

Operation Manual

Compact Rotary Actuator

CRQ2 Series

Rack Pinion Type

- ☐ Thoroughly read and understand this operation manual to install and operate this product.
- ☐ Pay particular attention to the safety statements.
- ☐ Retain this operation manual to read whenever needed.

Safety Precautions

These safety instructions are intended to prevent hazardous situations and/or equipment damage. These instructions indicate the level of potential hazard by labeling "Caution", "Warning" or "Danger". To ensure safety, be sure to observe ISO4414, JIS B 8370 and other safety practice.



Caution

Operator error could result in injury or equipment damage.



Warning

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



Danger

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



Warning

①The compatibility if 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.

②Only 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.

③Do 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.

④Contact 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.

Rotary Actuator

Caution on 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 larger amount of vibrations.

- ④ 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 has a large mass, it will be feasible for the rotary actuator's cushions alone to absorb shocks. Therefore, provide a speed reduction circuit to reduce the rotary actuator's speed before the thrust is applied to the cushions, or an external shock absorber to dampen the shocks. If these countermeasures are taken, make sure to take the rigidity of the mechanical equipment into consideration.

- ⑤ Consider the possibility of a reduction in the circuit air pressure that could be caused by power outages.

When the product is used for 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 it integrates safety features that will prevent hazards to humans or damage to the equipment.

- ⑥ Consider the possibility of power source related malfunctions that could occur.

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

- ⑦ 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.

⑧Consider the behavior of the rotary actuator in the event of an emergency stop.

Design the device that ensures safety so that if a person engages the emergency stop, orifice 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 human or damage the equipment.

⑨Consider the behavior of the rotary actuator when restarting after an emergency stop.

Design the device that ensure safety so that the restarting of the rotary actuator will not pose a hazard to human 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.

⑩Do 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 human and damage the machinery and equipment.

Selection



Warning

①Select 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.

②Provide 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.

③Do 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 poses a hazard to human and damage the machinery and equipment.



Caution

①Do 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.

②Do 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.

③The holding torque of the rotating end of 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.

④If 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.

⑤Do not use the product under hydraulic pressure.

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

Mounting



Warning

①Before 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.

②Do 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 human and damage the machinery and equipment.

③Do 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 human and damage the machinery and equipment.

④Do 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 human and damage the machinery and equipment.

⑤Do 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 human 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 human and damage the machinery and equipment.



Caution

- ① Do not wipe the label showing How to Order with organic solvent. It may erase the display.
- ② Do not hit the rotating shaft by securing the body or hit the body by securing the rotating shaft.
These actions could cause the shaft to bend or damage the bearing. When a load must be coupled to the rotating shaft, secure the rotating shaft.
- ③ Do not place your foot directly on the shaft or on the equipment that is coupled to the shaft.
Placing one's weight directly onto the rotating shaft could cause the rotating shaft 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 by 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 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 Install an air filter.

Install an air filter upstream, near the valve. Select an air filter with a filtration degree of 5 μm or finer.

- ② 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.

- ③Ensure that the fluid and ambient temperature are within the specified range.

If the fluid temperature is below 5° 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".

Environment



Warning

- ①Do not use the rotary actuator 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.

- ②Do not use the rotary actuator 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 and Bumper Adjustment



Warning

- ①To 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 human and damage the machinery and equipment.

- ②The cushion needle is not adjusted at the time of shipment. Therefore, an adjustment must be made in accordance with the operating speed and the moment of inertia of the load.

The adsorption of kinetic energy by the bumper is regulated by the adjustment of the needle.

An improper adjustment could lead to damage of the equipment and the product. As a result, it could pose a hazard to human and damage the machinery and equipment.

- ③Do not use the rotary actuator with its cushion needle in the fully closed state.

This could tear the seal, which could pose a hazard to human and damage the machinery and equipment.

- ④Do not apply excessive force to loosen the cushion needle.

The needle itself is provided with a pull-stop, however the pull-stop could be damaged if the needle is loosened through the application of excessive force. As a result, it could pose a hazard to human 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 Follow the procedures given in the operation manual to perform a maintenance inspection. Improper handling could lead to malfunction or damage the machinery and equipment.
- ② During a maintenance inspection, do not disassemble the equipment with electrical power or an air supply applied.
- ③ After the product has been disassembled for inspection, make sure to perform the appropriate functionality inspection.

The product specifications can not 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.

Auto Switch

Design & Selection

- ① Confirm the specification

Read the specification 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 precautions when multiple cylinders are used close together.

When two or more actuators with auto switches are used in parallel, keep them apart at least 40mm to avoid interference of the magnet of auto switches.

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

When an Autoswitch is set at 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 detectable piston speed is:

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

④Wiring 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 contact protection circuit, use a contact protection box when the wire length is 50m 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>

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

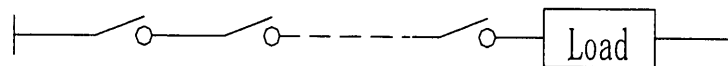
⑤Take precautions for the internal voltage drop of the switch.

<Reed switch>

1)Switch with an indicator light (Except D-A96·A96V)

• 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 cooperating 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.

Source voltage—Internal voltage drop of switch > Minimum operating voltage of load

2) If the internal resistance of a light emitting diode causes a problem, select a switch without an indicator light (Model D-A90·90V).

<Solid state switch>

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

⑥ Watch for current leakage.

<Solid state switch>

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

$$\text{Operating Current of load (FF condition)} > \text{Leakage Current}$$

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.

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 solenoid, which generates surge is directly driven, use a type of switch with a built-in surge absorbing element.

⑧ Cautions for use in 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 work.

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

Mounting • Adjustment



Warning

① Do not drop not bump.

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

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

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

③Mount switches using the proper tightening torque.

When a switch is tightened beyond the range of fastening torque, the mounting screw, mounting bracket or switch may be damaged. Tightening below the range of tightening torque may allow the switch to slip out of position.

④Mount 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 catalogue 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

①Avoid bending or stretching lead wire repeatedly.

Repeated bending and stretching stress lead to cause lead wire breakage.

②Supply power after connecting the load.

<2 wires>

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.

③Confirm 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.

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

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

⑤Do not allow short circuit 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>

D-F9□(V), F9□W(V) and PNP output type switches do not have built-in short-circuit prevention circuits. If loads are short circuit, 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.

⑥Avoid incorrect wiring.

<Reed switch>

A 24V DC switch with indicator light has polarity. The brown lead wire is (+), and the blue lead wire is (-). [D-97: No indication side (+), Black line side (-).]

1) If connections are reversed, a switch will operate, however, the light emitting diode will not illuminate.

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

Applicable models: D-93, A93V

<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 wire and the power supply line (-) is connected to the black wire, the switch will be damaged.

Environment



Warning

①Never use in an atmosphere with explosive gases.

The structure of auto switches is not intended to prevent explosion. However, never use in an atmosphere with an explosive gas since this may cause a serious explosion.

②Do 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)

③Do not use in an environment where the auto switch will be continually exposed to water.

Although switches satisfy the IEC standard IP67 structure (JIS C0920: anti-immersion structure) expect some models, do not use switches in applications where they are continually exposed to water splash or spray. Poor insulation or swelling of the potting resin inside switches may cause a malfunction.

④Do 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 auto 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 (300m/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.

