



Operation Manual

PRODUCT NAME

Rotary Table

MODEL / Series / Product Number

*MSQ*10 to 200**

SMC Corporation

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Safety Instructions

These safety instructions are intended to prevent hazardous situations and/or equipment damage. These instructions indicate the level of potential hazard with the labels of “**Caution**,” “**Warning**” or “**Danger**.” They are all important notes for safety and must be followed in addition to International Standards (ISO/IEC)*¹⁾, and other safety regulations.

*1) ISO 4414: Pneumatic fluid power - General rules and safety requirements for systems and their components
ISO 4413: Hydraulic fluid power - General rules and safety requirements for systems and their components
IEC 60204-1: Safety of machinery - Electrical equipment of machines - Part 1: General requirements
ISO 10218-1: Robots and robotic devices - Safety requirements for industrial robots - Part 1: Robots
etc.



Danger

Danger indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.

Warning

Warning indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.

Caution

Caution indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.

Warning

1. The compatibility of the product is the responsibility of the person who designs the equipment or decides its specifications.

Since the product specified here is used under various operating conditions, its compatibility with specific equipment must be decided by the person who designs the equipment or decides its specifications based on necessary analysis and test results. The expected performance and safety assurance of the equipment will be the responsibility of the person who has determined its compatibility with the product. This person should also continuously review all specifications of the product referring to its latest catalog information, with a view to giving due consideration to any possibility of equipment failure when configuring the equipment.

2. Only personnel with appropriate training should operate machinery and equipment.

The product specified here may become unsafe if handled incorrectly. The assembly, operation and maintenance of machines or equipment including our products must be performed by an operator who is appropriately trained and experienced.

3. Do not service or attempt to remove product and machinery/equipment until safety is confirmed.

1. The inspection and maintenance of machinery/equipment should only be performed after measures to prevent falling or runaway of the driven objects have been confirmed.
2. When the product is to be removed, confirm that the safety measures as mentioned above are implemented and the power from any appropriate source is cut, and read and understand the specific product precautions of all relevant products carefully.
3. Before machinery/equipment is restarted, take measures to prevent unexpected operation and malfunction.

4. Our products cannot be used beyond their specifications. Our products are not developed, designed, and manufactured to be used under the following conditions or environments. Use under such conditions or environments is not covered.

1. Conditions and environments outside of the given specifications, or use outdoors or in a place exposed to direct sunlight.
2. Use for nuclear power, railways, aviation, space equipment, ships, vehicles, military application, equipment affecting human life, body, and property, fuel equipment, entertainment equipment, emergency shut-off circuits, press clutches, brake circuits, safety equipment, etc., and use for applications that do not conform to standard specifications such as catalogs and operation manuals.
3. Use for interlock circuits, except for use with double interlock such as installing a mechanical protection function in case of failure. Please periodically inspect the product to confirm that the product is operating properly.



Safety Instructions

Caution

We develop, design, and manufacture our products to be used for automatic control equipment, and provide them for peaceful use in manufacturing industries.

Use in non-manufacturing industries is not covered.

Products we manufacture and sell cannot be used for the purpose of transactions or certification specified in the Measurement Act.

The new Measurement Act prohibits use of any unit other than SI units in Japan.

Limited warranty and Disclaimer/Compliance Requirements

The product used is subject to the following “Limited warranty and Disclaimer” and “Compliance Requirements”. Read and accept them before using the product.

Limited warranty and Disclaimer

1. The warranty period of the product is 1 year in service or 1.5 years after the product is delivered, whichever is first.*2)
Also, the product may have specified durability, running distance or replacement parts. Please consult your nearest sales branch.
2. For any failure or damage reported within the warranty period which is clearly our responsibility, a replacement product or necessary parts will be provided.
This limited warranty applies only to our product independently, and not to any other damage incurred due to the failure of the product.
3. Prior to using SMC products, please read and understand the warranty terms and disclaimers noted in the specified catalog for the particular products.

***2) Vacuum pads are excluded from this 1 year warranty.**

A vacuum pad is a consumable part, so it is warranted for a year after it is delivered.

Also, even within the warranty period, the wear of a product due to the use of the vacuum pad or failure due to the deterioration of rubber material are not covered by the limited warranty

Compliance Requirements

1. The use of SMC products with production equipment for the manufacture of weapons of mass destruction (WMD) or any other weapon is strictly prohibited.
2. The exports of SMC products or technology from one country to another are governed by the relevant security laws and regulations of the countries involved in the transaction. Prior to the shipment of a SMC product to another country, assure that all local rules governing that export are known and followed.

Warning

1. Confirm the specifications.

Products represented in this catalog are designed only for use in compressed air systems.

Do not operate at pressures or temperatures, etc., beyond the range of specifications, as this can cause damage or malfunction. (Refer to the specifications.)

We do not guarantee against any damage if the product is used outside of the specification range.

2. If the operation involves load fluctuations, ascending/descending movements, or changes in friction resistance, make sure to provide safety measures.

Operating speed will increase, and bodily injury may occur, or damage to the machinery itself may occur.

3. If there is a chance that the product will pose a hazard to humans, install a protective cover.

If the moving portion of the product will pose a hazard to humans or will damage machinery or equipment, provide a construction that prevents direct contact with those areas.

4. Be certain that the secured portions will not loosen.

Be certain to adopt a reliable connecting method if the rotary table is used very frequently or if it is used in a location that is exposed to a large amount of vibrations.

5. There may be cases in which a speed reduction circuit or a shock absorber is required.

If the driven object moves at high speeds or is heavy, it will be unfeasible for only the rotary table's cushion to absorb the shock. Therefore, provide a speed-reduction circuit to reduce the rotary table's speed before the thrust is applied to the cushion, or an external shock absorber to dampen the shock. If these countermeasures are taken, make sure to take the rigidity of the mechanical equipment into consideration.

6. Consider the possibility of a reduction in the circuit air pressure caused by a power failure.

When a rotary table is used as clamping mechanism, there is a danger of workpiece dropping if there is a decrease in clamping force, due to a drop in circuit pressure caused by a power failure. Therefore, safety equipment should be installed to prevent damage to machinery and bodily injury.

7. Consider the possibility of power source related malfunctions that could occur.

For the machinery equipment that rely on power sources such as compressed air, electricity, or hydraulic pressure, adopt countermeasure to prevent the equipment from causing a hazard to humans or damage to the machinery and equipment in the event of malfunction.

8. If a speed controller is provided in the exhaust restrictor, implement a safety design taking the residual pressure into consideration.

If air pressure is applied to the air supply side without residual pressure in the exhaust side, the rotary table will operate at abnormally high speeds, which could pose a hazard to humans and damage the machinery and equipment.

9. Consider the behavior of the rotary table in the event of an emergency stop.

Devise a safe system so that if a person engages the emergency stop, or if a safety device is tripped during a system malfunction such as a power failure, the movement of the rotary table will not cause a hazard to humans or damage the equipment.

10. Consider the action of the rotary table when restarting after an emergency stop.

Devise a safe design so that the restarting of the rotary table will not pose a hazard to humans or damage the equipment. Install manually controlled equipment for safety when the rotary table has to be reset to the starting position.

11. Do not use the product as a shock absorber.

If an abnormal pressure or air leakage occurs, the rotary table's speed reduction capability could become severely affected, which could pose a hazard to humans and damage the machinery and equipment.

12. Select a speed within the product's allowable energy value.

If the product's kinetic energy of the load exceeds the allowable value, it could damage the product, and cause a hazard to humans and damage the machinery and equipment.

13. Provide a shock absorber if the kinetic energy that is applied to the product exceeds the allowable value.

If the product's kinetic energy exceeds the allowable value, it could damage the product, and cause a hazard to humans and damage the machinery or equipment.

14. Do not stop or hold the product at midpoint by keeping air pressure in the product. (Air balancers etc.)

For a product lacking an external stopping mechanism, if the directional control valve is closed to keep the air pressure in the product, in an attempt to stop the product at midpoint, it might not be possible to maintain that stopped position due to an air leakage. As a result, it could pose a hazard to humans and cause damage to machinery and/or equipment.

15. Do not use two or more rotary tables with the aim of synchronized movement.

One of the rotary tables may bear the load of operation, making synchronized movement impossible, and possibly leading to deformation of the equipment.

16. Do not use in a location where adverse effect could be occurred by the oozing of the lubricant to the exterior.

The lubricant coating the interior of the product may leak to the outside of the product from connecting parts of the rotary body, cover, etc.

17. Do not disassemble the product or make any modifications, including additional machining.

This may cause human injury and/or an accident.

18. Refer to the Auto Switches Precautions for using with an auto switch.

Caution

1. Do not use below the speed adjustment range specified for the product.

If the product is used below the specified speed adjustment range, it could cause the product to stick, slip, or the movement to stop.

2. Do not apply an external torque to the product that exceeds the rated output.

If an external force that exceeds the product's rated output is applied to the product, it could damage the product.

3. The holding torque of the rotating end of the double piston type

If the internal piston of a double piston product comes in contact with the angle adjustment screen or the cover and stops, the holding torque at the rotating end is one half of the actual output.

4. If it is necessary to provide repeatability of the rotation angle, directly stop the load externally.

Even with a product that is equipped with an angle adjuster, there are times when the initial rotation angle could change.

5. Do not use under hydraulic pressure.

The product will be damaged if it is used by applying hydraulic pressure.

6. There is a possibility of backlash being generated when stopping the double piston style in the middle with a valve of the closed center type.

7. Do not use in a places where there are many temperature fluctuations.

When using in lower temperature applications, use caution so that frost does not occur inside the cylinder or the piston rod.

Operation may be unstable.

8. Adjust the speed control in the environment in which it will be used in.

Speed adjustment may be changed if the environment is different.

Mounting

Warning

1. Operation manual

Install the product and operate it only after reading the operation manual carefully and understanding its contents. Also, keep the manual in a location where it can be referred to as necessary.

2. Ensure sufficient space for maintenance activities.

When installing the products, allow access for maintenance.

3. Tighten threads with the proper tightening torque.

When installing the products, follow the listed torque specifications.

4. Before adjusting the angle by supplying air pressure, take appropriate measures to prevent the equipment from rotating unnecessarily.

When an adjustment is performed under air pressure, the equipment could rotate and fall during the adjustment, depending on the mounted posture of the equipment. As a result, it could pose a hazard to humans and damage the machinery and equipment.

5. Do not loosen the angle adjustment screw beyond the allowable adjustment range.

The angle adjustment screw could fall out if it is loosened beyond its allowable adjustment range, which could pose a hazard to humans and damage the machinery and equipment.

6. Do not place a magnetic object near the product.

The auto switch is a magnetic sensing type. If a magnetic object is placed close to it, the rotary table could operate suddenly, which could pose a hazard to humans and damage the machinery and equipment.

7. Do not perform additional machining to the product.

Additional machining to the product can result in insufficient strength and cause damage to the product. This can lead to possible human injury and damage to the surrounding equipment.

8. Do not enlarge the fixed throttle by modifying the pipe connectors.

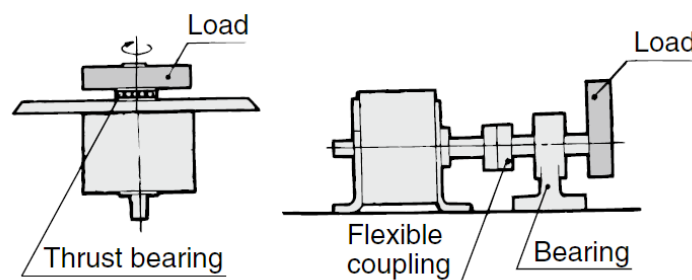
If the hole diameter is enlarged, the product's rotation speed will increase, causing the shock force to increase and damage to the product. As a result, it could pose a hazard to humans and damage the machinery and equipment.

9. If shaft couplings are used, use those with angular freedom.

If shaft couplings that lack angular freedom are used, they could scrape due to eccentricity, leading to equipment malfunction and product damage. As a result, it could pose a hazard to humans and damage the machinery and equipment.

10. Do not apply to the shaft a load that exceeds the values given in a catalog.

If a load that exceeds the allowable value is applied to the product, it could lead to equipment malfunction, a hazard to humans and damage to the machinery and equipment. Provided that a dynamic load is not generated, a load that is within the allowable radial / thrust load can be applied. However, applications in which the load is applied directly to the shaft should be avoided whenever possible. The methods such as those described below are recommended to prevent the load from being applied directly to the shaft in order to ensure a proper operating condition.



11. Do not use springs, etc., to add force in the rotational movement direction.

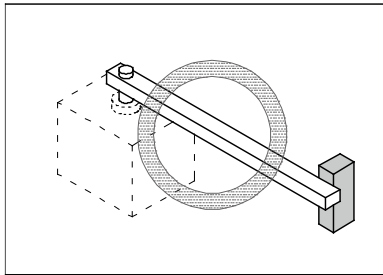
When rotational force from an external spring, etc., acts and generates negative pressure on the product's interior, breakage of the internal seal or acceleration of abrasion may occur.

12. Place an external stopper in a position that is away from the rotating table.

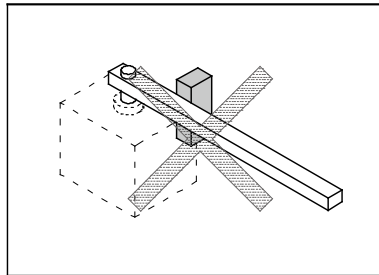
If the stopper is placed near the rotating table, the torque that is generated by the product itself will cause the reaction force which is directed to the stopper to be redirected and applied to the rotating table. This will lead to the breakage of the rotating table and bearing. As a result, it could pose a hazard to humans and damage the machinery and equipment.

Precautions when Using External Stoppers

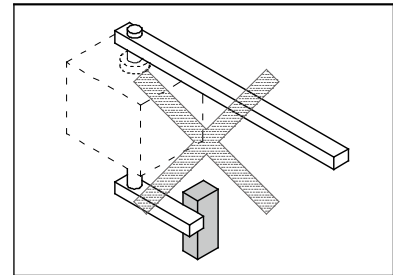
- Be sure to install external stoppers in the proper places. Installation in the wrong place can result in equipment breakage, which could damage other equipment or cause human injury.



Install the stopper at a sufficient distance from the rotating shaft.

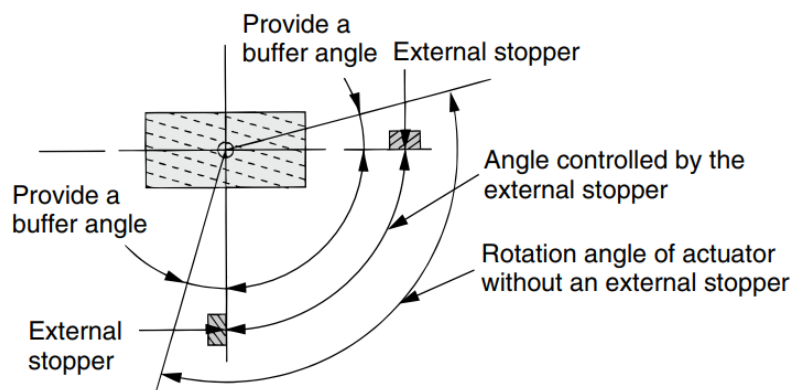


The external stopper becomes a fulcrum, resulting in the load's inertia force being applied to the table as a bending moment.



If an external stopper is installed on the opposite side of the load, the inertia force generated by the load is applied directly to the table.

