



# Operation Manual

Low-Speed Rotary Actuator

PRODUCT NAME

*CRQ2X Series*

MODE/ Series

**SMC Corporation**

## Table of Contents

<b>Safety Instruction</b>	2
<b>Outline</b>	13
Specification	13
<b>Effective torque</b>	14
Rotation range	14
<b>Internal construction and operation principle</b>	15
Size 10,15	15
<b>Size 20,30,40</b>	16
<b>Basic circuit</b>	17
Circuit structure	17
<b>Mounting</b>	18
<b>Restriction of the load to axis</b>	18
Operation of axis fitting referring	18
<b>Flange application</b>	19
Piping and operating direction	19
Operating air	19
<b>Setting rotation time</b>	20
<b>Moment of inertia</b>	20
Table for calculation of Inertia moment	21
Kinetic energy	22
<b>Auto switch type for rotary table</b>	23
Auto switch specification	23
Auto switch installation	25
Auto switch set position	25
Internal structure and operation principle	26
<b>Maintenance and Inspection</b>	27
Periodic inspection	27
Replacement procedure of the seal set	27
<b>Troubleshooting</b>	33

## Safety Instruction

These safety instructions are intended to prevent hazardous situations and/or equipment damage.

These instructions indicate the level of potential hazard by labels of

“**Caution**”, “**Warning**” or “**Danger**”. To ensure safety, be sure to observe ISO4414 <sup>Note 1)</sup>, JIS B 8370 <sup>Note 2)</sup> and other safety practices.

### **Caution**

In extreme conditions, there is a possibility of serious injury or loss of life.

### **Warning**

Operator error could result in serious injury or loss of life.

### **Danger**

Operator error could result in injury or equipment damage.

Note 1) ISO 4414 : Pneumatic fluid power-Recommendations for the application of equipment to transmission and control systems.

Note 2) JIS B 8370 : Pneumatic system axiom.

## **Warning**

### **1. The compatibility of pneumatic equipment is the responsibility of the person who designs the Pneumatic system or decides its specifications.**

Since the products specified here are used in various operating conditions, their compatibility with the specific pneumatic system must be based on specifications or after analysis and/or tests to meet your specific requirements.

### **2. Only trained personnel should operate pneumatically operated machinery and equipment.**

Compressed air can be dangerous if an operator is unfamiliar with it. Assembly, handling or repair of pneumatic systems should be performed by trained and experienced operators.

### **3. Do not service machinery/equipment or attempt to remove components until safety is confirmed.**

1. Inspection and maintenance of machinery/equipment should only be performed after confirmation of safe locked-out control positions.
2. When equipment is to be removed, confirm the safety process as mentioned above. Cut the supply pressure for the equipment and exhaust all residual compressed air in the system.
3. Before machinery/equipment is re-started, take measures to prevent quick extensions of the cylinder piston rod etc.(Bleed air into the system gradually to create back-pressure.)

### **4. Contact SMC if the product is to be used in any of the following conditions:**

1. Conditions and environments beyond the given specifications, or if product is used outdoors.
2. Installation on equipment in conjunction with atomic energy, railway, air navigation, vehicles, medical equipment, food and beverage, recreation equipment, emergency stop circuits, press applications, or safety equipment.
3. An application which has the possibility of having negative effects on people, property, or animals, requiring special safety analysis.

## Design

# **Warning**

- ① **If the operation involves load fluctuations, ascending/descending movements, or changes in friction resistance, make sure to provide safety measures.**  
Failure to provide such measures could accelerate the movement, which may be hazardous to humans, machinery, and other equipment.
- ② **If there is a chance that it will pose a hazard to humans, install a protective cover.**  
If the moving portion of the product will pose a hazard to humans or damage the machinery of equipment, provide a construction that prevents direct contact with those areas.
- ③ **Make sure that the secured portions will not loosen.**  
Be sure to adopt a reliable connecting method if the rotary actuator is used very frequently or if it is used in a location that is exposed to a large amount of vibrations.
- ④ **Consider the possibility of a reduction in the circuit air pressure that could be caused by power outages.**  
When the product is used for a clamping, if the circuit air pressure is reduced due to a power outage, the clamping force could decrease, thus creating a hazardous situation in which the work piece is released. Therefore, make sure to integrate safety features that will prevent hazards to humans or damage to the equipment.
- ⑤ **Consider the possibility of power source related malfunctions that could occur.**  
On the pieces of equipment that rely on power sources such as compressed air, electricity, or hydraulic pressure, adopt a countermeasure that will prevent these pieces of equipment from causing hazards to humans or damage to the equipment in the event of a malfunction in these power sources.
- ⑥ **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 actuator will operate at abnormally high speeds, which could pose a hazard to humans and damage the machinery and equipment.
- ⑦ **Consider the behavior of the rotary actuator in the event of an emergency stop.**  
Devise a design that ensures safety so that if a person engages the emergency stop, or if a safety device is tripped during a system malfunction such as a power outage, the halting of the machine will not cause the movement of the rotary actuator to pose a hazard to humans or damage the equipment.
- ⑧ **Consider the behavior of the rotary actuator when restarting after an emergency stop.**  
Devise a design that ensures safety so that the restarting of the rotary actuator will not pose a hazard to humans or damage the equipment.  
If it is necessary to reset the rotary actuator to its starting position, make sure to provide a safe, manually operated control device.
- ⑨ **Do not use the product as a shock absorber.**  
If an abnormal pressure or air leakage occurs, the rotary actuator's speed reduction capability could become severely affected, which could pose a hazard to humans and damage the machinery and equipment.

## Selection

### **Warning**

① **Confirm the specification**

Rotary actuator is designed for use only in industry compressed air system. Do not use the product out of pressure and temperature on its specification. If fluid other than compressed air is used, consult SMC.

② **Select a speed within the product's allowable energy value.**

If the product is used in a state in which the kinetic energy of the load exceeds the allowable value, it could damage the product, which could pose a hazard to humans and damage the machinery and equipment.

③ **Provide a shock absorber if the kinetic energy that is applied to the product exceeds the allowable value.**

If the product is used in a state in which the kinetic energy exceeds the allowable value, it could damage the product, which could pose a hazard to humans and damage the machinery and equipment.

④ **Do not stop or hold the product at midpoint by keeping air pressure in the product.**

With the 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 damage the machinery and equipment.

### **Caution**

① **Do not operate the product in the low speed range below the speed adjustment range Specified for the product.**

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

② **Do not apply 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 style.**

With a double piston product, if the internal piston is stopped by coming into contact with the angle adjustment screw or the cover, the holding torque at the rotating end is one-half that 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 in which the initial rotation angle could change.

⑤ **Do not use the product under hydraulic pressure.**

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

## Mounting

### **Warning**

- ① **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.
- ② **Do not loosen the angle adjustment screw beyond the allowable adjustment range.**  
The angle adjustment screw could pull out if it is loosened beyond its allowable adjustment range, which could pose a hazard to humans and damage the machinery and equipment.
- ③ **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 actuator could operate suddenly, which could pose a hazard to humans and damage the machinery and equipment.
- ④ **Do not modify the product.**  
By modifying the product, its strength could be affected, which could lead the product to break. As a result, it could pose a hazard to humans and damage the machinery and equipment.
- ⑤ **Do not enlarge the fixed throttle by modifying the pipe connectors.**  
If the hole diameter is enlarged, the product's rotation speed increases, causing the shock force to increase and damage the product. As a result, it could pose a hazard to humans and damage the machinery and equipment.
- ⑥ **If shaft couplings are to be 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.

### **Caution**

- ① **Do not use organic solvent to wipe the area of the nameplate that shows the model.**  
It will erase what is indicated on the nameplate.
- 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. When a load must be coupled to the rotating table, secure the rotating table.
- ③ **Do not place foot on piston rod and the load mounted to the piston rod directly.**  
Weighting piston rod directly causes damage of piston rod and bearing etc.
- ④ **Use within the range of angle adjustment.**  
Using over the range of angle adjustment leads to malfunction and damage of the product.

## Air Supply

### **Warning**

① **Use clean air.**

Do not use compressed air that contains synthetic oil, salt, and corrosive gases in which chemicals and organic solvents are present, because it could cause equipment damage or malfunction.

### **Caution**

① **If ultra dry air is used as a fluid, the lubrication characteristic of equipment will be deteriorated and this can affect the reliability (life) of the product. Contact SMC for using the ultra dry air beforehand.**

② **Install an air filter.**

Install an air filter upstream, near the valve. Select an air filter with a filtration degree of  $5\ \mu\text{m}$  or finer.

③ **Take appropriate measures to ensure air quality, such as by providing an after cooler, air dryer, or drain catch.**

Compressed air that contains a large amount of drainage could cause the rotary actuator or other types of pneumatic equipment to malfunction. Therefore, take appropriate measures to ensure air quality, such as by providing an after cooler, air dryer, or drain catch.

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

If the fluid temperature is below  $5^{\circ}\text{C}$ , the moisture in the circuit could freeze, causing damage to the seals and leading to equipment malfunction. Therefore, take appropriate measures to prevent freezing.

For detailed information regarding the quality of the compressed air described above, refer to SMC's "Air Cleaning Systems".

## Operating Environment

### **Warning**

① **Do not use the rotary table in an environment or location that poses the risk of corrosion.**

Refer to the respective construction diagram for details on the materials used in the rotary actuator.

② **Do not use the rotary table in an area that contains a large amount of dust, or an area in which water or oil could be splashed on the rotary actuator.**

## Speed 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.

## Lubrication

### **Caution**

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

## Maintenance

### **Warning**

- ① **During a maintenance inspection, do not disassemble the equipment with electrical power or an air supply applied.**
- ② **After the product has been disassembled for inspection, make sure to perform the appropriate functionality inspection.**  
The product specifications cannot be met unless a functionality inspection is performed.

### **Caution**

- ① **For lubrication, use the type of grease that is used for the respective product.**  
The use of a non-designated lubricant could damage the seals.

