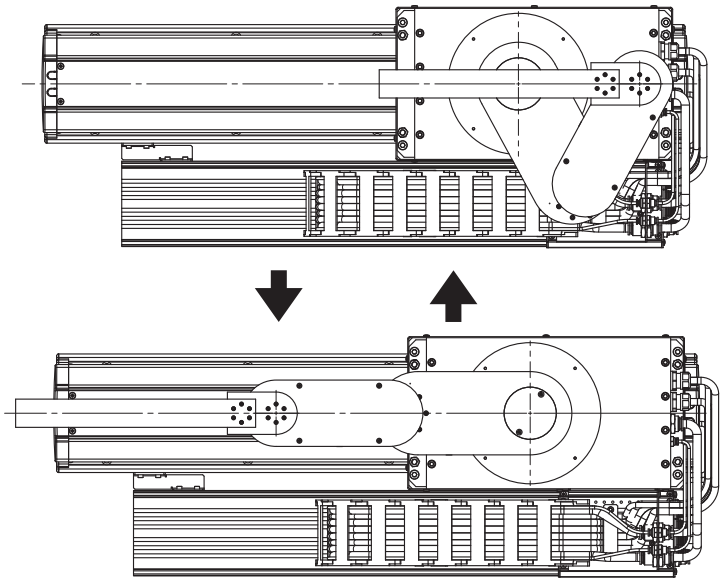
```
* L0:
  FOR I=1 TO 10
  MOVE P, P[ I ]
  DELAY 1000
  NEXT I
  GOTO * L0
```

■ Fig. 5-2 Robot motions

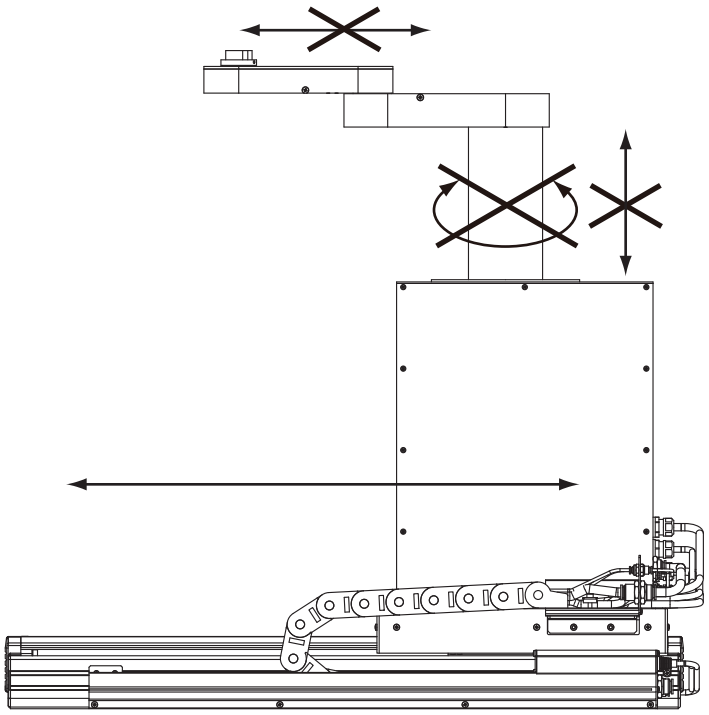
(a) X-axis motion only



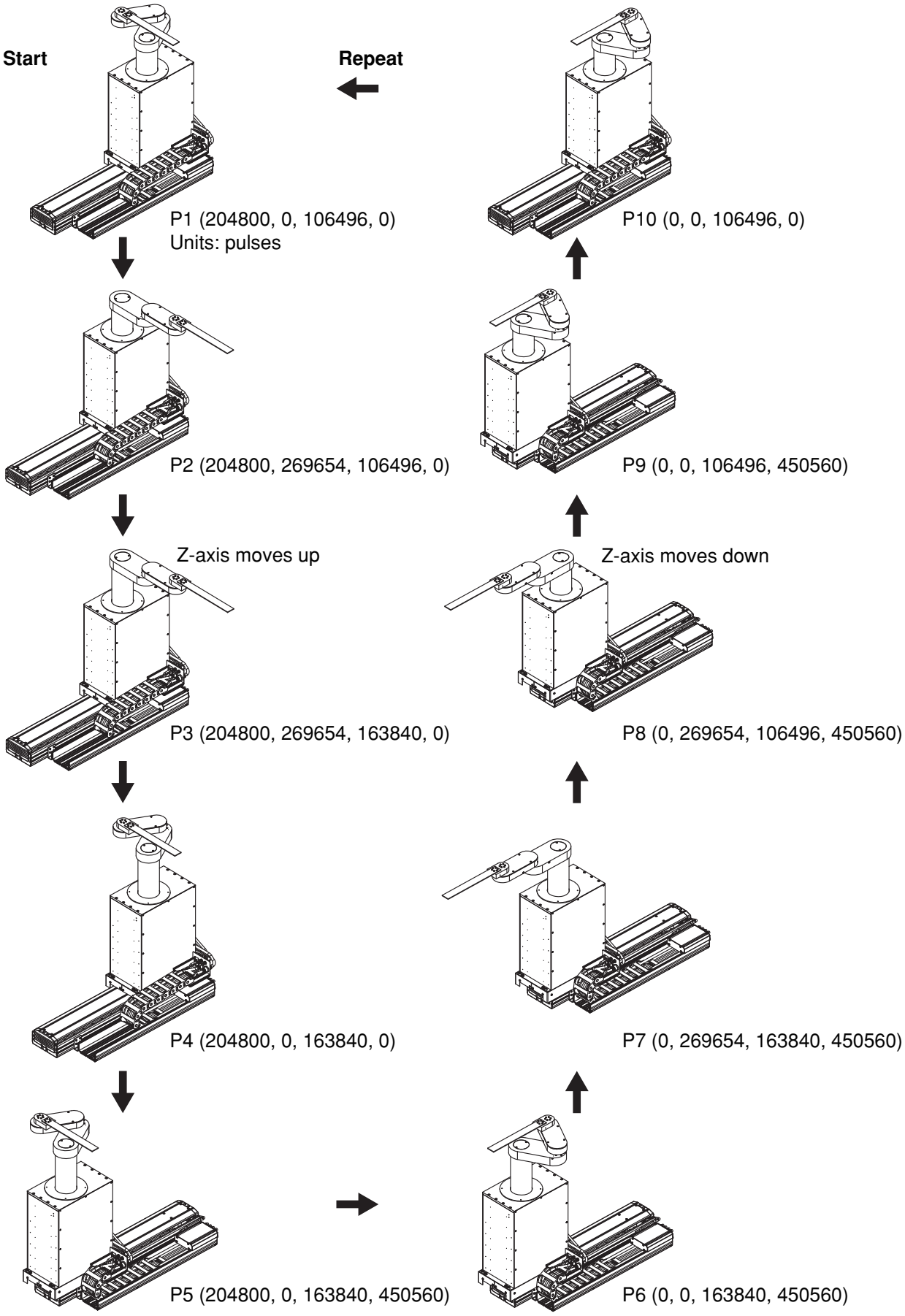
(b) Y-axis motion only



(c) X, Y and X axis operation prohibited during R-axis (travel axis) motion



■ Fig. 5-3


Start
Repeat
P1 (204800, 0, 106496, 0)
Units: pulses
P10 (0, 0, 106496, 0)
P2 (204800, 269654, 106496, 0)
P9 (0, 0, 106496, 450560)
Z-axis moves up
Z-axis moves down
P3 (204800, 269654, 163840, 0)
P8 (0, 269654, 106496, 450560)
P4 (204800, 0, 163840, 0)
P7 (0, 269654, 163840, 450560)
P5 (204800, 0, 163840, 450560)
P6 (0, 0, 163840, 450560)

3. Creating point data, direct teaching, and external forces to arms

Direct X and Y axis teaching is difficult when the servo is OFF because any attempt to rotate the X-axis by hand will result in Y-axis motion (Y-axis performs a straight forward motion). Since the Z-axis is heavy, it is hazardous to perform direct teaching.
X, Y and Z axis point data should therefore be created by a manual data-in or teaching playback operation.
For details, refer to the "YAMAHA Robot Controller RCX142 Series User's Manual".
Torque should never be applied to the Y-axis and tool attachment shaft by hand, as this could cause belt slippage in the X-axis and Y-axis arms, or could result in damage.

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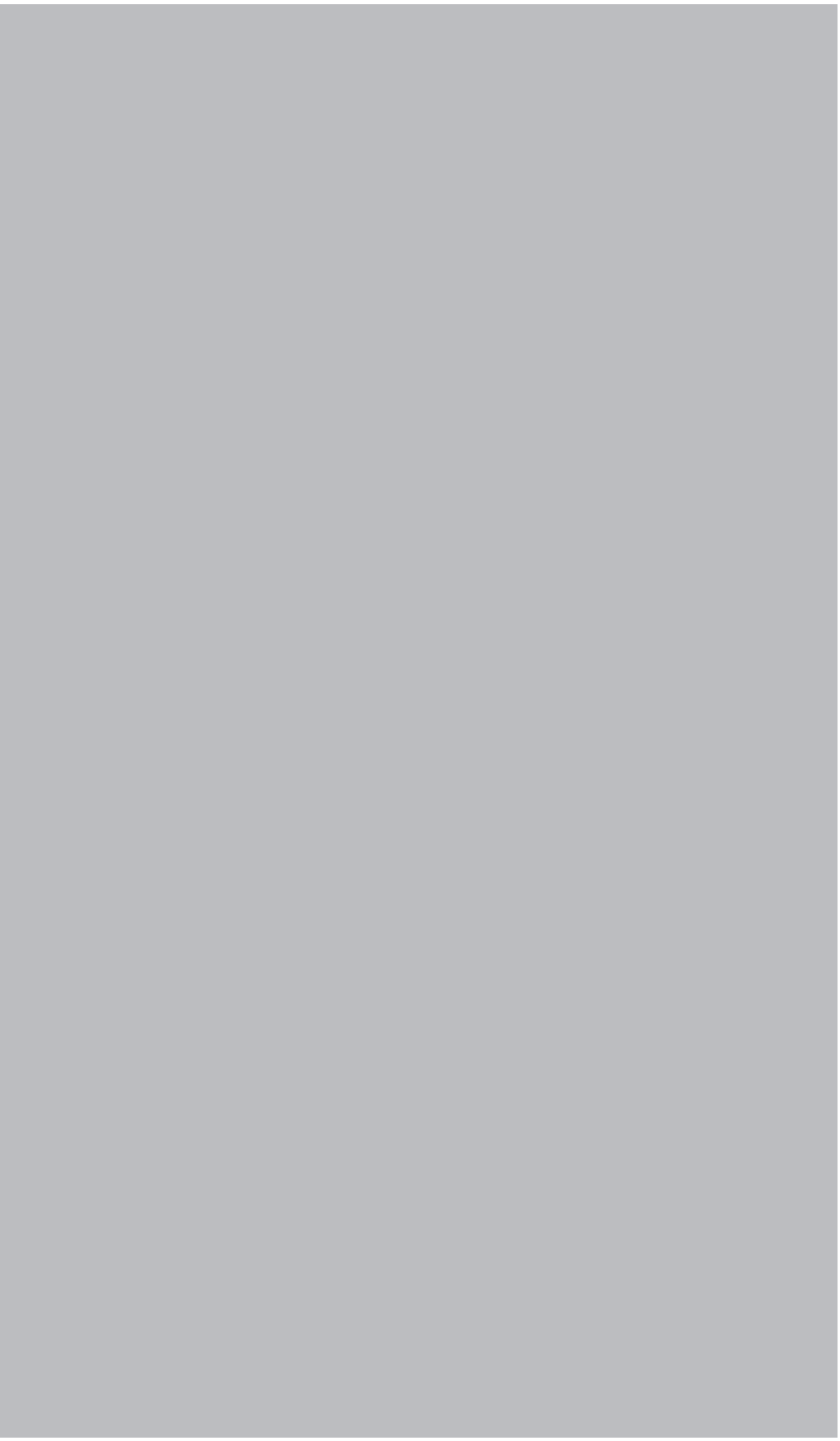
Chapter 6 Periodic Inspection

Contents



1. Overview

Daily and periodic inspection of the YAMAHA robot is essential in order to ensure safe and efficient operation. This chapter describes the periodic inspection items and procedures for the disk handling robots.

Periodic inspection includes:

- Daily inspection
- 6-month inspection
- Replacing the grease for speed reduction gear (harmonic drive)

Make sure that you thoroughly understand details of the inspection and follow the procedures and precautions explained in this chapter.

2. Precautions

(1) Periodic inspection must be performed by or in the presence of personnel who have received the Robot Training given by YAMAHA or YAMAHA dealers.

(2) Do not attempt any inspection, adjustment, repair and parts replacement not described in this manual. This work requires specialized technical knowledge and skill, and may also involve work hazards.

(3) When inspection is required inside the safety enclosure, always turn off the controller and also the external switch board.

(4) If the inspection or maintenance procedure calls for operation of the robot, stay outside the safety enclosure.

(5) Place a sign indicating the robot is being inspected, to keep others from operating the controller switch, programming unit or operation panel.

(6) Use only the lubricants specified by YAMAHA or YAMAHA dealers.

(7) To check the operation after inspection, see "6. Trial operation" in Chapter 1.

⚠WARNING

- **When you need to touch the terminals or connectors on the outside of the controller during inspection, always first turn off the controller power and also the power source in order to prevent possible electrical shock.**
- **Never touch any internal parts of the controller.**
- **The controller must be installed outside the safety enclosure.**
- **When inspecting the controller, it is dangerous to enter the safety enclosure while the controller power is ON.**

For precautions on handling the controller, refer to the "YAMAHA Robot Controller RCX142 Series User's Manual".

3. Daily inspection

The following inspections must be performed every day before and after operating the robot.

(1)Inspection to be performed with the controller turned off

1) Turn off the controller.

2) Place a sign indicating the robot is being inspected, to keep others from operating the controller switch.

3) Enter the safety enclosure and check the following points.

Checkpoint	Procedure
Wire harness in cable carrier Robot cable User cable and wiring	Check for scratches, dents and excessive bend and kinks. (If the wire harness in the cable carrier or robot cable is damaged, contact YAMAHA dealer.)
Air regulator, air coupler, air tube, solenoid valve, air cylinder	• Check air pressure. • Check for air leaks. • Check drain. • Check air filter for clogging or damage.
Robot exterior	Check for damage. (If damage is found, contact YAMAHA dealer.)

(2)Inspection to be performed with the controller turned on

1) Check that no one is inside the safety enclosure, and then turn on the controller.

2) Place a sign indicating the robot is being inspected, to keep others from operating the controller, programming unit or operation panel.

3) Check the following points from outside the safety enclosure.