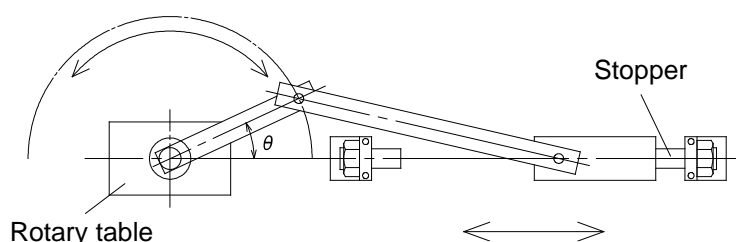
- Install external stoppers within the range of the rotating angle.
Installing an external stopper at the maximum rotation angle may result in an inability to fully absorb the kinetic energy generated, and damage to equipment may occur.
- Angle adjustment is available for this product. When using an external stopper, set in a position so that the adjusting bolt does not collide into the piston.



Precautions when Converting Rotational Motion to Linear Motion

When using a link mechanism, etc., to convert rotational motion to linear motion, and determining the operation end using the stopper on the linear motion end (see below), a small value for θ at the operation end may result in the torque of the rotary table causing excessive radial load to act on the output axle, and equipment breakage may occur.

Install a stopper on the rotation motion side, or increase the value of θ at the operation end, to make sure the load generated does not exceed the allowable value for the product.



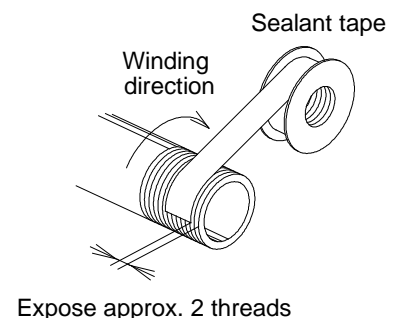
Caution

1. **Do not use organic solvent to wipe the area of the name plate that shows the model.**
It will erase what is indicated on the name plate.
2. **Do not hit the rotating table by securing the body or hit the body by securing the rotating table.**
These actions could cause the table to bend or damage the bearing.
3. **Do not place your foot directly on the table or on the equipment that is coupled to the table.**
Placing one's weight directly onto the rotating table could cause the rotating table or the bearing to become damaged.
4. **If a product is equipped with an angle adjustment function, use it within the specified adjustment range.**
If the product is used outside the specified adjustment range, it could lead to equipment malfunction or product damage. Refer to the product specifications for details on the adjustment range of the products.
5. **A product with an angle adjustment screw is temporarily secured at an arbitrary position near the rotation end. Before using the product, readjust it to the desired angle and tighten the screw firmly.**

Piping

Caution

1. **Refer to the Fittings and Tubing Precautions (Best Automation No.9) for handling one touch fittings.**
2. **Preparation before piping**
Before piping is connected, it should be thoroughly blown out with air (flushing) or washed to remove chips, cutting oil and other debris from inside the pipe.
3. **Wrapping of pipe tape**
When screwing piping or fittings into ports, ensure that chips from the pipe threads or sealing material do not enter the piping. Also, if tape is used, leave 1.5 to 2 thread ridges exposed at the end of the threads.



Speed and Cushion Adjustment

Warning

1. **To make a speed adjustment, gradually adjust starting from the low speed end.**
If the speed adjustment is performed from the high speed end, it could damage the product. As a result, it could pose a hazard to humans and damage the machinery and equipment.

2. For products with shock absorbers, when the shock absorber stops motion before reaching the stroke end using a stopper mechanism with the objective of shortening tact time be sure the shock absorber is stopped in a position where it has adequately absorbed the kinetic energy.

Failure to do so can result in damage to equipment.

3. **Note that a product with a shock absorber is not designed to achieve shock-less, smooth stop operation and constant deceleration of a load. The product absorbs the kinetic energy of a load to prevent its damage.**

Lubrication

Warning

1. This product should be used without lubrication. Although it will operate even if it is lubricated, it could lead to sticking or slipping.

Air Supply

Warning

1. **Type of fluids**

Use compressed air.

2. **When there is a large amount of moisture**

Compressed air containing a large amount of moisture can cause malfunction of pneumatic equipment. An air dryer or water separator should be installed upstream from filters.

3. **Drain flushing**

If condensation in the drain bowl is not emptied on a regular basis, the bowl will overflow and allow the condensation to enter the compressed air lines. This may cause malfunction of pneumatic equipment.

If the drain bowl is difficult to check and remove, installation of a drain bowl with an auto drain option is recommended.

4. **Use clean air.**

Do not use compressed air that contains chemicals, synthetic oils including organic solvents, salt or corrosive gases, etc., as it can cause damage or malfunction.

Caution

1. **When low dew point air is used as the fluid, degradation of the lubrication properties inside the equipment may occur, resulting in reduced reliability (or reduced service life) of the equipment.**

Please consider using low dew point products such as 25A-series.

2. **Install an air filter.**

Install an air filter upstream near the valve. Select an air filter with a filtration size of 5µm or smaller.

3. **Take measures to ensure air quality, such as by installing an aftercooler, air dryer, or water separator.**

Compressed air that contains a large amount of moisture can cause malfunction of pneumatic equipment such as rotary tables. Therefore, take appropriate measures to ensure air quality, such as by providing an aftercooler, air dryer, or water separator.

4. **Ensure that the fluid and ambient temperature are within the specified range.**

If the fluid temperature is 5°C or less, the moisture in the circuit could freeze, causing damage to the seals and equipment malfunction. Therefore, take appropriate measures to prevent freezing.

Operating Environment

Warning

1. **Do not use in an atmosphere having corrosive gases, chemicals, sea water, water, steam, or where there is direct contact with any of these.**
Refer to the construction for information on the rotary table material.
2. **Do not expose the product to direct sunlight for an extended period of time.**
3. **Do not use in a place subject to heavy vibration and/or shock.**
4. **Do not mount the product in locations where it is exposed to radiant heat.**
5. **Do not use in dusty locations or where water oil, etc., splash on the equipment.**

Maintenance

Warning

1. **Perform maintenance inspection according to the procedures indicated in the operation manual.**
If handled improperly, malfunction and damage of machinery or equipment may occur.
2. **Maintenance work**
If handled improperly, compressed air can be dangerous. Assembly, handling, repair and element replacement of pneumatic systems should be performed by a knowledgeable and experienced person.
3. **Drain flushing**
Remove drainage from air filters regularly.
4. **Removal of equipment, and supply/exhaust of compressed air**
When components are removed, first confirm that measures are in place to prevent workpieces from dropping, run-away equipment, etc. Then, cut off the supply pressure and electric power, and exhaust all compressed air from the system using the residual pressure release function.
When machinery is restarted, proceed with caution after confirming that appropriate measures are in place to prevent cylinders from sudden movement.

Caution

1. **For lubrication, use the designated grease for each specific product.**
The use of a non-designated lubricant could damage the seals.
Please refer to Table 19 on page 44 for where to apply grease and the grease to use.

Auto Switches Precautions

Design / Selection

Warning

1. Confirm the specifications.

If the product is used with excess load applied or beyond the specification range, this may cause the product to break or malfunction. We do not guarantee against any damage if the product is used outside of the specification range.

2. Cautions for use in an interlock circuit.

When an auto switch is used for an interlock signal requiring high reliability, devise a double interlock system to avoid trouble by providing a mechanical protection function, or by also using another switch (sensor) together with the auto switch.

Also, perform regular maintenance and confirm proper operation.

3. Do not attempt to disassemble, modify (including exchanging the printed circuit boards), or repair the product.

An injury or failure can result.

Caution

1. Pay attention to the length of time that a switch is ON at an intermediate stroke position.

When an auto switch is placed at an intermediate position of the stroke and a load is driven, at the time the piston passes the auto switch will operate, but if the speed is too great the operating time will be shortened and the load may not operate properly.

The maximum piston speed is:

$$V(\text{mm/s}) = \frac{\text{Auto switch operating range (mm)}}{\text{Load applied time (ms)}} \times 1000$$

2. Take precautions when multiple rotary tables are used close together.

When multiple auto switch rotary tables are used in close proximity, magnetic field interference may cause the auto switches to malfunction. Maintain a minimum cylinder separation of 40 mm. (When the allowable interval is specified for each cylinder series, use the indicated value.)

The auto switches may malfunction due to interference from the magnetic fields.

Use of a magnetic screen plate (MU-S025) or commercially available magnetic screen tape can reduce the interference of magnetic force.

3. Ensure sufficient clearance for maintenance activities.

When designing an application, be certain to allow sufficient clearance for maintenance.

4. Do not mount rotary table with the auto switch on a footing.

If work personnel gets on or puts the work personnel's foot on the footing accidentally, an excessive load is applied to the rotary table, causing the rotary table to break.

5. Design the circuit so that any back-flow current does not flow in if a short-circuit trouble occurs or forced operation is performed to check the operation.

If a back-flow current occurs, this may cause the switch to malfunction or break.

6. When multiple auto switches are required.

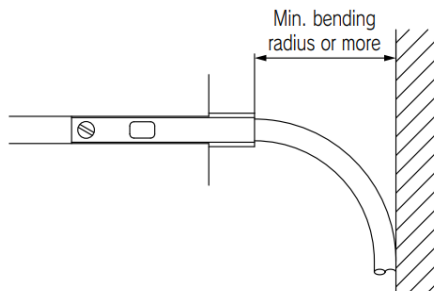
"n" indicates the number of auto switches which can be physically mounted on the rotary tables. Detection intervals depends on the auto switch mounting structure and set position, therefore some required interval and set positions may not be available.

7. Limitations on detectable position

There are positions or surfaces (bottom surface of the foot bracket, etc.) where the auto switch cannot be mounted due to the physical interference depending on the rotary table mounting status or mounting bracket. Select an appropriate auto switch setting position where the auto switch does not interfere with the rotary table mounting bracket (trunnion or reinforcing ring) after checking it sufficiently.

8. Provide enough space for the lead wire.

Applying stress to the lead wire and auto switch body connection part increases the risk of disconnection. Provide a space of at least the min. bending radius from the lead wire and auto switch body connection part.



9. Keep wiring as short as possible.

<Reed>

As the length of the wiring to a load gets longer, the rush current at switching ON becomes greater, and this may shorten the product's life. (The switch will stay ON all the time.)

- 1) Use a contact protection box when the wire length is 5m or longer.
- 2) Even if an auto switch has a built-in contact protection circuit, when the wiring is more than 30 m long, it is not able to adequately absorb the rush current and its life may be reduced.

<Solid state>

Be sure to use a wire length 100m or less.

When the wire length is long, we recommend the ferrite core should be attached to the both ends of the cable to prevent excess noise. A contact protection box is not necessary for solid state switches due to the nature of this product construction.

10. Do not use a load that generates surge voltage.

<Reed>

If a surge voltage is generated, the discharge occurs at the contact, possibly resulting in the shortening of product life.

If driving a load such as a relay that generates a surge voltage, use an auto switch with built-in contact protection circuit or use a contact protection box.

<Solid state>

If driving a load such as a relay that generates a surge voltage, use a built-in surge absorbing element type device.

11. Pay attention to the internal voltage drop of the auto switch.

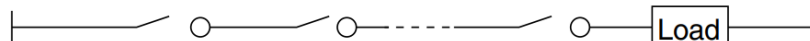
<Reed>

- 1) Auto switch with an indicator light

- If auto switches are connected in series as shown below, take note that there will be a large voltage drop because of internal resistance in the light emitting diodes. (Refer to the internal voltage drop in the auto switch specifications.)

[The voltage drop will be "n" times larger when "n" auto switches are connected.]

Even though an auto switch operates normally, the load may not operate.



- In the same way, when operating under a specified voltage, although an auto switch may operate normally, the load may not operate. Therefore, the formula below should be satisfied after confirming the minimum operating voltage of the load.

$$\text{Supply voltage} - \text{Internal voltage drop of auto switch} > \text{Minimum operating voltage of load}$$

- 2) If the internal resistance of a light emitting diode causes a problem, select an auto switch without an indicator light.

<Solid state / 2-wire type>

Generally, the internal voltage drop of the solid state auto switch is larger than that of the reed auto switch. When the auto switches ("n" pcs.) are connected in series, the voltage drop is multiplied by "n". In this case, the auto switches operate correctly, but the loads may not operate. Additionally, note that the 12 VDC relay does not apply to the auto switch.

12. Pay attention to leakage current.

<2-wire type>

Current (leakage current) flows to the load to operate the internal circuit even when in the OFF state.

$$\text{Operating current of load (OFF condition)} > \text{Leakage current}$$

If the criteria given in the above formula are not met, it will not reset correctly (stays ON). Use a 3-wire switch if this specification will not be satisfied.

Moreover, leakage current flow to the load will be "n" times larger when "n" auto switches are connected in parallel.

13. Output operation of the solid state auto switch is not stable for 50 [ms] after powered ON.

In the output operation immediately after powered ON or AND connection operation, the input device (PCL or relay, etc.) may judge the ON position as OFF output or the OFF position as ON output. So, please make the setting on the equipment so that the input judgement signal is set disabled for 50 [ms] immediately after powered ON or AND connection. When using SMC's AHC system (Auto Hand Changing System) Series MA, please also make this setting.

Mounting / Adjustment

Warning

1. Do not drop or bump.

Do not drop, bump or apply excessive impacts (300m/s² or more for reed auto switches and 1000m/s² or more for solid state auto switches) while handling. Although the body of the auto switch may not be damaged, the inside of the auto switch could be damaged and cause malfunction.

2. Observe the proper tightening torque for mounting an auto switch.

When an auto switch is tightened beyond the range of tightening torque, auto switch mounting screws, auto switch mounting brackets or auto switch may be damaged.

On the other hand, tightening below the range of tightening torque may allow the auto switch to slip out of position.

3. Do not carry a rotary table by the auto switch lead wires.

This may cause disconnection of the lead wire or the internal element to break.

4. Do not use screws other than the set screws installed on the auto switch body to secure the auto switch.

If using other screws, auto switch may be damaged.

5. Mount an auto switch at the center of the operating range.

In the case of 2-color display auto switch, mount it at the center of the green LED illuminating range.

Adjust the mounting position of the auto switch so that the piston stops at the center of the operating range. (The mounting position shown in the catalog indicates the optimum position at stroke end.)

If mounted at the end of the operating range (around the borderline of ON and OFF), operation will be unstable depending of the operating environment. Also there are some rotary tables with individual setting methods for auto switches. If so, mount it in accordance with the indicated method.

Even if 2-color indication solid state auto switches are fixed at a proper operating range (the green light lights up), the operation may become unstable depending on the installation environment or magnetic field disturbance.

(Magnetic body, external magnetic field, proximal installation of rotary actuators with built-in magnet and actuators, temperature change, other factors for magnetic force fluctuation during operation, etc.)

6. Check the actual actuation status and adjust the auto switch mounting position.

According to the installation environment, the rotary table may not operate even at its proper mounting position. Even when setting at a midpoint of the stroke, check the actuation status and make the adjustment in the same manner.

7. Be very careful when handling the auto switch mounting band, as it has a thin structure.

Wiring

Warning

1. Confirm proper insulation of wiring.

If there is any improper insulation (mixed contact with other circuit, grounding fault, or improper insulation between terminals, etc.) in the wiring, an over-current flows in, causing the auto switch to break.

2. Wire separately from power lines of high voltage lines, avoiding parallel wiring of wiring in the same conduit with these lines.

If an inrush current is generated, the noise may cause the auto switch to malfunction.

3. Be certain to connect the load before power is applied.

<2-wire type>

If the power is turned ON when an auto switch is not connected to a load, the auto switch will be instantly damaged because of excess current (short circuit).

It is the same as when the 2-wire brown lead wire (+, output) is directly connected to the (+) power supply terminal.