## Attention of auto switch

## Design&Selection

### **Caution**

- ① **Confirm the specifications.**  
Read the specifications carefully and use this product appropriately. The product may be damaged or malfunction if it is used outside the range of specifications of current load, voltage, temperature or impact.



② **Take precaution when multiple actuators are used close together.**

When multiple actuators are used close and parallel, magnetic field interference could cause malfunction of the switch. Maintain a minimum actuator separation of 40mm.

③ **Pay attention to the length of time when a switch is ON at an intermediate stroke position.**

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

The maximum piston speed is:

$$V(\text{mm/s}) = \frac{\text{Auto switch operating range (mm)}}{\text{Load applied time (ms)}} \times 100$$

④ **Wiring should be kept as short as possible.**

<Reed switch>

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) For an auto switch without a contact protection circuit, 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 30m long, it is not able to adequately absorb the rush current and its life may be reduced. It is again necessary to connect a contact protection box in order to extend its life. Please contact SMC in this case.

<Solid state switch>

- 3) Although wire length should not affect switch function, use a wire 100m or shorter.

⑤ **Take precautions for the internal voltage drop of the switch.**

<Reed switch>

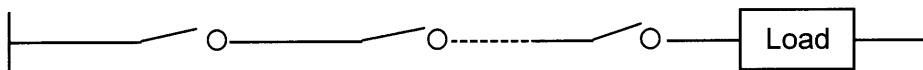
- 1) Switches with an indicator light Except (D-A56, A76H, A96, A96V, C76 and E76A)

- 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 diode. (Refer to 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.

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

- 2) If the internal resistance of a light emitting diode causes a problem, select a switch without an indicator for right (MODEL D-A6□, A-80, A80H, A90, A90V, C80, R80, 90, E80A and Z80)

<Solid state switch>

- 3) Generally, the internal voltage drop will be greater with a 2 wire solid state auto switch than with a reed switch. Take the same precautions as in 1). Also, note that a 12VDC relay is not applicable.

⑥ **Pay attention to leakage current.**

<Solid state switch>

With a 2 wire solid state auto switch, current (leakage current) flows to the load to operate the internal circuit even when in the OFF state.

Operating current of load (OFF condition) > 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.

⑦ **Do not use a load that generates surge voltage.**

<Reed switch>

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

<Solid state switch>

Although a zener diode for surge protection is connected at the, output side of a solid state auto switch, damage may still occur if the surge is applied repeatedly. When a load, such as a relay or solenoid, which generates surge is directly driven, use a switch with a built-in surge absorbing element.

⑧ **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 periodic maintenance and confirm proper operation.

⑨ **Ensure sufficient clearance for maintenance activities.**

When designing an application, be sure to allow sufficient clearance for maintenance and inspections.

## Mounting & Adjustment

### **Warning**

① **Do not drop or bump.**

Do not drop, bump or apply excessive impacts ( $300\text{m/s}^2$  or more for reed switches and  $1000\text{m/s}^2$  or more for solid state switches) while handling.

Although the body of the switch may not be damaged, the inside of the switch could be damaged and cause a malfunction.

② **Do not carry a cylinder by the auto switch lead wires.**

Never carry a cylinder by its lead wires. This may not break the lead wires, but it may cause internal elements of the switch to be damaged by the stress.

③ **Mount switches using the proper fastening torque.**

When a switch is tightened beyond the range of fastening torque, the mounting screws, mounting bracket or switch may be damaged. On the other hand, tightening below the range of fastening torque may allow the switch to slip out of position. (Refer to switch mounting for each series regarding switch mounting, moving, and fastening torque, etc...)

④ **Mount a switch at the center of the operating range.**

Adjust the mounting position of an auto switch so that the piston stops at the center of the operating range (the range in which a switch is ON). (The mounting position shown in a 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.

## Wiring

### **Warning**

① **Avoid repeatedly bending or stretching lead wires.**

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

② **Be sure 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 switch will be instantly damaged because of excess current.

③ **Confirm proper insulation of wiring.**

Be certain that there is no faulty wiring insulation (contact with other circuits, ground fault, improper insulation between terminals, etc...) Damage may occur due to excess current flow into a switch.

④ **Do not wire with power lines or high voltage lines.**

Wire separately from power lines or high voltage lines, avoiding parallel wiring or wiring in the same conduit with these lines. Control circuits, including auto switches, may malfunction due to noise from these other lines.

⑤ **Do not allow short circuit of loads.**

<Reed switch>

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 switch>

Model D-M9□(V), M9□W(V), G5NB and all models of PNP output switches do not have built-in short circuit prevention circuits. If loads are short circuited, the switches will be instantly damaged. Take special care to avoid reverse wiring with the brown (red) power supply line and the black (white) output line on 3 wire type switches.

⑥ **Avoid incorrect wiring.**

<Reed switch>

A 241V DC 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, a switch will operate, however, the light emitting diode will not light up.

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

Applicable models : D-A73, A73H, A73A

<Solid state switch>

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

## Operation Environment

### **Warning**

- ① **Never use in an atmosphere with explosive gases.**  
The structure of auto switches is not designed to prevent explosion. Never use in an atmosphere with an explosive gas since this may cause a serious explosion.
- ② **Do not use in an area where a magnetic field is generated.**  
Auto switches will malfunction or magnets inside cylinders will become demagnetized. (Consult SMC regarding the availability of a magnetic field resistant auto switch.)
- ③ **Do not use in an environment where the auto switch will be continually exposed to water.**  
Although switches except satisfy the IEC standard IP67 structure (JIS C 0920: anti-immersion structure), do not use switches in applications where continually exposed to water splash or spray. Poor insulation or swelling of the potting resin inside switches may cause malfunction.
- ④ **Do not use in an environment with oil or chemicals.**  
Consult SMC if auto switches will be used in an environment with coolant, cleaning solvent, various oils or chemicals. If auto switches are used under these conditions for even a short time, they may be adversely affected by improper insulation, malfunction due to swelling of the potting resin, or hardening of the lead wires.
- ⑤ **Do not use in an environment with temperature cycles.**  
Consult SMC if switches are used where there are temperature cycles other than normal temperature changes, as they may be adversely affected.
- ⑥ **Do not use in an environment where there is excessive impact shock.**  
<Reed switch>  
When excessive impact ( $300\text{m/s}^2$  or more) is applied to a reed switch during operation, the contact point will malfunction and generate or cut off a signal momentarily (1ms or less). Consult SMC regarding the need to use a solid state switch depending upon the environment.
- ⑦ **Do not use in an area where surges are generated.**  
<Solid state switch>  
When there are units (solenoid lifter, high frequency induction furnace, motor, etc.) which generate a large amount of surge in the area around table with solid state auto switches, this may deteriorate or damage to the switch. Avoid sources of surge generation and disorganized lines.
- ⑧ **Avoid accumulation of iron powder or close contact with magnetic substances.**  
When a large amount of ferrous powder such as machining chips or spatter is accumulated, or a magnetic substance is brought into close proximity with an auto switch table, it may cause the auto switch to malfunction due to a loss of the magnetic force inside the cylinder.

## Maintenance

### **Warning**

- ① **Perform the following maintenance periodically in order to prevent possible danger due to unexpected auto switch malfunction.**
  - 1) Secure and tighten 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 switches or repair lead wires, etc., if damage is discovered.

- 3) Confirm the lighting of the green light on the 2 color indicator switch.  
Confirm that the green LED is on when stopped at the established position. If the red LED is on, the mounting position is not appropriate. Readjust the mounting position until the green LED light up.

#### Other

## **Warning**

- ① **Consult SMC concerning water resistance, elasticity of lead wires, and usage at welding sites, etc.**

## Outline

This operation manual is for rack pinion type low-speed rotary actuator. Cautions will be given on the load (inertia moment), rotation time and others. Please read through the manual before starting operation.

### ■ Specification

Table 1 Specification

Size	10	15	20	30	40
Operating fluid	Air (Non-lube)				
Max. operating pressure	0.7 MPa			1 Mpa	
Min. operating pressure	0.15 Mpa			0.1 MPa	
Ambient temp. and operating fluid temp.	0~60°C (No freeze)				
Cushion	None				
Angle adjustment	±5°				
Rotation angle	80° ~ 100° , 170° ~ 190°				
Port size	M5 × 0.8			Rc 1/8 , G 1/8, NPT 1/8 , NPTF 1/8	
Output (N·m) { At 0.5MPa }	0.3	0.75	1.8	3.1	5.3

Table 2 Allowable kinetic energy and adjustment range of rotating time

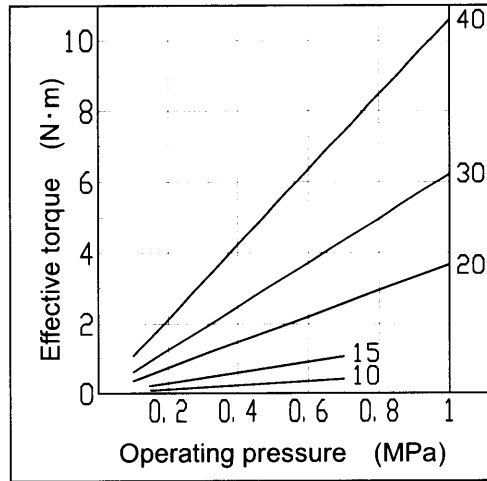
サイズ	Allowable kinetic energy (J)	Rotating speed adjustment range having stable operation (s/90°)
10	0.00025	0.7 ~ 5
15	0.00039	
20	0.025	1 ~ 5
30	0.048	
40	0.081	

Table 3 Weight (g)

Size	Weight ※	
	90°	180°
10	120	150
15	220	270
20	600	700
30	900	1100
40	1400	1600