Checkpoint	Procedure
Safety enclosure	Check if the safety enclosure is in place. Check if emergency stop is triggered when the door is opened. Check if warning labels are affixed at the entrance and clearly visible.
Emergency stop device	Press the emergency stop button to check if it works.
Robot movement	Check for abnormal movement and excessive vibration and noise. (If an abnormal condition is found, contact YAMAHA dealer.)
Z-axis brake operation *1	Check if the brake works to stop the Z-axis from dropping more than 3mm from the stationary point. (If an abnormal condition is found, contact YAMAHA dealer.)

***1**: Visually check the Z-axis movement when you press the emergency stop button from outside the safety enclosure and also when you turn off the controller.

(3)Adjustment and parts replacement

1) After inspection, if you notice any adjustment or parts replacement is needed, first turn off the controller and then enter the safety enclosure to perform the necessary work. After adjustment or replacement is finished, again review the checkpoints outlined in (1) and (2) above.

2) If repair or parts replacement is required for the robot or controller, please contact your YAMAHA dealer. This work requires specialized technical knowledge and skill, so do not attempt it by yourself.

4. Six-month inspection

The following inspections must be performed every 6 months.

⚠WARNING

- **The Z-axis will slide down when the Z-axis brake is released, causing a hazardous situation. Do not release the brake when lubricating the Z-axis parts.**
- **Injury can occur if hands or fingers are squeezed between the drive pulley and belt. Always turn off the controller and use caution when handling these parts.**

⚠CAUTION

The ball screw and guide life may shorten if the grease recommended by YAMAHA is not used.

(1)Inspection to be performed with the controller turned off

1) Turn off the controller.

2) Place a sign showing that the robot is being inspected, to keep others from operating the controller switch.

3) Enter the safety enclosure and check the following points.

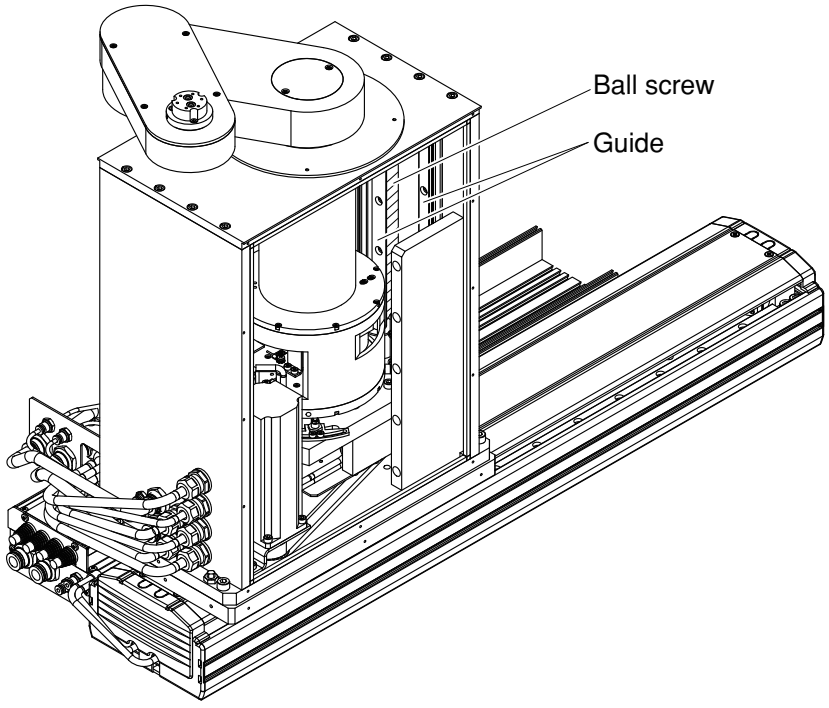
Checkpoint	Procedure
Major bolts and screws on robot (only for bolts and screws exposed externally)	Check for looseness and tighten if necessary.*1
X, Y, Z and R axis timing belts	Check belt tension. (See 6 in Chapter 4.)
Detection areas of X and Y axis origin sensors	Clean if it is dirty. (See 3.5 in Chapter 4.)
Controller	Check for looseness at each terminal and connector on the controller panel. (See 4 in Chapter 3 and also "YAMAHA Robot Controller RCX142 Series User's Manual.)
Grease on Z-axis ball screw and guide	After removing old grease with wiping cloth, apply LG2 (NSK) grease to the Z-axis ball screw shaft surface and guide rail. (See Fig. 6-1.) (To remove the cover, see "3.4 Removing the robot covers" in Chapter 4.
Z-axis ball screw and guide	Check for play or backlash. (If an abnormal condition is found, contact YAMAHA dealer.)

■ **Table 6-1 *1: Bolt tightening torque**

Bolt size	Tightening torque (kgf·cm)	Tightening torque (N·m)
M3 button head bolt	14	1.4
M4 set screw	20	2.0
M3	20	2.0
M4	46	4.5
M5	92	9.0
M6	156	15.3
M8	380	37
M10	720	71
M12	1310	128
M14	2090	205

For 6-month inspection of the R-axis (travel axis), refer to the F17 single-axis robot described in the "FLIP-X Series User's Manual".

■ **Fig. 6-1**



(2)Adjustment and parts replacement

1) After inspection, if you notice any adjustment or parts replacement is needed, first turn off the controller and then enter the safety enclosure to perform the necessary work. After adjustment or replacement is finished, again review the checkpoints outlined in (1) above.

2) If repair or parts replacement is required for the robot or controller, please contact your YAMAHA dealer. This work requires specialized technical knowledge and skill, so do not attempt it by yourself.

5. Replacing the harmonic drive grease

The disk handling robot uses harmonic drives as the X-axis and Y-axis reduction gears. The harmonic drive grease (HC-1A or SK-1A) must be replaced periodically. The grease replacement interval should be determined according to the guidelines given below. As the robot base must be completely disassembled in order to replace the harmonic drive grease, please contact a YAMAHA sales office or dealer for assistance.

5.1 Replacement interval

The harmonic drive grease replacement interval is determined according to the total number of wave generator turns. It is recommended to replace the harmonic drive grease when the total number of turns has reached 1.5×10^8 (at ambient operating temperatures of 0°C to +40°C). This means that the replacement interval will differ depending on the following operating conditions. If the robot operation duty ratio is high or the robot is operated in environments at higher temperatures, the harmonic drive should be replaced earlier.

Replacement interval = 1.5×10^8 / ($n\times60\times h\times D\times N\times\theta$) years

where

n : Number of robot motions per minute

θ : Average rotation of axis per motion

N : Speed reduction ratio

h : Operation time per day

D : Operation days per year

θ is 1/4 of a turn relative to an axis rotation of 90°.
Because the robot construction is such that the X-axis rotates as the Y-axis reduction gear rotates, the axis rotation must be obtained from the point data.
Both in case of the X-axis and Y-axis, one rotation consists of 819200 pulses.

[Ex] If the robot moves 10 times per minute, averaging 1/4 of a turn per motion, the harmonic drive grease replacement period would be calculated as shown below (operation time: 24 hours/day, operation days: 240 days/year)

n :10

θ : 0.25

N :50

h : 24 hours per day

D : 240 days per year

Replacement interval = 1.5×10^8 / ($n\times60\times h\times D\times N\times\theta$)

= 1.5×10^8 / ($10\times60\times24\times240\times50\times0.25$)

= 3.5 years

■ **Table 6-2 Harmonic speed reduction ratio**

X-axis	Y-axis
50	50

⚠ WARNING

The motor and speed reduction gear casing are extremely hot after automatic operation, so burns may occur if these are touched. Before touching these parts, turn off the controller, wait for a while and check that the temperature has cooled.

⚠ WARNING

Precautions when handling harmonic grease and cleaning oil:
- Inflammation may occur if they get in the eyes. Before handling them, wear safety goggles to ensure they will not come in contact with the eyes.
- Inflammation may occur if they come into contact with skin. Be sure to wear protective gloves to prevent contact with skin.
- Do not take orally or eat. (Eating will cause diarrhea and vomiting.)
- Hands and fingers might be cut when opening the container, so use protective gloves.
- Keep out of the reach of children.
- Do not heat them or place near an open flame since this could lead to sparks and fires.

Emergency treatment:
- If they get in the eyes, wash liberally with pure water for about 15 minutes and consult a physician for treatment.
- If they come in contact with the skin, wash away completely with soap and water.
- If taken internally, do not induce vomiting but promptly consult a physician for treatment.

⚠ WARNING

Disposing of harmonic grease, cleaning oil and the container:
- Proper disposal is compulsory under federal, state and local regulations. Take appropriate measures in compliance with legal regulations.
- Do not pressurize the empty container. Pressurizing may cause the container to rupture.
- Do not attempt to weld, heat up, drill holes or cut this container. This might cause the container to explode and the remaining materials inside it to ignite.

⚠ WARNING

When removing the wave generator from the motor shaft or reinstalling it back onto the motor shaft, use caution to avoid as much as possible applying a thrust load to the motor shaft. If a load is applied, the resolver may be damaged resulting in a hazardous situation of the robot trouble.

⚠ CAUTION

The harmonic drive may be damaged if the grease recommended by YAMAHA is not used.

Recommended grease

Use the following harmonic drive grease.

HC-1A or SK-1A (made by Harmonic Drive Systems Inc.)

(Do not use 4B No.2 grease as it may leak out.)

⚠CAUTION

Harmonic drive

- **Do not apply strong shocks or impacts to these parts such as with a hammer. Also, do not scratch, scar or dent these parts by dropping, etc. Such actions will damage the harmonic drive.**
- **The specified performance cannot be maintained if any part of the harmonic drive is used in a damaged state. This damage or wear may also lead to trouble with the harmonic drive.**

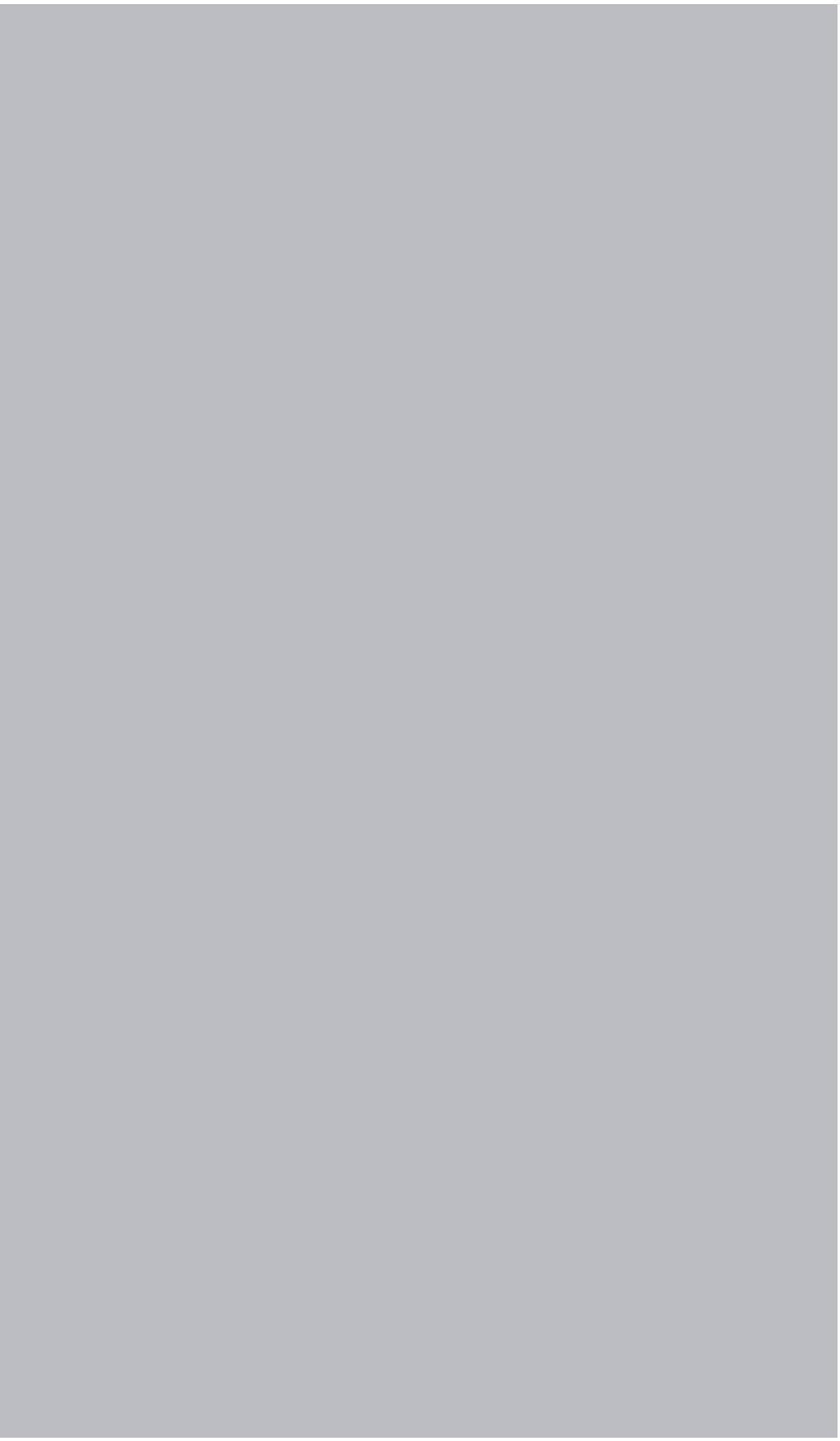
⚠CAUTION

A positional shift occurs when the harmonic drive grease is replaced. Therefore, an absolute reset and point data resetting are required after replacing the grease.