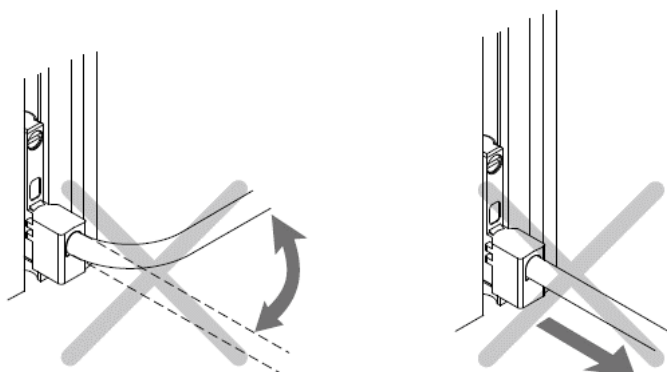
4. Carry out the wiring work after shutting down the power.

If the wiring work is performed with the power turned ON, this may cause electric shock, malfunction, or damage to the auto switch.

5. Avoid repeatedly bending or stretching lead wires.

Broken lead wires will result from repeatedly applying bending stress or stretching force to the lead wires.

Stress and tensile force applied to the connection between the lead wire and auto switch increases the possibility of disconnection.



6. Do not allow short-circuit of loads.

<Reed>

If the power is turned ON with a load in a short circuit condition, the switch will be instantly damaged because of excess current flow into the switch.

<Solid state>

PNP output type auto switches do not have built-in short circuit protection circuits.

Carefully handle as the auto switch may be damaged.

7. Avoid incorrect wiring.

<Reed>

A 24 VDC auto switch with indicator light has polarity. The brown lead wire or terminal No.1 is (+), and the blue lead wire or terminal No.2 is (—).

- 1) If connections are reversed, an auto switch will operate, however, the light emitting diode will not light up.

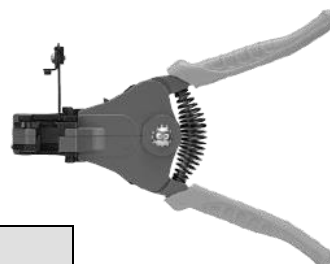
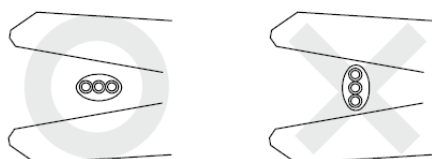
Also, take note that a current greater than that specified will damage a light emitting diode and it will no longer operate.

Applicable model: D-93, A93V

<Solid state>

- 1) If connections are reversed on a 2-wire type auto switch, the auto switch will not be damaged if protected by a protection circuit, but the auto switch will always stay in an ON state. However, it is still necessary to avoid reversed connections, since the auto switch could be damaged by a load short circuit in this condition.
- 2) If connections are reversed (power supply line + and power supply line—) on a 3-wire type auto switch, the auto switch will be protected by a protection circuit. However, if the power supply line (+) is connected to the blue wire and the power supply line (—) is connected to the black wire, the auto switch will be damaged.

8. When the lead wire sheath is stripped, confirm the stripping direction. The insulator may be split or damaged depending on the direction. (D-M9□ only)



Recommended Tool

Description	Model
Wire stripper	D-M9N-SWY

* Stripper for a round cable (Ø2.0) can be used for a 2-wire type cable.

Operation Environment

Warning

1. Never use in an atmosphere with explosive gases.

The structure of auto switches is not intended to prevent explosion. This may lead to explosion hazard.

Caution

1. Do not use in an area where a magnetic field is generated.

Auto switches will malfunction or magnets inside rotary tables will become demagnetized.

2. Do not use in an environment where the auto switch will be continually exposed to water.

Although auto switches satisfy IEC standard IP67 construction expect some models (D-A3□, A44□, G39□, K39□, RNK, RPK) do not use auto switches in applications where continually exposed to water splash or splay. This may cause improper insulation or malfunction.

3. Do not use in an environment with oil or chemicals.

If auto switches are used in an environment containing coolant, cleaning solvent, various oils, or chemicals even for a short period of time, this may adversely affect the auto switches, resulting in improper insulation, malfunction due to swelling of the potting resin, or hardening of the lead wires.

4. Do not use in an environment with temperature cycles.

If temperature cycles other than normal temperature changes are applied, this may adversely affect the insides of the auto switches.

5. Do not use in an environment where there is excessive impact shock.

<Reed>

When excessive impact (300m/s² or more) is applied to a reed auto switch during operation, the contacts may malfunction and generate or cut off a signal momentarily (1ms or less).

6. Do not use in an area where surges are generated.

<Solid state>

If there is an equipment unit (electromagnetic lifter, high-frequency induction furnace, motor, or radio, etc.) that generates large surges or electromagnetic waves around cylinders with solid state auto switches or actuators, this may cause the circuit element inside the auto switch to break.

7. Avoid accumulation of iron waste or close contact with magnetic substances.

If many iron particles, such as cutting chips or spatters accumulate around a rotary table with the auto switches if a magnetic substance (attracted by a magnet) is put close to a rotary table with the auto switch, the magnetic force inside the rotary table loses, causing the auto switch to malfunction.

8. Do not use in direct sunlight.

9. Do not mount the product in locations where it is exposed to radiant heat.

10. Take appropriate measures against the lightning surge on the equipment side as the auto switches do not have any lightning surge resistance specified in the CE marking.

Maintenance

Warning

1. Removal of equipment, and supply/exhaust of compressed air.

Before any machinery or equipment is removed, first ensure that the appropriate measures are in place to prevent the fall or erratic movement of driven objects and equipment, then cut off the electric power and reduce the pressure in the system to zero. Only then should you proceed with the removal of any machinery and equipment.

When machinery is restarted, proceed with caution after confirming that appropriate measures are in place to prevent rotary tables from moving suddenly.

2. Do not touch a terminal during energizing.

Touching a terminal during energizing may cause electric shock, malfunction, or auto switch breakage.

Caution

1. Perform the following maintenance periodically in order to prevent possible danger due to unexpected auto switch malfunction.

1) Secure and tighten auto switch mounting screws.

If screws become loose or the mounting, position is dislocated, retighten them after readjusting the mounting position.

2) Confirm that there is no damage to lead wires.

To prevent faulty insulation, replace auto switches or repair lead wires, etc., if damage is discovered.

3) Confirm the detection setting position.

• Red light of 1-color display auto switch

Confirm that the set position stops at the center of the operating range (red display area).

• Conform the green light and position of the 2-color display auto switch.

Conform that the set position stops at the center of the appropriate operating range (green display area). If stopped with the red LED lit, the operation may become unstable due to effects of the equipment environment or external disturbance. So, set the mounting position at the center of the appropriate operating range again.

2. Do not use solvents such as benzene, thinner etc. to clean the product.

They could damage the surface of the body and erase the markings on the body. For heavy stains, use a cloth lightly dampened with diluted neutral detergent, then wipe up any residue with a dry cloth.

Handling Precautions

Caution

1. Do not remove the protective cover attached to the auto switch (D-A9 · (V)/Z7 · /Z80 type) product body until immediately before the product is to be mounted to the rotary table.

The protective cover attached to the body of the D-A9 · (V)/Z7 · /Z80 type auto switch is intended to reduce impact during handling and prevent the auto switch holding screw from falling out.

In particular, it reduces impact to the auto switch body if it is accidentally bumped when mounting a connector or tubing to the auto switch, so do not remove it until immediately before mounting it to the rotary table.

Outline

This operation manual explains “Rack and Pinion Type Rotary Cylinder”.
When using the product, load (moment of inertia), rotation time and other factors have to be considered.
So, confirm the specification of the product prior to use.

Specifications

Table 1. Specifications

Size		10	20	30	50	70	100	200
Fluid		Air (non-lube)						
Maximum Operating Pressure	With adjustment bolt	1MPa						
	With internal shock absorber	0.6MPa						
	With external shock absorber	1MPa				—		
Minimum Operating Pressure	With adjustment bolt	0.1MPa ^{Note1)}						
	With internal shock absorber							
	With external shock absorber	0.2MPa				—		
Ambient and fluid temperature		0 to 60°C (no freezing)						
Cushion		Rubber bumper						
		Shock absorber						
		External shock absorber				—		
Allowable Kinetic Energy (J)	With adjustment bolt	0.007[J]	0.025[J]	0.048[J]	0.081[J]	0.240[J]	0.320[J]	0.560[J]
	With internal shock absorber	0.039[J]	0.116[J]	0.116[J]	0.294[J]	1.100[J]	1.600[J]	2.900[J]
	With external shock absorber (For low energy)	0.161[J]	0.574[J]	0.805[J]	1.310[J]	—		
	With external shock absorber (For high energy)	0.231[J]	1.060[J]	1.210[J]	1.820[J]			
Angle adjustment Range	With adjustment bolt	0 to 190 ^{Note2)}						
	With internal shock absorber							
	With external shock absorber	Each rotation end ±3° ^{Note3)}						
Maximum Rotation	With adjustment bolt	190°						
	With internal shock absorber							
	With external shock absorber	96°, 186°				—		
Rotation Time Adjustment Range	With adjustment bolt	0.2 to 1.0s/90°				0.2 to 1.5s/90°	0.2 to 2.0s/90°	0.2 to 2.5s/90°
	With internal shock absorber	0.2 to 0.7s/90°				0.2 to 1.0s/90°		
	With external shock absorber	0.2 to 1.0s/90° ^{Note4)}				—		
Cylinder bore size		Ø15	Ø18	Ø21	Ø25	Ø28	Ø32	Ø40
Port size		M5x0.8			Rc1/8 (G1/8, NPT1/8, NPTF1/8), M5x0.8			

Note1) Minimum operating pressure of MSQA10* (High precision type: size 10) is 0.2MPa.

Note2) Be careful if the rotation angle of a type with internal shock absorber is set below the value in the table below. The piston stroke will be smaller than the shock absorber's effective stroke, resulting in decreased energy absorption ability.

Note 3) For external absorber type there are two rotating angles, 90° specification and 180° specification.

Note 4) The values in the table indicate the time from the start of rotation until the shock absorber acts, reducing the speed. After deceleration, the time required to reach the rotating end is about 0.2 to 2s. However, it varies according to the operating conditions (moment of inertia for load, rotating speed, operating pressure).

The shock absorber acts in the range between the rotating end and the angles shown table 3.

Table 2. Minimum rotation angle that will not allow decrease of energy absorption ability
(Internal shock absorber type)

Size	10	20	30	50	70	100	200
Minimum rotation angle that will not allow decrease of energy absorption ability	52°	43°	40°	60°	71°	62°	82°

Table 3. Rotating angle at which the shock absorber acts (External shock absorber type)

Size	10	20	30	50	70	100	200
For low energy	7.1°	6.9°	6.2°	9.6°	—		
For high energy	8.6°	8.0°	7.3°	10.5°			

Mass

Table 4. Mass

[g]

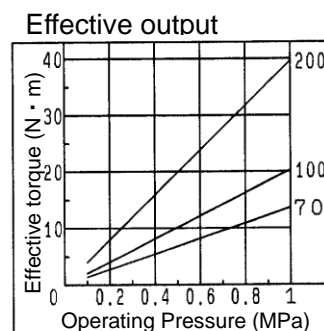
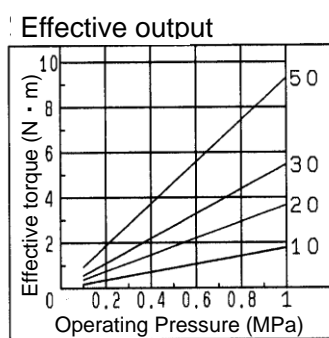
Size			10	20	30	50	70	100	200
Basic Type	With adjustment bolt		500	940	1230	1990	2880	4090	7580
	With internal shock absorber		510	940	1230	2010	2890	4100	7650
	With external shock absorber	90° specification	600	1150	1460	2390	—		
		180° specification	570	1090	1390	2280			

[g]

Size			10	20	30	50
High precision type	With adjustment bolt		530	1040	1350	2150
	With internal shock absorber		540	1040	1350	2170
	With external Shock absorber	90° specification	670	1340	1690	2720
		180° specification	640	1290	1620	2600

Note) Values above do not include auto switch mass.