※ Values except weight of auto switch

■ Effective torque

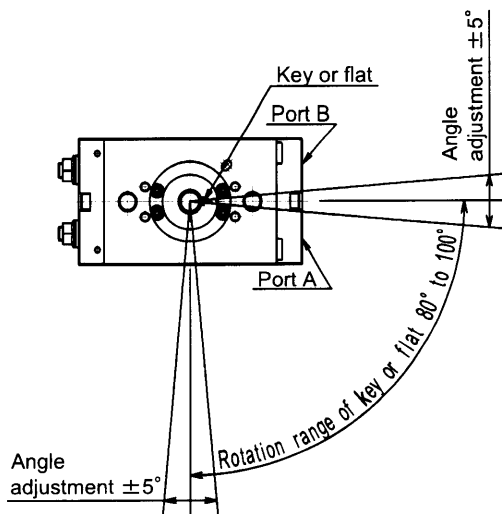


Graph.1 Effective torque

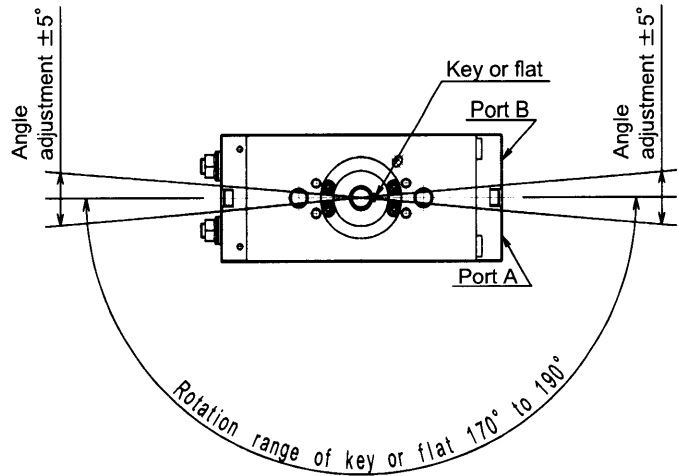
■ Rotation range

When pressurized from the Port A, the shaft will rotate clockwise.

Flat face and parallel key position indicate B port is pressurized.



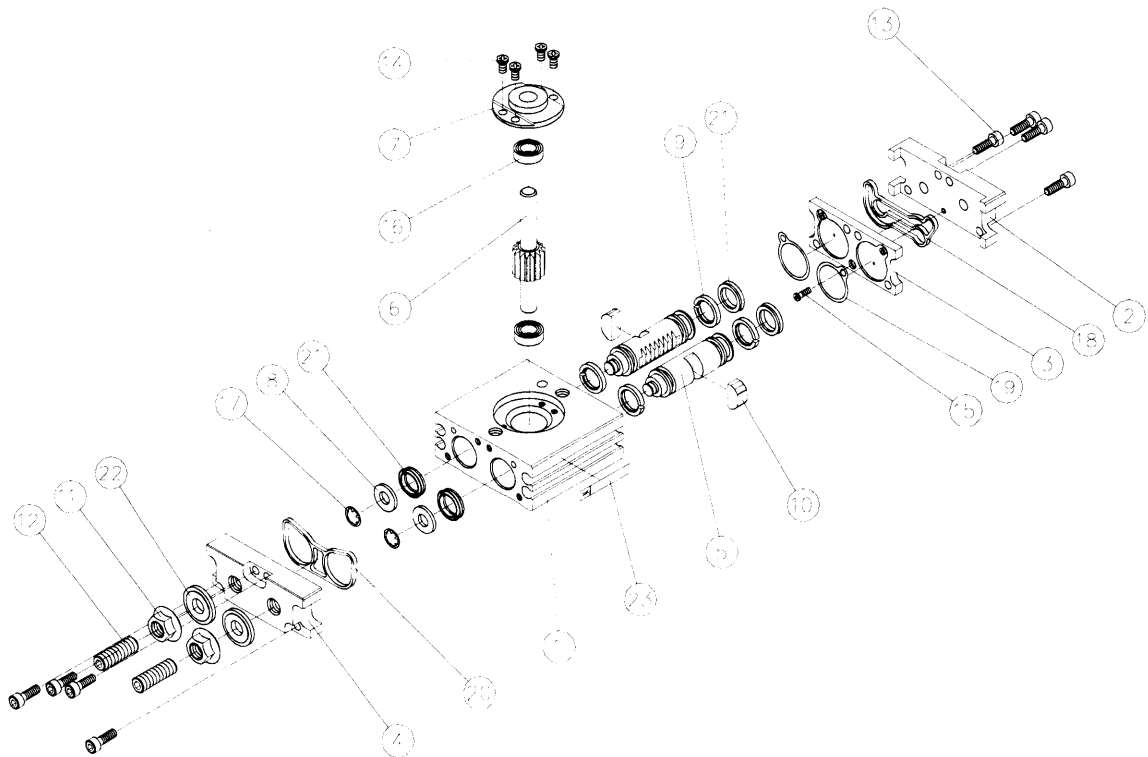
Rotation range : 90°



Rotation range : 180°

# Internal structure and parts description

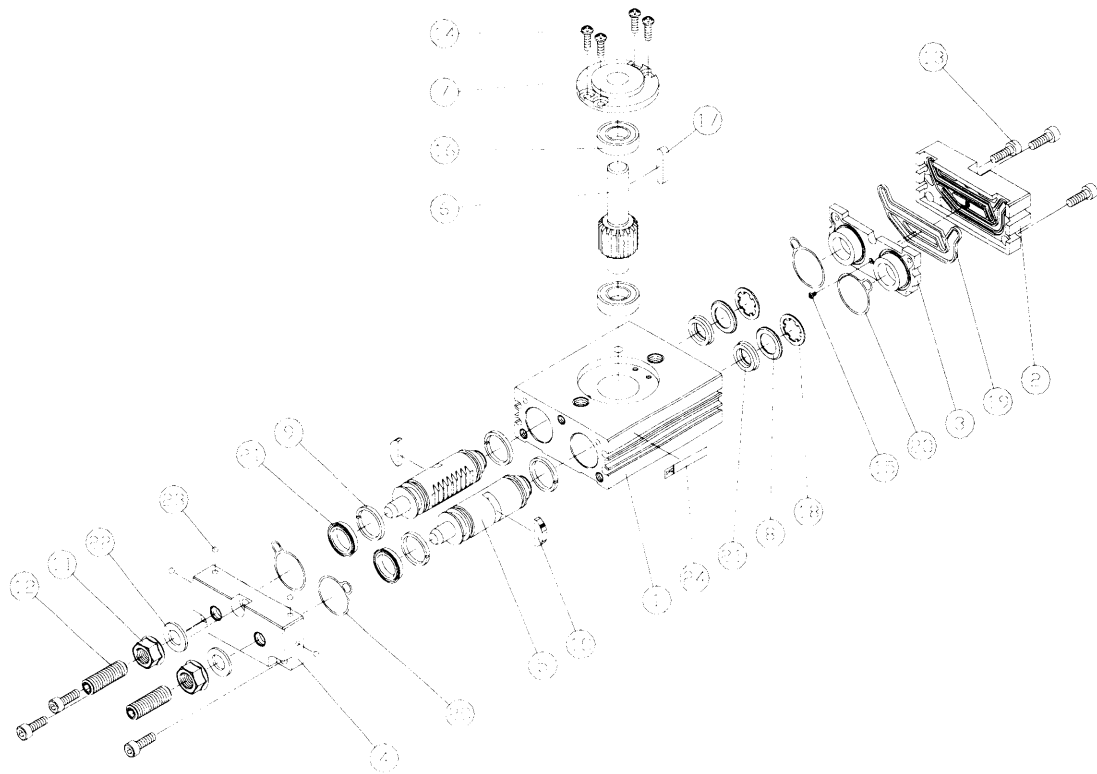
■ Size 10 , 15



23	Heat transferred label	1	
22	Seal washer	2	
21	Piston packing	4	
20	End cover gasket	1	
19	Cover gasket	2	
18	Packing	1	
17	Retainer	2	
16	Bearing	2	
15	Cross recessed No.0 screw	1	
14	Cross recessed No.0 screw	4	
13	Hexagon socket head screw	8	
12	Adjust bolt	2	
11	Hexagon nut with flange	2	
10	Magnet	2	Including magnet built-in type
9	Wear ring	4	
8	Packing retainer	2	
7	Bearing retainer	1	
6	Shaft	1	
5	Piston	2	
4	End cover	1	
3	Plate	1	
2	Cover	1	
1	Body	1	
No.	Description	Qty.	Note



■ Size 20 , 30 , 40



24	Heat transferred label	1	
23	Steel ball	4	
22	Seal washer	2	
21	Piston packing	4	
20	Gasket	4	
19	Packing	1	
18	Retainer	2	
17	Parallel key	1	
16	Bearing	2	
15	Cross recessed No.0 screw	1	
14	Cross recessed socket head screw	4	
13	Hexagon socket head bolt	6	
12	Hexagon socket head cap screw	2	
11	Hexagon nut with flange	2	
10	Magnet	2	Only magnet built-in type included
9	Wear ring	4	
8	Packing retainer	2	
7	Bearing retainer	1	
6	Shaft	1	
5	Piston	2	
4	End cover	1	
3	Plate	1	
2	Cover	1	
1	Body	1	
No.	Description	Qty.	Note

## Basic circuit

### ■ Circuit structure

See below for the circuit to operate the rotary actuator using air filter, regulator, solenoid valve, and speed controller.

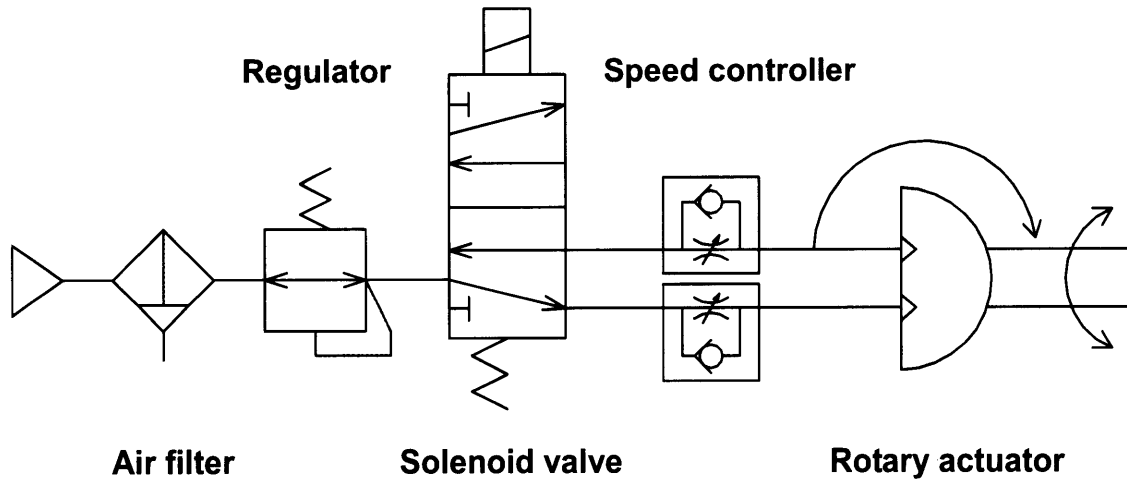


Fig.1 Basic circuit

# Mounting

## Restriction of the load to axis

Table of load below shows the allowable load when no moving load applied to axis direction. Avoid applying load to the axis directly as much as possible.