MEMO

Chapter 7 Specifications

Contents



1. Basic specifications

(1)4-axis specifications

Payload	0.2kg (R-axis rotational moment of inertia 0.04kgfcms^2)	
Working envelope	Y-axis forward stroke	532mm
	X-axis rotation angle	340°
	Z-axis up/down stroke	200mm
	R-axis travel stroke	550mm
Motor	X-axis	200w
	Y-axis	100w
	Z-axis	400w
	R-axis	400w
Maximum speed	Y-axis forward direction	300mm/s
	X-axis rotation	290°/s
	Z-axis up/down direction	1000mm/s
	R-axis travel direction	1000mm/s
Resolution	Y-axis forward direction	50μm
	X-axis rotation direction	0.0010°
	Z-axis up/down direction	20μm
	R-axis travel direction	20μm
Repeatability *	X and Y axes: tool attachment shaft position	±0.1mm
	Z and R axes: tool attachment shaft position	±0.05mm
Cleanliness degree	Class 1000 (0.3μm base during suction. Tool attachment shaft, Z-axis up/down stroke range, and R-axis travel area do not conform to clean room specs.)	
Suction rate	60Nl/min	
User tubing	ϕ4, 2 tubes	
User wiring	0.1mm^2, 4 wires	
Weight	Robot body: 70kg	
	RCX142 controller: W180×D235×H250mm, 6.5kg	
Travel limit	1. Soft limit (X, Y, Z and R axes) 2. Mechanical limit (X, Y, Z and R axes)	
Robot cable	3.5m, option: 1m, 2m, and 4m to 10m (in 1m steps)	
Arm and base	Almite coated aluminum	
Arm and base covers	Almite coated aluminum	
Outer bolts and screws	Stainless	

* At constant ambient temperature

(2) 3-axis specifications

Payload	0.2kg (R-axis rotational moment of inertia 0.04kgfcms^2)	
Working envelope	Y-axis forward stroke	532mm
	X-axis rotation angle	340°
	Z-axis up/down stroke	200mm
Motor	X-axis	200w
	Y-axis	100w
	Z-axis	400w
Maximum speed	Y-axis forward direction	300mm/s
	X-axis rotation	290°/s
	Z-axis up/down direction	1000mm/s
Resolution	Y-axis forward direction	50μm
	X-axis rotation direction	0.0010°
	Z-axis up/down direction	20μm
Repeatability *	X and Y axes: R-axis position at arm end	±0.1mm
	Z axis: R-axis position at arm end	±0.05mm
Cleanliness degree	Class 1000 (0.3μm base during suction, R-axis position at arm end in Z-axis up/down stroke range)	
Suction rate	60Nl/min	
User tubing	ϕ4, 2 tubes	
User wiring	0.1mm^2, 4 wires	
Weight	Robot body: 40kg	
	RCX142 controller: W180×D235×H250mm, 6.5kg	
Travel limit	1. Soft limit (X, Y and Z axes) 2. Mechanical limit (X, Y and Z axes)	
Robot cable	3.5m, option: 5m, 10m	
Arm and base	Almite coated aluminum	
Arm and base covers	Almite coated aluminum	
Outer bolts and screws	Stainless	

* At constant ambient temperature

Sound level

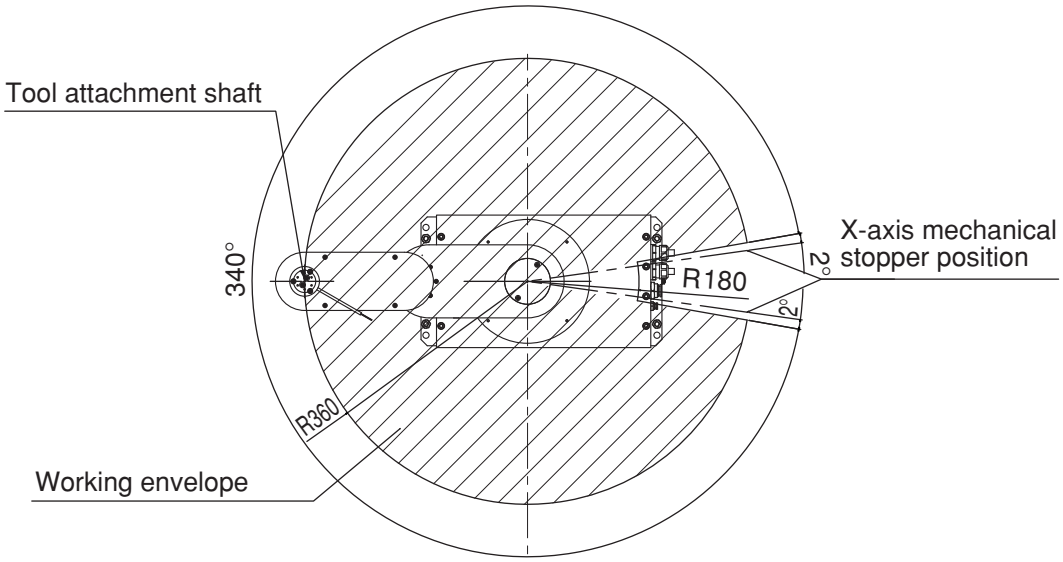
Maximum sound pressure level of robot (at 10dB or more difference from background sound pressure level)	Position of maximum sound pressure level
77.0dB	In direction of 45° to right, as viewed from front of robot 1.0m away from arm's movable section 1.4m height

⚠CAUTION

Sound level may increase when sound reflecting objects are located near the robot.

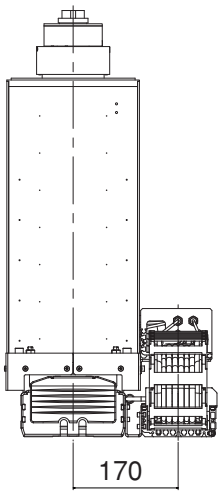
2. External view and dimensions

■ Fig. 7-1 4-axis specifications (without hand holder) (1)

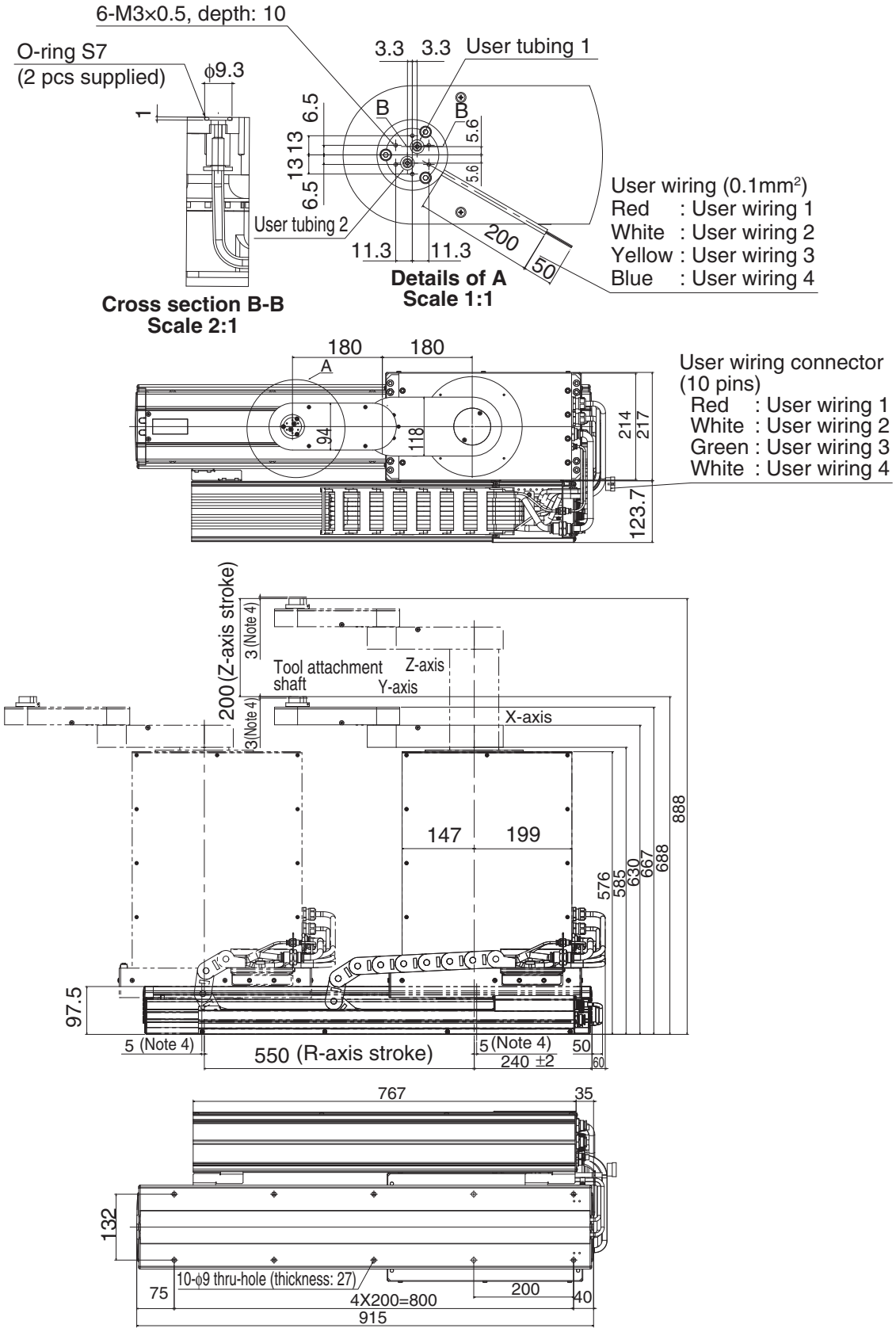


Working envelope (tool attachment shaft position) and X-axis mechanical stopper position

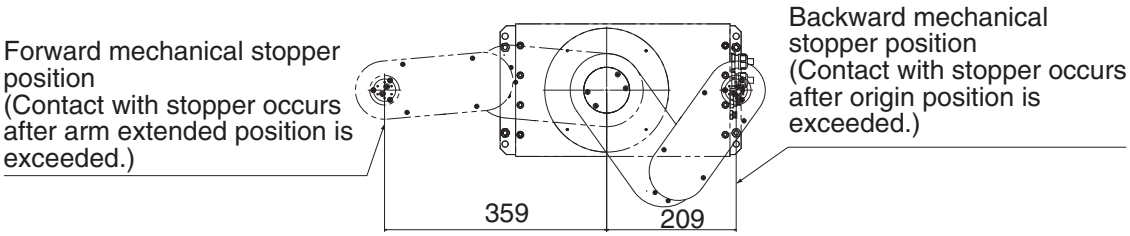
Mechanical stopper position may vary somewhat depending on parts machining accuracy. X and Y axis arms and tool attachment shaft may not extend fully, depending on parts machining accuracy or assembly condition.



■ Fig. 7-1 4-axis specifications (without hand holder) (2)

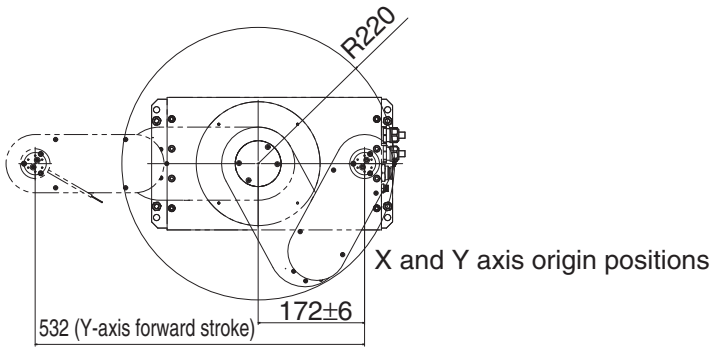


■ Fig. 7-1 4-axis specifications (without hand holder) (3)

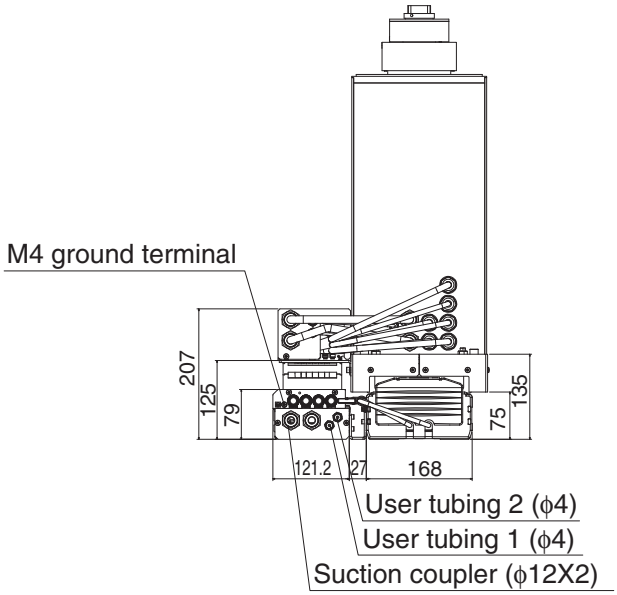


Y-axis forward mechanical stopper position

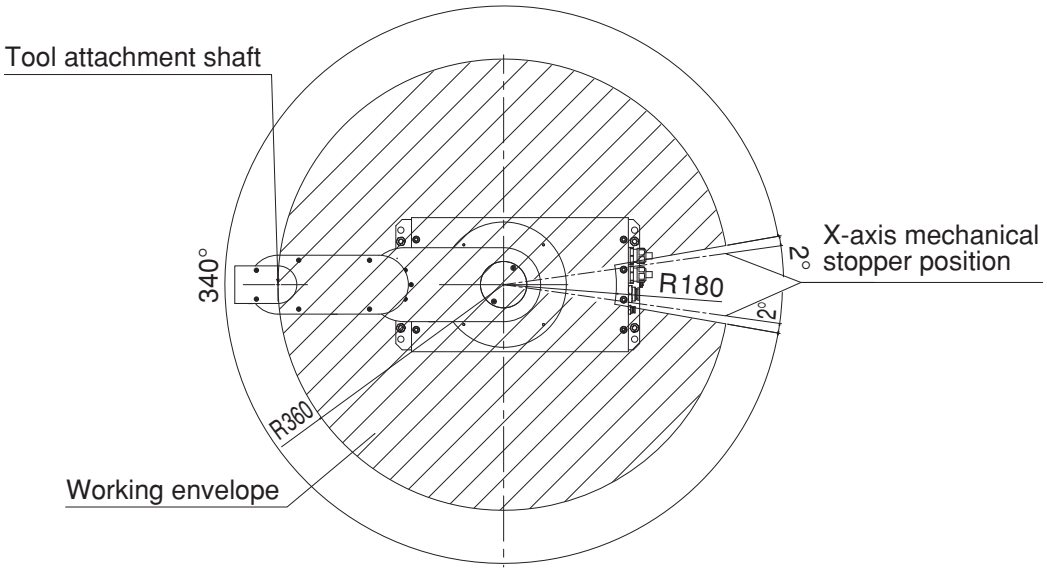
Mechanical stopper position may vary somewhat depending on parts machining accuracy.



Origin position may differ slightly from those shown above due to origin position adjustments.