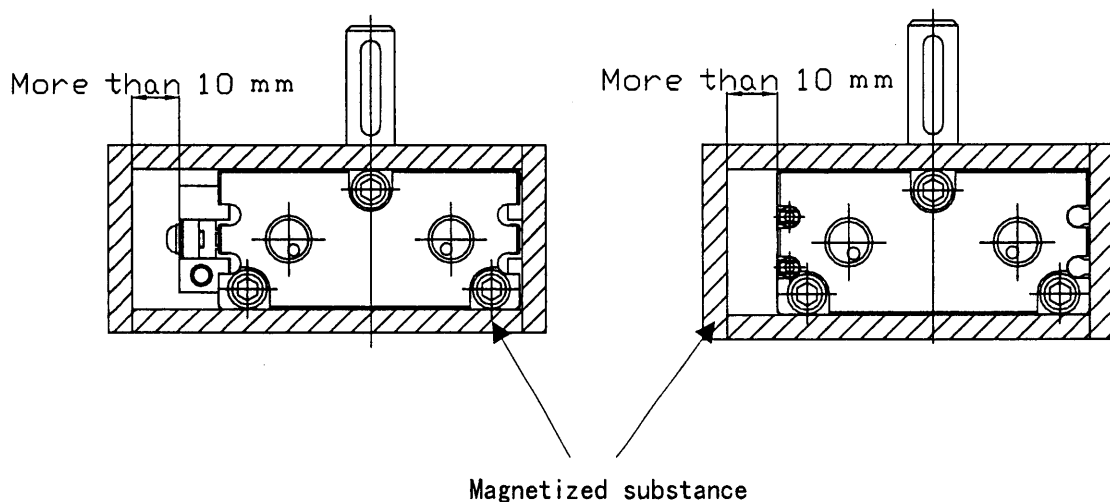
<Solid State switch>

When there are units (solenoid type, lifter, high frequency induction furnace, motor, etc.) which generate a large amount of surge in the area around cylinders with solid state auto switches, this may cause deterioration 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 (something attracted by a magnet) is brought into close proximity with an auto switch cylinder, it may cause the auto switches to malfunction due to a loss of the magnetic force inside the cylinder.

As picture below, ensure clearance between the magnetized body and the auto switch when the rotary actuator is close to magnetized substance like iron. If the clearance is lower than the value below, the auto switch may not turn ON (malfunction).



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 screw. 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 2 color indicator type switch.

Confirm that the green LED is on when stopped at the established position. If the green LED is on, the mounting position is not appropriate. Readjust the mounting position until the green LED lights up.

Others



Warning

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

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1. Outline

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

1 - 1 Specification

Table 1 Specification-1

Size	1 0	1 5	2 0	3 0	4 0
Operating fluid	Air (Non-lube)				
Max. operating pressure	0 . 7 MP a		1 MP a		
Min. operating pressure	0 . 1 5 MP a		0 . 1 MP a		
Ambient temp. and operating fluid temp.	0 ~ 6 0° (No freeze)				
Cushion	Rubber cushion		No. Air cushion		
Angle adjustment	± 5°				
Rotation angle	8 0° ~ 1 0 0°、1 7 0° ~ 1 9 0°				
Port size	M5 × 0 . 8		R c 1 / 8, G 1 / 8, N P T 1 / 8, N P T F 1 / 8		
Supporting style	Basic type				
Output(N·m)	0 . 3	0 . 7 5	1 . 8	3 . 1	5 . 3

Table 2 Specification-2

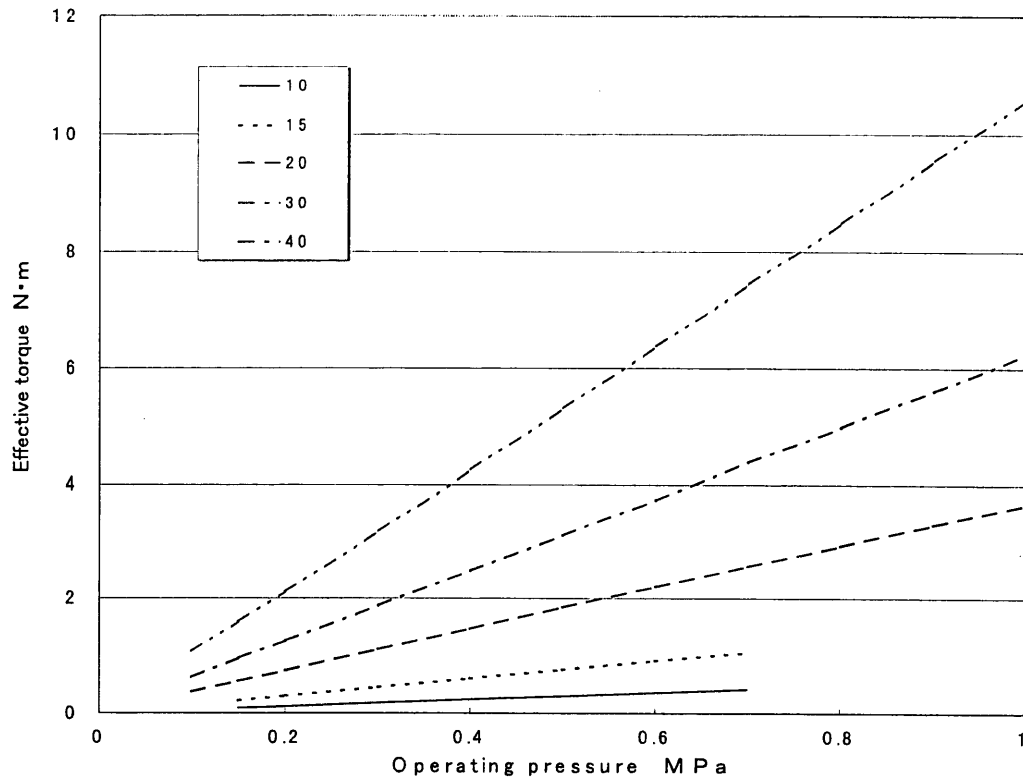
Size	Allowable kinetic energy			Cushion angle	Safe adjustment range of rotating time
	Allowable kinetic energy (J)				
	No air cushion	Rubber cushion	Air cushion	Rotation time (s/90°)	
10	—	2.5×10^{-4}	—	—	0.2~0.7
15	—	3.9×10^{-4}	—	—	0.2~0.7
20	0.025	—	0.12	40°	0.2~1
30	0.048	—	0.25	40°	0.2~1
40	0.081	—	0.4	40°	0.2~1

Allowable kinetic energy of cushion type is the max. adsorbing energy when the cushion needle adjustment is optimum. Operation with the speed lower than adjustment range lead to cause stick clip or termination of operation.

Table3 Specification-3

Size	Weight (g)		Internal capacity (cm ³)	
	90°	180°	90°	180°
10	120	150	1.2	2.2
15	220	270	2.9	5.5
20	600	700	7.8	13.4
30	900	1100	11.8	22.7
40	1400	1600	20	38.5

1 - 2 Effective output



1 - 3 Rotation range

When pressurized from the power indicated by the arrow, the shaft will rotate clockwise.