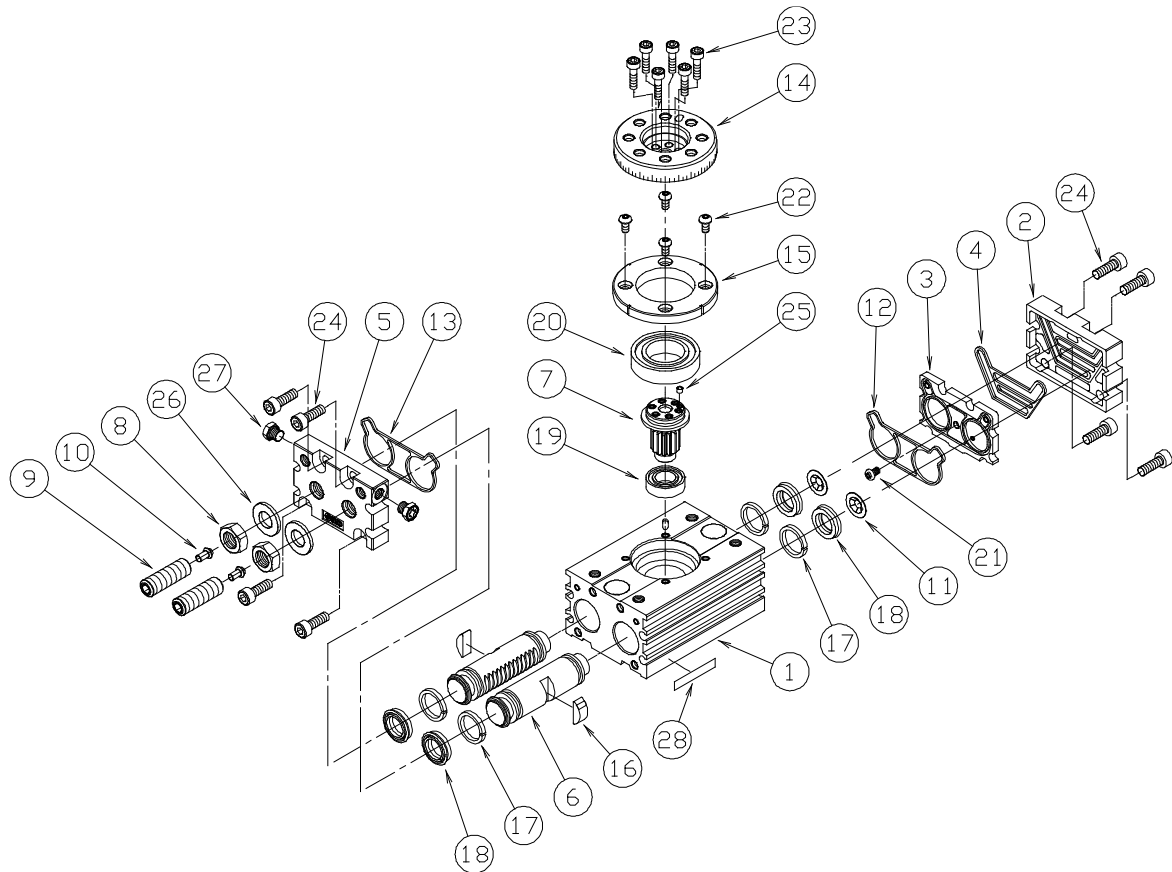
Effective torque



Graph 1

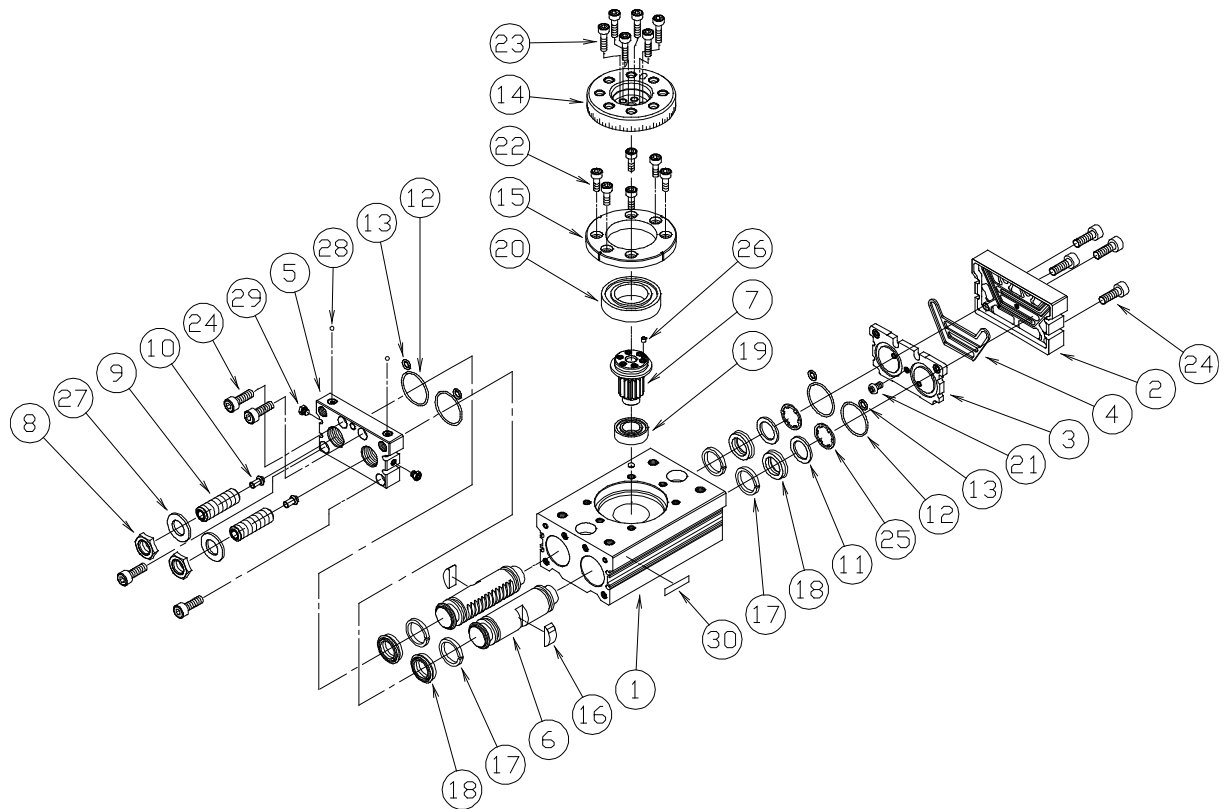
Internal construction and parts

MSQ*10~50* (Adjustment bolt type, Internal shock absorber type)

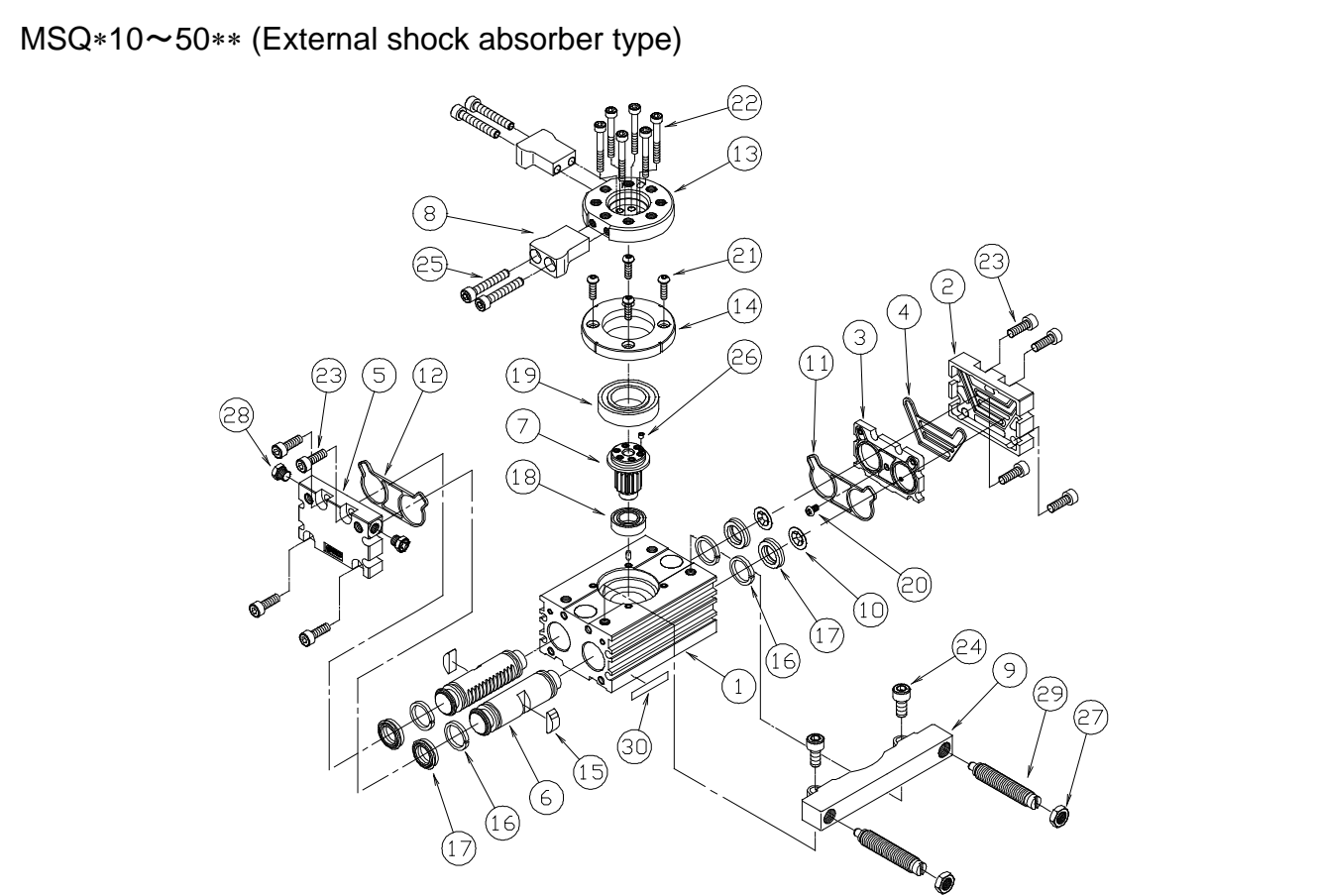


28	Product label	1	
27	Plug	2	
26	Seal washer	2	
25	Parallel pin	1	
24	Hexagon socket head cap screw	8	
23	Hexagon socket head cap screw	6	
22	Hexagon thin socket head bolt (Size10 Cross recessed round head screw)	4	
21	Round head no.0 Philips screw	1	
20	Bearing	1	High precision type:2 (angular duplex bearing)
19	Bearing	1	
18	Piston seal	4	
17	Wear ring	4	
16	Magnet	2	
15	Bearing retainer	1	
14	Table	1	
13	Gasket (End cover)	1	
12	Gasket (Cover)	1	
11	Push nut	2	
10	Cushion pad	2	Not required for models with shock absorber.
9	Adjustment bolt(or shock absorber)	2	
8	Compact hexagon nut	2	
7	Pinion	1	
6	Piston	2	
5	End cover	1	
4	Seal	1	
3	Plate	1	
2	Cover	1	
1	Body	1	
No	Description	Qty	Note

MSQB70~200* (Adjustment bolt type, Internal shock absorber type)



30	Product label	1	
29	Plug	2	
28	Steel ball	2	
27	Seal washer	2	
26	Parallel key	1	
25	Type CS retaining ring	2	
24	Hexagon socket head cap screw	8	
23	Hexagon socket head cap screw	6	
22	Hexagon socket head cap screw	6	
21	Round head no.0 Philips screw	1	
20	Bearing	1	
19	Needle bearing	1	
18	Piston seal	4	
17	Wear ring	4	
16	Magnet	2	
15	Bearing retainer	1	
14	Table	1	
13	O-ring	4	
12	Gasket	4	
11	Seal retainer	2	
10	Cushion pad	2	Not required for models with shock absorber.
9	Adjustment bolt (or shock absorber)	2	
8	Hexagon nut	2	
7	Pinion	1	
6	Piston	2	
5	End cover	1	
4	Seal	1	
3	Plate	1	
2	Cover	1	
1	Body	1	
No	Description	Qty	Note



30	Product label	1	
29	Shock absorber	2	
28	Plug	2	
27	Hexagon nut	2	
26	Parallel pin	1	
25	Hexagon socket head cap screw		90° : 4 pcs., 180° : 2 pcs.
24	Hexagon socket head cap screw	2	
23	Hexagon socket head cap screw	8	
22	Hexagon socket head cap screw	6	
21	Hexagon thin socket head bolt (Size10 Round head Philips screw)	4	
20	Round head no.0 Philips screw	1	
19	Bearing	1	High precision type:2 (angular duplex bearing)
18	Bearing	1	
17	Piston seal	4	
16	Wear ring	4	
15	Magnet	2	
14	Bearing retainer	1	
13	Table	1	
12	Gasket (End cover)	1	
11	Gasket (Cover)	1	
10	Push nut	2	
9	Shock absorber holder	1	
8	Arm		90° : 2 pcs. 180° : 1 piece
7	Pinion	1	
6	Piston	2	
5	End cover	1	
4	Seal	1	
3	Plate	1	
2	Cover	1	
1	Body	1	
No	Description	Qty	Note

Basic circuit

Circuit structure

The standard circuit for operating a rotary cylinder with an air filter, regulator, solenoid valve and speed controller is shown in Figure 1 below.

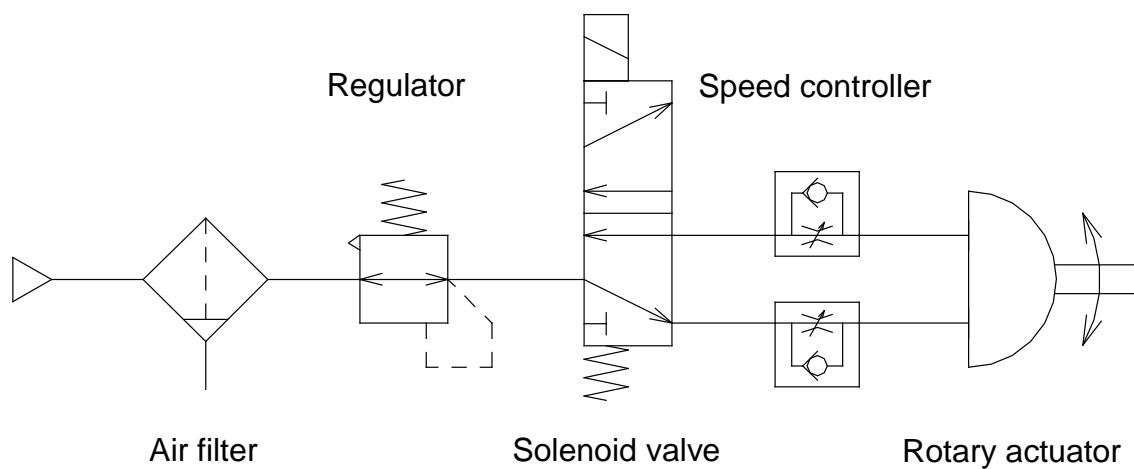


Fig. 1 Basic circuit

Recommended models

Recommended models for the standard circuit in Figure 1 are shown in Table 5 below.

Table 5. Recommended models

Table of Recommended Models			
Size	Solenoid valve (CV value)	Speed controller	Tubing
10	0.15 to 0.2	AS2000 series	Ø4 / Ø6
20			
30			
50			
70	0.2 to 1.0		Ø6 / Ø8
100			
200			

Mounting

Load restrictions

Set the load and moment to be applied to the table within the allowable values shown in the table below. (Values exceeding the allowable range will cause excessive play, reduce accuracy, and shorten service life.)

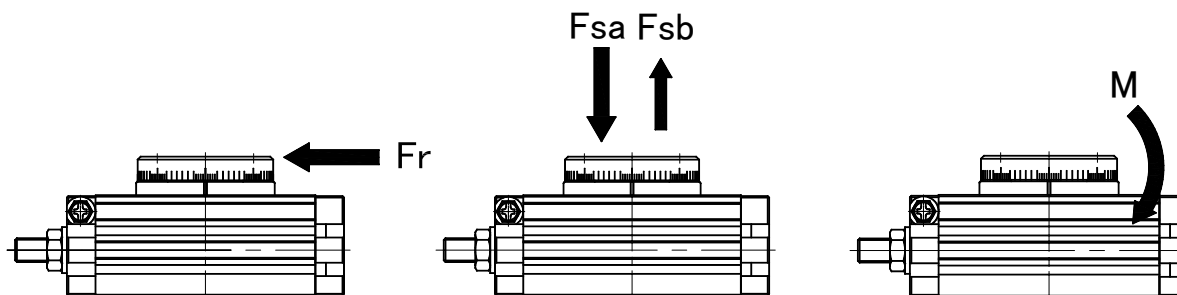


Fig. 2

Table 6 [N]

Size - Basic type	Load direction			
	Fsa	Fsb	Fr	M[Nm]
10	78	74	78	2.4
20	137	137	147	4.0
30	363	197	196	5.3
50	451	296	314	9.7
70	476	296	333	12.0
100	708	493	390	18.0
200	1009	740	543	25.0

[N]

Size - High precision type	Load direction			
	Fsa	Fsb	Fr	M[Nm]
10	107	74	86	2.9
20	197	137	166	4.8
30	398	197	233	6.4
50	517	296	378	12.0

Flange application

Table 7 shows L-dimension of the body.

When JIS standard hexagonal socket head cap screw is used, bolt head fits into counter bore.

Table 7 Bolt dimension [mm]

Size	L	Bolt
10	27	M6
20	28	M8
30	31	M8
50	35	M10
70	42.5	M10
100	48.5	M10
200	61.5	M12

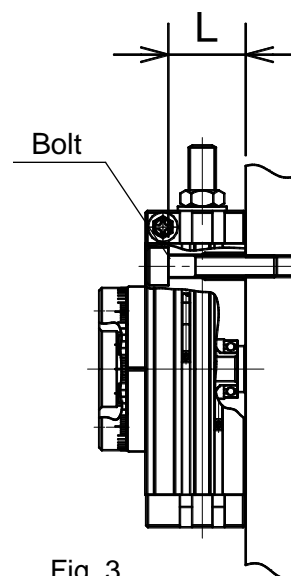


Fig. 3

Direction and Angle of Rotation (Adjusting bolt, Internal shock absorber type)

- When the cylinder is pressurized from port A, the table rotates clockwise.
- To obtain the desired rotation angle, the rotation ends can be set within the range shown in the diagram by regulating the adjustment bolt. (Internal shock absorber)

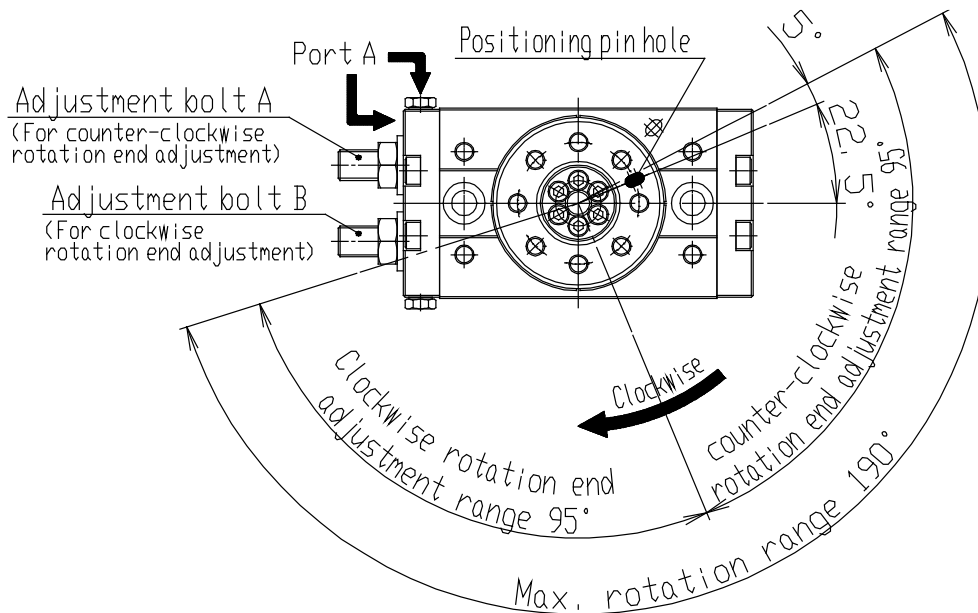


Fig. 4 Rotation direction and rotation angle

Note)

- The drawing shows the rotation range of the positioning pin hole.
- The pin hole position in the drawing shows anticlockwise rotation end when the rotation angle is set at 180° by equally tightening the adjusting bolts A and B.
- Refer to the setting example of the rotation angle range. (Fig.4)

Table 8 shows adjusting angle per one rotation of adjust bolt (internal absorber).