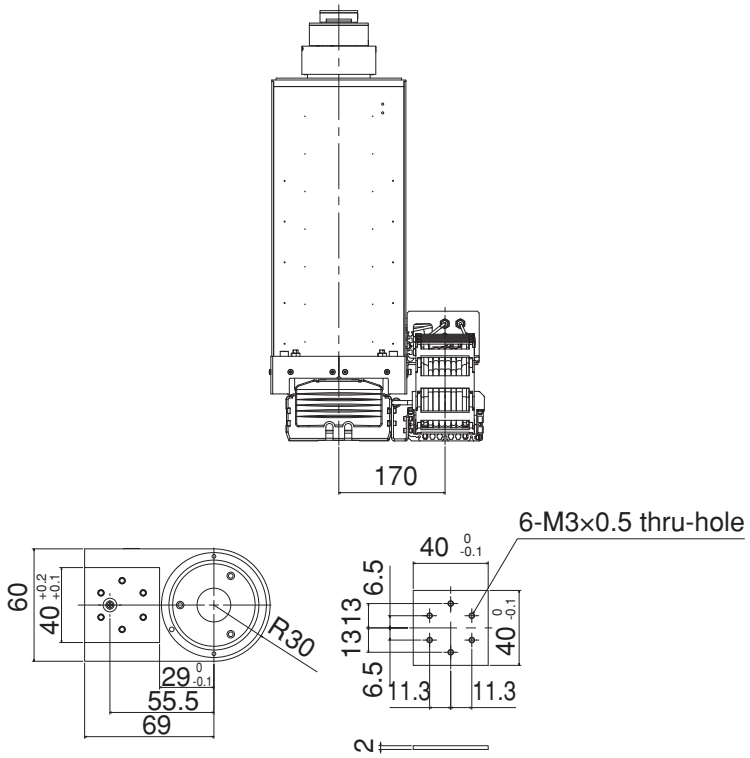


■ Fig. 7-2 4-axis specifications (with hand holder) (1)



Working envelope (tool attachment shaft position) and X-axis mechanical stopper position

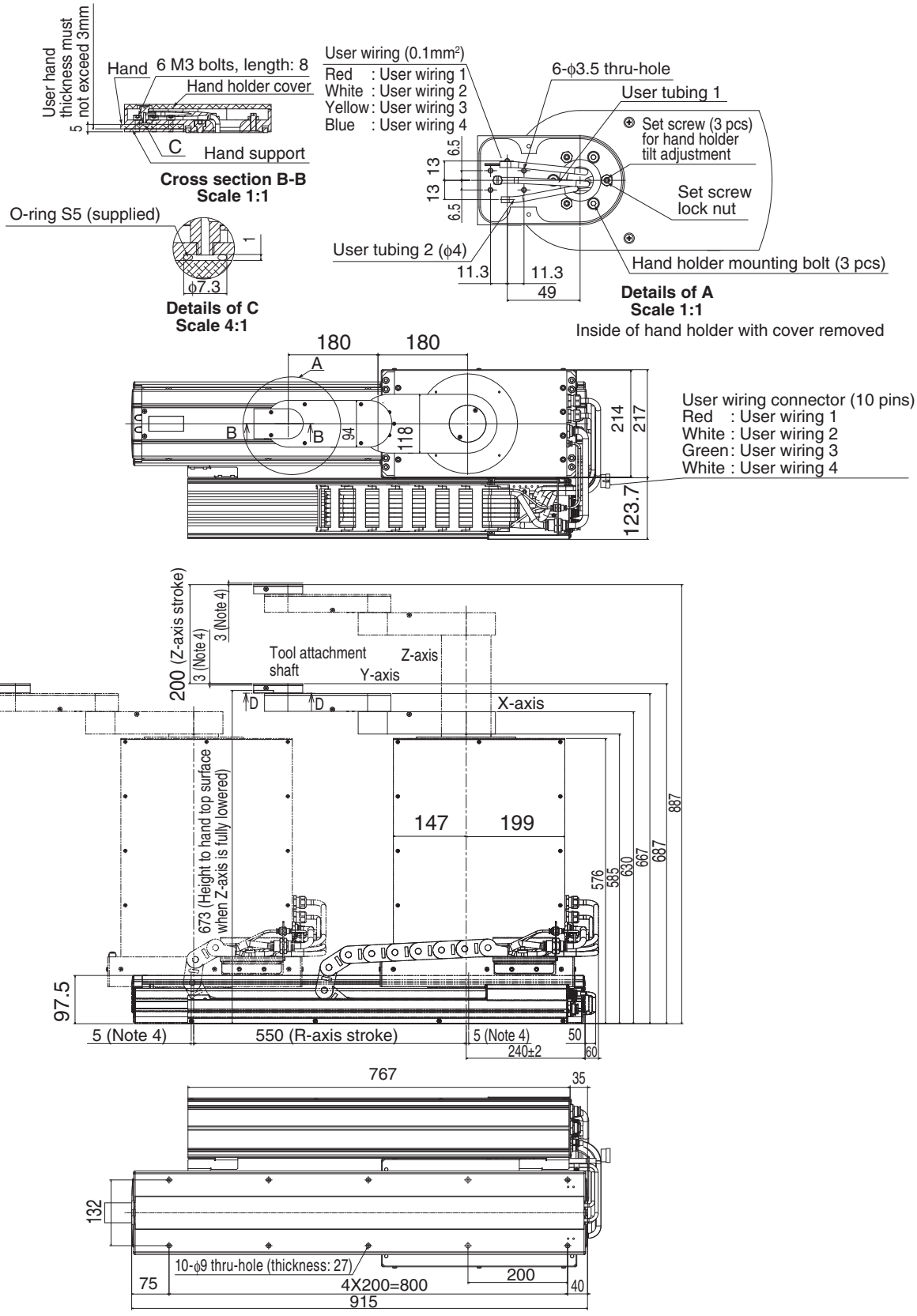
Mechanical stopper position may vary somewhat depending on parts machining accuracy. X and Y axis arms and tool attachment shaft may not extend fully, depending on parts machining accuracy or assembly condition.



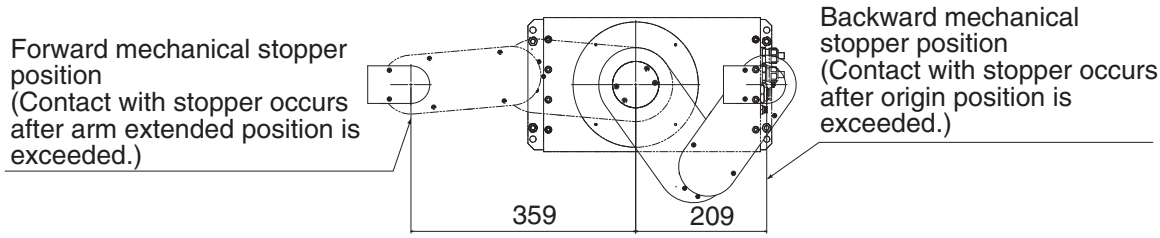
Cross section D-D
Scale 1:1

Hand support

■ Fig. 7-2 4-axis specifications (with hand holder) (2)

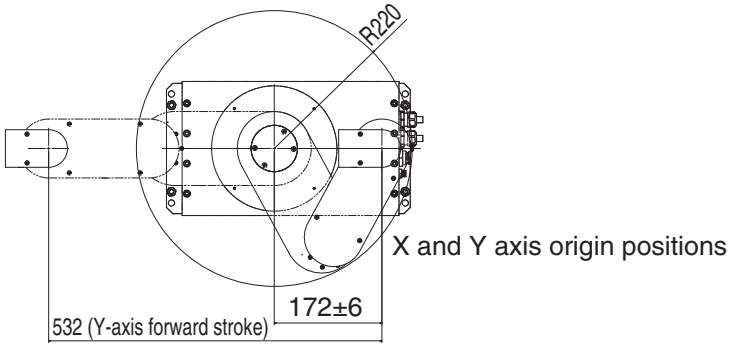


■ Fig. 7-2 4-axis specifications (with hand holder) (3)

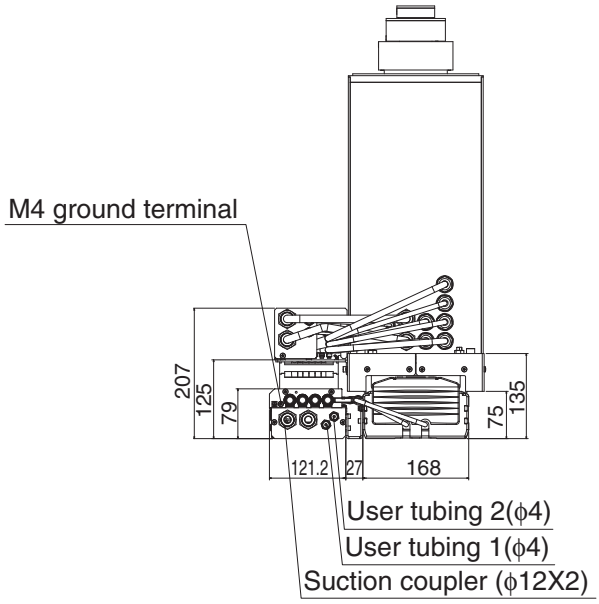


Y-axis forward mechanical stopper position

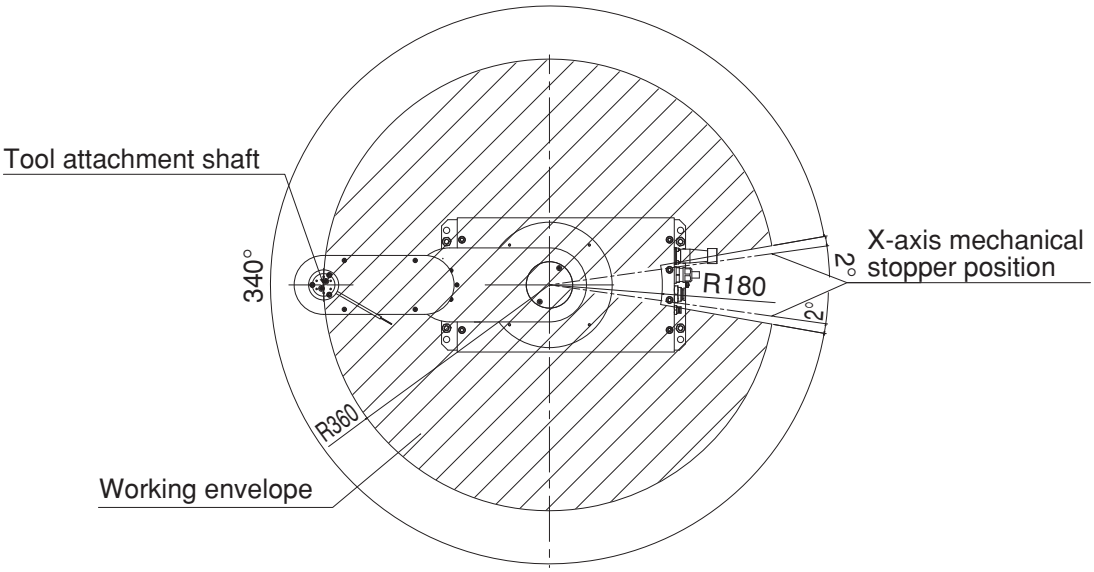
Mechanical stopper position may vary somewhat depending on parts machining accuracy.



Origin position may differ slightly from those shown above due to origin position adjustments.

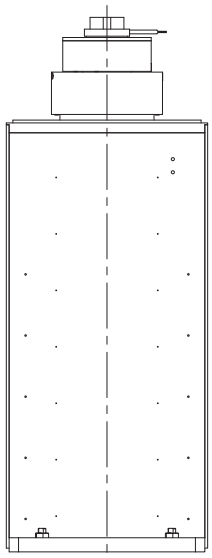


■ Fig. 7-3 3-axis specifications (without hand holder) (1)

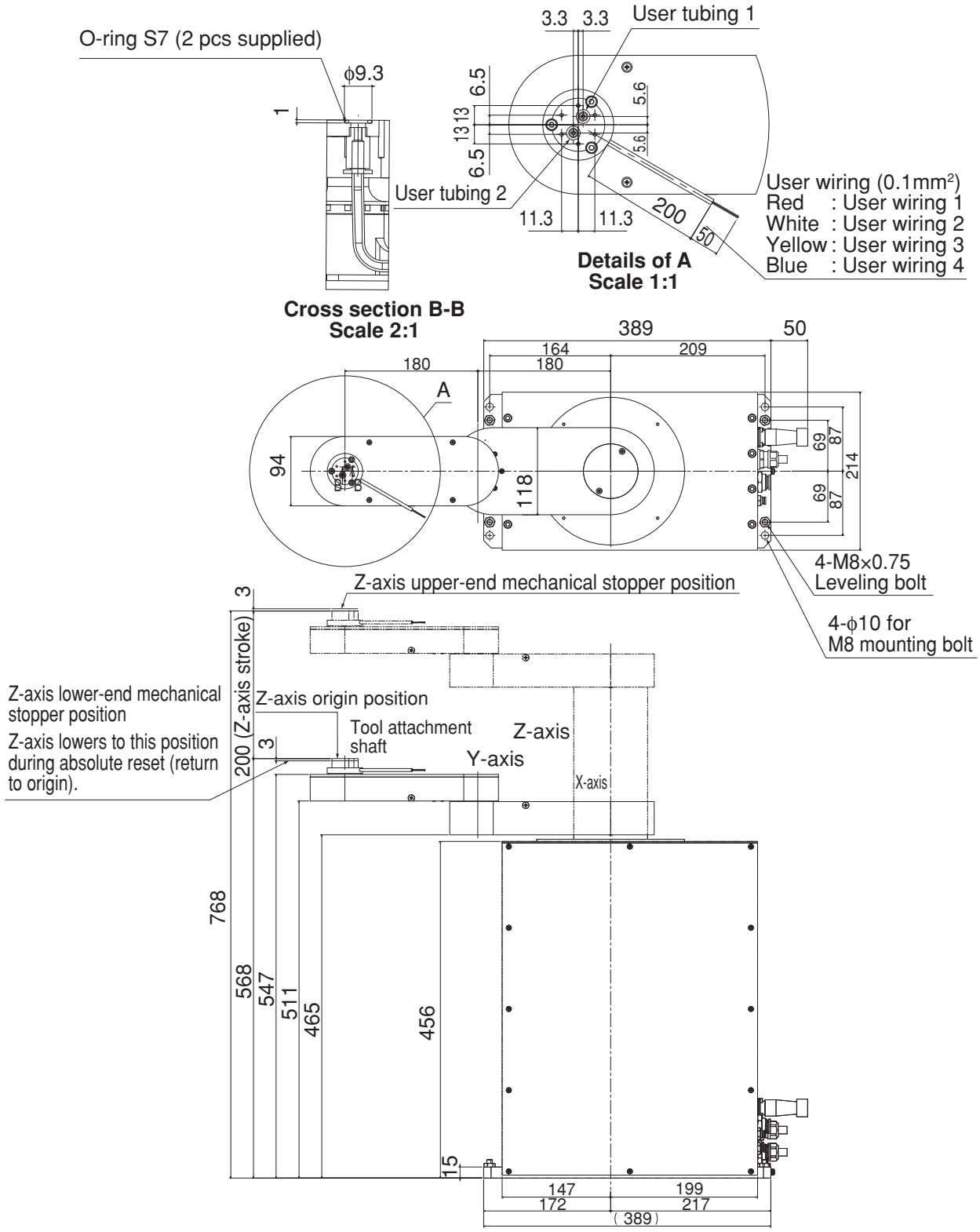


Working envelope (tool attachment shaft position) and X-axis mechanical stopper position

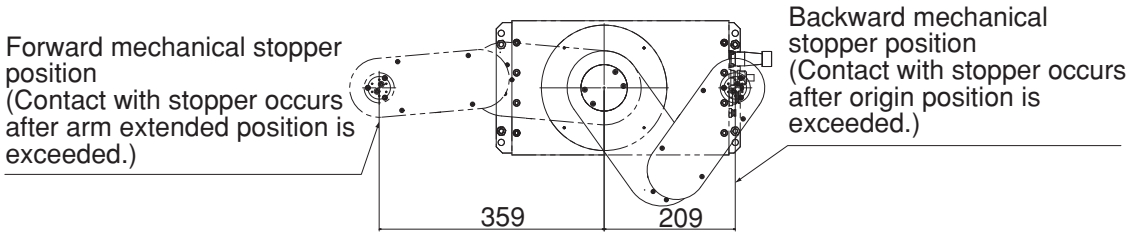
Mechanical stopper position may vary somewhat depending on parts machining accuracy. X and Y axis arms and tool attachment shaft may not extend fully, depending on parts machining accuracy or assembly condition.