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

Flat face rotation range

Parallel key rotation range

Sizes 10, 15

Sizes 20, 30, 40

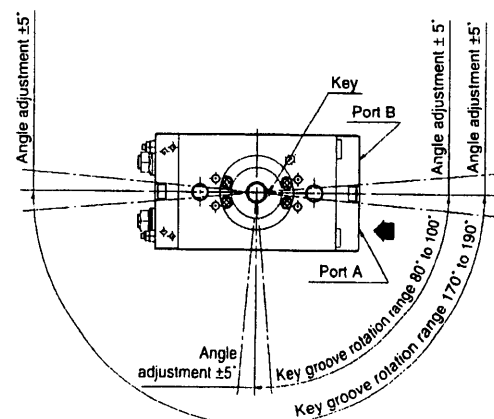
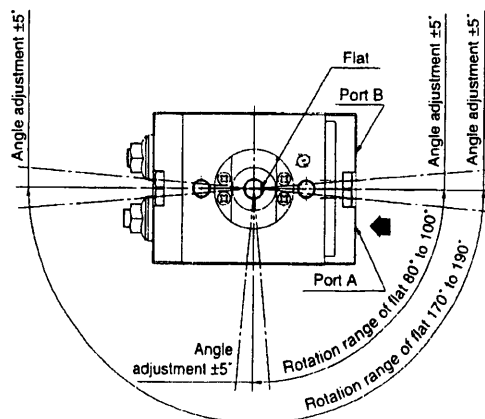
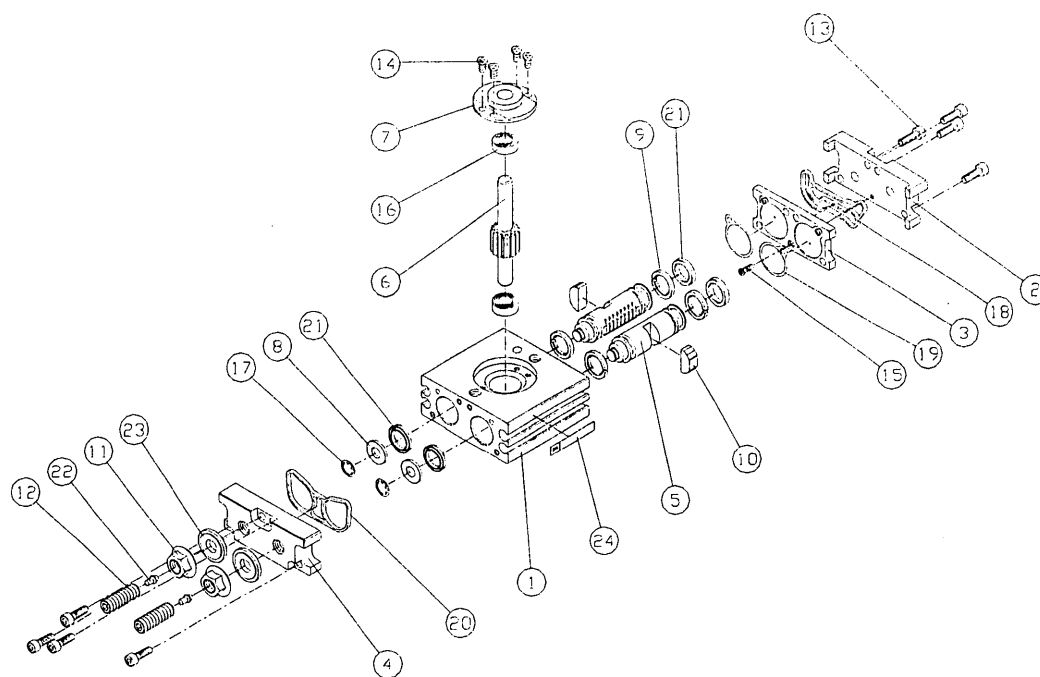


Fig. 1

2. Internal structure and parts description

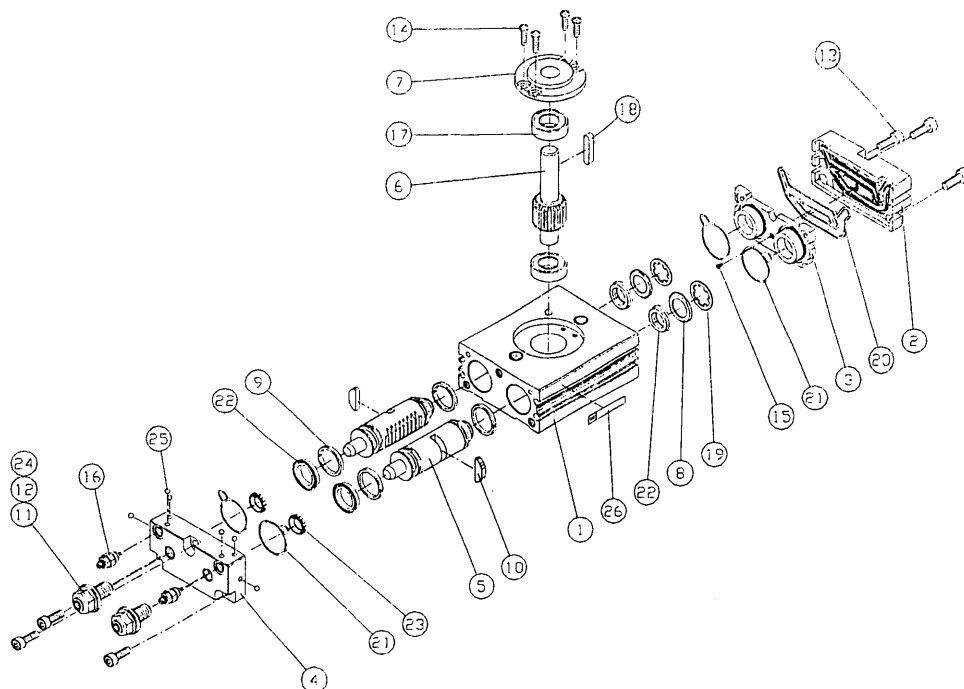
2-1 Size 10,15



24	Heat transferred label	1	
23	Seal washer	2	
22	Cushion pad	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

4/22

2 - 2 Size 20,30,40



26	Heat transferred label	1	
25	Steel ball		No cushion : 4pcs., with cushion: 6pcs.
24	Seal washer	2	
23	Cushion packing	2	Only cushion type included
22	Piston packing	4	
21	Gasket	4	
20	Packing	1	
19	Retainer	2	
18	Parallel key	1	
17	Bearing	2	
16	Cushion valve Ass'y	2	Only cushion type included
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

3 . Basic circuit of the rotary actuator

3 - 1 Circuit structure

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

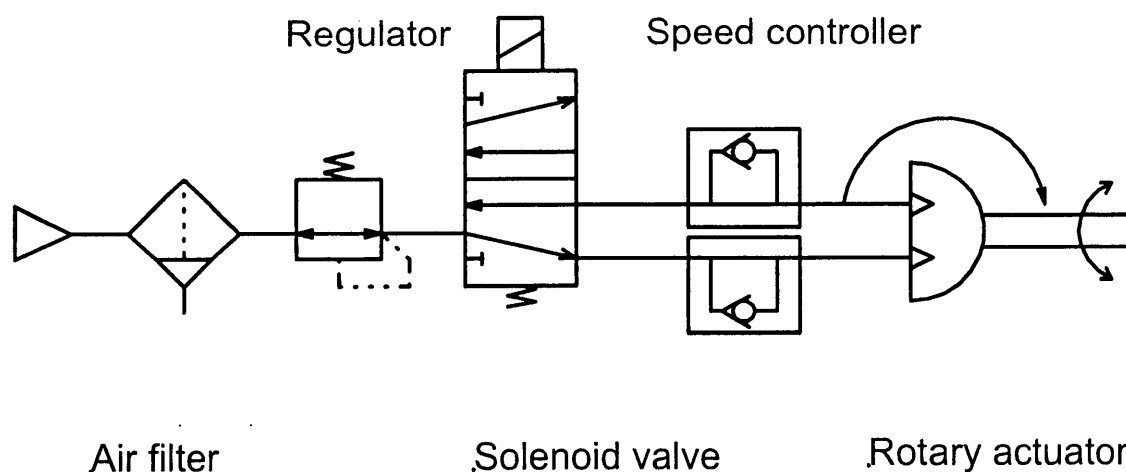


Fig.2 Basic circuit

3 - 2 Recommended equipment

Table 4 shows recommended solenoid valve, speed controller, tube for the basic circuit in Fig.2.

Table 4 Recommended equipment

Size	Solenoid valve	Speed controller	Tube	
1 0	VZ1000 series (M5,Cv=0.05)	AS1000 series(M5)	ϕ 4 / ϕ 2.5	
1 5	VJ3000 series (M5,Cv=0.2)			
2 0	VZ3000 series (Rc1/8,Cv=0.2)	AS2000 series(Rc1/8)	ϕ 6 / ϕ 4	
3 0	VF1000 series (Rc1/8,Cv=0.15)			
4 0				

※Solenoid valve is selected by elastic seal method

4. Mounting

4-1 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 5 Allowable load (N)

Size	Load direction		
	Fsa	Fsb	※Fr
1 0	15.7	7.8	14.7
1 5	19.6	9.8	19.6
2 0	49	29.4	49
3 0	98	49	78
4 0	108	59	98

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

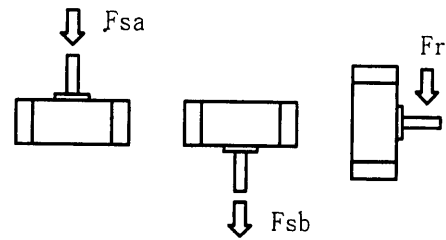


Fig.3 Load direction

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.