Table 4 Allowable load (N)

Size	Load direction		
	Fsa	Fsb	※Fr
10	15.7	7.8	14.7
15	19.6	9.8	19.6
20	49	29.4	49
30	98	49	78
40	108	59	98

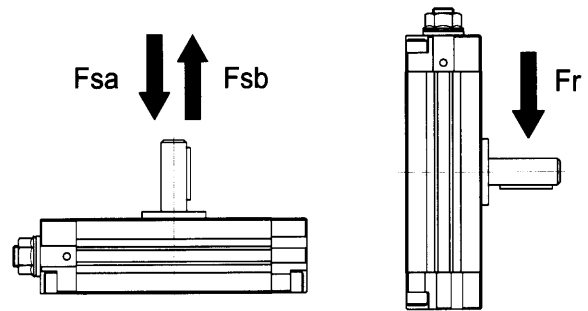


Fig.2 Load direction

※ Point of application of force of Fr is the center of shaft flat face and longer dimension of the key.

Although allowable radial, thrust load can be applied where no moving load exist, direct load to the axis should be avoided as much as possible. Example below is recommended so that the load is not applied to the axis directly.

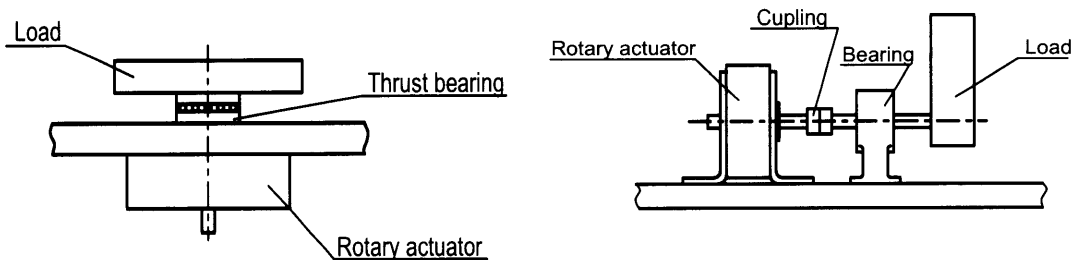


Fig.3

## Operation of axis fitting referring

As in Fig.4, alignment of the rotary actuator and the mating axis is necessary when the rotary actuator is used with its axis lengthened. If misaligned, the axis is applied with excessive bend moment. Under this condition, stable operation is not available which lead to cause the damage of axis. In this case, flexible fitting (flexible joint specified by JIS) becomes necessary.

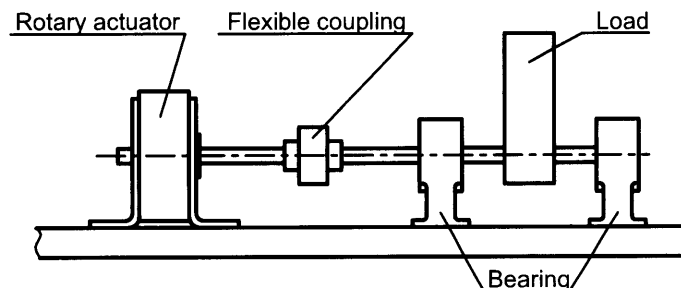


Fig.4

■ Flange application

See table 5 for L dimension of the body.  
 JIS hexagon socket head bolt is neatly placed in the rotary actuator groove.

Table 5 (mm)

Size	L	Bolt
10	13	M 4
15	16	M 4
20	22.5	M 6
30	24.5	M 8
40	28.5	M 8

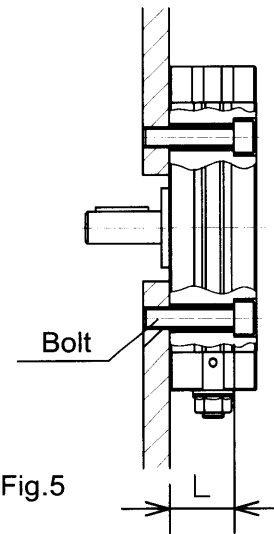


Fig.5

■ Piping and operating direction

Fig.6 shows piping ports of the rotary actuator.  
 Table 6 shows the port size.

Table 6

Size	Port size
10	M5 × 0.8
15	
20	Rc 1/8 , G 1/8 NPT 1/8 , NPTF 1/8
30	
40	

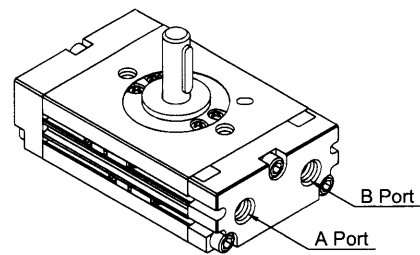


Fig.6 Port location

The rotary actuator is provided with a fixed orifice at the inside of port. Don't enlarge the hole. Enlarged hole increases the operation speed of the rotary actuator and the impact, which lead to cause the breakage of the rotary actuator.

Perform followings before piping.

- a) Flush or clean the piping to eliminate metal swarf, cutting oil and dust before connecting piping.
- b) Mind so that the piping swarf and sealing material do not enter into the piping when screwing in piping and fitting. When using the seal tape, leave 1.5~2 threads.

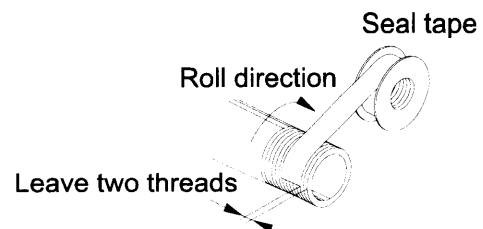


Fig.7 Applying seal tape

■ Operating air

Air supplied to the rotary actuator shall be cleaned by the filter. CRQ2X series is lubrication free.

## Setting rotation time

The load inertia lead to cause the damage of the shaft and internal parts even if generated torque of rotary actuator is small. The calculation of load inertia moment and kinetic energy is necessary to set the rotation time for operating the rotary actuator.

### ■ Moment of inertia

Inertia moment indicates scales how hard to rotate the object, and also how hard to stop rotating object.

An object started by the rotary actuator is getting to have inertia force. When the rotary actuator stops at the stroke end, the actuator received big impact (kinetic energy) due to inertia force. Please refer below for calculation of kinetic energy.

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

E : Kinetic energy	J
I : Inertia moment	kg · m <sup>2</sup>
ω : Angular speed	rad/s

Allowable kinetic energy for the rotary actuator is limited. The limit of rotation time is obtained by calculating inertia moment. Please refer following for obtaining inertia moment.

#### Basic inertia moment

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

m : Weight of load.	kg
r : Load center of gravity and distance of rotation axis.	m

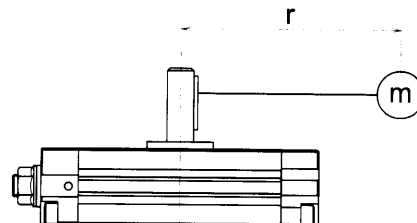
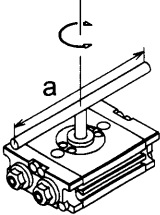
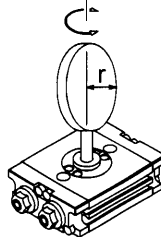
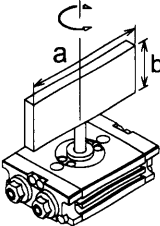
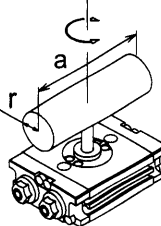
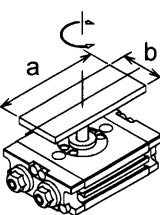
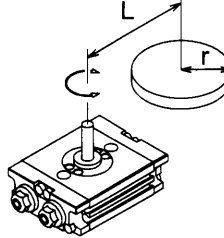
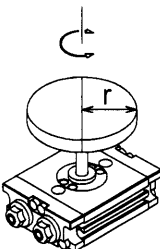
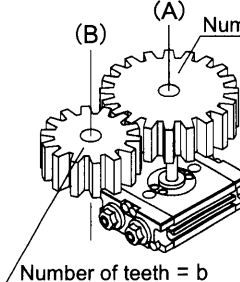
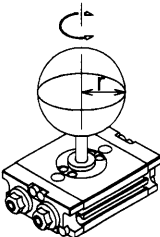


Fig. 8

This shows inertia moment of “m (weight)” at “r” from the rotation axis. Calculation of inertia moment depends on the shape of the object. Please refer the table on the next page for inertia moment calculation.