■ Fig. 7-3 3-axis specifications (without hand holder) (2)

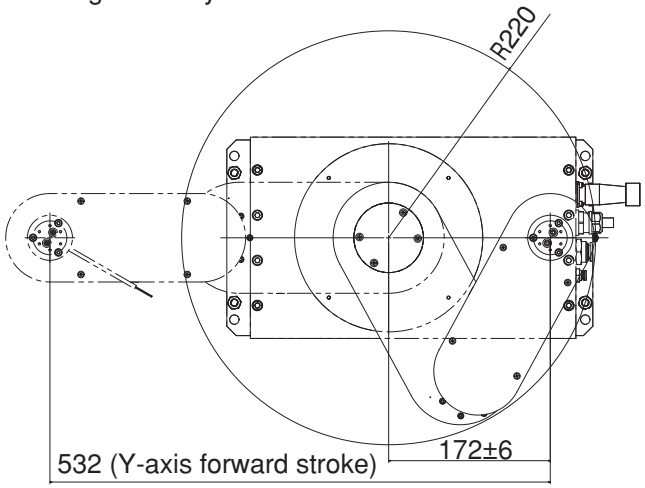


■ Fig. 7-3 3-axis specifications (without hand holder) (3)



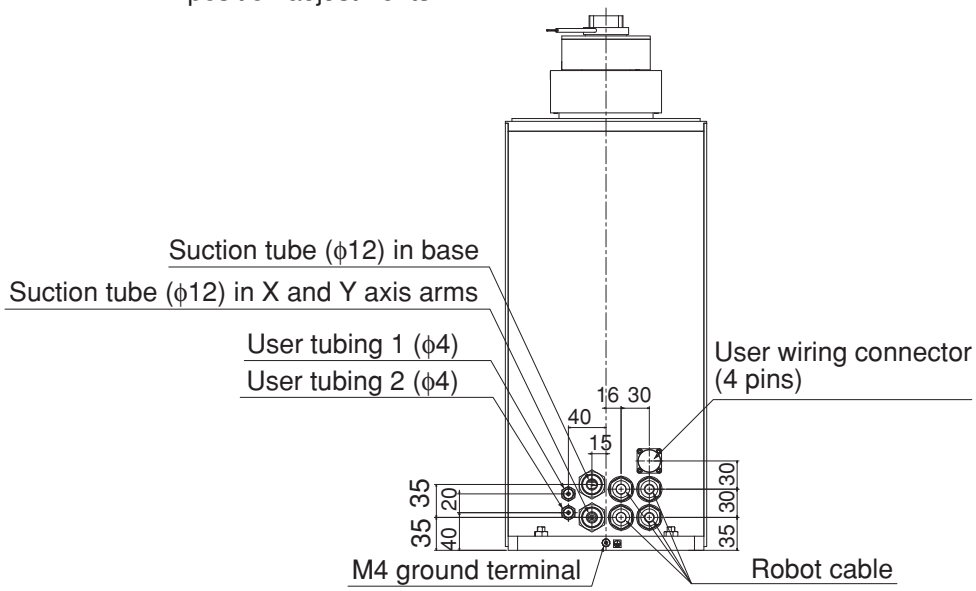
Y-axis forward mechanical stopper position

Mechanical stopper position may vary somewhat depending on parts machining accuracy.

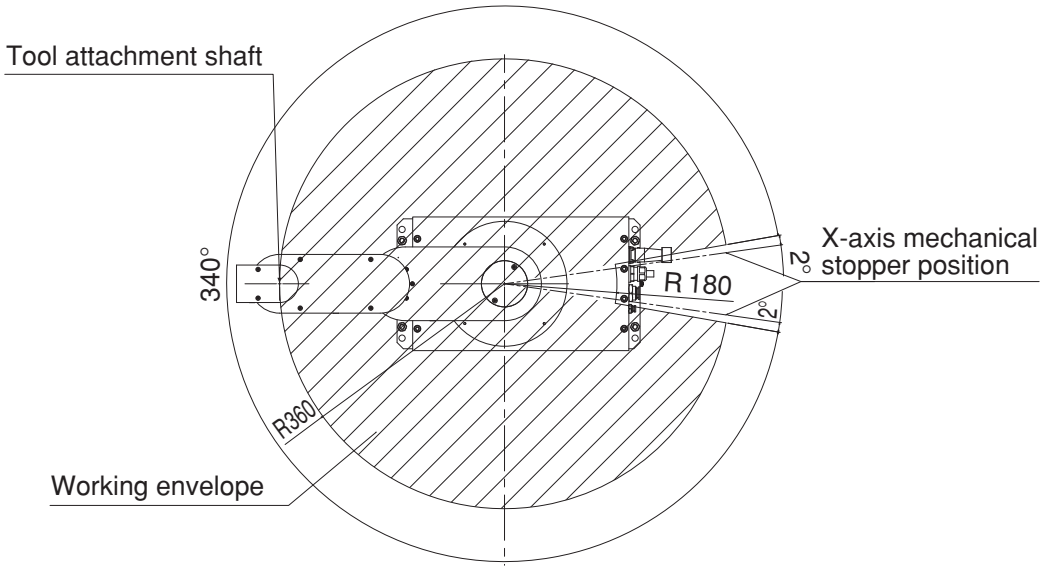


X and Y axis origin positions

Origin position may differ slightly from those shown above due to origin position adjustments.

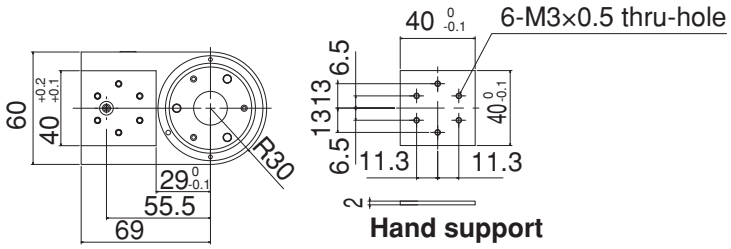


■ Fig. 7-4 3-axis specifications (with hand holder) (1)

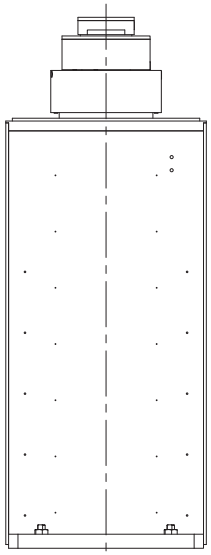


Working envelope (tool attachment shaft position) and X-axis mechanical stopper position

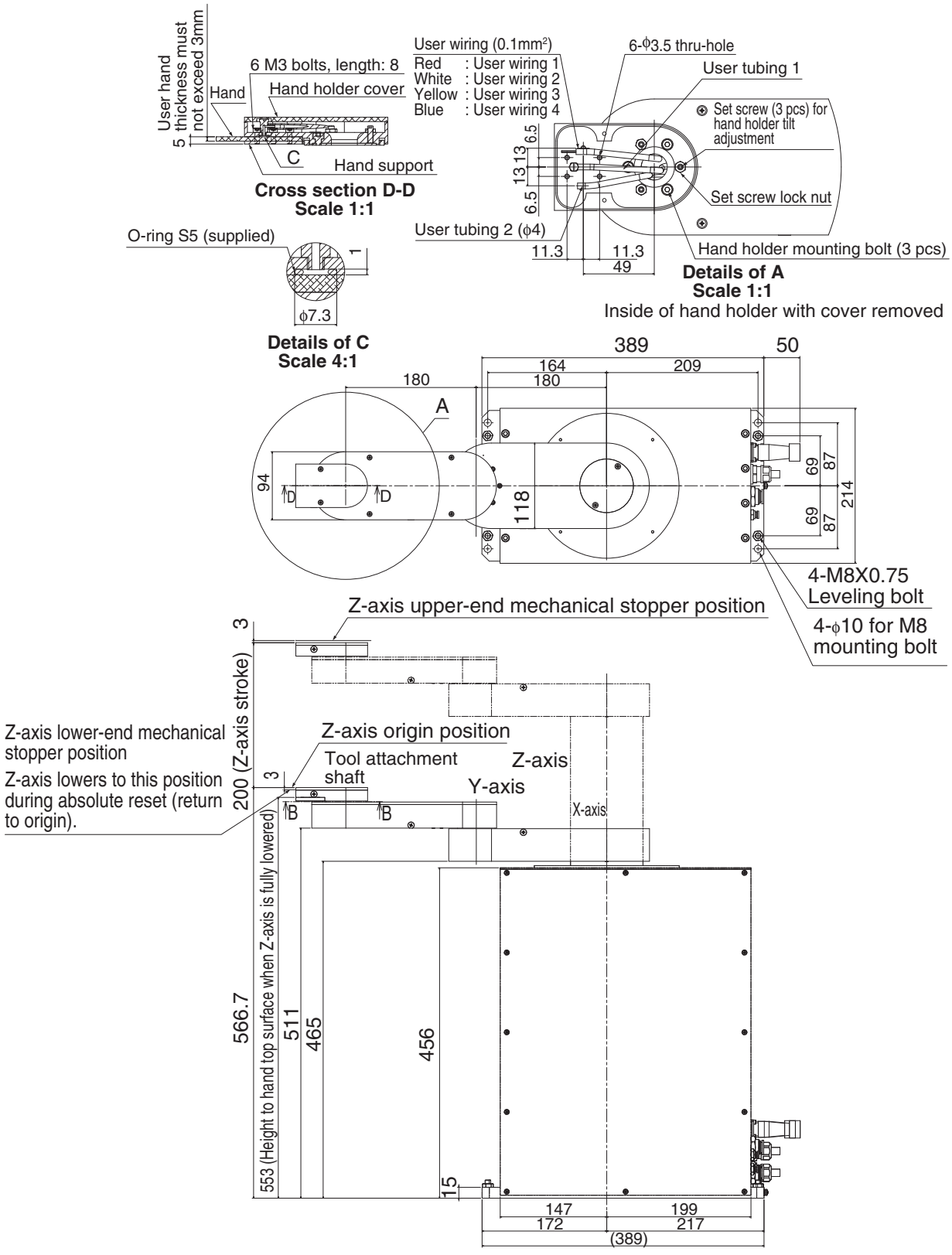
Mechanical stopper position may vary somewhat depending on parts machining accuracy. X and Y axis arms and tool attachment shaft may not extend fully, depending on parts machining accuracy or assembly condition.



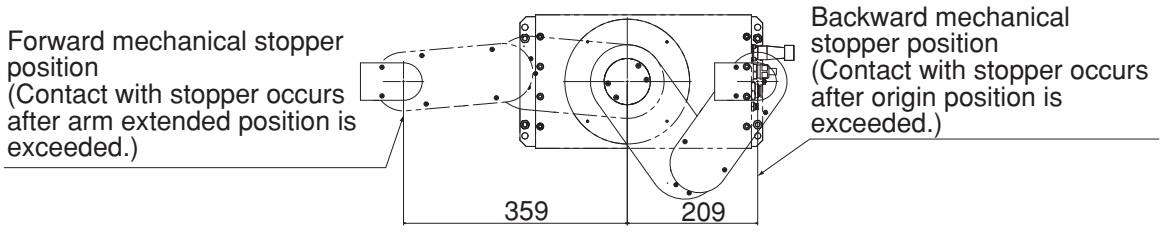
Cross section B-B
Scale 1:1



■ Fig. 7-4 3-axis specifications (with hand holder) (2)

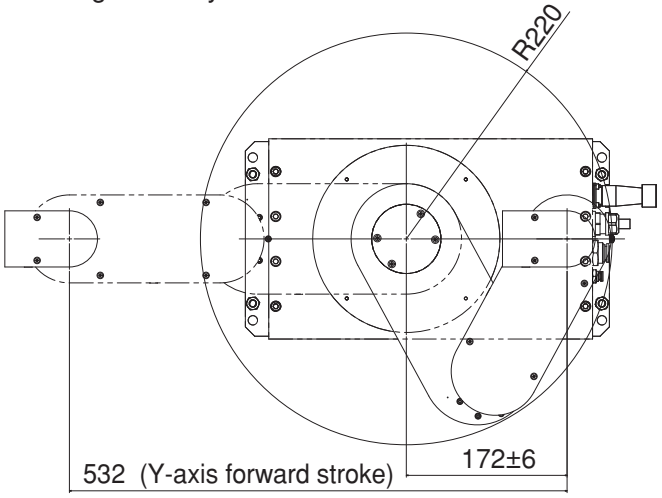


■ Fig. 7-4 3-axis specifications (with hand holder) (3)



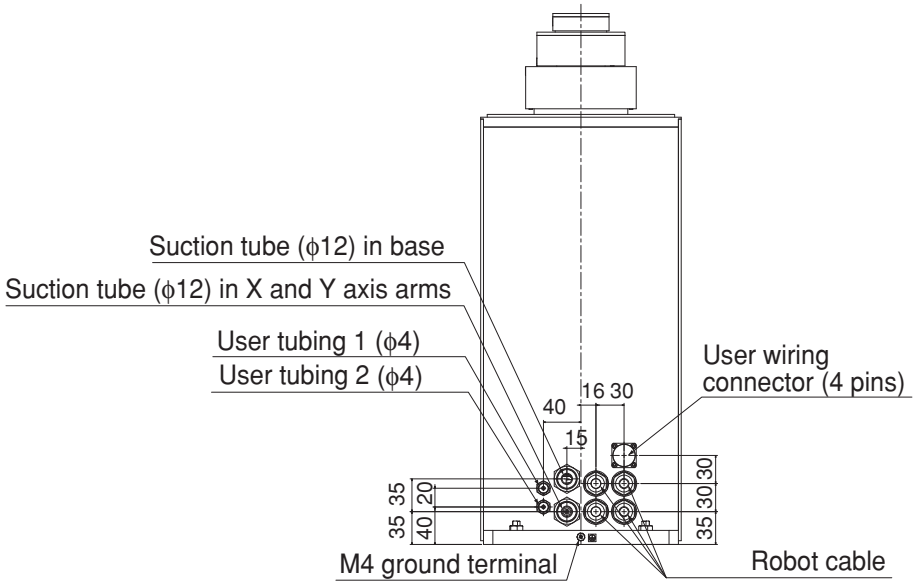
Y-axis forward mechanical stopper position

Mechanical stopper position may vary somewhat depending on parts machining accuracy.



X and Y axis origin positions

Origin position may differ slightly from those shown above due to origin position adjustments.

