文書 No. CRA1-OM00002-D

Operation Manual

Rotary Actuator

Rack Pinion Type

Model CRA1

- 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.

SMC CORPORARION

CONTENTS

6. MAINTENANCE AND INSPECTION

1. OUTLINE

This instruction manual describes a rack and pinion type rotary actuator. The conditions attendant to the operation of this unit include the size of the load (moment of inertia), swing time, and so on. Accordingly, before using the unit, please check its specifications.

1) Specifications

Table 1 Specification (1)

Model	Oilless type	Air-hydro type
Operating fluid	Air (oilless)	Hydraulic fluid
* Proof pressure	1. 5MPa	
Maximum operating pressure	1. 0MPa	
Minimum operating pressure	0. 1MPa	
Ambient temperature and operating fluid temperature	0～60℃	
Cushion	None, air cushion	None
I.D. of tube (mm)	30, 50, 63, 80, 100	50, 63, 80, 100
Mounting method	Basic type (only ϕ 30) foot type, flange type	

* In the case of an air hydro type, the allowable surge pressure is within the guaranteed pressure resistance.

Table 2 Specification (2)

Model	Allowable kinetic energy			Operational safety swing time adjustable range	Internal volume cm^3			
	Allowable kinetic energy (J)		Cushion angle	Swing time	Swing angle			
	Without Cushion	With Cushion		(s/90°)	90°	180°	100°	190°
CRA1BW30	0.01	-	-	0.2 - 1	7.4	14	-	-
CRA1○50	0.05	0.98	35°	0.2 - 2	32	65	36	68
CRA1○63	0.12	1.5	35°	0.2 - 3	60	120	67	127
CRA1○80	0.16	2.0	35°	0.2 - 4	111	221	123	233
CRA1○100	0.54	2.9	35°	0.2 - 5	259	518	288	547

* The allowable kinetic energy of a cushioned type unit is the maximum energy which is absorbed when the cushion needle is optimally adjusted.

* In the case of speed control in which the limit upper is exceeded, sticking sometimes occurs.

Table 3 Weight Table

kg

Model	Reference weight		Additional weight			
	90°	180°	W/Auto switch	W/solenoid valve	Foot mount	Flange mount
CRA1BW30	0.3	0.4	0.1	-	0.1	-
CRA1BS50	1.5	1.7	0.2	0.2	0.3	0.5
CRA1BS63	2.5	3.0	0.4	0.2	0.5	0.9
CRA1BS80	4.3	5.0	0.6	0.2	0.9	1.5
CRA1BS100	8.5	9.5	0.9	0.2	1.2	2.0

Note 1) When there are two auto switches.

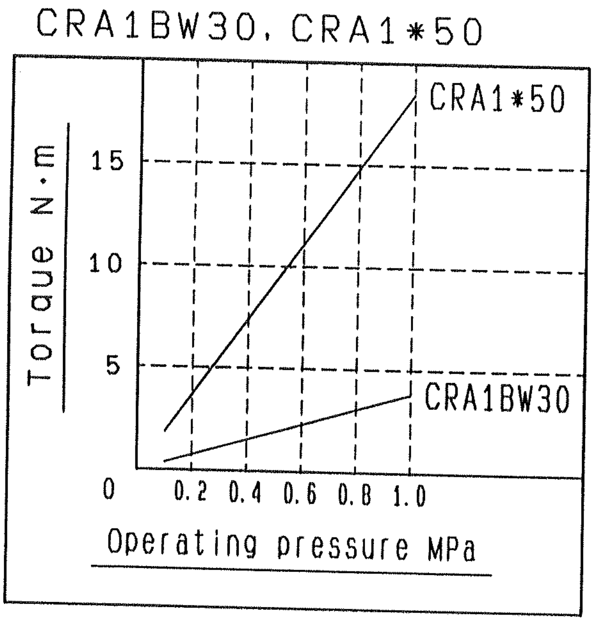
Note 2) The weight of the solenoid valve is not included.