■ Table for calculation of Inertia moment

I : Moment of inertia  $\text{kg} \cdot \text{m}^2$     m : Load weight  $\text{kg}$

<p>① <b>Thin rod</b> Location of rotation axis : Perpendicular to the rod and through the rod's center of gravity</p>  $I = m \cdot \frac{a^2}{12}$	<p>⑥ <b>Thin round board</b> Location of rotation axis : Cross the board's diameter</p>  $I = m \cdot \frac{r^2}{4}$
<p>② <b>Thin rectangular board</b> Location of rotation axis : Parallel to the side b and through the board's center of gravity</p>  $I = m \cdot \frac{a^2}{12}$	<p>⑦ <b>Cylinder</b> Location of rotation axis : Cross the cylinder's diameter and through the cylinder's center of gravity</p>  $I = m \cdot \frac{3r^2 + a^2}{12}$
<p>③ <b>Thin rectangular board (including rectangular parallelepiped)</b> Location of rotation axis : Perpendicular to the board and through the board's center of gravity</p>  $I = m \cdot \frac{a^2 + b^2}{12}$	<p>⑧ <b>Inconsistent center of gravities between rotation axis and load</b></p>  $I = K + m \cdot L^2$ <p>K : Moment of inertia around the Center of gravity of load</p> <p>④ Round board <math>I = m \cdot \frac{r^2}{2}</math></p>
<p>④ <b>Round board (including Column)</b> Location of rotation axis : Through the board's center axis</p>  $I = m \cdot \frac{r^2}{2}$	<p>⑨ <b>Gear Transmission</b></p>  <p>Number of teeth = a Number of teeth = b</p> <ol style="list-style-type: none"> <li>1. Calculate the moment of inertia <math>I_B</math> around shaft (B)</li> <li>2. Next, <math>I_B</math> is converted into moment of inertia around the (A) axis.</li> </ol> $I_A = \left(\frac{a}{b}\right)^2 \cdot I_B$
<p>⑤ <b>Sphere</b> Location of rotation axis : Cross the sphere's diameter</p>  $I = m \cdot \frac{2r^2}{5}$	

■ Kinetic energy

Table 8 shows the allowable kinetic energy of the rotary actuator.

The end angular speed  $\omega$  is obtained by:

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

$\theta$  : Rotation angle                      rad  
 $t$  : Rotation time                              s

Kinetic energy E is obtained by:

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

Table 7 Allowable kinetic energy

Size	Allowable kinetic energy J
10	0.00025
15	0.00039
20	0.025
30	0.048
40	0.081

Therefore, the rotary actuator rotation time is:

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

E : Allowable kinetic energy              J  
 $\theta$  : Rotation angle                              rad  
I : Inertia moment                              kg · m<sup>2</sup>

Note) If the rotating speed is slower than 2s/90 degree, it should be calculated to 2s/90 degree.

## Auto switch type for rotary actuator

The rotary actuator with auto switch has a piston with magnet mounted and an auto switch mounted on the body externally to detect the piston (magnet) position.

### Auto switch specification

Table 8 Reed auto switch

Part no.	Load voltage	Max. load current and load current range	Internal voltage drop	Indication light (illuminated when ON)	Applicable load
D-A90 D-A90V	AC 24V or less	50mA	—	Not provided	Relay PLC IC circuit
	DC 48V or less	40mA			
	AC 100V or less	20mA			
D-A93 D-A93V	DC24V	5 to 40mA	D-A93 2.4V or less (up to 20mA) 3.0V or less (up to 40mA) D-A93V 2.7V or less	Provided	Relay PLC
	AC100V	5 to 20mA	2.7V or less		
D-A96 D-A96V	DC4 to 8V	20mA	0.8V or less	Provided	IC circuit

- Lead wire — D-A90(V) and D-A93(V): Oil proof vinyl cable cord  
 $\phi$  2.7 0.18mm<sup>2</sup>×2-core (brown, blue) 0.5m  
 D-A96(V): Oil proof vinyl cable cord  
 $\phi$  2.7 0.15mm<sup>2</sup>×3-core (brown, black, blue) 0.5m
- Isolation resistance — 50 M $\Omega$  or more at DC500VM (between lead wire and case)
- Withstand voltage — AC1500V for 1 minute (between lead wire and case)
- Operating time — 1.2ms
- Ambient temperature — -10 to 60 °C
- Shock resistant — 300m/s<sup>2</sup>
- Current leakage — None
- Enclosure — Standard: IEC529, watertight: IP67(JISC0920)
- For lead wire length of 3m, L is indicated at the end of model no. Ex.) D-A90L



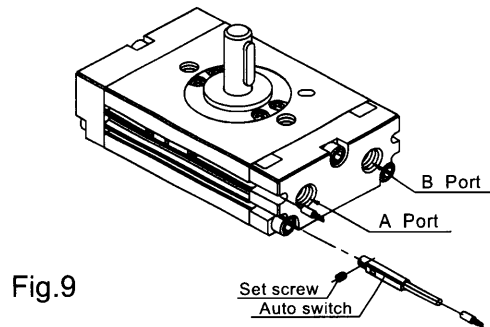
Table 9 Solid state auto switch specification (D-M9□)

Auto switch part no.	Output	Power voltage	Current consumption	Load voltage	Load current	Internal voltage drop	Current leakage	Applicable load
D-M9N D-M9NV D-M9NW D-M9NWV	NPN type	DC5·12·24V (4.5 to 28V)	10mA or less	DC28V or less	40mA or less	0.8V or less  For D-M9※W※ At 10mA 0.8V or less At 40mA 2V or less	100 μA or less at DC24V	Relay PLC IC circuit
D-M9P D-M9PV D-M9PW D-M9PWV	PNP type			—				
D-M9B D-M9BV D-M9BW D-M9BWV	—	—	—	DC24V (DC10 to 28V)	2.5 to 40mA	4V or less	0.8mA or less	DC24V Relay PLC

- Lead wire — D-M9B(V): Oil proof vinyl cabtire cord  
 $\phi 2.7 \times 3.2$  ellipse 0.15mm<sup>2</sup>×2-core (brown, blue) 0.5m  
 D-M9N(V), D-M9P(V): Oil proof vinyl cabtire cord  
 $\phi 2.7 \times 3.2$  ellipse 0.15mm<sup>2</sup>×3-core (brown, black, blue) 0.5m
- Isolation resistance — 50MΩ or more at DC500VM (between lead wire and case)
- Withstand voltage — AC1000V for 1 minute (between lead wire and case)
- Operating time — 1ms or less
- Ambient temperature — -10 to 60°C
- Shock resistant — 1000m/s<sup>2</sup>
- Enclosure — Standard: IEC529, watertight: IP67(JISC0920)
- For lead wire length of 3m, L is indicated at the end of model no. Ex.) D-M9NL

### ■ Auto switch installation

Use small driver (5~6mm of grip diameter) to tighten auto switch set screws with 0.1~0.2 N·m of tightening torque. Use slotted setscrew (with urethane damper) as setscrew.



### ■ Auto switch set position

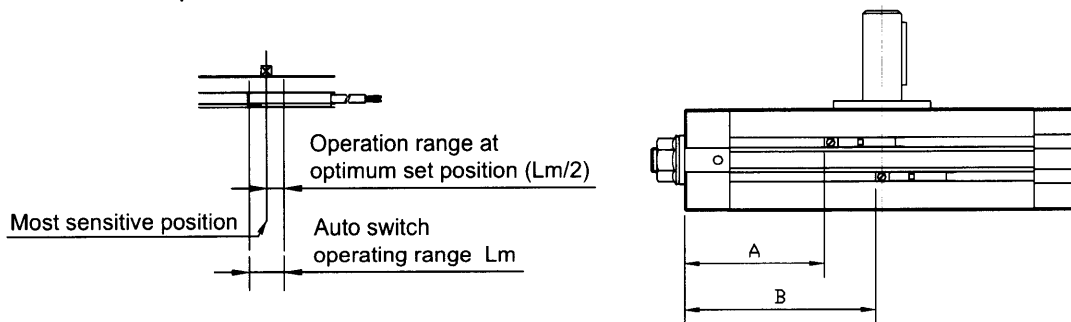


Table 10

Size	Rotation	Reed auto switch				Solid state auto switch			
		A	B	Operation angle $\theta_m$	Hysteresis angle	A	B	Operation angle $\theta_m$	Hysteresis angle
10	90°	15	21.5	63°	12°	19	25.5	75°	3°
	180°	18	31			22	35		
15	90°	18.5	27	52°	9°	22.5	31	69°	3°
	180°	22.5	39.5			26.5	43.5		
20	90°	36	48.5	41°	9°	40	52.5	56°	4°
	180°	42	67.5			46	71.5		
30	90°	43	59	32°	7°	47	63	43°	3°
	180°	51	82			55	86		
40	90°	50	69	24°	5°	54	73	36°	4°
	180°	59.5	97.5			63.5	101.5		

Operation angle  $\theta_m$  : The value in which the auto switch operating range “Lm” is converted to axis rotating value

Hysteresis angle : Value in which the auto switch hysteresis is converted to angle

If the auto switch is set in dimension “A”, the magnet is placed around the most sensitive area of the switch when the piston reaching the stroke ends.

## ■ Internal structure and operation principle

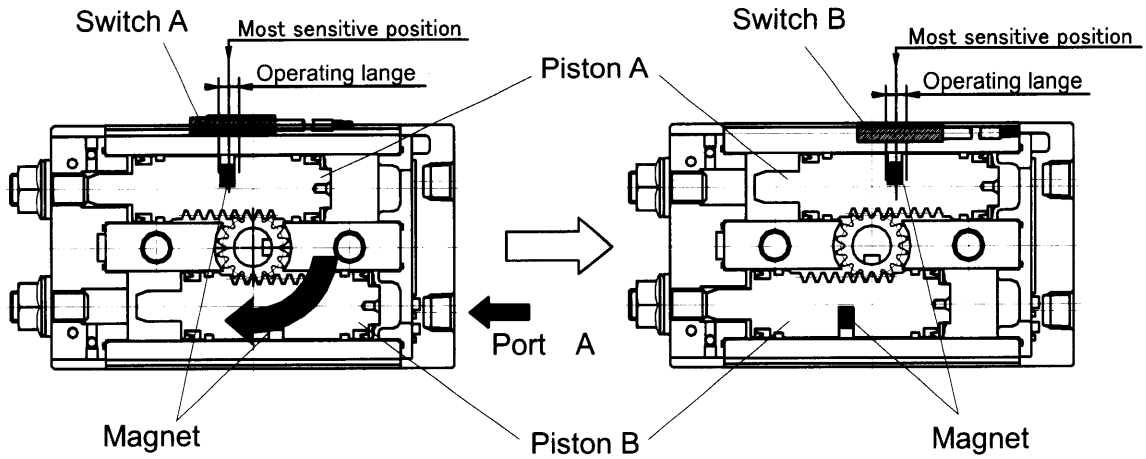


Fig.11

In Fig.11, the switch A is turned on. When pressurized from port A, piston B moves to the left and piston A moves to the right, and the shaft rotates clockwise. At this point, magnet goes out of switch A's operation range to turn off switch A. Then, piston A moves right, and the magnet goes into switch B's operation range to turn on switch B.