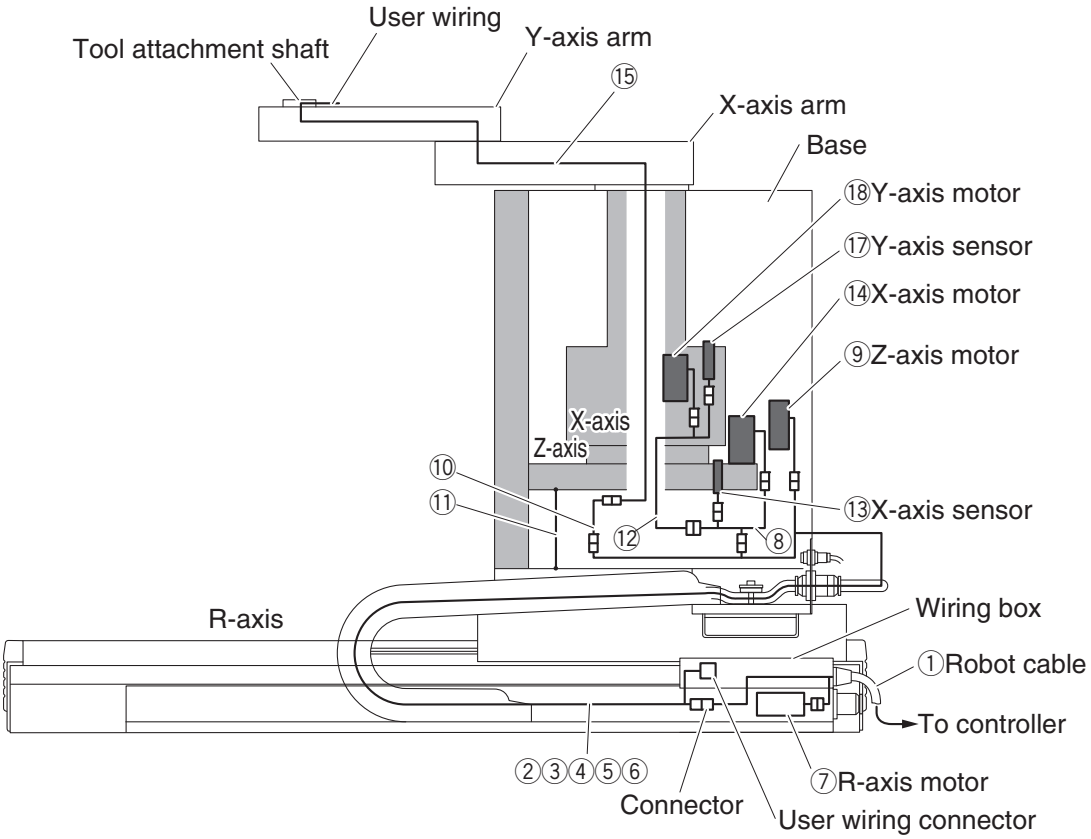


3. Robot's internal wiring diagram

(1)4-axis specifications

See "5. Wiring tables" for items numbered ① to ⑱.

■ **Fig. 7-5**



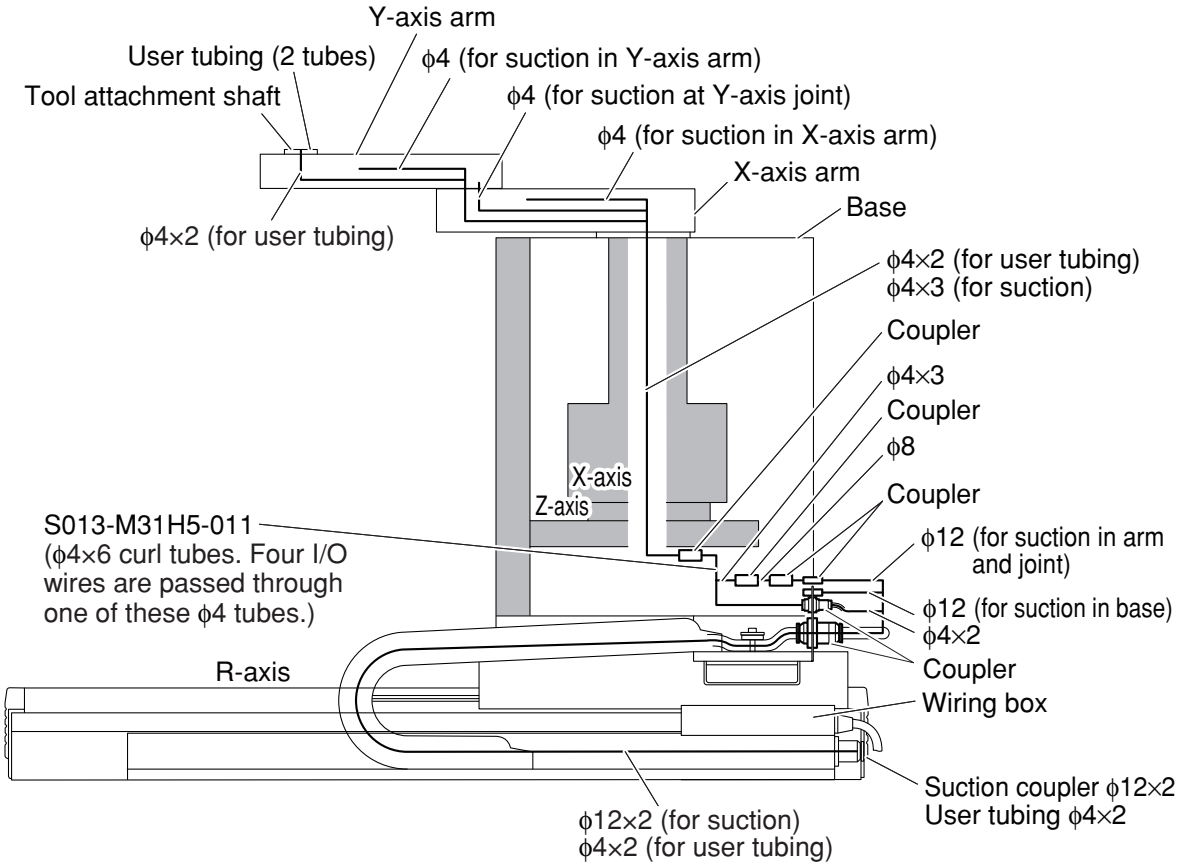
(2)3-axis specifications

The 3-axis model has no R-axis. Robot cable and user wiring connector directly come out of the base.

4. Robot's internal tubing

(1)4-axis specifications

■ Fig. 7-6



(2)3-axis specifications

The 3-axis model has no R-axis. User tubing and suction couplers directly come out of the base.

5. Wiring tables

(1)4-axis specifications

4-axis specifications ①-1

S00R-M3643-X02 (Robot cable
X=1 (Length: 1.0m) , X=2 (2.0m), X=3 (3.5m),
X=4 (4.0m) , X=5 (5.0m) , X=6 (6.0m),
X=7 (7.0m) , X=8 (8.0m) , X=9 ((9.0m) , X=A (10.0m))

Wiring box side Signal		Connector	No.	Connection	No.	Connector	Color/No.	Wire	Controller side
Resolver	S2	XP	1		1	XY	Blue	0.3sq Twisted pair	
	S4		2		2		Orange		
	S1		3		3		Green	0.3sq Twisted pair	
	S3		4		4		Brown		
	R1		5		5		Gray	0.3sq Twisted pair	
	R2		6		6		Red		
	DG		7		7			Drain wire	
Brake	MB+	XBK	1		14		Black	0.3sq Twisted pair	
	MB-		2		16		Yellow		
Resolver	S2	YP	1		19		Pink	0.3sq Twisted pair	
	S4		2		20		Violet		
	S1		3		21		White	0.3sq Twisted pair	
	S3		4		22		Blue/red		
	R1		5		23		Orange/white	0.3sq Twisted pair	
	R2		6		24		Green/white		
	DG		7		25			Shield	
Brake	MB+	YBK	1		32		Brown/white	0.3sq Twisted pair	
	MB-		2		34		Gray/white		
	HLIM				10		Green		
	GND24				11				
	HLIM				28		Green		
	GND24				29				
Sensor	24V	ORG	1		9		Red/white	0.3sq Twisted	
	ORG		2		12		Yellow/black	0.3sq Twisted pair	
	GND24		3		13		Pink/black		
Sensor	24V	ORG	1		27		White/blue	0.3sq Twisted	
	ORG		2		30		Blue/red	0.3sq Twisted pair	
	GND24		3		31		Orange/white		
	U	XM	1		2	XM	1	0.75sq	
	V		2		3		2	0.75sq	
	W		3		4		3	0.75sq	
	FG	Ring terminal	4		1		Yellow/green	0.75sq	
	U	YM	1		2	YM	4	0.75sq	
	V		2		3		5	0.75sq	
	W		3		4		6	0.75sq	
	FG	Ring terminal	4						

Grounded in wiring box → M4 ground terminal on the rear of wiring box

4-axis specifications ①-2

Signal		Connector	No.	Connection	No.	Connector	Color/No.	Wire
Resolver	S2	ZP	1		1	ZR	Blue	0.3sq Twisted pair
	S4		2		2		Orange	
	S1		3		3		Green	0.3sq Twisted pair
	S3		4		4		Brown	
	R1		5		5		Gray	0.3sq Twisted pair
	R2		6		6		Red	
	DG		7		7		Green	Drain wire
Brake	MB+	ZBK	1		14		Black	0.3sq Twisted pair
	MB-		2		16		Yellow	
Resolver	S2	RP	1		19		Pink	0.3sq Twisted pair
	S4		2		20		Violet	
	S1		3		21		White	0.3sq Twisted pair
	S3		4		22		Blue/red	
	R1		5		23		Orange/white	0.3sq Twisted pair
	R2		6		24		Green/white	
	DG		7		25		Green	Shield
Brake	MB+	RBK	1		32		Brown/white	0.3sq Twisted pair
	MB-		2		34		Gray/white	
	HLIM				10		Green	
	GND24				11			
	HLIM				28		Green	
	GND24				29			
Sensor	24V	ORG	1		9		Red/white	0.3sq Twisted
	ORG		2		12		Yellow/black	0.3sq Twisted pair
	GND24		3		13		Pink/black	
Sensor	24V	ORG	1		27		White/blue	0.3sq Twisted
	ORG		2		30		Blue/red	0.3sq Twisted pair
	GND24		3		31		Orange/white	
	U	ZM	1		2	ZM	1	0.75sq
	V		2		3		2	0.75sq
	W		3		4		3	0.75sq
	FG	Ring terminal	4		1		Yellow/green	0.75sq
	U	RM	1		2	RM	4	0.75sq
	V		2		3		5	0.75sq
	W		3		4		6	0.75sq
	FG	Ring terminal	4					

Grounded in wiring box → M4 ground terminal on the rear of wiring box

4-axis specifications ②

KT8-M4814-N12 (Cable-carrier X and Y axis power wires, R-axis stroke 550mm)

Base side

Signal	Connector	No.	Connection	No.	Connector	Remarks	Wiring box side
Motor U	M1	1		1	M1	0.75sq	
V		2		2			
W		3		3			
F. G.		4		4		Green/yellow 0.75sq	
Motor U	M2	1		1	M2	0.75sq	
V		2		2			
W		3		3			
F. G.		4		4		Green/yellow 0.75sq	

4-axis specifications ③

KT8-M4813-N12 (Cable-carrier Z-axis power wire, R-axis stroke 550mm)

Base side

Signal	Connector	No.	Connection	No.	Connector	Remarks	Wiring box side
Motor U	M	1		1	M	Red	
V		2		2		White	
W		3		3		Black	
F. G.		4		4		Yellow/green	

4-axis specifications ④

KT8-M4811-N13 (Cable-carrier Z-axis resolver and brake wires, R-axis stroke 550mm)

Base side

Signal	Connector	No.	Connection	No.	Connector	Remarks	Wiring box side
Encoder S2	P	1		1	P	Red	0.3sq Twisted pair
S4		2		2		White	
S1		3		3		Green	
S3		4		4		White	
R1		5		5		Yellow	
R2		6		6		White	
D, G		7		7		Drain wire	
Brake 24V	BK	1		1	BK	Blue	0.3sq Twisted pair
GND		2		2		White	

4-axis specifications ⑤

KT8-M4815-N04 (Cable-carrier I/O wire, R-axis stroke 550mm)

Base side

Signal	Connector	No.	Connection	No.	Connector	Remarks	Wiring box side
General-purpose I/O	I/O	1		1	I/O	Red	0.3sq Twisted pair
		2		2		White	
		3		3		Green	
		4		4		White	
		5		5		Yellow	
		6		6		White	
		7		7		Blue	
		8		8		White	
		9		9		Violet	
		10		10		White	Only No.1 to No.4 are usable.

4-axis specifications ⑥

KT8-M4816-N04: 2 pieces (Cable-carrier X and Y axis resolver and sensor wires, R-axis stroke 550mm)

Base side

Signal	Connector	No.	Connection	No.	Connector	Remarks		Wiring box side
Encoder S2	P	1		1	P	Red	0.3sq Twisted pair	
S4		2		2		White		
S1		3		3		Green		
S3		4		4		White		
R1		5		5		Yellow		
R2		6		6		White		
D, G		7		7			Drain wire	
Brake BK+	BK	1		1	BK	Blue	0.3sq Twisted pair	
BK-		2		2		White		
Origin sensor 24V	ORG	1		1	ORG	Violet	0.3sq Twisted pair	
ORG		2		2		Blue		
24VGND		3		3		Brown		

4-axis specifications ⑦

90K92-840240 (R-axis motor)

R-axis side

Signal	Color	CN	Connection	CN	Remarks	Wiring box side
S2	Yellow			CN1 1	S2	
S4	Blue			2	S4	
S1	Red			3	S1	
S3	Black			4	S3	
R1	White			5	R1	
R2	Green			6	R2	
SHIELD	Black (Heat shrinkable tube)			7	SHIELD	
U	Red			CN2 1	U	
V	White			2	V	
W	Black			3	W	
PE	Yellow/green	Ring terminal		4	PE	

Grounded to R-axis frame and R-axis motor

Grounded in wiring box

4-axis specifications ⑧

S013-M31H6-012 (X and Y axis curl cable, Z-axis stroke 200mm)

Z-axis side

Signal		Connector	No.	Connection	No.	Connector	Color	Wire		Base side
X resolver	S2	XP	1		1	XP	Red	0.2mm²	Unit 1b	
	S4		2		2		White	Twisted pair		
	S1		3		3		Yellow	0.2mm²		
	S3		4		4		Blue	Twisted pair		
	R1		5		5		Gray	0.2mm²		
	R2		6		6		Black	Twisted pair		
	DG		7		7		Green	Shield		
Y resolver	S2	YP	1		1	YP	Red	0.2mm²	Unit 1c	
	S4		2		2		White	Twisted pair		
	S1		3		3		Yellow	0.2mm²		
	S3		4		4		Blue	Twisted pair		
	R1		5		5		Gray	0.2mm²		
	R2		6		6		Black	Twisted pair		
	DG		7		7		Green	Shield		
Origin sensor	GND	XORG	3		3	XORG	Red		Unit 1d	
	ORG		2		2		White			
	24V		1		1		Yellow	0.2mm²		
Origin sensor	24V	YORG	1		1	YORG	Blue	Twisted pair		
	ORG		2		2		Gray			
	GND		3		3		Black			
						Ring terminal	Green	Shield		
X motor	U	XM	1		1	XM	Red		Unit 1a	
	V		2		2		White	0.2mm²		
	W		3		3		Yellow			
					4					
						Ring terminal	Yellow/green	0.75mm²		
Y motor	U	YM	1		1	YM	Blue		Unit 1a	
	V		2		2		Gray	0.2mm²		
	W		3		3		Black			
					4					
						Ring terminal	Yellow/green	0.75mm²		

Ring terminal is grounded to Z-axis. Ring terminal is grounded to base.
Only "Unit 1a" insulator coating is 0.3mm thick. Others are 0.15mm thick.