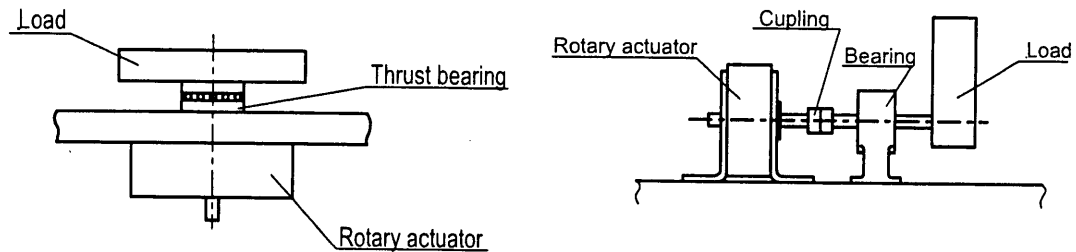


Fig.4

4-2 Operation of axis fitting referring

As in Fig.5, alignment of the rotary actuator and the mating axis is necessary when the rotary actuator is used with its axis lengthened. If misaligned, partial load becomes high and 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.

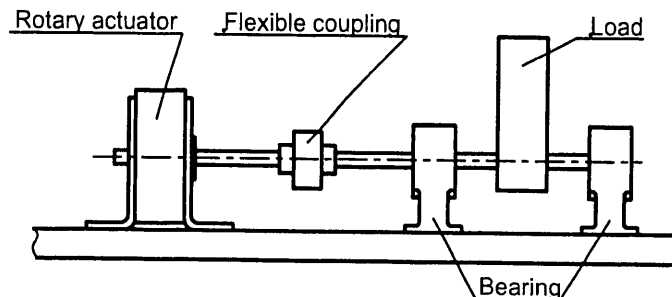


Fig.5

4 - 3 Flange application

See table 6 for L dimension of the body.

JIS hexagon socket head bolt is neatly placed in the rotary actuator groove.

Table 6

Size	L	Bolt
1 0	13	M 4
1 5	16	M 4
2 0	22.5	M 6
3 0	24.5	M 8
4 0	28.5	M 8

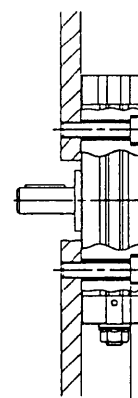


Fig6

4 - 4 Piping and operating direction

Fig-7 shows piping ports of the rotary actuator.

Table-7 shows the port size.

Table 7 Port size

Size	Port size
1 0	M 5 × 0. 8
1 5	
2 0	R c 1 / 8, G 1 / 8 N P T 1 / 8, N P T F 1 / 8
3 0	
4 0	

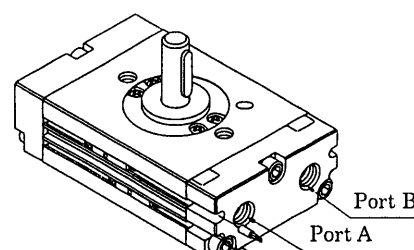


Fig-7 Port location

Fixed orifice is equipped in the rotary actuator 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.

The axis rotates clockwise when pressurized from B port. Perform followings before piping.

- Flush or clean the piping to eliminate metal swarf, cutting oil and dust before connecting piping.
- 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.

4 - 5 Operating air

Air supplied to the rotary actuator shall be cleaned by the filter. CRQ2 series is lubrication free.

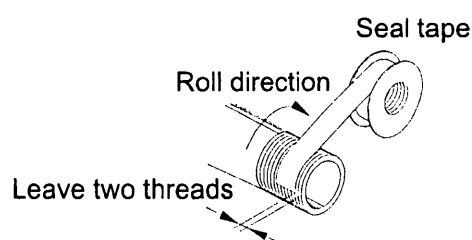


Fig.8 Applying seal tape

5. 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.

5 - 1 Inertia moment

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	$\text{kg} \cdot \text{m}^2$
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

$$I = m \cdot r^2 \quad m : \text{Weight} \quad \text{kg}$$

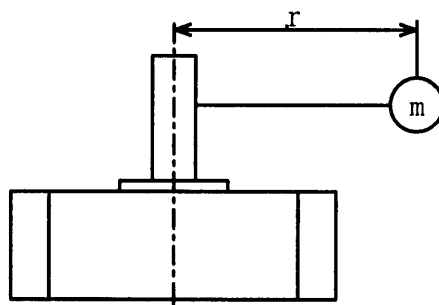


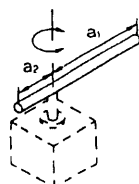
Fig. 9

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

① Thin rod

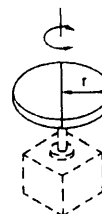
Location of rotation axis: Perpendicular to the rod and passes one end



$$I = m_1 \frac{a_1^2}{3} + m_2 \frac{a_2^2}{3}$$

⑥ Column (Including thin round board)

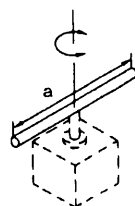
Location of rotation axis: Center axis



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

② Thin rod

Location of rotation axis: Passes the center of gravity of the rod



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

⑦ Sphere

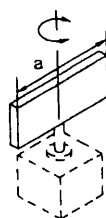
Location of rotation axis: Diameter



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

③ Thin rectangular board (Rectangular parallelepiped)

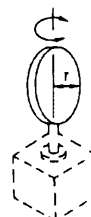
Location of rotation axis: Passes the center of gravity of the board



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

⑧ Thin round board

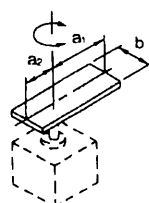
Location of rotation axis: Diameter



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

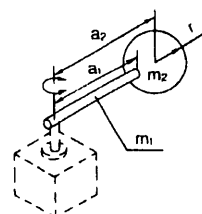
④ Thin rectangular board (Rectangular parallelepiped)

Location of rotation axis: Perpendicular to the board and passes one end (It is the same for the rectangular parallelepiped made with thicker board)



$$I = m_1 \frac{4a_1^2 + b^2}{12} + m_2 \frac{4a_2^2 + b^2}{12}$$

⑨ With a load at the end of the lever

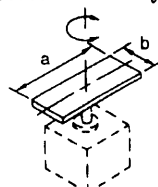


$$I = m_1 \frac{a_1^2}{3} + m_2 a_2^2 + K$$

Example) $K = m_2 \frac{2r^2}{5}$, referring to the case ⑦ that the state of m_2 is a ball.

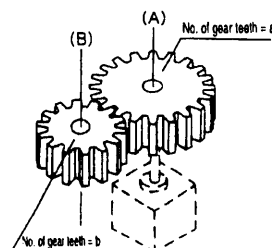
⑤ Thin rectangular board (Rectangular parallelepiped)

Location of rotation axis: Passes the center of gravity of the board and perpendicular to the board (It is the same for the rectangular parallelepiped made with thicker board)



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

⑩ Gear Transmission



1. Calculate moment of inertia I_B around axis (B).
2. Replace moment of inertia I_B around axis (A) with I_A .
 $I_A = \left(\frac{a}{b}\right)^2 I_B$

5 - 2 Kinetic energy

Table 8 shows the allowable kinetic energy of the rotary actuator. The rotary actuator may reach the stroke end in the middle of accelerating process due to the short piston stroke. The end angular speed ω is obtained by:

Table 8 Allowable kinetic energy

Size	Allowable kinetic energy J		Cushion angle
	No cushion	Cushion type	
1 0	2.5×10^{-4}	—	—
1 5	3.9×10^{-4}	—	—
2 0	0.025	0.12	40°
3 0	0.048	0.25	40°
4 0	0.081	0.4	40°

※ Allowable kinetic energy of cushion type is max. adsorption energy when the cushion needle adjustment is optimum.

$$\omega = \frac{2\theta}{t} \quad \begin{array}{ll} \theta : \text{Rotation angle} & \text{r a d} \\ t : \text{Rotation time} & \text{s} \end{array}$$

Kinetic energy E is obtained by:

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

Therefore, the rotary actuator rotation time is:

$$t \geq \sqrt{\frac{2 \times I \times \theta^2}{E}} \quad \begin{array}{ll} E : \text{Allowable kinetic energy} & \text{J} \\ \theta : \text{Rotation angle} & \text{r a d} \\ I : \text{Inertia moment} & \text{kg} \cdot \text{m}^2 \end{array}$$

Angular speed ω after t sec. at isometric acceleration is obtained as below

$$\omega = \dot{\omega} \times t \text{ ----- (1)} \quad \dot{\omega} : \text{Angular acceleration}$$

$$\theta = \int \dot{\omega} t \, dt = \frac{1}{2} \dot{\omega} t^2 + C \text{ ----- (2)} \quad C : \text{Integral constant}$$

Seconds of arc at $t = 0$ is $\theta = 0$. Therefore $C = 0$.