## Maintenance and Inspection

Periodic inspection is necessary for optimum use. Generally, annual inspection is recommended for the rotary actuator. Even if no problem is found, seal parts replacement is recommended every three years. It is highly possible that the actuator is operated out of specification when the components like shaft, pinion, rack, bearing are broken. Please revise the operating condition. In this case, please return the broken actuator to SMC to repair.

### ■ Periodic inspection

Check followings for periodic inspection

- (1) If the rotary actuator set screw become loose
- (2) If the rotary actuator set frame become loose
- (3) Is the operation smooth?
- (4) Is there no leakage to outside?

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 set

#### ■ Caution on disassemble

- (1) Disassemble where clean and spacious place.
- (2) Cover the rotary actuator pipe inlet and the end of rubber hose after removing the rotary actuator.
- (3) Mind not to damage internal sliding surface of the rotary actuator when disassembling it.
- (4) Please consult with us when you have any question on disassembling and inspection.

■ Disassembling procedure

- (1) Loosen cross recessed no.0 screw (size 10,15) or roundhead screw (size 20,30,40) .
- (2) Pull out the bearing retainer and the shaft from the body. Remove the bearing from the housing at this time.
- (3) Loosen hexagon socket head bolt to remove the cover Ass'y and the end cover Ass'y.
- (4) Push piston Ass'y from one side to pull out two piston Ass'ys from the body.
- (5) Take out the bearing from the body.

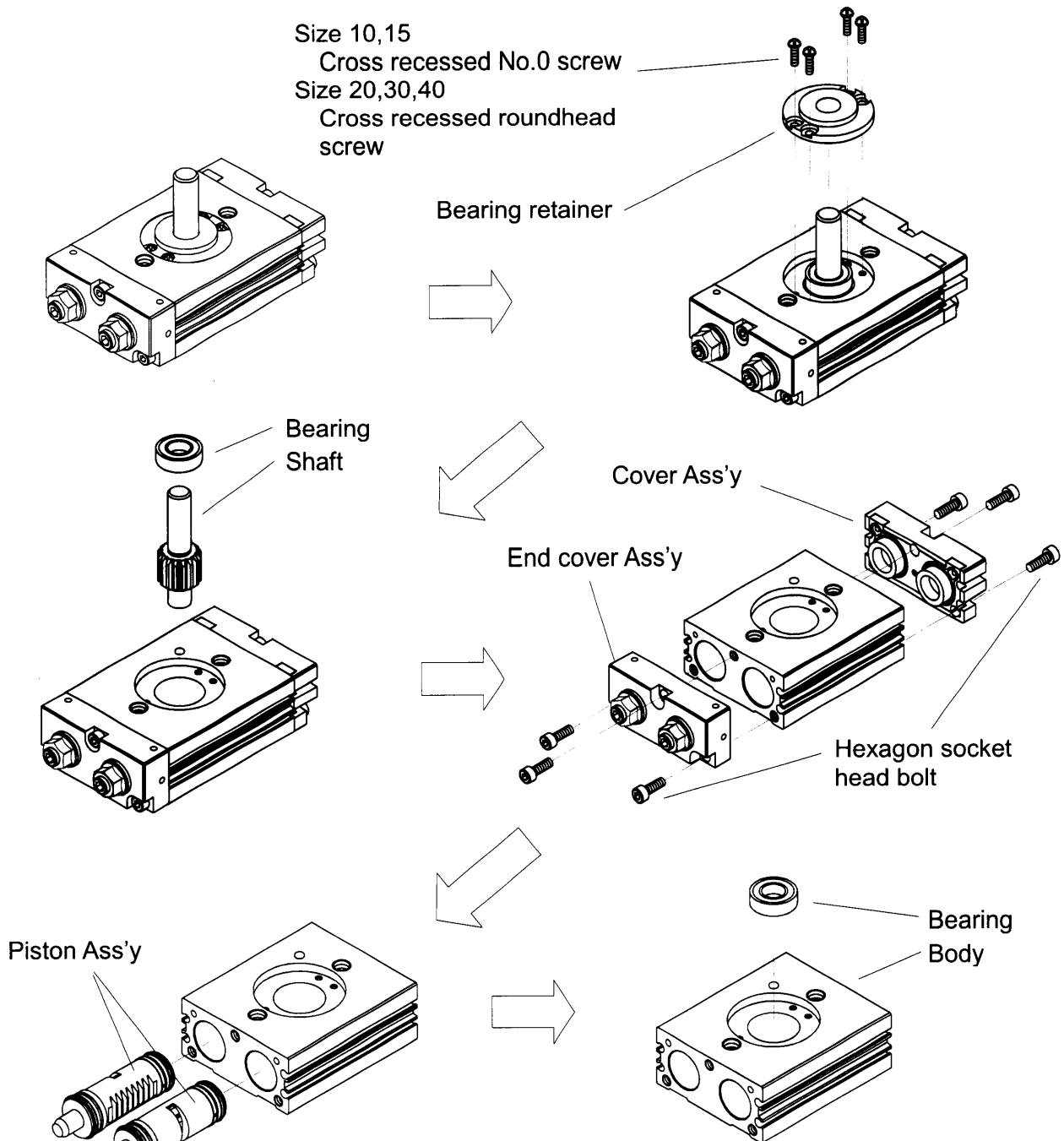


Fig.12

■ Assemble procedure

- (1) Clean each component sufficiently before assembled to prevent a dust from attaching.  
 Apply the grease which is enclosed to the seal set to each part shown in Table 11. The referential amount of applied grease is to the extent which can brighten the surface of components.  
 After that, mount a piston seal to a piston with care not to damage the piston seal.

Table 11 Parts applied with grease

Grease applied parts
Cylinder internal surface
Piston packing groove
Piston packing
Cover gasket (Size 10,15)
End cover gasket (Size 10,15)
Gasket (Size 20,30,40)
Packing

**Body Ass'y**

Wipe off the internal face of the cylinder body with alcohol, apply grease, and set the bearing to the housing of the body.

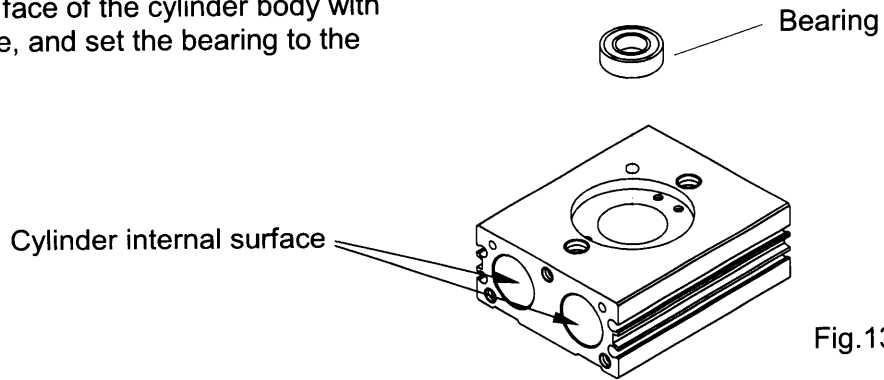


Fig.13

**Piston Ass'y**

Mind the mounting orientation of the piston seal.

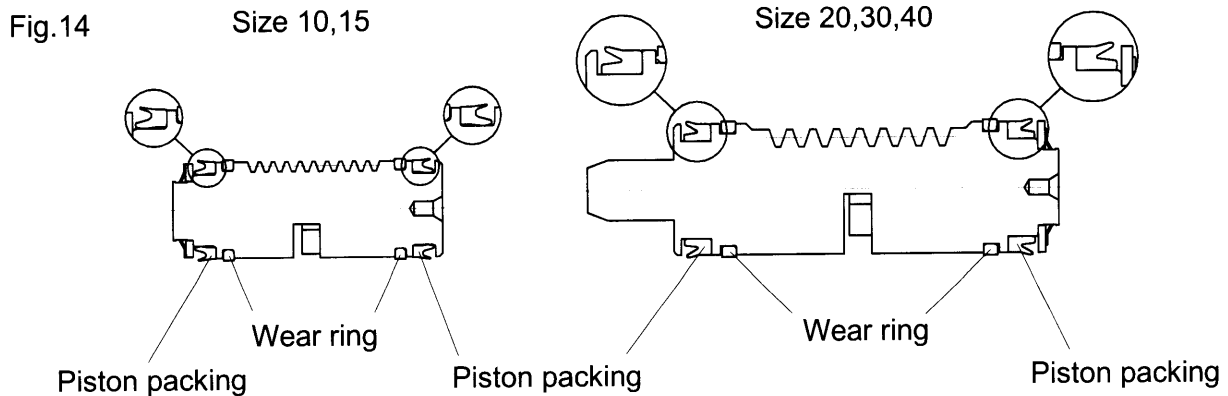


Fig.14

**Cover Ass'y**

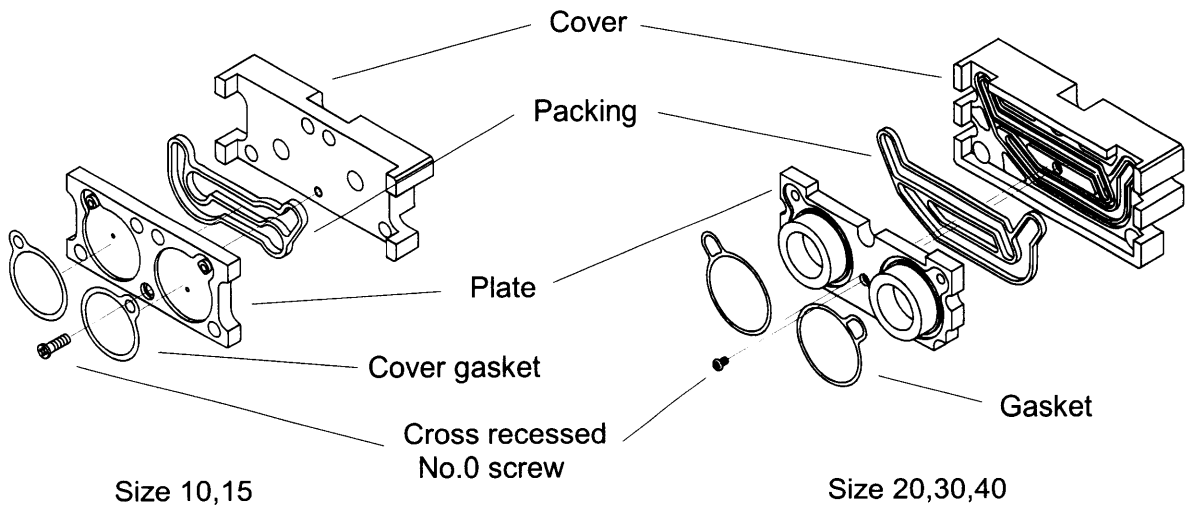


Fig.15

Insert and attach the cushion packing and the packing with the direction in the drawing below.