Table 4 Net Weight of Solenoid Valve

kg

Position and No. of Solenoids	Weight
2-position, single	0.2
2-position, double	0.3
3-position, closed center	0.4
3-position, exhaust center	0.4

2) Effective Output



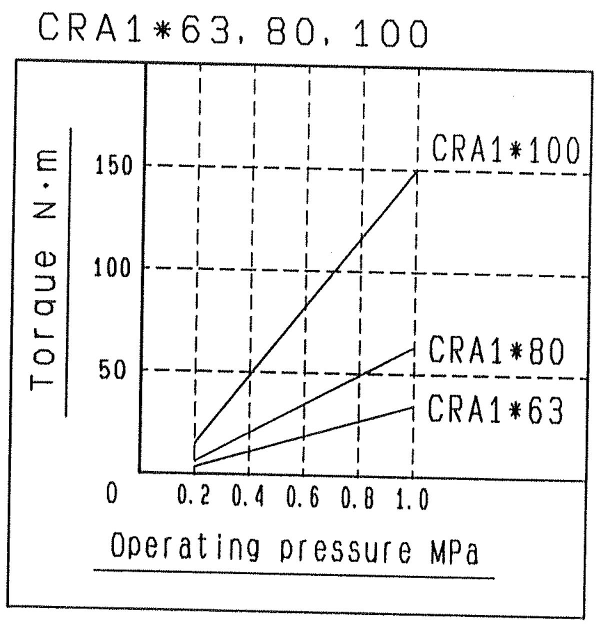
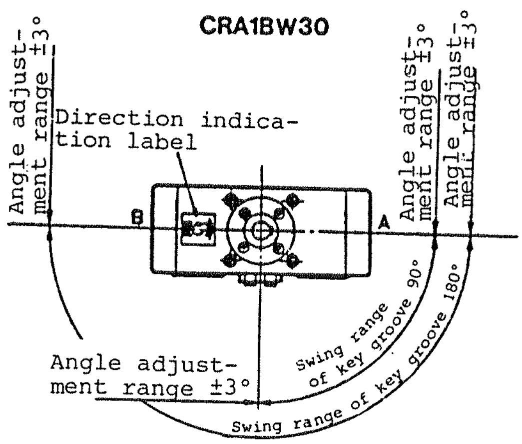
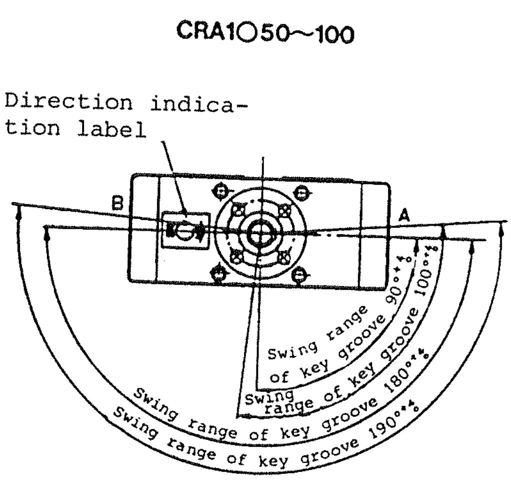