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

Therefore,

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

5 – 3 External stopper

When kinetic energy generating the load exceeds the rotary actuator allowable kinetic energy, the inertia force has to be adsorbed by externally installed cushioning function.

5 – 3 – 1 Install position of external stopper

External stopper lead to cause the rotary actuator axis torsion, damage and the breakage of the axis bearing depending on install location of stopper and load shape and the place.

Place an external stopper in apposition that is away from the rotary actuator or the material point.

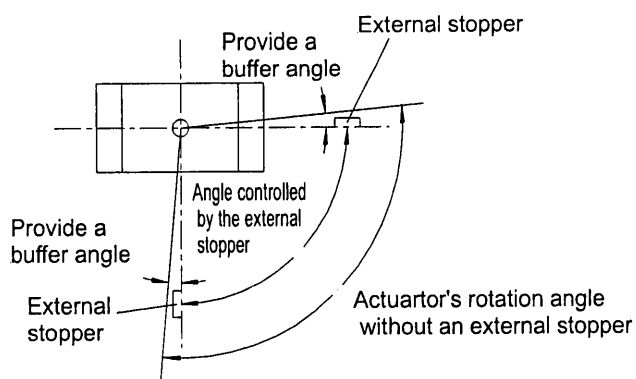
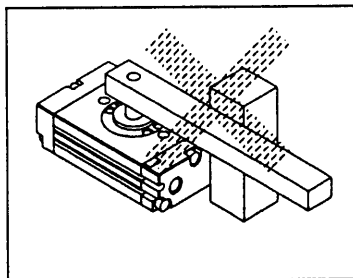
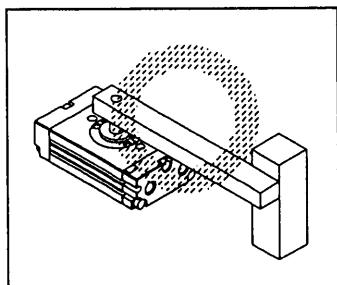
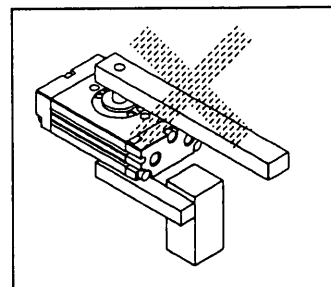


Fig. 10



External stopper acts as fulcrum. Load inertia force is applied to the shaft as bending moment



Inertia force generated by the load is directly applied to the axis if the external stopper on the opposite side of the load.

Fig. 11

5 – 3 – 2 Caution on using external stopper

- Angle adjustment is available for C R Q 2 series rotary actuator. Mind so that the hexagon socket set screw (angle adjusting screw) does not collide into the piston.
- The method in Fig-11 is possible if shock absorber is used or the load is within the allowable energy. Careful when selecting the shock absorber.

6. Rotary actuator with auto switch

The piston of rotary actuator with auto switch is attached with magnet on it, and equipped with auto switch outside to detect the piston position (shaft flat face and key groove position). Rotary actuator piston stroke is short. Position detection is made at the stroke end.

6 - 1 Auto switch specification

Table 9

Type	Special function	Electrical entry	Indicator	Wiring (Output)	Load voltage		Autoswitch part no.		Lead wire length (m)			Applied load			
					DC	AC	Electrical entry		0.5 (Nil)	3 (L)	5 (Z)				
							Vertical	Horizontal							
Reed auto switch	—	Grommet	Presense	3 wires Equivalent to NPN	—	5V	—	A96V	A96	●	●	—	IC circuit	—	
				2 wires	24V	—	100V	A93V	A93	●	●	—	—	Relay PLC	
						5V,12V	00V or less	A90V	A90	●	●	—	IC circuit		
Solid state auto switch	—	Grommet	Presence	3 wires(NPN)	24V	5V,12V	—	F9NV	F9N	●	●	○	—	Relay PLC	
				3 wires(PNP)	—	—		F9PV	F9P	●	●	○			
				2 wires	24V	24V		F9BV	F9B	●	●	○			
	3 wires(NPN)			24V	5V,12V	F9NWV		F9NW	●	●	○				
	3 wires(PNP)			—	—	F9PWV		F9PW	●	●	○				
	Diagnosis display (2 color display)			2 wires	24V	12V		F9BWV	F9BW	●	●	○			
				Better water resistance	2 wires	24V		(10~28V)	—	F9BAL	—	●			○

Lead switch

- Lead wire-D - A90□、A93□: Oil resisting vinyl cap tire cord ϕ 2.7
18mm² × 2 core (brown, blue) 0.5m
D - A96□: Oil resisting vinyl cap tire cord ϕ 2.7
15mm² × 3 core (brown, black, blue) 0.5m
- Insulation resistance-50M Ω or more at DC500V mega (Between the lead wire and the case)
- Voltage resistance-AC1000V for 1min. (Between the lead wire and the case)
- Operation time-1.2ms
- Ambient temp. - 10~60°C
- Impact resistance-300m/s²{30.6G}
- Leak current-0
- Protection rate-IEC529 standard IP67 (JIS0920) watertight
- When the lead wire length is 3m, the part number is suffixed with "L". ex) D-A90L

Solid state switch

- Lead wire-Oil resisting vinyl cap tire cord ϕ 2.7
0.15mm² × 3 core (brown, black, blue) 0.5m, 18mm² × 2 core (brown, blue) 0.5m
- Insulation resistance-50M Ω or more at DC500V (Between lead wire and the case)
- Voltage resistance-AC1000V for 1 min. (between lead wire and the case)
- Operation time-1ms or less
- Ambient temp. - 10~60°C
- Impact resistance-1000m/s²{102G}
- Protection-IEC529 standard IP65 (JIS0920) jet proof
- When the lead wire length is 3m, the part number is suffixed with "L". ex) D-A90L

6 - 2 Auto switch installation

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

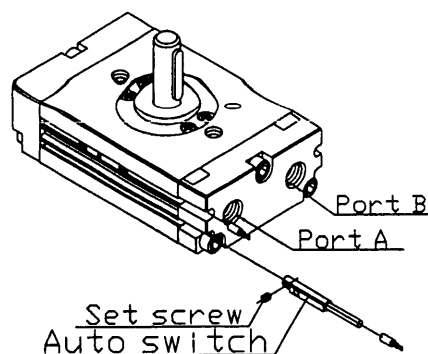


Fig.12

6 - 3 Auto switch set position

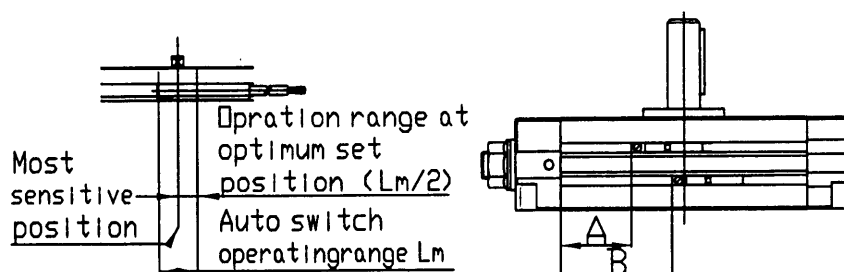


Fig 13

Table 10

Size	Rotation	Reed autoswitch				Solid state autoswith			
		A	B	Operation angle θ_m	Hysteresis angle	A	B	Operation angle θ_m	Hysteresis angle
10	90°	6.5	13.0	63°	12°	10.5	17.0	75°	3°
	180°	9.5	22.5			13.5	26.5		
15	90°	9.5	18.0	52°	9°	13.5	22.0	69°	3°
	180°	13.5	30.5			17.5	34.5		
20	90°	22.0	34.5	41°	9°	26.0	38.5	56°	4°
	180°	28.0	53.5			32.0	57.5		
30	90°	29.0	45.0	32°	7°	33.0	49.0	43°	3°
	180°	37.0	68.0			41.0	72.0		
40	90°	34.0	53.0	24°	5°	38.0	57.0	36°	4°
	180°	43.5	81.5			47.5	85.5		

Operation angle θ_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.
(When rotation angle is 90° and 180°)
- If minimum rotation angle is selected when using two switches, both switches may turn on.