Table 8 With adjustment bolt, With internal shock absorber

Size	10	20	30	50	70	100	200
Rotation adjustment per single rotation of rotation adjustment screw	10.2°	7.2°	6.5°	8.2°	7.0°	6.1°	4.9°

Note) Since the end of adjust bolt of Series MSQ has a built-in rubber cushion, when angle adjustment is made, push the piston rod completely while pressurizing (minimum operating pressure : 0.1MPa or more) as shown in Figure 5(b).

Adjustment of with internal, with external and with both shock absorber types should also be made by pushing the piston rod of shock absorber completely.

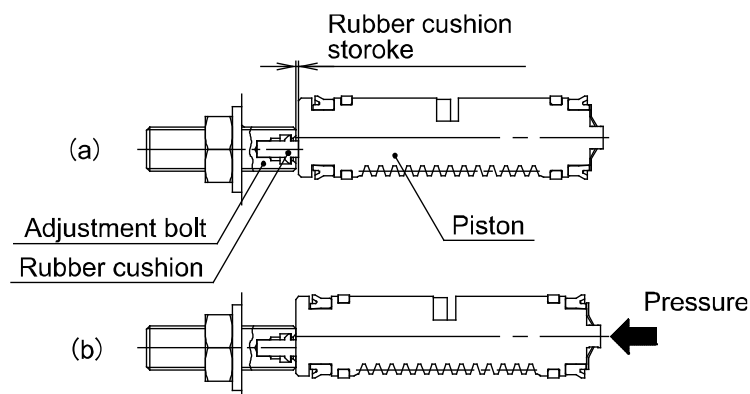


Fig. 5

Rotating range examples (Adjustment bolt, Internal shock absorber type)

Various rotation ranges are possible as shown in the drawings below using adjustment bolts A and B.
(The drawings show the rotation range of the positioning pin hole.)

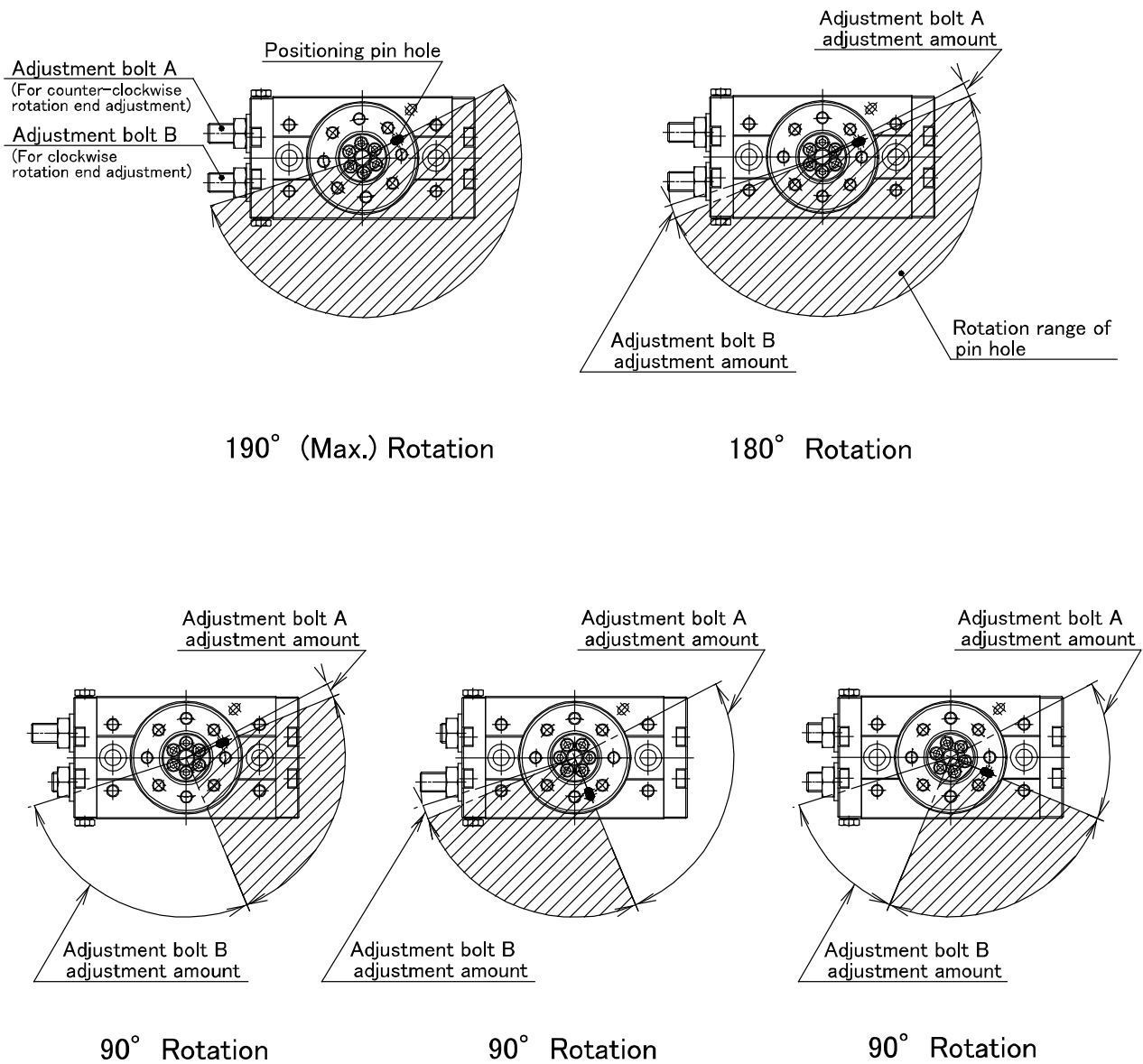


Fig. 6

Rotating direction and rotating angle (External shock absorber type)

- When the cylinder is pressurized from port A, the table rotates clockwise.
- To obtain the desired rotation angle, the rotation ends can be set within the range shown in the diagram by regulating the shock absorber.

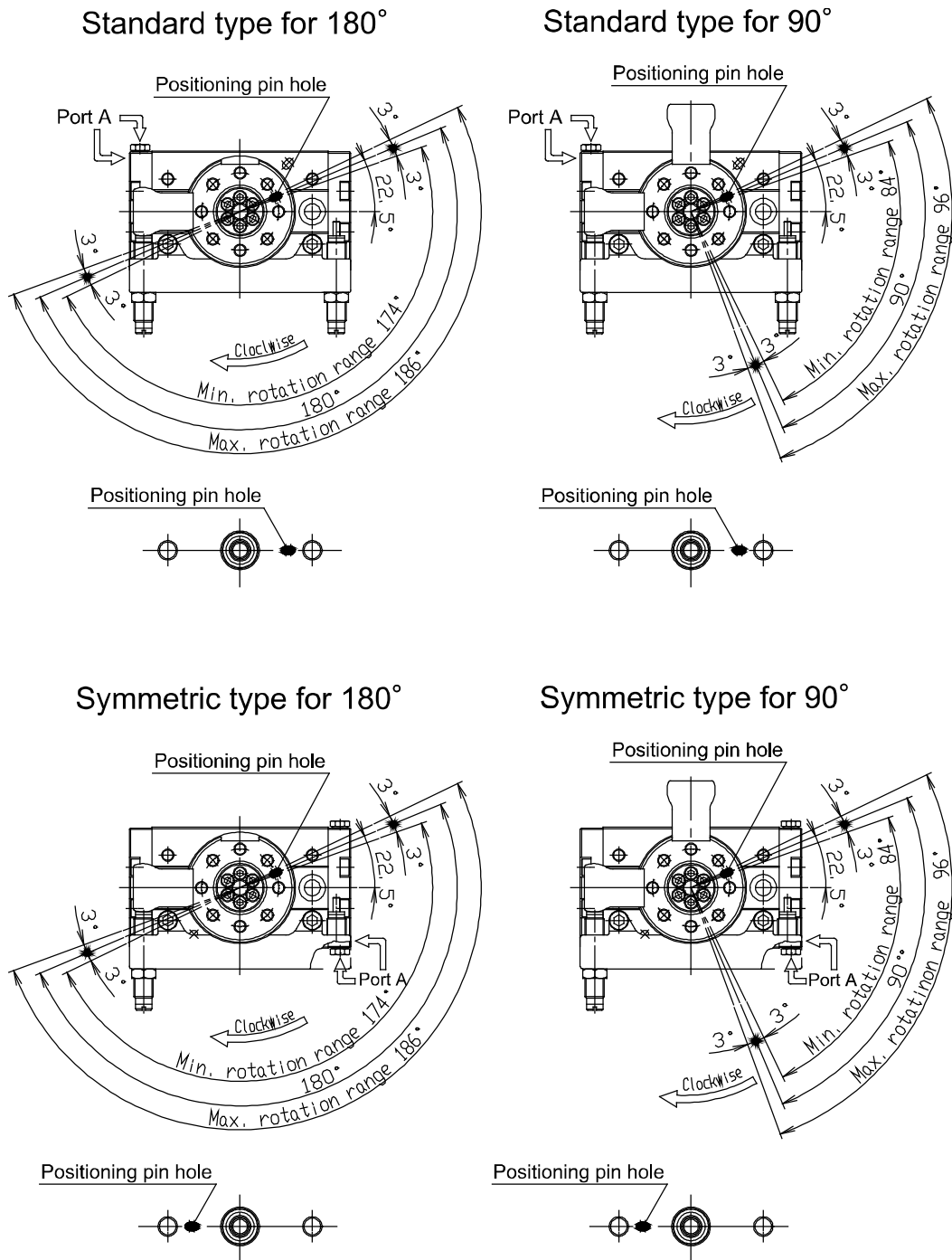


Fig. 7

- Note)
- The drawings show the rotation range for the top positioning pin hole of the table.
 - The pin hole position in the drawings shows the counter-clockwise rotation end when the shock absorbers are tightened equally and the rotation is adjusted to 180° and 90°.

- Note)
- Although the rotating angle of external absorber type can be made smaller by screwing in a shock absorber, do not make it smaller than the minimum rotating angle of 84° (90° specification) and 174° (180° specification). This will increase the deflection angle on the working face of the shock absorber's piston rod and arm, causing damage to the shock absorber.
 - Pay attention that the hexagon nuts of the shock absorbers for size 10 external absorbers are directional. Mount it so that the surface without chamfers is the seating surface.

Piping

Figure 8 and Table 9 show locations and sizes of piping ports.

Ports can be selected from two sides. Plug the ports that are not used.

Table 9 Port size

Size	Port size A1, B1
10	M5x0.8
20	
30	
50	Rc1/8 G1/8 NPT1/8 NPTF1/8
70	
100	
200	

Size	Port size A2, B2
10	M5x0.8
20	
30	
50	
70	
100	
200	

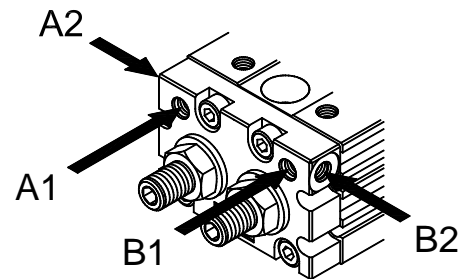


Fig. 8

- Rotary table ports and plate have a fixed orifice. Do not make the diameter of this hole larger by additional processing.
If the hole diameter is made larger, rotation speed and impact will increase, which may cause breakage of the product.

Preparation before piping.

- Before piping is connected, it should be thoroughly blown out with air to remove dust and scale from inside the pipe. Dust and scale on the inlet side of the filter can be removed, but those on the outlet side cannot be removed, so they can enter the solenoid valve or rotary table, which causes malfunction or shortens product life.
- When screwing piping or fittings into ports, ensure that chips from the pipe threads or sealing material do not enter the piping. Also, if pipe tape is used, leave 1.5 to 2 thread ridges exposed at the end of the threads.

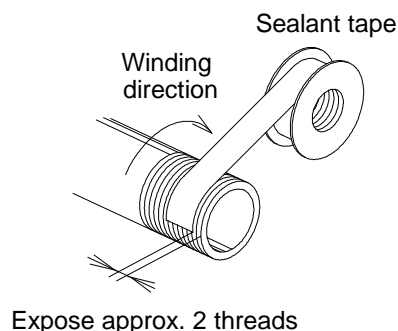


Fig. 9 Wrapping of pipe tape

Air supply

Air should be filtered with an air filter before it is supplied to the rotary table.

Since Series MSQ requires no lubrication, it is not necessary to lubricate using a lubricator.

Setting of rotation time

Even if the torque that is required by the load in the rotation movement is small, the internal parts could become damaged depending on the inertia of the load.

Therefore, select an appropriate model for your application by taking the load's moment of inertia, kinetic energy, and rotation time into consideration. (A chart that depicts the moments of inertia and the rotation time is provided to facilitate the selection process.)

Moment of inertia

Moment of inertia is the tendency of a still object to resist rotation, or, conversely, the tendency of a rotating object to resist stopping.

When the actuator moves an object (load), inertia (kinetic energy) is generated in the object.

The actuator stops at the rotation end, but due to inertia, a large shock (kinetic energy) is applied to the rotary table. The kinetic energy can be calculated using the formula below.

$$E = \frac{1}{2} \cdot I \cdot \omega^2$$

E: Kinetic energy [J]

I: Moment of inertia [$\text{kg} \cdot \text{m}^2$]

ω : Angular speed [rad/s]

There is a threshold of kinetic energy that a rotary actuator allows. Therefore, by finding the moment of inertia, it is possible to find the threshold value of the rotation time.

The basic formula for finding the moment of inertia is shown below.

$$I = m \cdot r^2$$

m : Weight [kg]

r : Center of gravity of load and distance of rotational axis [m]

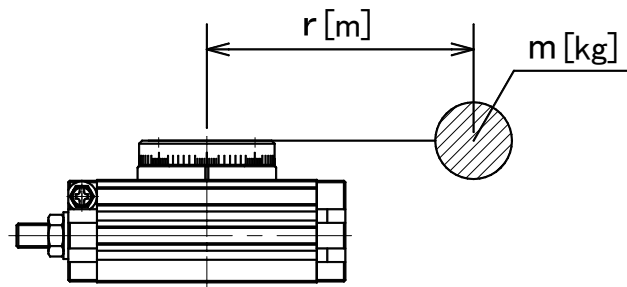


Fig. 10

This represents the moment of inertia for a shaft with mass m, which is located at distance r from the shaft. The formula for finding the moment of inertia depends on the shape of the object.