Fig. 1 Effective Output

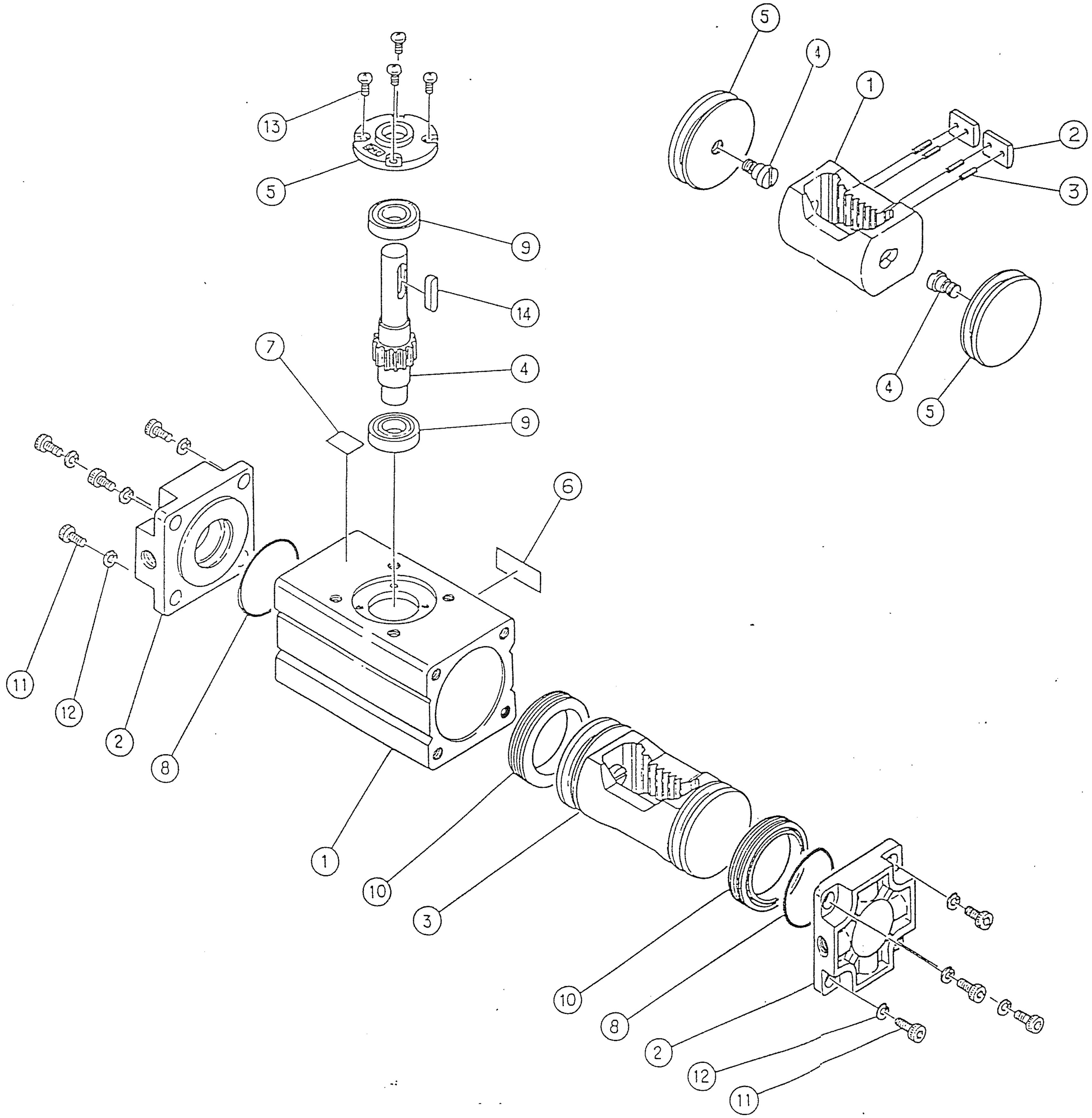
3) Swing Range of Key Groove

When pressure is applied from the direction indication label B side, the shaft rotates clockwise when pressure is applied from the A side, the shaft rotates counter-clockwise.





2. INNER STRUCTURE AND NAME OF EACH PART



No.	Name	Qty	Remarks
5	Piston	2	Chromate treatment
4	Connecting screw	2	Chromate treatment after zinc plating
3	Spring pin	4	
2	Slider	2	
1	Rack	1	

No.	Name	Qty	Remarks
14	Key	1	
13	Cross recessed pan head screw	4	Blackening
12	Spring washer	8	Blackening
11	Hex. head cap bolt	8	Blackening
10	Piston packing	2	
9	Bearing	2	
8	Tube gasket	2	
7	Rotating direction indicator	1	
6	Name plate	1	
5	Bearing retainer	1	Black
4	Shaft	1	
3	Piston Assy	1	
2	Cover	2	Black
1	Body	1	Hard alumite
Rotary Actuator			

3. BASIC CIRCUIT FOR USING ROTARY ACTUATOR

1) Circuit Configuration

The basic circuit for operating the rotary actuator using an air filter, regulator, solenoid valve, and speed controller is shown in Fig. 2.