6 – 4 Internal structure and operation principle

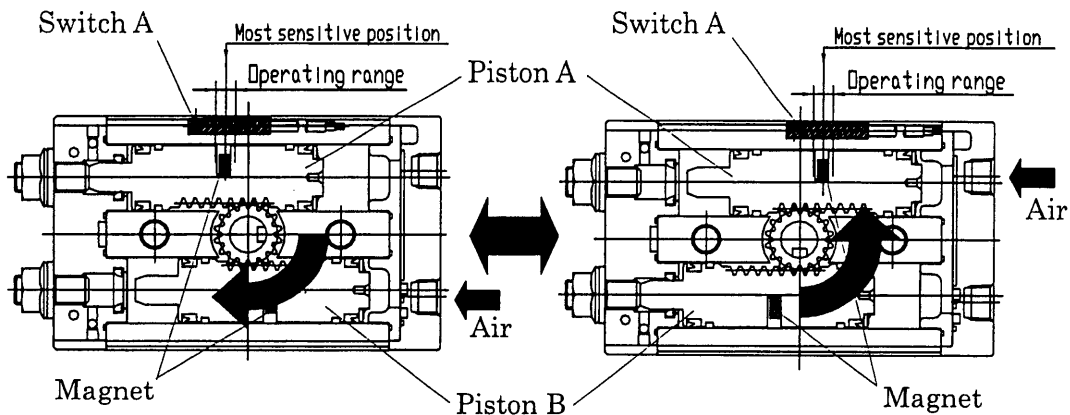


Fig14

In figure 14, the switch A is turned on. When pressurized from arrow direction, piston B moves to the left and piston A moves to the right, and the shaft rotates clockwise. At this point, magnet A goes out of switch A's operation range to turn off switch A. Then, piston moves right and left, and the magnet goes into switch B's operation range to turn on switch B.

7. Cushions

- a) Rotary actuator is not adjusted so that the cushions work during shipment. Adjust the cushion valve attached to the cover depending on rotation time and load inertia moment. (See Fig 15)
- b) Rotating the cushion valve reduces the orifice diameter and increases cushion effect. Counterclockwise increase orifice diameter and reduces cushion effect.
- c) Tighten the cushion valve lock nut properly. Loose lock nut lead to cause the cushion valve to rotate and initially set cushion value changes. Re-adjustment is necessary in this case.
- d) Cushion packing wears out during long period of operation, and cushion effect becomes weaker. Re-adjustment is necessary.
- e) Don't operate the actuator with the cushion valve orifice completely closed. The piston may bumps into the stroke end, not fully travel the stroke, or the pressure exceeds the proof pressure of the cushion packing.
- f) Don't start the actuator with the cushion valve orifice completely open. Since this means an actuator without a cushion, the impact is big. If the actuator operate with allowable energy in table 2 with this condition, the rotary actuator may be broken. Open the cushion valve and the speed controller gradually from closed condition.

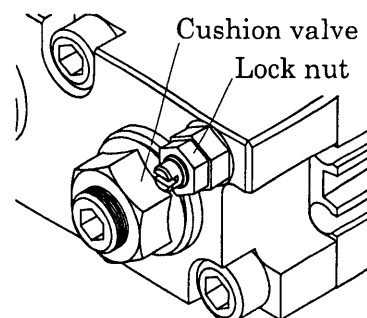


Fig.15

8. Maintenance · 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.

8 - 1 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) Smooth operation
- (4) External leak

If problem found, tighten additionally or disassemble to repair.

8 - 2 Disassemble and reassemble

8 - 2 - 1 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) Size 10, and 15 can not be disassembled easily since the cushion pad is pressed in to the angle adjusting screw (adjust bolt). Avoid disassembling the adjust bolt 10 and 15 as much as possible

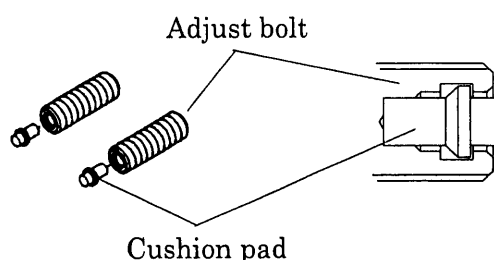


Fig. 16

- (5) Please consult with us when you have any question on disassembling and inspection.

8 - 2 - 2 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.