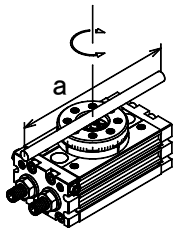
A table of formulae for calculating moment of inertia is shown on the following page.

Calculation formulae for moment of inertia

I: Moment of inertia [kg · m²] m: Load mass [kg]

1. Thin shaft

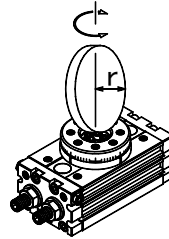
Position of rotational axis: Perpendicular to the shaft through the center of gravity



$$I = m \cdot \frac{a^2}{12}$$

6. Thin round plate

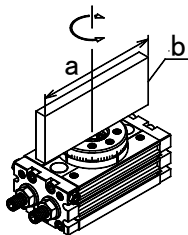
Position of rotational axis: Through the center of diameter



$$I = m \cdot \frac{r^2}{4}$$

2. Thin rectangular plate

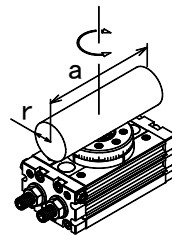
Position of rotational axis: Parallel side b and through the center of gravity



$$I = m \cdot \frac{a^2}{12}$$

7. Cylinder

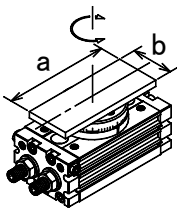
Position of rotational axis: Through the center of diameter and gravity



$$I = m \cdot \frac{3r^2 + a^2}{12}$$

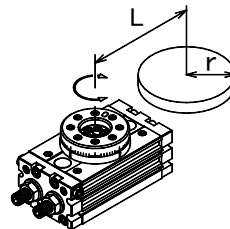
3. Thin rectangular plate (Including Rectangular parallelepiped)

Position of rotational axis: Perpendicular to the plate through the center of gravity



$$I = m \cdot \frac{a^2 + b^2}{12}$$

8. When the rotational axis and load center of gravity are not consistent



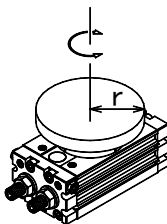
$$I = K + m \cdot L^2$$

K: Moment of inertia around the load center of gravity

4.Round plate $K = m \cdot \frac{r^2}{2}$

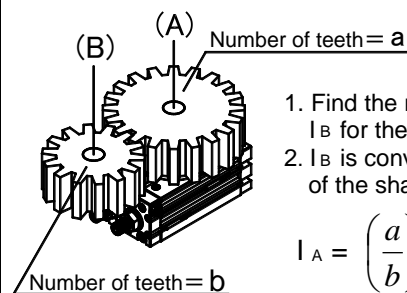
4. Round plate (Including column)

Position of rotational axis: Through the center axis



$$I = m \cdot \frac{r^2}{2}$$

9. Gear transmission

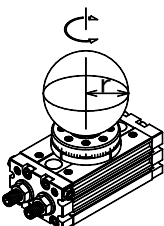


1. Find the moment of inertia I_B for the rotation of shaft (B).
2. I_B is converted to the rotation of the shaft (A).

$$I_A = \left(\frac{a}{b} \right)^2 \cdot I_B$$

5. Solid sphere

Position of rotational axis: Through the center of diameter



$$I = m \cdot \frac{2r^2}{5}$$

Kinetic energy

Table 10 shows the allowable kinetic energy of the rotary table.

Here, the angular speed ω can be found from the formula below.

$$\omega = \frac{2\theta}{t}$$

θ : Rotation angle [rad]

t : Rotation time [s]

The kinetic energy E can be found from the formula below.

$$E = \frac{1}{2} \times I \times \omega^2$$

Therefore, the rotation time of the rotary actuator is:

$$t \geq \sqrt{\frac{2 \times I \times \theta^2}{E}}$$

Table 10 Allowable kinetic energy

Size	Allowable kinetic energy J			
	Adjusting bolt	Internal shock absorber	External shock absorber	
			Low energy	High energy
10	0.007	0.039	0.161	0.231
20	0.025	0.116	0.574	1.060
30	0.048	0.116	0.805	1.210
50	0.081	0.294	1.310	1.820
70	0.240	1.100	—	
100	0.320	1.600		
200	0.560	2.900		

E : Allowable kinetic energy [J]

θ : Rotation range [rad]

I : Moment of inertia [kg · m²]

During uniform acceleration, the angular acceleration ω after t seconds can be found as follows.

$$\omega = \dot{\omega} \cdot t \quad \dots (1)$$

$$\theta = \dot{\omega} dt = \frac{1}{2} \dot{\omega} t^2 + C \quad \dots (2)$$

When $t = 0$, rotation angle $\theta = 0$, so the integration constant is $C=0$.

$$\theta = \frac{1}{2} \dot{\omega} t^2 = \frac{1}{2} \omega t$$

thus,

$$\omega = \frac{2\theta}{t}$$

Auto switch type for rotary table

The rotary table has a magnet mounted on its piston and an auto switch on the outside of the body to detect the piston position (table position). Rotary tables have a short piston stroke, so detection should be done at the stroke end.

Auto switch specification

Table 11. Reed auto switch

Auto switch model	Load voltage	Load current range and Maximum load current	Internal voltage drop	Indicator light	Applicable load
D-A90 D-A90V	24V AC or less	50mA	—	None	Relay PLC IC circuit
	48V AC or less	40mA			
	100V AC or less	20mA			
D-A93 D-A93V	24VDC	5 to 40mA	D-A93 2.4V or less (up to 20mA) 3V or less (up to 40mA) D-A93V 2.7V or less	Red LED illuminates when turned ON.	Relay PLC
	100VAC	5 to 20mA	2.7V or less		
D-A96 D-A96V	4 to 8VDC	20mA	0.8V or less	Red LED illuminates when turned ON.	IC circuit

- Lead wire — D-A90(V) and D-A93(V): Oil proof vinyl cabtire cord
 $\varnothing 2.7$ 0.18mm²×2-core (brown, blue) 0.5m
D-A96(V): Oil proof vinyl cabtire cord
 $\varnothing 2.7$ 0.15mm²×3-core (brown, black, blue) 0.5m
- Insulation resistance — 50 MΩ or more (500 VDC measured via megohmmeter)
(between lead wire and case)
- Withstand voltage — 1000 VAC for 1 minute (between lead wire and case)
- Operating time — 1.2ms
- Ambient temperature — -10 to 60°C
- Impact resistance — 300m/s²
- Leakage current — None
- Enclosure — IEC60529 Standard IP67

Table 12 Solid state auto switch specification (D—M9□)

Auto switch model	Output type	Power supply voltage	Current consumption	Load voltage	Load current	Internal voltage drop	Leakage current	Applicable load
D-M9N D-M9NV D-M9NW D-M9NWV	NPN	5·12· 24VDC (4.5 to 28V)	10mA or less	28VDC or less	40mA or less	At 10mA 0.8V or less At 40mA 2V or less	100μA or less at 24VDC	Relay PLC IC circuit
D-M9P D-M9PV D-M9PW D-M9PWV	PNP			—				
D-M9B D-M9BV D-M9BW D-M9BWV	—	—	—	24VDC (10 to 28VDC)	2.5 to 40mA	4V or less	0.8mA or less	24VDC Relay PLC

- Lead wire — D-M9B(V): Flexible vinyl sheath cable
2.7×3.2 ellipse 0.15mm²×2-core (brown, blue) 0.5m
D-M9N(V), D—M9P(V): Flexible vinyl sheath cable
2.7×3.2 ellipse 0.15mm²×3-core (brown, black, blue) 0.5m
- Insulation resistance — 50 MΩ or more (500 VDC measured via megohmmeter)
(between lead wire and case)
- Withstand voltage — 1000 VAC for 1 minute (between lead wire and case)
- Operating time — 1ms or less
- Ambient temperature — -10 to 60°C
- Impact resistance — 1000m/s²
- Enclosure — IEC60529 Standard IP67

Mounting of auto switch

Use a watchmaker's screwdriver of grip diameter 5 to 6mm to tighten the auto switch mounting screws to a tightening torque of D-M9*:0.05 to 0.15N·m, D-A9*:0.10 to 0.20 N·m. Use the designated slotted set screws.

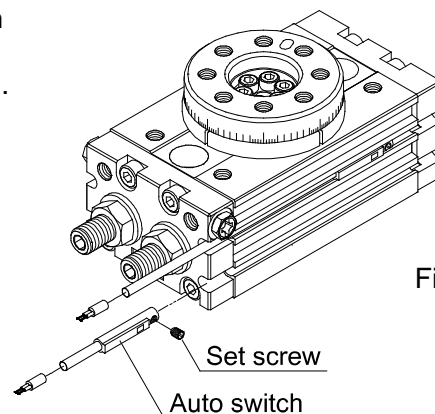


Fig. 11

Proper auto switch mounting position at rotation end

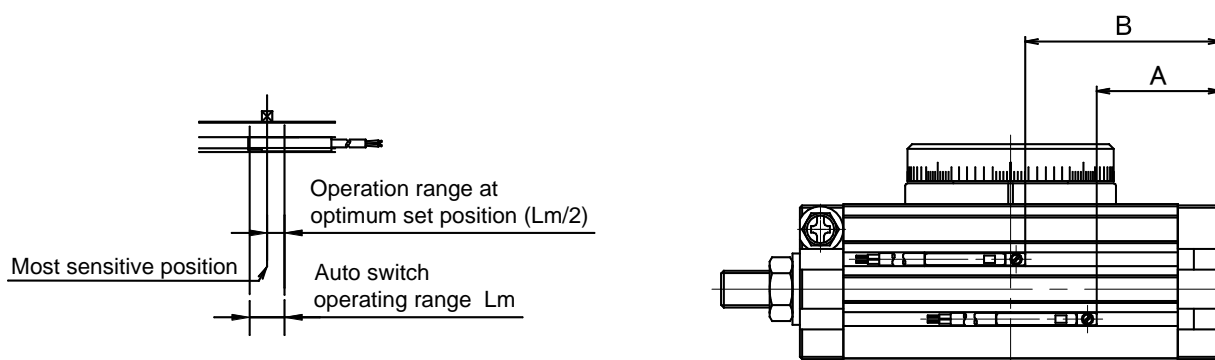


Fig. 12

Table 13 Auto Switch Rotation range / Actuation / most sensitive position

Size	Rotation	Reed switch				Solid state switch			
		A	B	Operation range θ_m	Hysteresis range	A	B	Operation range θ_m	Hysteresis range
10	190°	27	45	53°	10° or less	31	49	37°	5° or less
20	190°	35	62	50°	10° or less	39	66	33°	5° or less
30	190°	39	68	43°	10° or less	43	72	29°	5° or less
50	190°	49	83	33°	10° or less	53	87	22°	5° or less
70	190°	54	95	30°	10° or less	58	99	21°	5° or less
100	190°	61	108	27°	10° or less	65	112	18°	5° or less
200	190°	81	139	21°	10° or less	85	143	15°	5° or less

Operating range θ_m : Value of the operating range Lm of a single auto switch converted to an axial rotation angle.

Hysteresis range : Value of auto switch hysteresis converted to an angle.

Note) The above values are only provided as a guideline, and they are not guaranteed.

In the actual setting, adjust them after confirming the auto switch operating condition.

Internal structure and operation principle

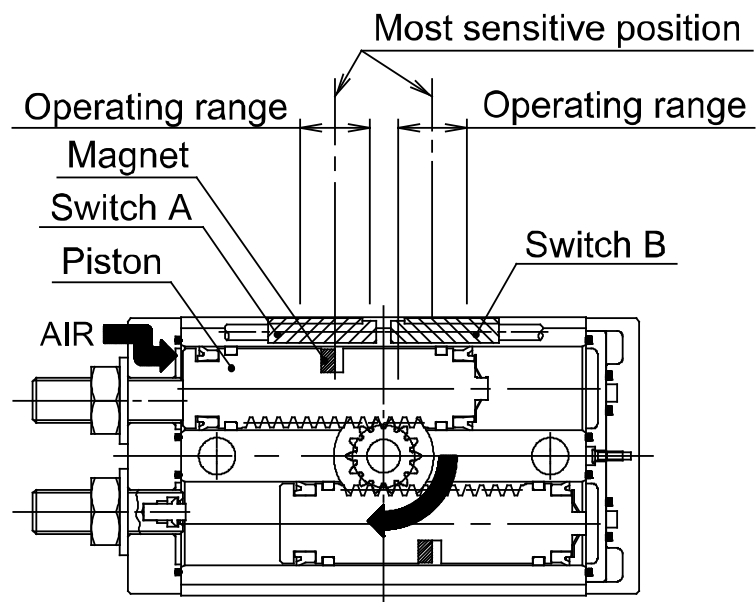


Fig. 13

When switch A is turned on and pressure is supplied in the direction indicated by the arrows in Fig. 13, the piston moves and the table rotates clockwise.

At this point, magnet A goes out of switch A's operation range to turn off switch A. Then the piston moves further, and the magnet goes into switch B's operation range to turn on switch B.

External stopper

If the kinetic energy that is generated by the load exceeds the actuator's threshold value, an external dampening function must be provided to absorb the energy.

Mounting position of external stopper

Installing the stopper near to the centre of the table should be avoided.

When the rotation arm strikes the stopper, a reaction force generated by the load's inertia will be redirected and applied to the table itself.

This will lead to damage to the table and bearings.

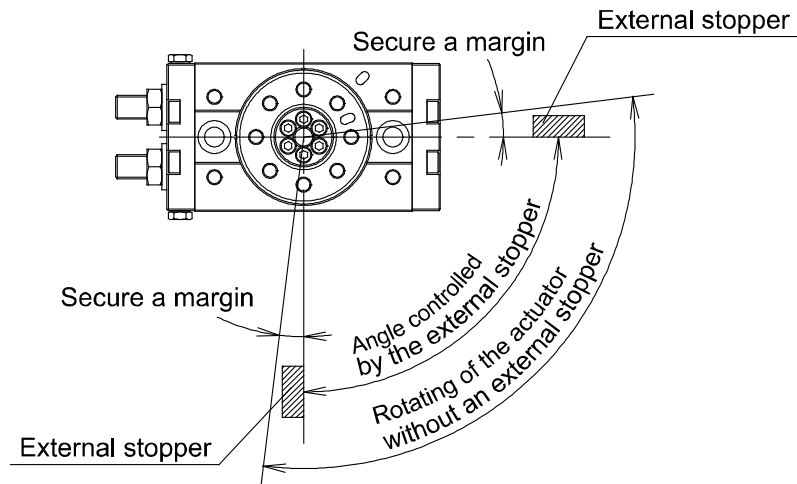
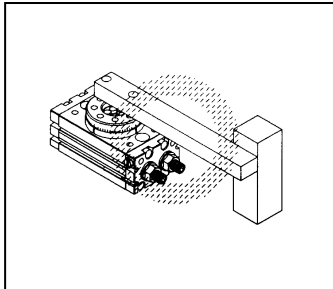
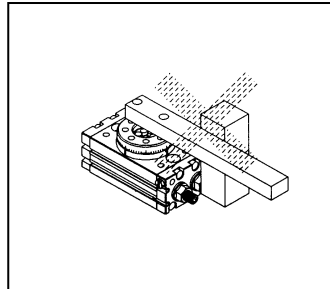


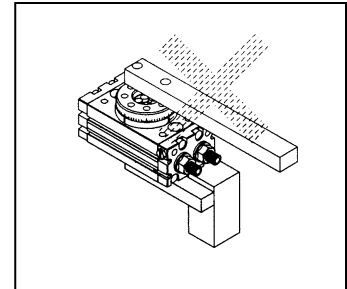
Fig. 14



Install the stopper at a sufficient distance from the table centre.