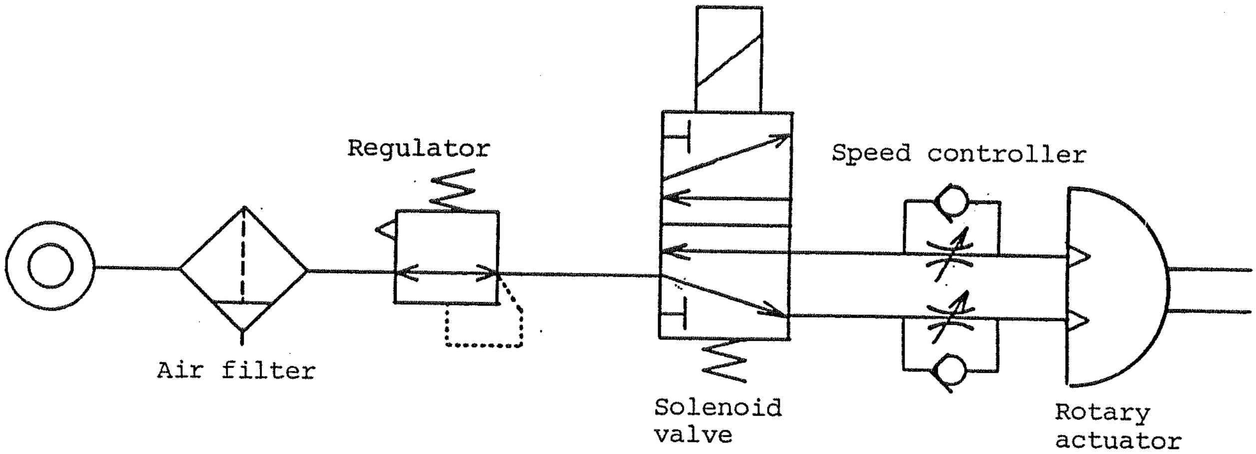


Fig. 2 Basic Circuit

2) Recommended Devices

The recommended solenoid valve, speed controller, and tube for the basic circuit shown in Fig. 2 are indicated in Table 5.

Table 5 Recommended Devices

Model	Solenoid valve *	Speed controller	Tube
ϕ 30	VZ1000 series, VF1000 series	AS1000 series	O.D.4/I.D.2.5
ϕ 50	VZ3000 series, VF3000 series	AS2000 series	O.D.6/I.D.4
ϕ 63	VZ3000 series, VF3000 series	AS2000 series	O.D.6/I.D.4
ϕ 80	VZ5000 series, VF3000 series	AS3000 series	O.D.8/I.D.6
ϕ 100	VF3000 series	AS3000 series	O.D.10/I.D.7.5

* The selected solenoid valves are flexible seal types.

4. INSTALLATION

1) Limit of Load Applied to Shaft

When the actuator is in a statically loaded condition, the maximum load indicated in Table 6 can be applied to it, however you should not apply a load directly to the shaft.

Table 6 Allowable Load to Shaft

N

Model	Load direction		
	Fsa	Fsb	Fr
CRA1BW30	29.4	29.4	29.4
CRA1○50	490	196	196
CRA1○63	588	196	294
CRA1○80	882	196	392
CRA1○100	980	196	588

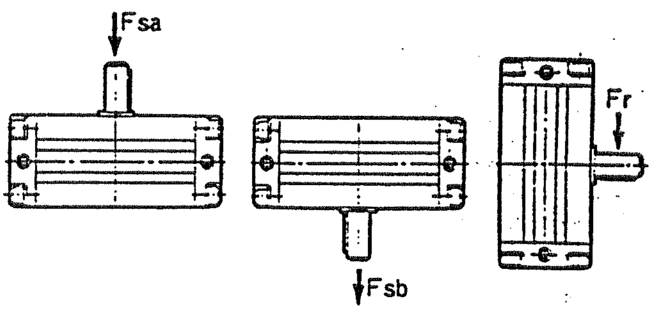


Fig. 3 Load Direction

* The point of application of load Fr is at the center of the key in the longitudinal direction.

To ensure optimum operating conditions, it is recommended that you use a method such as that shown below in order to avoid placing a direct load on the shaft.