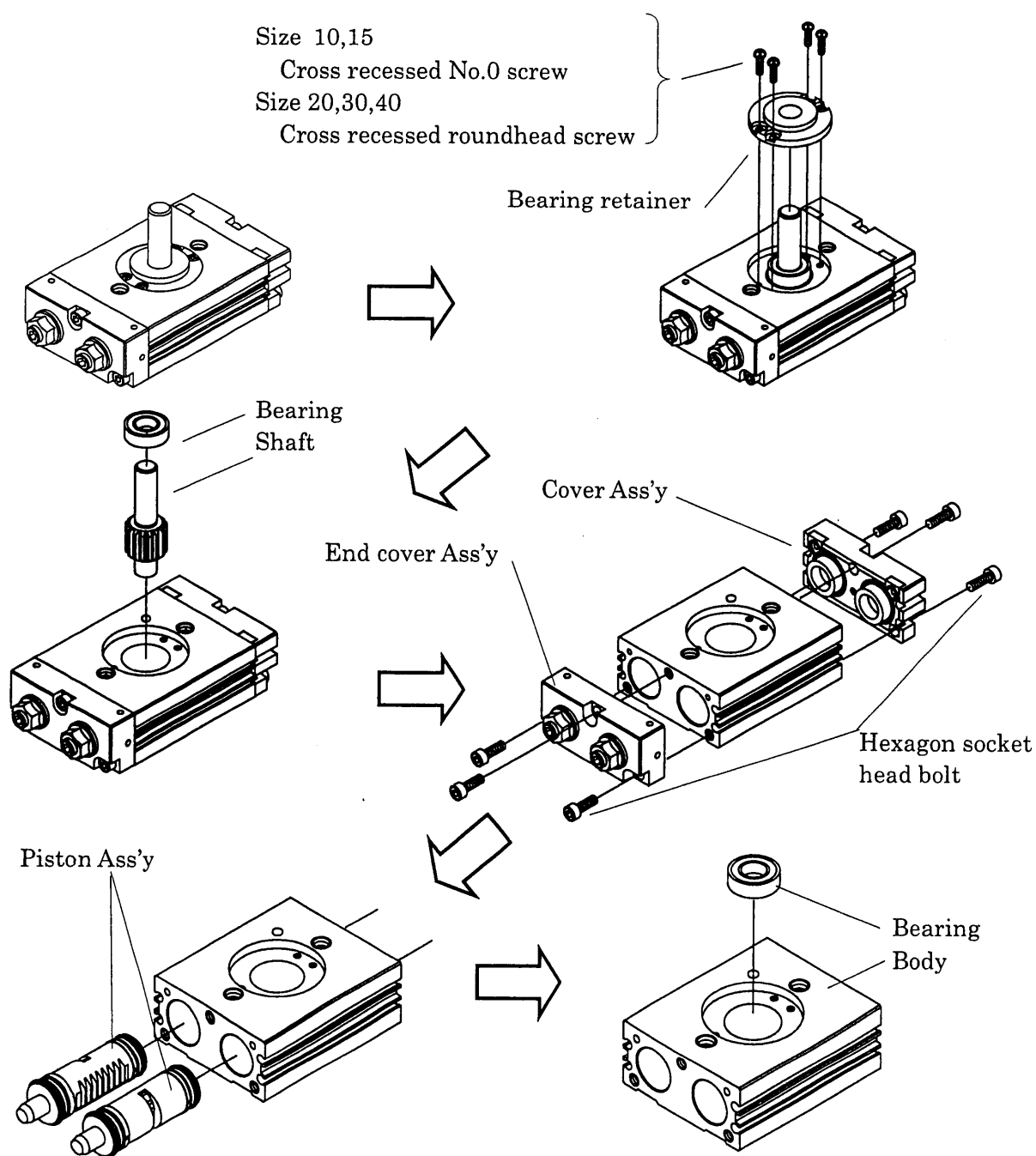


Fig 17

8 - 2 - 3 Assemble procedure

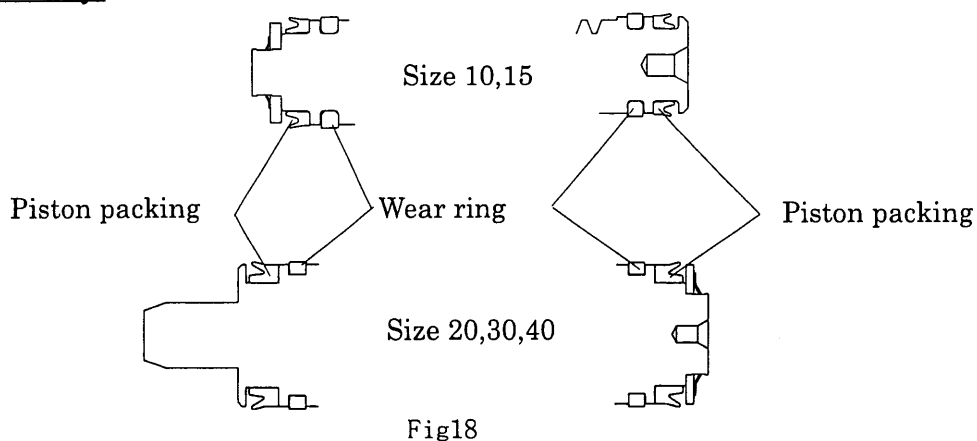
- (1) Clean parts thoroughly before assembling to remove dust. Mind so that packing not to be swollen during cleaning.

Apply grease to parts where specified in table 12 so that the surface become glossy (Not too much!). Don't damage the packing when attaching the piston packing to the piston.

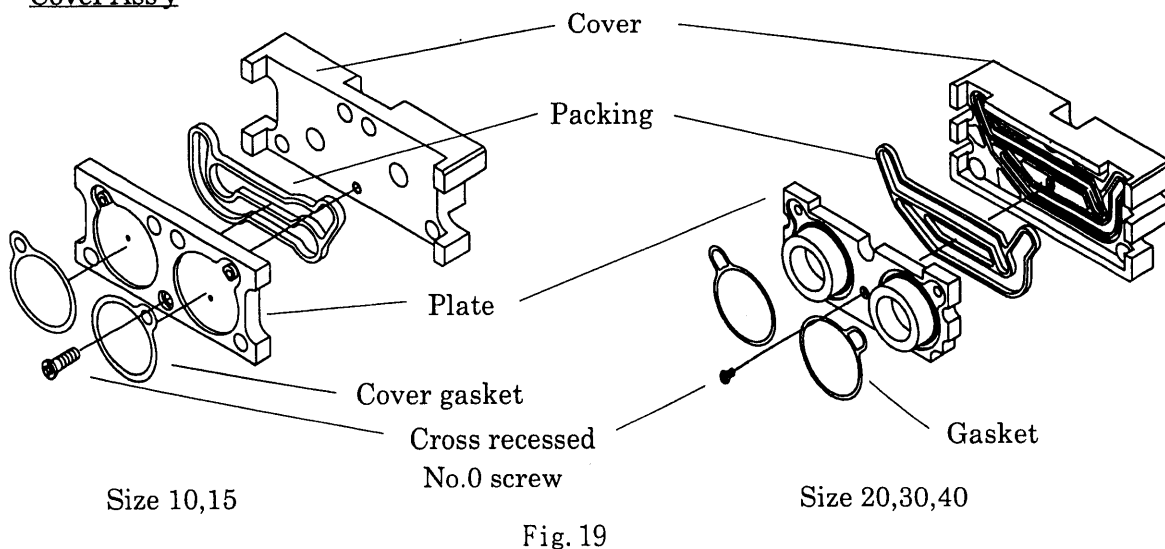
Table 12 Parts applied with grease

Grease applied parts	Grease
Cylinder internal surface	Mitsubishi diamond grease Multi-purpose No.2 (N)
Piston packing groove	
Piston packing	
Cover gasket	
End cover gasket	
Gasket	
Cushion packing	
Pinion gear	Dow coring Molykote BR2-Plus