The external stopper becomes a fulcrum, resulting in the load's inertia force being applied to the table as a bending moment.



If an external stopper is installed on the opposite side to the load, the inertia force generated by the load is applied directly to the pinion.

* Caution for using external stopper

Angle adjustment is available for MSQ series rotary actuator. When using an external stopper, set in a position so that the adjusting bolt does not collide into the piston.

Maintenance and Inspection

In order to use the rotary table in an optimal condition, it is necessary to perform maintenance regularly depending on the operating conditions. It is preferable to perform maintenance of the rotary table once a year in general. Even if no problem is found, seal parts replacement is recommended every three years. Note that if mechanical components such as pinion, rack, bearing etc. are damaged, they are likely to have been used outside of the specification of the rotary table, so review the operating conditions. In that case, be sure to ask your SMC representatives to repair the rotary actuator.

Regular inspection

The regular inspection should be performed on the following items.

- (1) Looseness of the bolt used for fixing the rotary table
- (2) Looseness at the frame for fixing rotary table
- (3) Smooth operation
- (4) External air leakage

If any items are found by the inspection that require repairing, tighten any loose parts or disassemble the product to repair.

Replacement procedure of the seal kit

Cautions for disassembly

- (1) Disassemble in a clean location with plenty of space.
- (2) Cover the rotary actuator pipe inlet and the end of piping after removing the rotary table.
- (3) Take care not to damage the internal sliding surface of the rotary actuator when disassembling it.
- (4) Please consult with us if you have any questions about disassembly and inspection.
- (5) MSQA (high precision type) cannot be disassembled because the table is press-fitted into the bearing.

Table 14 Replacement parts

< Adjustment bolt type, Internal shock absorber type >

Description	Size											
	10			20			30			50		
Seal kit	P523010-5			P523020-5			P523030-5			P523040-5		
Parts included in seal kit	No.	Description	Qty.	No.	Description	Qty.	No.	Description	Qty.	No.	Description	Qty.
	4	Seal	1	4	Seal	1	4	Seal	1	4	Seal	1
	12	Gasket	1	12	Gasket	1	12	Gasket	1	12	Gasket	1
	13	Gasket	1	13	Gasket	1	13	Gasket	1	13	Gasket	1
	17	Wear ring	4	17	Wear ring	4	17	Wear ring	4	17	Wear ring	4
	18	Piston seal	4	18	Piston seal	4	18	Piston seal	4	18	Piston seal	4
	26	Seal washer	2	26	Seal washer	2	26	Seal washer	2	26	Seal washer	2

Description	Size							
	70			100			200	
Seal kit	P391050-5			P391060-5			P391070-5	
Parts included in seal kit	No.	Description	Qty.	No.	Description	Qty.	No.	Description
	4	Seal	1	4	Seal	1	4	Seal
	12	Gasket	4	12	Gasket	4	12	Gasket
	13	O-ring	4	13	O-ring	4	13	O-ring
	17	Wear ring	4	17	Wear ring	4	17	Wear ring
	18	Piston seal	4	18	Piston seal	4	18	Piston seal
	27	Seal washer	2	27	Seal washer	2	27	Seal washer

< External shock absorber type >

Description	Size											
	10			20			30			50		
Seal kit	P523010-6			P523020-6			P523030-6			P523040-6		
Parts included in seal kit	No.	Description	Qty.	No.	Description	Qty.	No.	Description	Qty.	No.	Description	Qty.
	4	Seal	1	4	Seal	1	4	Seal	1	4	Seal	1
	11	Gasket	1	11	Gasket	1	11	Gasket	1	11	Gasket	1
	12	Gasket	1	12	Gasket	1	12	Gasket	1	12	Gasket	1
	16	Wear ring	4	16	Wear ring	4	16	Wear ring	4	16	Wear ring	4
	17	Piston seal	4	17	Piston seal	4	17	Piston seal	4	17	Piston seal	4

Please refer to P19 to 21 for the product construction.

A grease pack (10g) is included.

When only a grease pack is needed, order with the following part number.

Grease pack part no : GR-S-010(10g)

■ Disassembly procedure

- (1) Loosen hexagon socket head cap screw and pull out the table. Loosen hexagon thin socket head bolt (Size 10 Cross recessed round head screw Size 70, 100, 200 Hexagon socket head cap screw) to remove the bearing retainer.
- (2) Pull out the pinion and the bearing from the body.
- (3) Loosen hexagon socket head bolt to remove the cover assembly and the end cover assembly.
- (4) Push piston assembly from one side to pull out two piston assemblies from the body.
(Do not scratch the piston seals when pulling out the piston.)
- (5) Take out the bearing from the body. On size 70, 100 and 200 the bearing cannot be removed as the bearing is press-fitted.

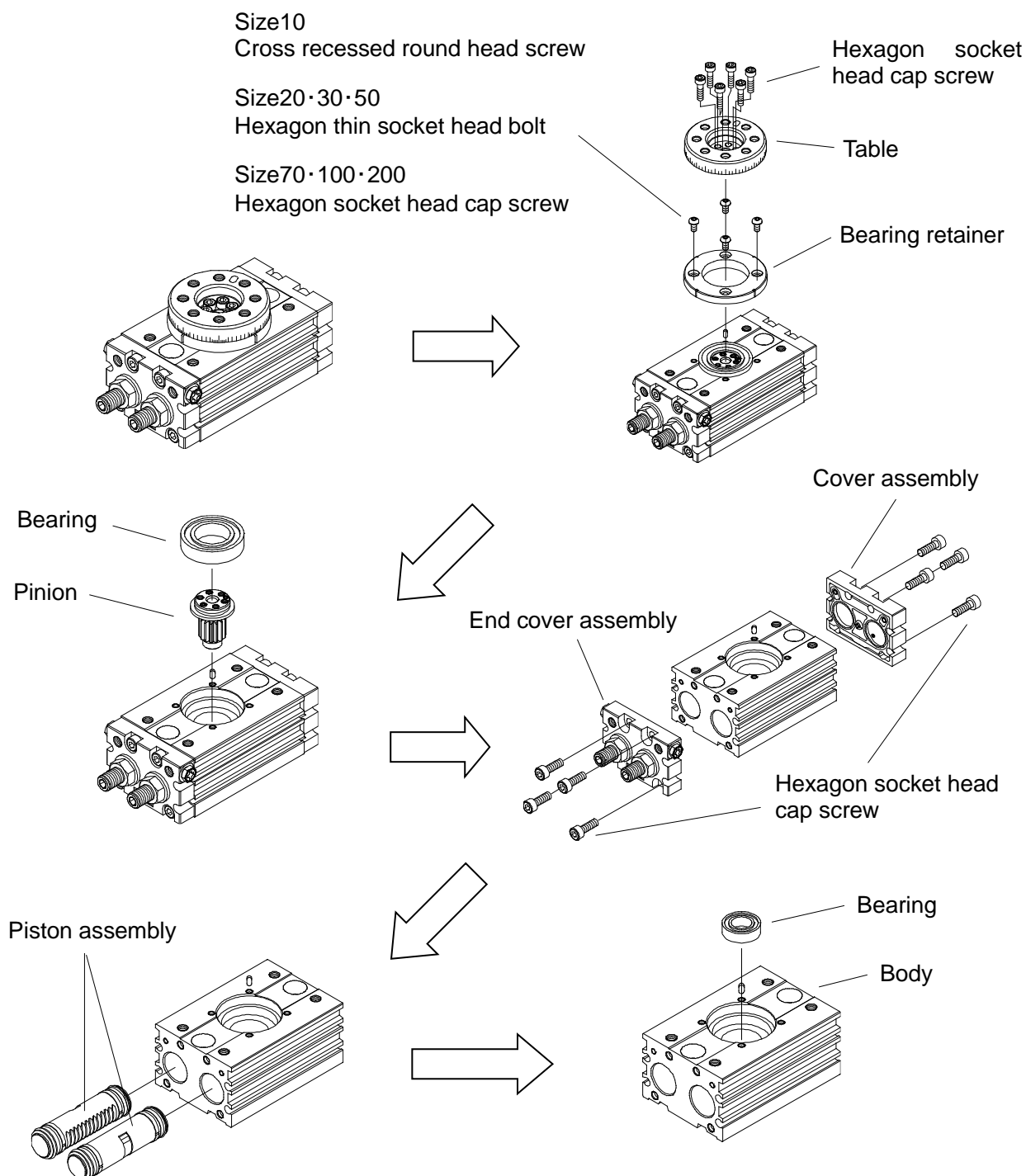


Fig. 15

■ Assembly procedure

(1) Clean each component sufficiently before assembly to remove any dust etc.

Apply the grease provided in the seal set to each part shown in Table 14. As a guideline, apply enough grease to make the surface shiny.

Table 14. Parts where grease is to be applied

Grease applied parts	Grease
Cylinder internal surface	GR-S-010
Piston packing groove	
Piston seal	
Cover seal	
End cover gasket	
Seal	
O-ring (Size 70·100·200)	

Body assembly

Apply grease after wiping the inside of the cylinder with alcohol, and mount the bearing on the housing.

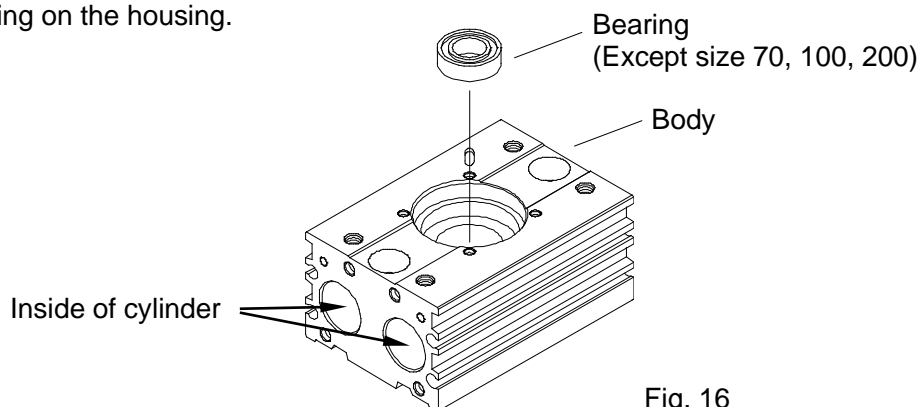


Fig. 16

Piston assembly

Pay attention to the installation direction of the piston seal as the direction is specified. Then mount the piston seal to the piston, taking care not to damage the piston seal.

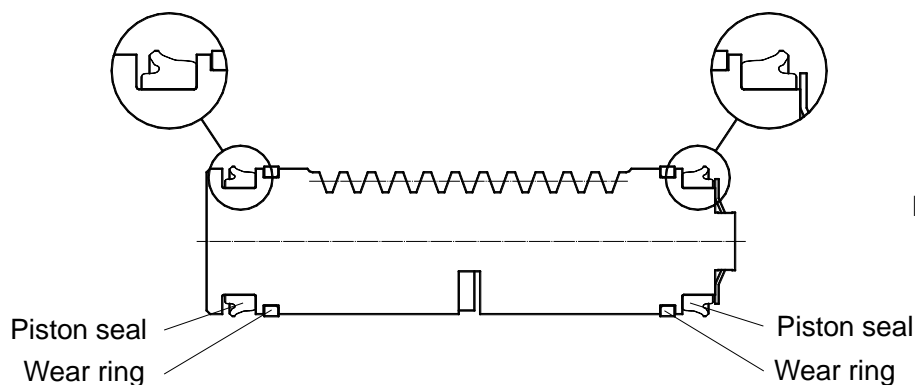


Fig. 17

Cover assembly

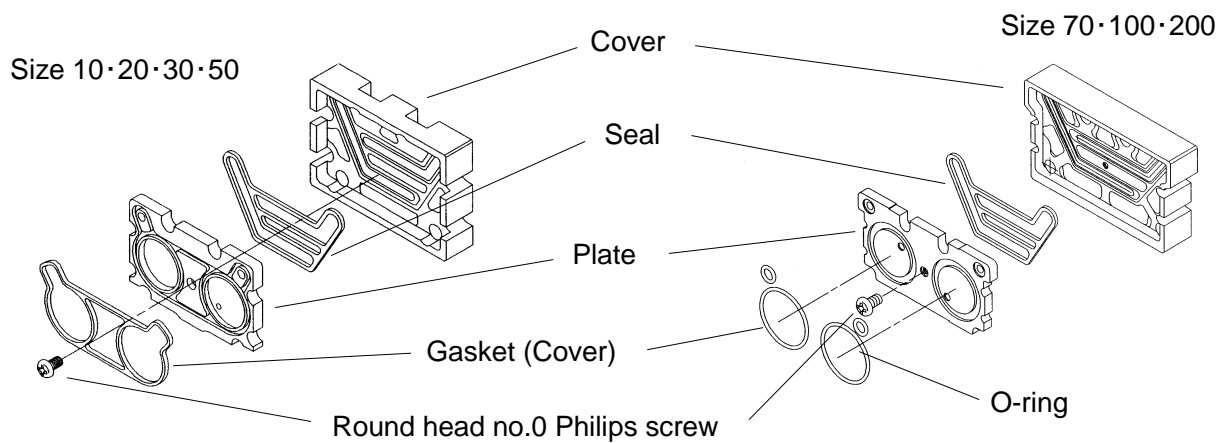
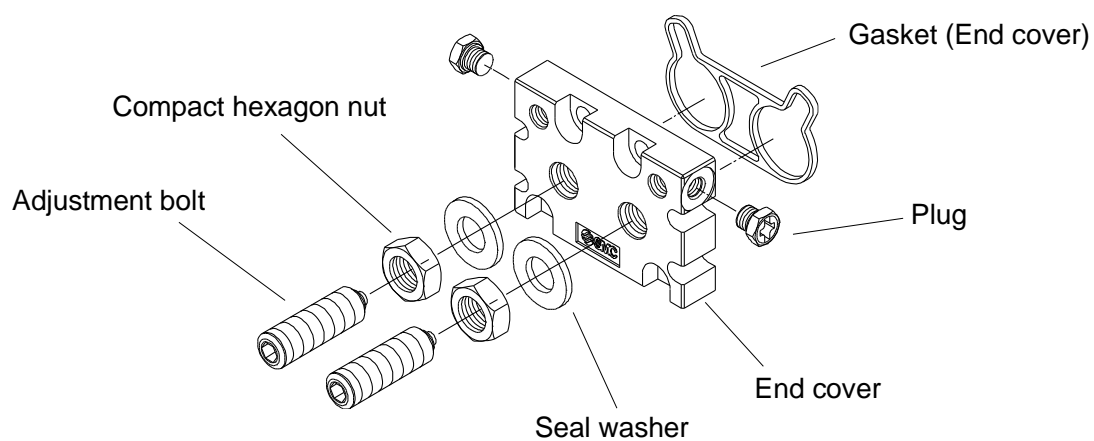