4-axis specifications ⑨

S013-M31K9-002 (Z-axis motor)

No.	Signal	Color	Connection	CN		Remarks	Base side
1	S2	Yellow		CN1	1	S2	
	S4	Blue			2	S4	
	S1	Red			3	S1	
	S3	Black			4	S3	
	R1	White			5	R1	
	R2	Green			6	R2	
	SHIELD	Black (Heat shrinkable tube)			7	SHIELD	
	U	Red		CN2	1	U	
	V	White			2	V	
	W	Black			3	W	
					4		
				Ring terminal		PE	
	PE	Yellow/green		Ring terminal		PE	
	BK	Yellow		CN3	1	BK	
	BK	Yellow			2	BK	

Ring terminal is grounded to base.

4-axis specifications ⑩

S013-M31H5-011 (I/O curl cable + 5Xϕ4 air tube, Z-axis stroke: 200mm)

Z-axis side

Signal	Connector	No.	Connection	No.	Connector	Color	Wire
User signal wire	IO	1		1	IO	Red	0.1mm²
		2		2		White	
		3		3		Yellow	
		4		4		Blue	
				⋮			
				10			

Base side

4-axis specifications ⑪

S013-M31E0-001 (FG curl cable, Z-axis stroke: 200mm)

Z-axis side

Signal	Connector	No.	Connection	No.	Connector	Color	Wire
	Ring terminal				Ring terminal	Yellow/green	0.75mm²

Base side

Ring terminal is grounded to Z-axis. Ring terminal is grounded to base.

4-axis specifications ⑫

S013-M3146-003 (X-axis curl cable)

X-axis side

Signal	Connector	No.	Connection	No.	Connector	Color	Wire	
Y resolver S2	XP	1		1	YP	Red	0.2mm²	Unit 1b
S4		2		2		White	Twisted pair	
S1		3		3		Yellow	0.2mm²	
S3		4		4		Blue	Twisted pair	
R1		5		5		Gray	0.2mm²	
R2		6		6		Black	Twisted pair	
DG		7		7		Green	Shield	
Y motor U	YM	1		1	YM	Red		Unit 1a
V		2		2		White	0.2mm²	
W		3		3		Yellow	Coating t0.3	
Origin sensor 24V	YORG	1		1	YORG	Blue		
ORG		2		2		Gray	0.2mm²	
GND		3		3		Black	Coating t0.15	
	Ring terminal				Ring terminal	Yellow/green	0.2mm² Coating t0.3	

Z-axis side

Ring terminal is grounded to X-axis. Ring terminal is grounded to Z-axis.

4-axis specifications ⑬

KN3-M4850-301 (X-axis sensor)

No.	Signal	Color		Connection	CN
1	+24	Brown			1
2	ORG	Black			2
3	GND	Blue			3

Z-axis side

4-axis specifications ⑭

90K90-62012X (X-axis motor)

Signal	Color	Connection	CN		Remarks
S2	Yellow		CN1	1	S2
S4	Blue			2	S4
S1	Red			3	S1
S3	Black			4	S3
R1	White			5	R1
R2	Green			6	R2
SHIELD	Black (Heat shrinkable tube)			7	SHIELD
U	Red		CN2	1	U
V	White			2	V
W	Black			3	W
PE	Yellow/green		Ring terminal		PE

Z-axis side

Ring terminal is grounded to Z-axis.

4-axis specifications ⑮

S013-M31H4-001 (Arm I/O wire)

Tool attachment shaft	Signal	Connector	No.	Connection	No.	Connector	Color	Wire
	User signal wire		1		1		Red	
			2		2	IO	White	0.1mm²
			3		3		Yellow	
			4		4		Blue	

Z-axis side

4-axis specifications ⑰

KN3-M4850-501 (Y-axis sensor)

No.	Signal	Color		Connection	CN
1	+24	Brown			1
2	ORG	Black			2
3	GND	Blue			3

X-axis side

4-axis specifications ⑱

S013-M31K0-011 (Y-axis motor)

Signal	Color	Connection	CN		Remarks
S2	Yellow		CN1	1	S2
S4	Blue/black			2	S4
S1	Brown			3	S1
S3	Brown/black			4	S3
R1	Red			5	R1
R2	Black			6	R2
SHIELD	Black (Heat shrinkable tube)			7	SHIELD
U	Red		CN2	1	U
V	White			2	V
W	Black			3	W
PE	Yellow/green		Ring terminal		PE

X-axis side

Ring terminal is grounded to X-axis.

(2)3-axis specifications

Cables different from 4-axis specifications are shown below.

3-axis specifications ①-1

S00K-M8714-X02 (Robot cable
X=1 (Length: 3.5m), X=2 (5.0m), X=3 (10m))

Base side Signal	Connector	No.	Connection	No.	Connector	Color/No.	Wire	Controller side
Resolver S2	ZP	1		1	ZR	Blue	0.15sq Twisted pair	
S4		2		2		Orange		
S1		3		3		Green	0.15sq Twisted pair	
S3		4		4		Brown		
R1		5		5		Gray	0.15sq Twisted pair	
R2		6		6		Red		
DG		7		7		Green	0.3sq	
Brake MB+	ZBK	1		14		Black	0.15sq Twisted pair	
MB-		2		16		Yellow		
				15		Pink	0.15sq Twisted pair	
				17		Violet		
Resolver S2	RP	1		19		White	0.15sq Twisted pair	
S4		2		20		Blue/red		
S1		3		21		Orange/white	0.15sq Twisted pair	
S3		4		22		Green/white		
R1		5		23		Brown/white	0.15sq Twisted pair	
R2		6		24		Gray/white		
DG		7		25		Green	0.3sq	
FG	FG	1		18		Red/white	0.15sq	
				36		Black/white	0.15sq	
HLIM				10		Green	0.3sq	
GND24				11				
HLIM				28		Green	0.3sq	
GND24				29				
Origin sensor 24V	RORG	1		27		White/blue	0.15sq	
ORG		2		30		Blue/red2	0.15sq Twisted pair	
GND		3		31		Orange/white2		
U	ZM	1		2	ZM	1	0.75sq	
W		2		3		2	0.75sq	
V		3		4		3	0.75sq	
FG	Ring terminal			1		4	0.75sq	
U	RM	1		2	RM	5	0.75sq	
W		2		3		6	0.75sq	
V		3		4		7	0.75sq	

3-axis specifications ①-2

Signal	Connector	No.	Connection	No.	Connector	Color/No.	Wire
Resolver S2	XP	1		1	XY	Blue	0.15sq Twisted pair
S4		2		2		Orange	
S1		3		3		Green	0.15sq Twisted pair
S3		4		4		Brown	
R1		5		5		Gray	0.15sq Twisted pair
R2		6		6		Red	
DG		7		7		Green	0.3sq
Resolver S2	YP	1		19		Black	0.15sq Twisted pair
S4		2		20		Yellow	
S1		3		21		Pink	0.15sq Twisted pair
S3		4		22		Violet	
R1		5		23		White	0.15sq Twisted pair
R2		6		24		Blue/red	
DG		7		25		Green	0.3sq
FG	FG	1		18		Orange/white	0.15sq
				36		Green/white	0.15sq
HLIM				10		Green	0.3sq
GND24				11			
HLIM				28		Green	0.3sq
GND24				29			
Origin sensor GND	XORG	3		13		Yellow/black	0.15sq Twisted pair
ORG		2		12		Pink/black	
24V		1		9		Violet/white	0.15sq Twisted pair
Origin sensor 24V	YORG	1		27		White/blue	
ORG		2		30		Blue/red2	0.15sq Twisted pair
GND		3		31		Orange/white2	
U	XM	1		2	XM	1 Black	0.75sq
W		2		3		2 White	0.75sq
V		3		4		3 Red	0.75sq
FG	Ring terminal			1		4 Green	0.75sq
U	YM	1		2	YM	5 Yellow	0.75sq
W		2		3		6 Brown	0.75sq
V		3		4		7 Blue	0.75sq

Ring terminal is grounded to base.

3-axis specifications ②

90K93-64214Z (Z-axis motor)

No.	Signal	Color	Connection	CN		Remarks
	S2	Yellow		CN1	1	S2
	S4	Blue			2	S4
	S1	Red			3	S1
	S3	Black			4	S3
	R1	White			5	R1
	R2	Green			6	R2
	SHIELD	Black (Heat shrinkable tube)			7	SHIELD
1						
	U	Red		CN2	1	U
	V	White			2	V
	W	Black			3	W
	PE	Yellow/green		Ring terminal		PE
	BK	Yellow		CN3	1	BK
	BK	Yellow			2	BK

Base side

Ring terminal is grounded to base.

3-axis specifications ③

S013-M31K4-001 (User wiring connector)

Base side	Signal	Connector	No.	Connection	No.	Connector	Color	Wire	User wiring side
			1		1		Red		
			2		2		White		
			3		3		Yellow	0.3mm²	
			4		4		Blue		
	For user	IO	5		5	IO			
			6						
			7						
			8						
			9						
			10						

6. Maintenance parts

Part No. beginning with "S" is a custom item and requires about 1 month for delivery.

(1)4-axis specifications

	No.	Part No.	Part name	Qty	Remarks
X-axis	X1	KN5-M1892-000	BRG., 2	1	Lower bearing for supporting speed reduction gear input section
	X2	KN5-M1891-000	BRG., 1	1	Upper bearing for supporting speed reduction gear input section
	X3	90990-17J016	O RING	1	Lower bearing outer O-ring for supporting speed reduction gear input section
	X4	KN5-M1821-004	HARMONIC DRIVE ASSY.	1	Speed reduction gear
	X5	KN5-M181H-000	O RING, 4	1	O-ring for X-axis speed reduction gear input section
	X6	90K90-62012X	AC SERVO MOTOR	1	Motor (See "5. Wiring table ⑭.)
	X7	S013-M3156-000	BELT, 1	1	Belt
	X8	S013-M3138-201	STOPPER	1	Mechanical stopper
	X9	S013-M3139-000	DAMPER, 1	2	Mechanical stopper damper
	X10	KN3-M4850-301	PROXIMITY SW. ASSY	1	Origin sensor (See "5. Wiring table ⑬.)
	X11	KN5-M1886-000	SEAL	1	Edge-face seal for speed reduction gear input section
	X12	KN3-M2159-000	O RING, 1	1	O-ring for speed reduction gear output section
	X13	S013-M31H4-001	HARNESS	1	I/O wire in arm (See "5. Wiring table ⑮.)
	X15	S013-M3146-003	HARNESS, MACHINE 2	1	Curl cable (See "5. Wiring table ⑫.)
Y-axis	Y1	S013-M31K0-011	AC SERVO MOTOR	1	Motor (See "5. Wiring table ⑱.)
	Y2	KN4-M1892-000	BRG., 2	1	Upper bearing for supporting speed reduction gear input section
	Y3	KN4-M1891-000	BRG.	1	Lower bearing for supporting speed reduction gear input section
	Y4	KN4-M181H-000	O RING, 4	1	Upper bearing outer O-ring for supporting speed reduction gear input section
	Y5	KN4-M1821-007	HARMONIC DRIVE ASSY.	1	Speed reduction gear
	Y6	KN4-M181G-000	O RING, 3	1	O-ring for speed reduction gear input section
	Y7	S013-M3155-000	BELT, 1	1	Belt
	Y8	KN3-M4850-501	PROXIMITY SW. ASSY	1	Origin sensor (See "5. Wiring table ⑰.)
	Y9	KN4-M1896-000	O RING, 2	1	O-ring for speed reduction gear output section
	Y10	S013-M31L1-000	SEAL	1	Edge-face seal for speed reduction gear input section
	Y11	S013-M3125-000	BEARING	1	Y-axis upper support bearing

	No.	Part No.	Part name	Qty	Remarks
X-axis arm	A1	S013-M3102-000	BRG.	1	Y-axis support bearing
	A2	90933-02J626	BEARING	4	Tensioner bearing
	A3	S013-M3103-000	BELT, 2	1	Belt
Y-axis arm	B1	S013-M3102-000	BRG.	1	Tool attachment shaft support bearing
	B2	90933-02J626	BEARING	4	Tensioner bearing
	B3	S013-M3104-000	BELT, 1	1	Belt
	B4	S013-M3145-101	STOPPER	2	Mechanical stopper
	B5	S013-M3144-000	DAMPER	2	Mechanical stopper damper
	B6	S013-M3154-000	O RING 2	2	Tool attachment shaft O-ring (S7)
Z-axis	Z1	90K72-0L0400	LM RAIL, 20	1	Guide
	Z2	90K72-0U0400	LM RAIL, 20	1	Guide
	Z3	90K80-020R00	LM BROCK, HSR20-R	2	Guide bearing
	Z4	90K80-020L00	LM BROCK, HSR20-L	2	Guide bearing
	Z5	KN4-M2281-001	STOPPER	1	Upper end stopper
	Z6	kN3-M2596-002	DAMPER	1	Upper end damper
	Z7	S013-M31K9-002	MOTOR ASSY., 1	1	Motor (See "5. Wiring table ⑨.)
	Z8	KX7-M2231-000	BRG.	1	Ball screw support bearing
	Z9	S013-M31G3-000	BELT	1	Belt
	Z10	S013-M31G2-100	BOLT	1	Lower end stopper
	Z11	S013-M31H6-012	HARNESS	1	X and Y axis curl cable Z-axis stroke: 200mm (See "5. Wiring table ⑧.)
	Z12	S013-M31H5-011	HARNESS	1	I/O curl cable (See "5. Wiring table ⑩.)
	Z13	S013-M31E0-001	HARNESS, EARTH	1	FG curl cable (See "5. Wiring table ⑪.)
	Z14	KT8-M4814-N12	CABLE, TERMINAL4	1	Cable-carrier X and Y axis power wires R-axis stroke 550mm (See "5. Wiring table ②.)
	Z15	KT8-M4813-N12	CABLE, TERMINAL4	1	Cable-carrier Z axis power wire R-axis stroke 550mm (See "5. Wiring table ③.)
	Z16	KT8-M4815-N04	CABLE, TERMINAL4	1	Cable-carrier I/O wire R-axis stroke 550mm (See "5. Wiring table ⑤.)
	Z17	KT8-M4811-N13	CABLE, TERMINAL4	1	Cable-carrier Z-axis resolver and brake wires R-axis stroke 550mm (See "5. Wiring table ④.)
	Z18	KT8-M4816-N04	CABLE, TERMINAL4	2	Cable-carrier X and Y axis resolver and sensor wires R-axis stroke 550mm (See "5. Wiring table ⑥.)
	Z19	90K41-000110	LABEL, ALERT	1	Warning label (Japanese: 動作中のロボットに接触すると …)
	Z20	90K41-000140	LABEL, ALERT	1	Warning label (English: Serious injury or death …)