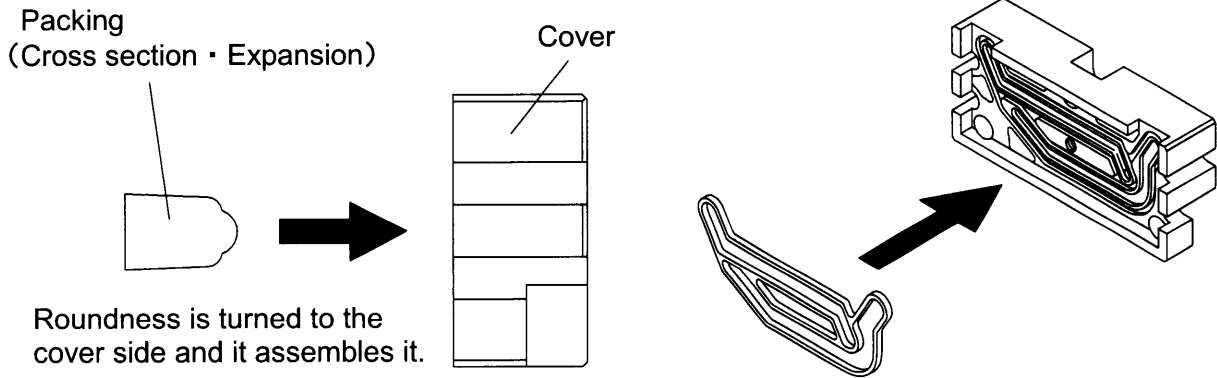
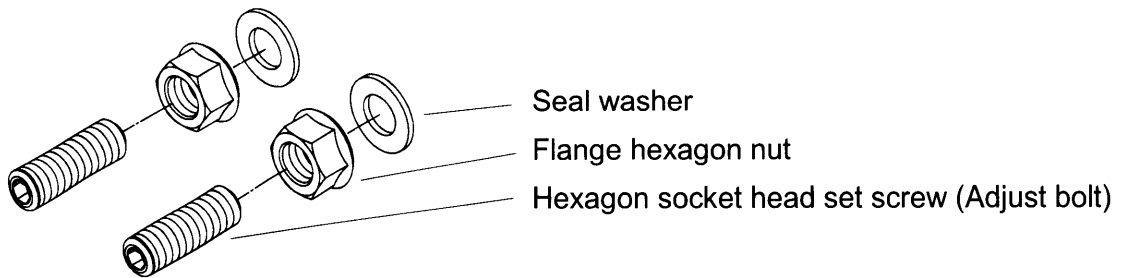


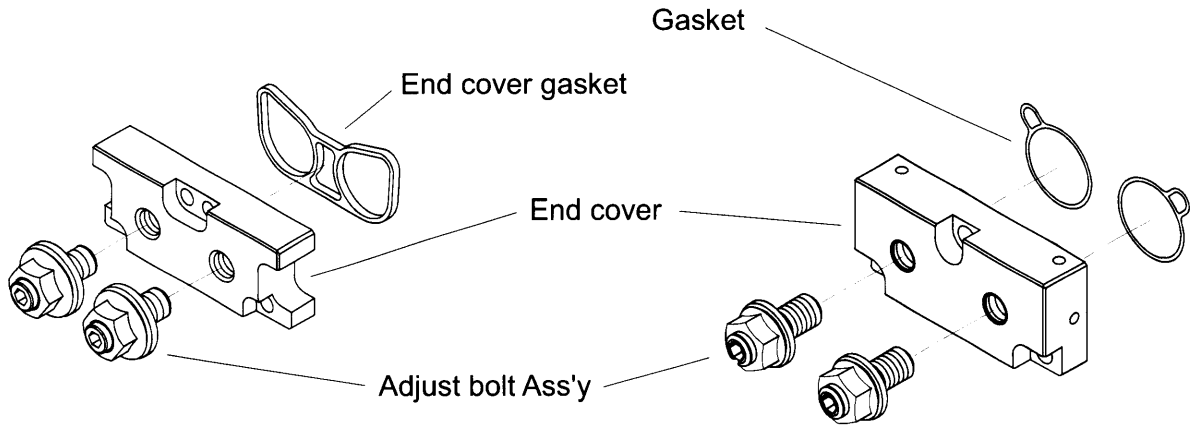
Fig.16

**Adjust bolt Ass'y**

Fig.17



**End cover Ass'y**



Size 10·15

Fig.18

Size 20·30·40

- (2) Insert the piston Ass'y to the body. At this time, the piston seal passes the opening of the cylinder and should be pressed inward not to be scratched. Also, mind the mounting orientation of the piston. (See fig.19)