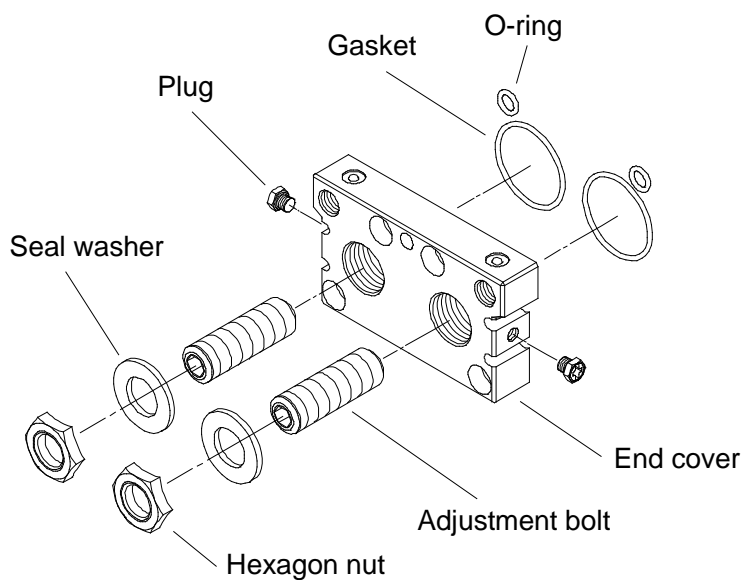
Fig. 18

End cover assembly

Size 10·20·30·50
(Adjust bolt, Internal shock absorber type)



Size 70·100·200
(Adjust bolt, Internal shock absorber type)



Size 10·20·30·50
(External shock absorber type)

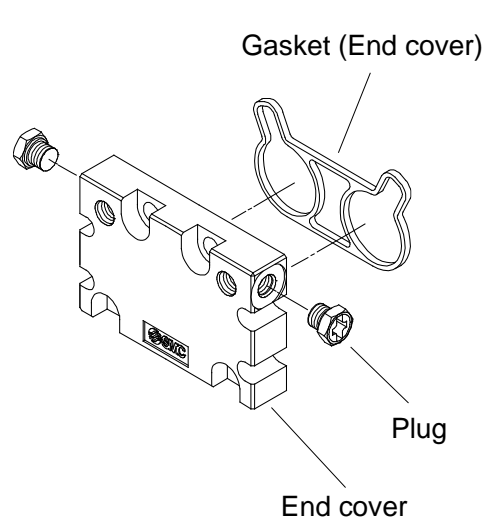


Fig. 19

- (2) Insert the piston assembly into the body assembly. In this case, the piston seals pass through the cylinder opening, so install the seals into the opening while squeezing them to prevent the seals from being damaged.
Pay attention to the insertion direction of the piston and the body as they are specified. (Figure 20)

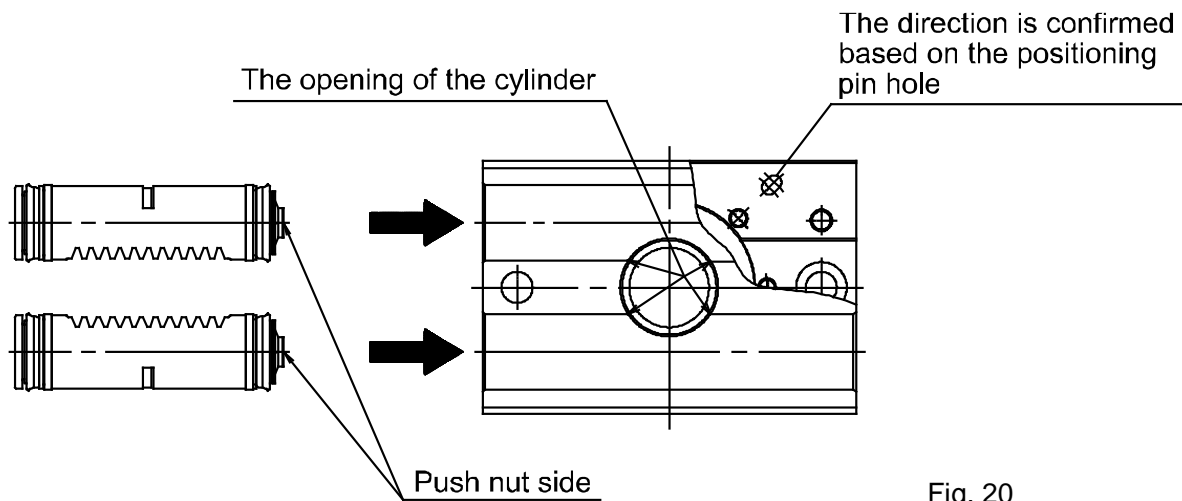
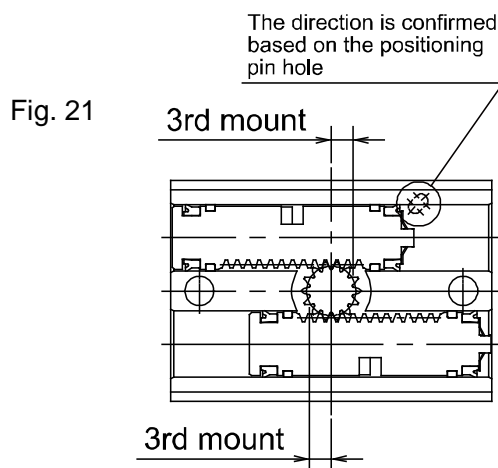
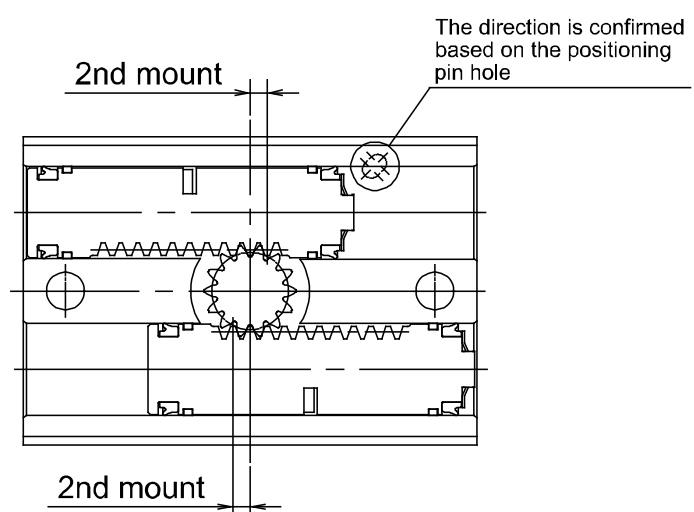


Fig. 20

- (3) Hold the piston in place and install the pinion gear on the piston.
Figure 21 shows the piston position and Figure 22 shows the pinion gear assembly angle.



Size 10



Size 20 · 30 · 50 · 70 · 100 · 200

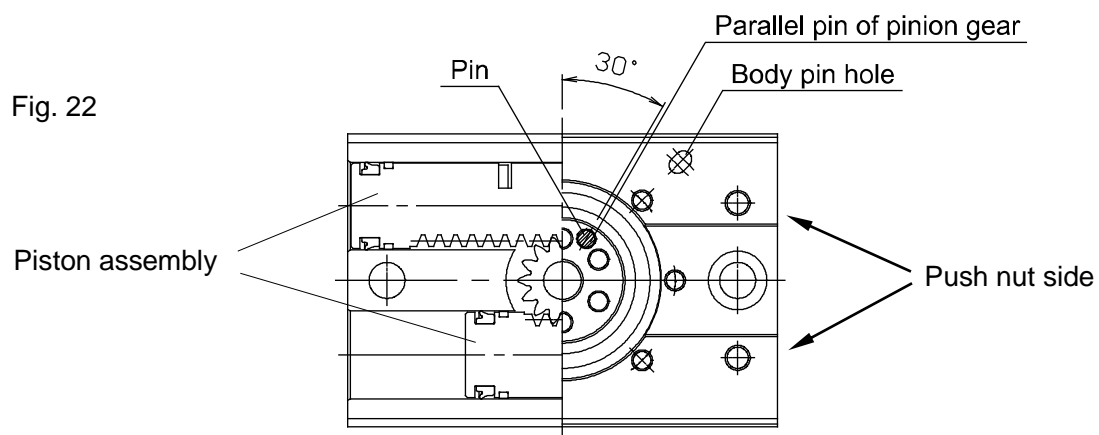
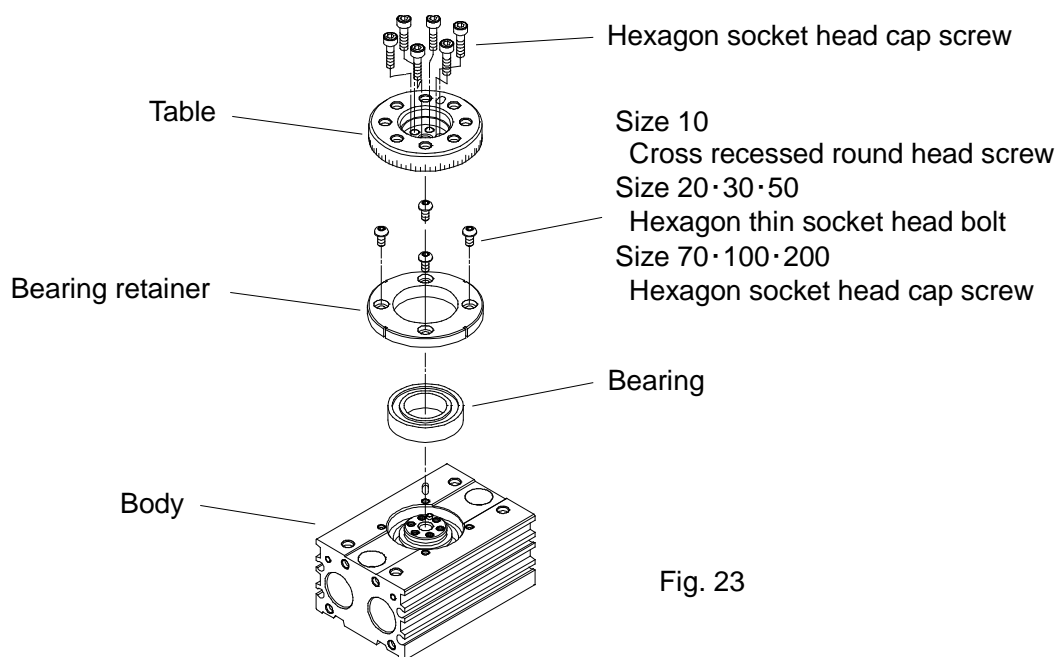
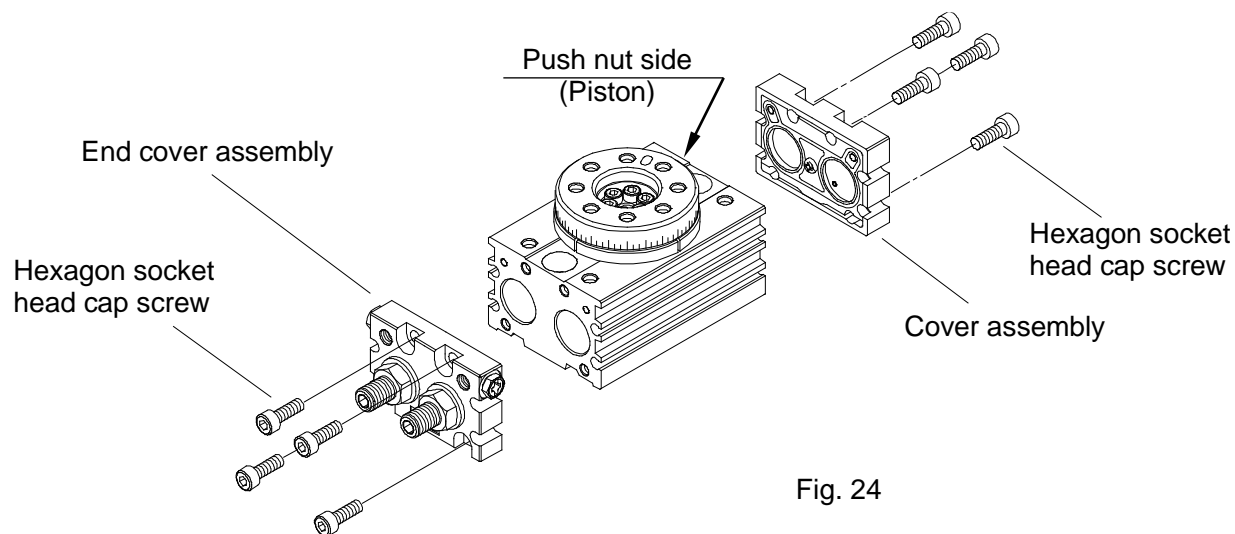


Fig. 22

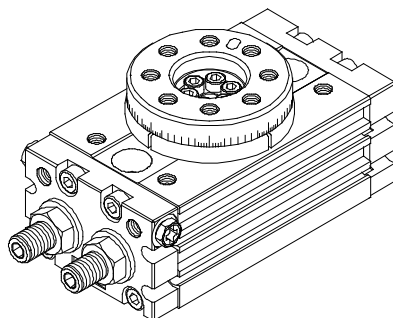
(4) Install the bearing, bearing holder and table on the body.



(5) Install the cover assembly and end cover assembly on the body.



(6) After assembly is completed, perform an operation test and check that there is no air leakage.



Troubleshooting

Problem	Possible cause	Solution
Rotary table does not move	Supply pressure is not applied correctly.	Correctly set the regulator at the supply pressure side.
	The directional switching valve (such as a solenoid valve) does not switch.	Correctly apply a signal to the directional switching valve (such as a solenoid valve).
	Air leakage from piping.	Inspect the piping and stop the leakage.
	The restrictor in the port is clogged.	Clean the restrictor. Take the following countermeasures: (1) Blow air through the piping again. (2) Inspect the air filter.
Operation is not smooth. (stick-slip)	The load has some friction.	Reduce the friction resistance.
	The rotation table and the item used with it are not aligned.	Align the two centers or use a flexible fitting.
	Insufficient output due to a low supply pressure.	To obtain stable operation, adjust the supply pressure to make the load ratio appropriate.
	Speed controller is restricted too much.	Adjust the speed controller so that the rotating marks will be in the adjusting range.
Extreme rotating angle changes.	Internal parts are broken.	Replace the rotary table with the new one. After that, take the measures below. • Calculate the kinetic energy applied to the rotary table and adjust the load and rotation speed to make the value within the allowable kinetic energy. • Mount an external stopper or shock absorber to absorb the impact force. In this case, adjust so that the adjusting bolt does not come into contact with the piston. Set the rotation end with an external stopper.

Problem	Possible cause	Solution
Air leakage from the table	Piston seal is worn out.	The seal parts need to be replaced. Contact SMC.
The pinion gear is broken.	Excessive kinetic energy was applied to the rotary table.	<p>Replace the rotary table with the new one. After that, take the measures below.</p> <ul style="list-style-type: none"> • Calculate the kinetic energy applied to the rotary table and adjust the load and rotation speed to make the value within the allowable kinetic energy. • Mount an external stopper or shock absorber to absorb the impact force. <p>In this case, adjust so that the adjusting bolt does not come into contact with the piston. Set the rotation end with an external stopper. • Do not apply external torque to the product that exceeds the rated output.</p>
	Excessive external torque was applied to the rotary table.	
Insufficient rotating Angle.	The adjustment bolt for angle adjustment is set at a smaller angle than required.	Set the adjustment bolt correctly.
The auto switch will not operate or operates incorrectly.	The auto switch is mounted in an inappropriate position.	Mount the auto switch in the correct position.
	Effect of an external magnetic field	Check that there is no strong magnetic field present.
	Trouble with the electrical circuit	Check that there is no trouble with the electrical circuit.
	Trouble with the electrical specification	Check there is no trouble with the electrical specification.

Revision history
A: Corrected the mounting position of the auto switch.
B: Corrected product mounting bolt size.
C: Erratum Correction.
D: Fully revised following product review.
E: Added a note of caution.
F: Added the type of port.
G: Revised safety instructions.

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Note: Specifications are subject to change without prior notice and any obligation on the part of the manufacturer.
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