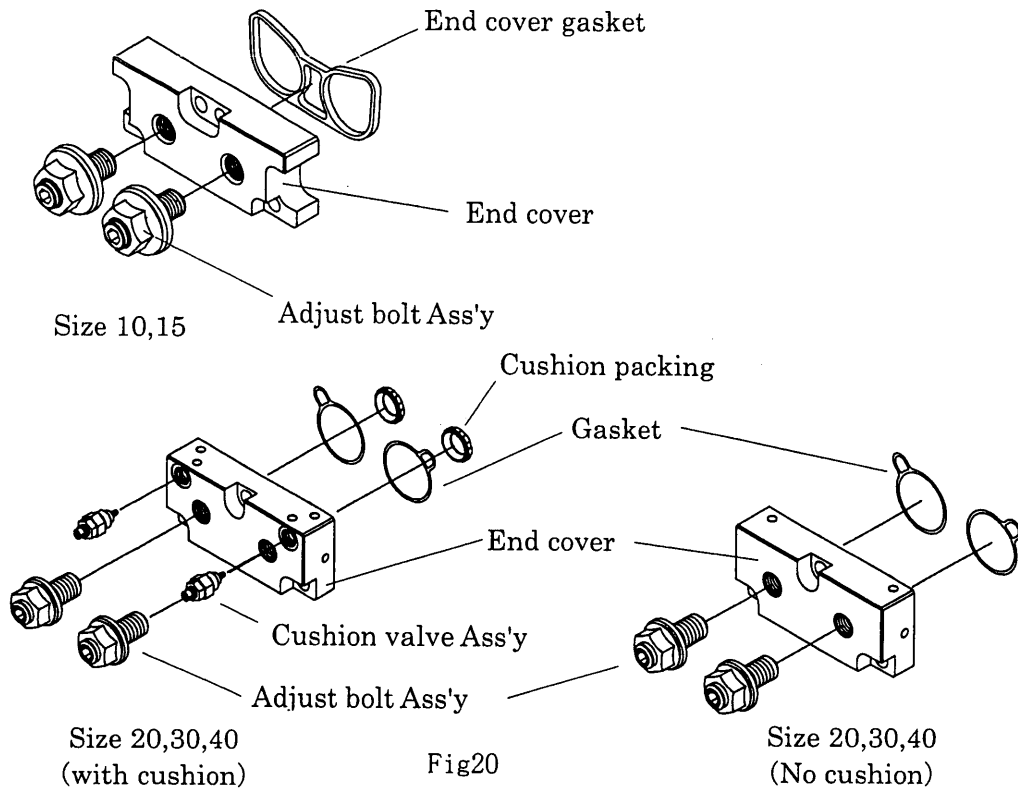
Piston Ass'y



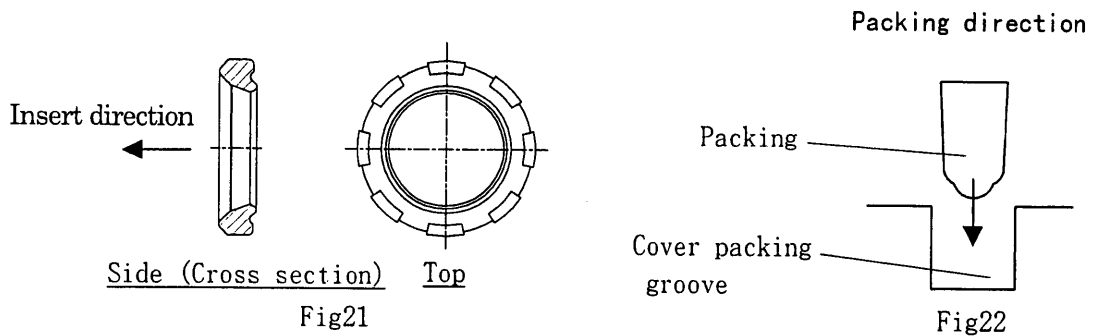
Cover Ass'y



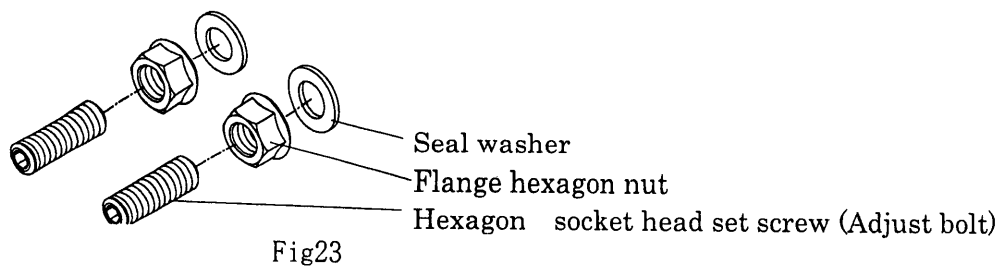
End cover Ass'y



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



Adjust bolt Ass'y



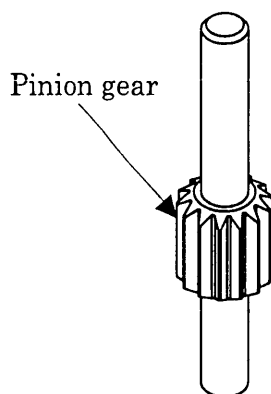
Shaft

Fig24

- (2) Set the bearing to the housing of the body, and insert the piston Ass'y to the body. Since the piston packing goes through the bearing housing, insert the piston Ass'y slowly pressing the packing inside so that packing is not gouged. (See fig. 25)
- (3) Mount the cover and the end cover, and push the piston Ass'y and the cover until they touch the end cover as in Fig 25. Adjust the hexagon socket head set screw (adjust bolt) so that the screw does not contact with the piston Ass'y.

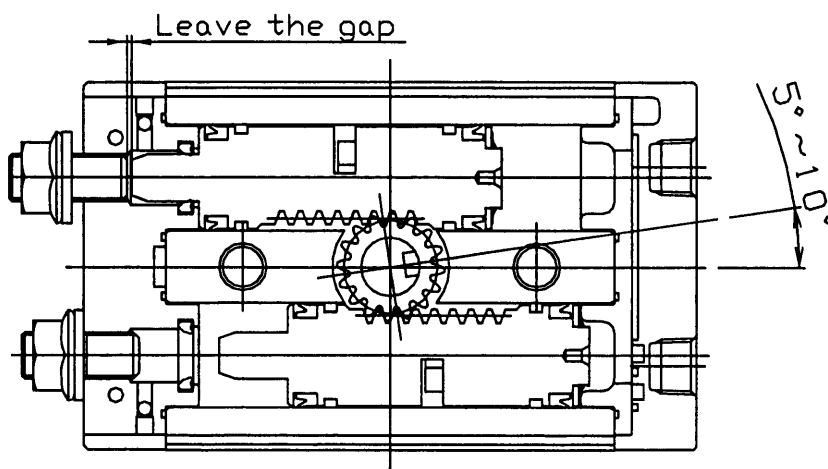


Fig 25

- (4) Mount the shaft. Key groove direction is the same as the cover direction, and mount the shaft so that the shaft is on the right turning upward by 5~10° to horizontal line(see above). If the key groove rotation range is inadequate, it means the piston Ass'y is displaced. If the key groove rotation range is displaced, the pinion gear is displaced. In these cases, correct the piston Ass'y to the right position and assemble as specified in clause (4).
- (5) Mount the bearing retainer and tighten cross recessed round head screw.
- (6) Perform operation test after assembling and check external leakage.

8 - 3 Trouble shoot

Phenomenon	Possible cause	Remedy
Actuator not operate	Correct supply pressure is not applied	Adjust the setting of the regulator at pressure supply side
	Directional valve(solenoid valve) is not switched	Apply correct signal to directional valve(solenoid valve)
	Air leakage from the piping	Check piping to stop leakage
	Orifice clogging in the cover port	Remove the cover and clean the orifice. 1.Flush piping 2.Check the air filter
Operation is not smooth	Partial friction of the load	Reduce the friction resistance
	Actuator axis and mating axis not aligned	Use flexible fitting for the joint
	Output shortage due to inadequate supply pressure	Adjust the supply pressure so that load rate is less than 50% for stable operation
	Speed controller works too much	Each size has its actuator speed adjusting rage. Readjust the speed controller
Rotation angle changes dramatically	Internal parts damage	Replace by a new actuator, and do followings. 1. Calculate the kinetic energy applied to the actuator, and adjust the speed controller so that the rotation time is appropriate. 2. Adsorb the load kinetic energy by applying the external stopper and shock absorber. Adjust the adjust bolt so that it does not contact with the piston, and determine the rotation end by external stopper.

Phenomenon	Possible cause	Remedy
Air leaks from the shaft	Piston packing wears out	Replace with new actuator
Pinion gear breakage	Pinion gear broken by excess kinetic energy applied to the actuator	Replace by new actuator, and do followings 1. Calculate the kinetic energy applied to the actuator, and adjust the speed controller so that the rotation time is appropriate. 2. Adsorb the load kinetic energy by applying the external stopper and shock absorber. Adjust the adjust bolt so that it does not contact with the piston, and determine the rotation end by external stopper.
	(when cushion equipped) Cushion needle adjustment is not optimum. Kinetic energy is not adsorbed by the cushion.	Replace by new actuator, and do followings. 1. Adjust the cushion needle at optimum condition 2. Check if kinetic energy generated by the load is less than cushion absorbable energy
Rotation angle inadequate	CRQ2 series has $\pm 5^\circ$ of angle adjusting function. The adjust bolt is set lower than necessary rotation angle	Adjust the adjust bolt to the correct position
	No allowance in actuator rotation angle. Actuator rotation angle deviated to the external stopper.	Remove the external stopper to check the all rotation range of actuator to set the external stopper to the correct place. When using external stopper, rotation bolt is adjusted at 100° or more than 190° by adjust bolt.
	(When cushion equipped) Cushion needle is closed	Adjust the cushion needle
Auto switch not turn ON/OFF	Auto switch set position is not correct	Set the auto switch at correct position

8 - 4 Spare parts list

No.	Description	Qty.	Part Number				
			Size 10	Size 15	Size 20	Size 30	Size 40
20	End cover gasket	1	P4730162#1	P4730262#1	—	—	—
	Cover gasket	1	P4730161	P4730261	—	—	—
	Gasket	4	—	—	P4730361	P4730461	P4730561
19	Packing	1	P4730112	P4730212	P4730312	P4730412#1	P4730512
21	Piston packing	4	MYP-10	MYP-14	PPY-18	PPY-21	PPY-25
9	Wear ring	4	P4730151	P4730251	P3040351	P3040451	P3040551
23	Seal washer	2	WCS5X0.8	WCS6X1	WCS8X1	WCS8X1	WCS10X1
22	Cushion packing	2	—	—	MC-8	MC-8	MC-10
25	Cushion valve Ass'y	2	—	—	P473000-1	P473000-1	P473000-1
Packing set			P473010-1	P473020-1	P473030-1	P473040-1	P473050-1
Content			19, 20, 21, 23 above				