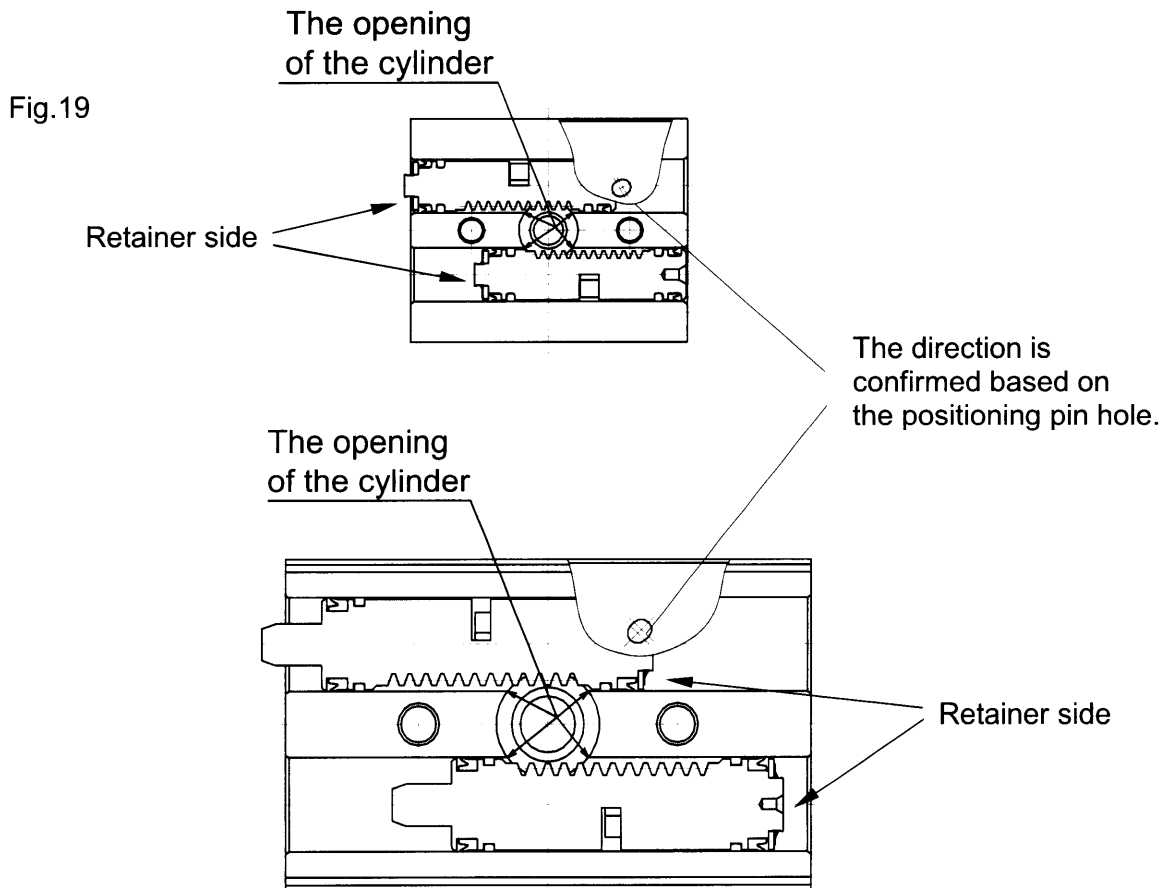
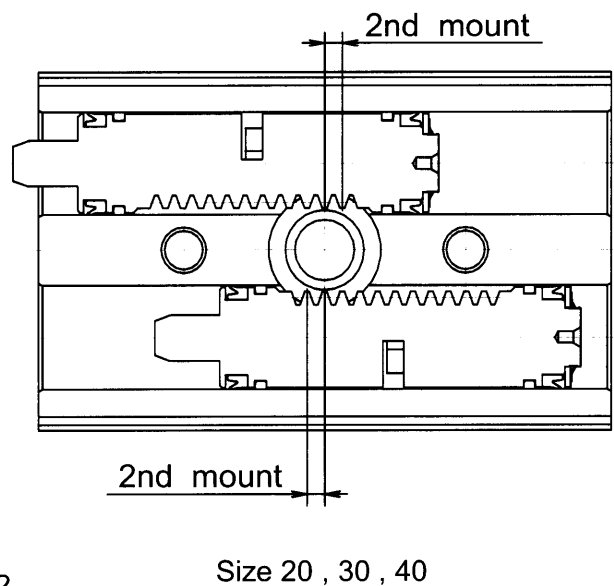
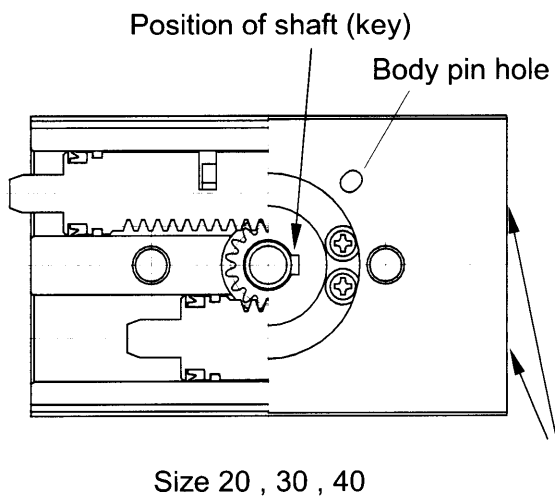
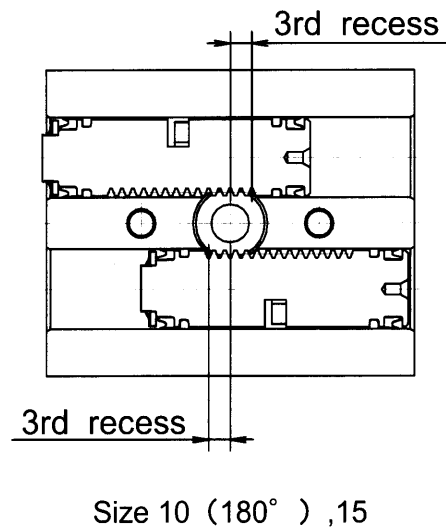
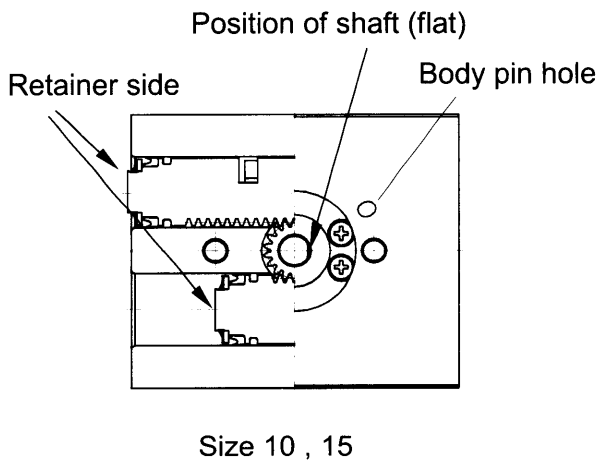
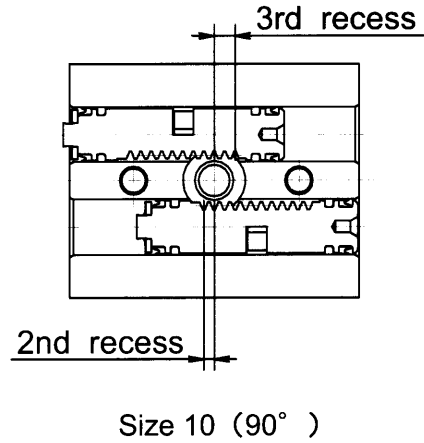
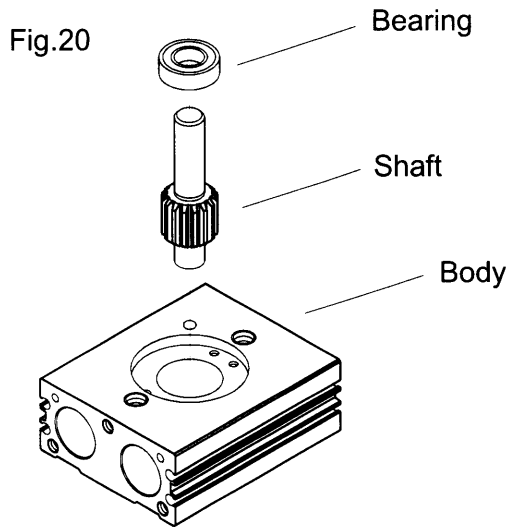


Fig.19

Size 20,30,40



(3) Mount the shaft and bearing to the body. The shaft should be mounted by positioning the piston assembly with reference to the flat of the shaft (size 10 and 15) and key (size 20, 30 and 40).



(4) Mount the bearing retainer and tighten cross recessed No.0 screw or cross recessed round head screw.

Size 10,15  
Cross recessed No.0 screw  
Size 20,30,40  
Cross recessed roundhead screw

Bearing retainer

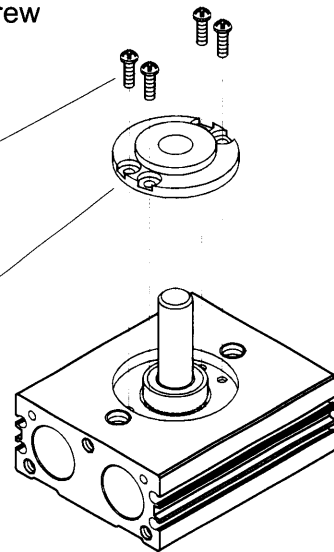
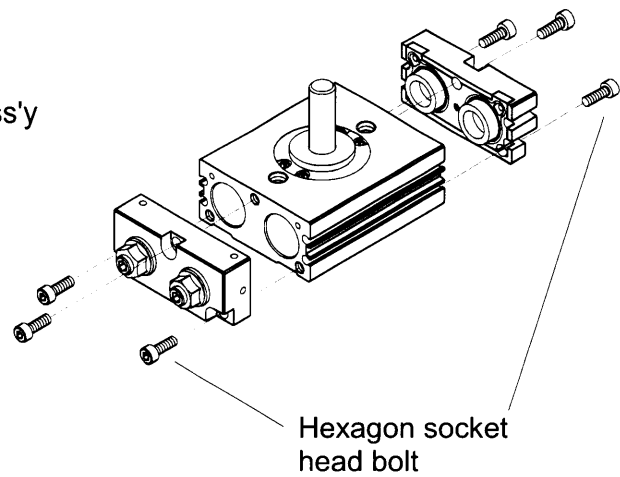
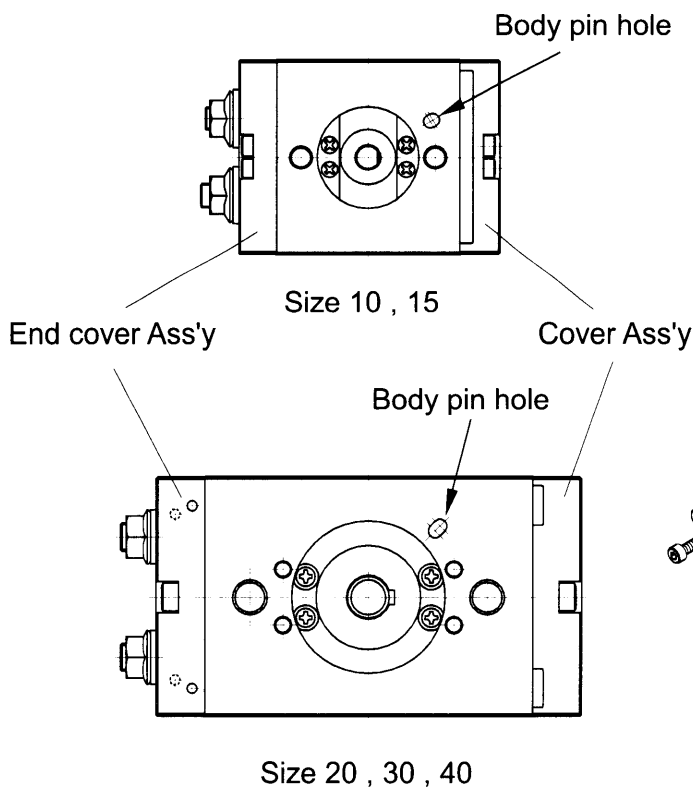


Fig.21

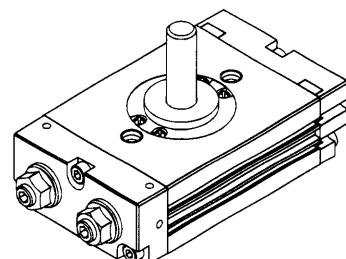
(5) Mount the cover Ass'y and the end cover Ass'y, tighten hexagon socket head bolt.



Hexagon socket head bolt

Fig.22

(6) Perform operation test after assembling and check external leakage.



## Troubleshooting

Problem	Possible cause	Solution
Rotary table doesn't move	Supply pressure isn't applied correctly.	Correctly set the regulator at the supply pressure side.
	The directional switching valve (such as a solenoid valve) doesn't 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)	A load has some friction.	Reduce the friction resistance.
	Actuator axis and mating axis 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 so that the load rate becomes 50% or less.
	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 with a new actuator. Then calculate the kinetic energy applied to the rotary table, and adjust the load and rotating speed so that the kinetic energy will be within the allowable range.
Air leakage from the shaft.	Piston packing is worn out.	Please exchange it for new piston packing.

Problem	Possible cause	Solution
The pinion gear is broken.	Excessive kinetic energy was applied to the rotary actuator.	Replace with a new actuator. Then calculate the kinetic energy applied to the rotary table, and adjust the load and rotating speed so that the kinetic energy will be within the allowable range.
Insufficient rotating Angle.	The adjustment bolt for adjusting angles is set at smaller angle than the needed angle.	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.
	Influence from 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.

vision history

## SMC Corporation<sup>®</sup>

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