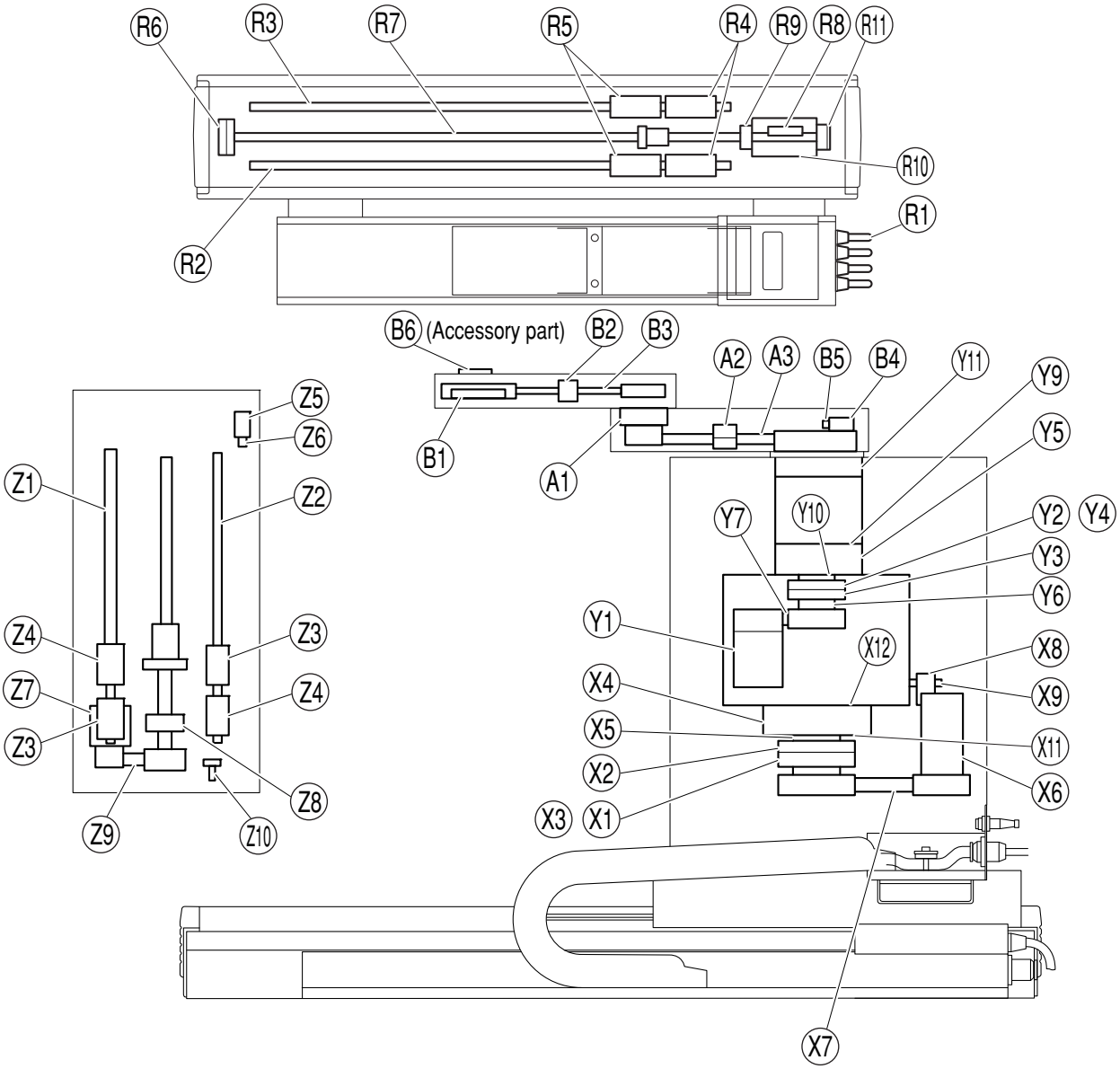
	No.	Part No.	Part name	Qty	Remarks
R-axis	R1	S00R-M3643-X02	CABLE, ROBOT	1	Robot cable (See "5. Wiring table ①.) (X=N (length N m). Note that X=3 is 3.5m and X=A is 10.0m.)
	R2	90K72-0U0730	LM RAIL, 20	1	Guide
	R3	90K72-0L0730	LM RAIL, 20	1	Guide
	R4	90K80-020L00	LM BROCK, HSR20-L	2	Guide bearing
	R5	90K80-020R00	LM BROCK, HSR20-L	2	Guide bearing
	R6	90933-01J005	BEARING	2	Non-motor side bearing
	R7	KX8-M2271-501	BALL SCREW, 1	1	Ball screw
	R8	90990-04J002	KEY	1	Motor section key
	R9	KX8-M2231-000	BRG.6302V DB C5	2	Ball screw support bearing
	R10	90K72-840240	AC SERVO MOTOR	1	Motor (See "5. Wiring table ⑦.)
	R11	KX9-M2231-000	BRG	1	Resolver bearing
	R12	KT1-M4891-000	PART, CONNECTOR	1	User wiring connector and pin

(2)3-axis specifications

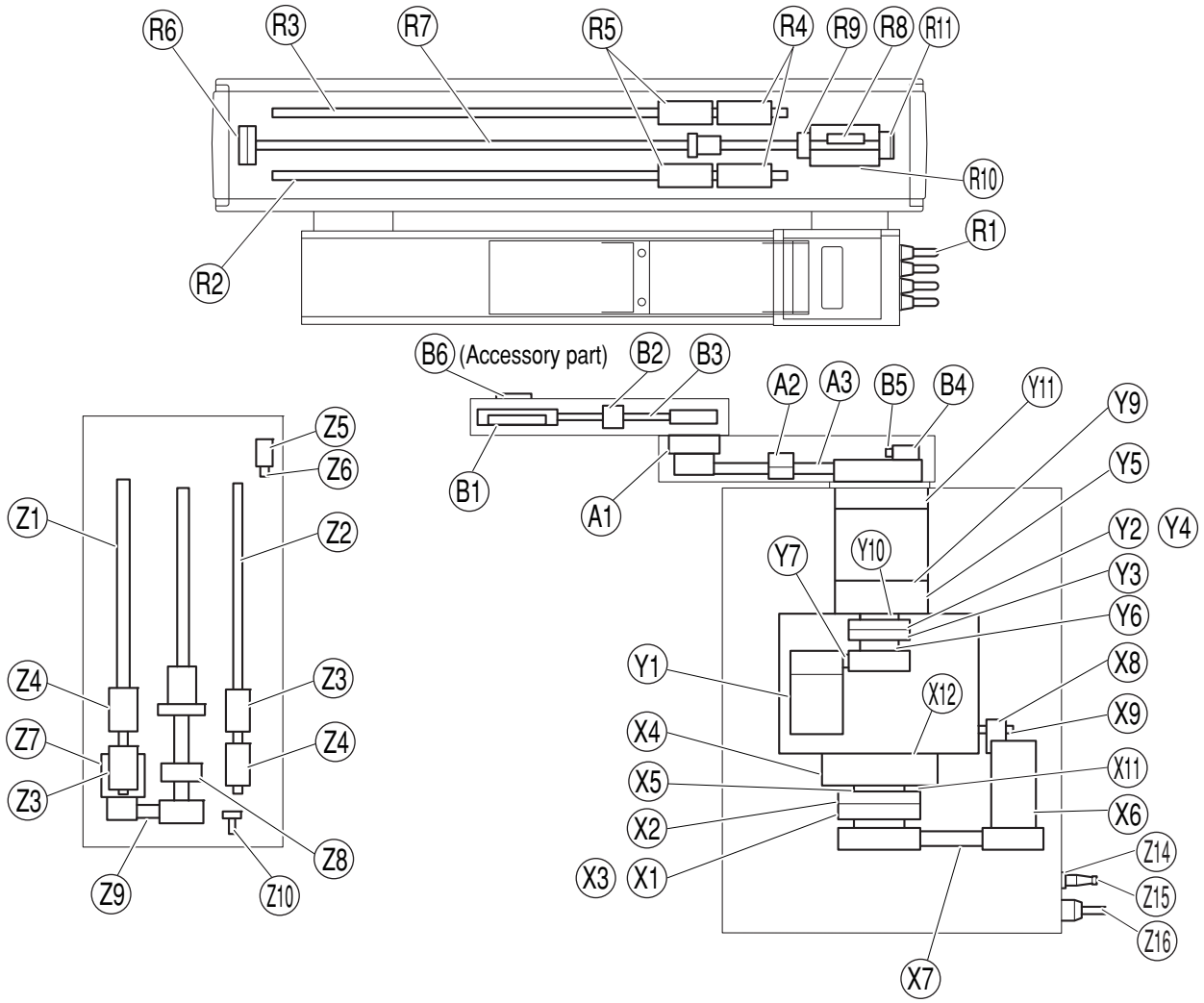
	No.	Part No.	Part name	Qty	Remarks
X-axis	X1	KN5-M1892-000	BRG., 2	1	Lower bearing for supporting speed reduction gear input section
	X2	KN5-M1891-000	BRG., 1	1	Upper bearing for supporting speed reduction gear input section
	X3	90990-17J016	O RING	1	Lower bearing outer O-ring for supporting speed reduction gear input section
	X4	KN5-M1821-004	HARMONIC DRIVE ASSY.	1	Speed reduction gear
	X5	KN5-M181H-000	O RING, 4	1	O-ring for X-axis speed reduction gear input section
	X6	90K90-62012X	AC SERVO MOTOR	1	Motor (See "5. Wiring table ⑭.)
	X7	S013-M3156-000	BELT, 1	1	Belt
	X8	S013-M3138-201	STOPPER	1	Mechanical stopper
	X9	S013-M3139-000	DAMPER, 1	2	Mechanical stopper damper
	X10	KN3-M4850-301	PROXIMITY SW. ASSY	1	Origin sensor (See "5. Wiring table ⑬.)
	X11	KN5-M1886-000	SEAL	1	Edge-face seal for speed reduction gear input section
	X12	KN3-M2159-000	O RING, 1	1	O-ring for speed reduction gear output section
	X13	S013-M31H4-001	HARNESS	1	I/O wire in arm (See "5. Wiring table ⑮.)
	X15	S013-M3146-003	HARNESS, MACHINE 2	1	Curl cable (See "5. Wiring table ⑫.)
Y-axis	Y1	S013-M31K0-011	AC SERVO MOTOR	1	Motor (See "5. Wiring table ⑱.)
	Y2	KN4-M1892-000	BRG., 2	1	Upper bearing for supporting speed reduction gear input section
	Y3	KN4-M1891-000	BRG.	1	Lower bearing for supporting speed reduction gear input section
	Y4	KN4-M181H-000	O RING, 4	1	Upper bearing outer O-ring for supporting speed reduction gear input section
	Y5	KN4-M1821-007	HARMONIC DRIVE ASSY.	1	Speed reduction gear
	Y6	KN4-M181G-000	O RING, 3	1	O-ring for speed reduction gear input section
	Y7	S013-M3155-000	BELT, 1	1	Belt
	Y8	KN3-M4850-501	PROXIMITY SW. ASSY	1	Origin sensor (See "5. Wiring table ⑰.)
	Y9	KN4-M1896-000	O RING, 2	1	O-ring for speed reduction gear output section
	Y10	S013-M31L1-000	SEAL	1	Edge-face seal for speed reduction gear input section
	Y11	S013-M3125-000	BEARING	1	Y-axis upper support bearing

	No.	Part No.	Part name	Qty	Remarks
X-axis arm	A1	S013-M3102-000	BRG.	1	Y-axis support bearing
	A2	90933-02J626	BEARING	4	Tensioner bearing
	A3	S013-M3103-000	BELT, 2	1	Belt
Y-axis arm	B1	S013-M3102-000	BRG.	1	Tool attachment shaft support bearing
	B2	90933-02J626	BEARING	4	Tensioner bearing
	B3	S013-M3104-000	BELT, 1	1	Belt
	B4	S013-M3145-101	STOPPER	2	Mechanical stopper
	B5	S013-M3144-000	DAMPER	2	Mechanical stopper damper
	B6	S013-M3154-100	O RING 2	2	Tool attachment shaft O-ring (S5)
Z-axis	Z1	90K72-0L0400	LM RAIL, 20	1	Guide
	Z2	90K72-0U0400	LM RAIL, 20	1	Guide
	Z3	90K80-020R00	LM BROCK, HSR20-R	2	Guide bearing
	Z4	90K80-020L00	LM BROCK, HSR20-L	2	Guide bearing
	Z5	KN4-M2281-001	STOPPER	1	Upper end stopper
	Z6	kN3-M2596-002	DAMPER	1	Upper end damper
	Z7	90K93-64214Z	MOTOR ASSY., 1	1	Motor (See "5. Wiring table ⑨.)
	Z8	KX7-M2231-000	BRG.	1	Ball screw support bearing
	Z9	S013-M31G3-000	BELT	1	Belt
	Z10	S013-M31G2-100	BOLT	1	Lower end stopper
	Z11	S013-M31H6-012	HARNESS	1	X and Y axis curl cable Z-axis stroke: 200mm (See "5. Wiring table ⑧.)
	Z12	S013-M31H5-011	HARNESS	1	I/O curl cable (See "5. Wiring table ⑩.) (X=0 (length: 3.5m, X=1 (5.0m), X=2 (10.0m))
	Z13	S013-M31E0-001	HARNESS, EARTH	1	FG curl cable (See "5. Wiring table ⑪.)
	Z14	S013-M31K4-001	CONNECTOR E/L, 1	1	User wiring connector
	Z15	S013-M31K5-000	CONNECTOR E/L, 2	1	User wiring connector (soldering side by user)
	Z16	S00K-M8714-X02	CABLE, ROBOT	1	Robot cable
	Z17	90K41-000110	LABEL, ALERT	1	Warning label (Japanese: 動作中のロボットに接触すると …)
	Z18	90K41-000140	LABEL, ALERT	1	Warning label (English: Serious injury or death …)

■ Fig. 7-7 4-axis specifications



■ Fig. 7-8 3-axis specifications



MEMO

Revision record

Manual version	Issue date	Description
Ver. 1.00	Feb. 2008	English manual Ver. 1.00 is based on Japanese manual Ver. 1.00.
Ver. 1.01	Mar. 2008	English manual Ver. 1.01 is based on Japanese manual Ver. 1.01.

User's Manual

YAMAHA Disk Handling Robot

(3, 4-axis specifications)

Mar. 2008
Ver. 1.01
This manual is based on Ver. 1.01 of Japanese manual.

IM Operations