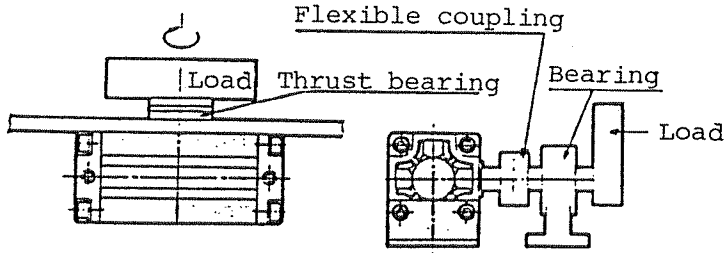


Fig. 4

2) Using Shaft Coupling

As shown in Fig. 5, when you use the rotary actuator with a shaft extension piece, it is necessary to align the shaft of the rotary actuator with the mating shaft. If the shafts are misaligned, a high localized load or an excessive bending moment may be applied to the shaft. If the rotary actuator is used in such a condition, stable operation will not be obtained and the shaft may actually break. In such a case, therefore, it is necessary to use a flexible coupling (flexible coupling indicated in JIS, etc.)

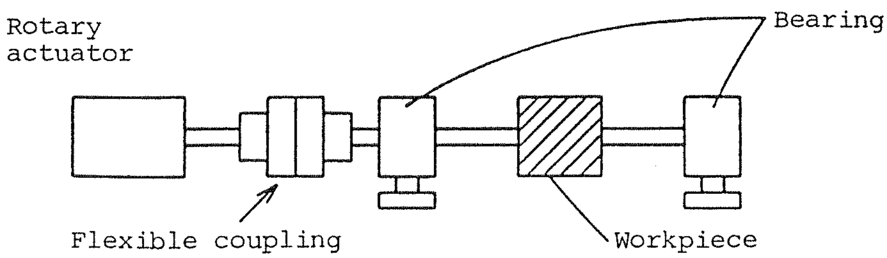


Fig. 5

3) Piping and Operating Direction

The piping port of the actuator is in the position shown in Fig. 6. Its size is shown in Table 7.

Table 7 Port size

Model	Port size
CRA1 30	M5 x 0.8
CRA1 50	Rc 1/8
CRA1 63	Rc 1/8
CRA1 80	Rc 1/4
CRA1 100	Rc 3/8

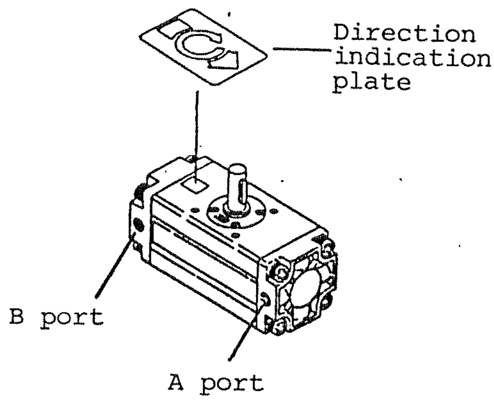


Fig. 6 Port Position

A fixed throttle is installed inside the actuator port. Do not increase the size of this hole by re-machining, etc. If you do, the swing velocity of the actuator will increase, causing the shock force to increase, which may damage the actuator.

When pressure is applied from the B side port, the shaft swings in the clockwise direction. On the rotary actuator is a direction indicator plate which indicates this.

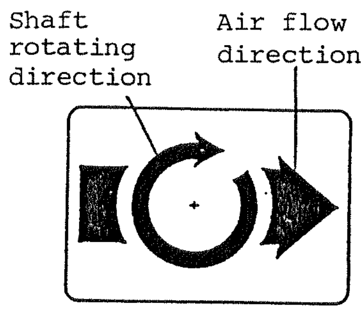


Fig. 7 Direction Indication Label

When carrying out piping work, perform the following work.

a) Dirt and scale in the piping upstream of the filter can be removed by the filter, however dirt and scale downstream of it cannot be removed and will enter the solenoid valve and cylinder, resulting in misoperation and reduced equipment life. Be sure, therefore, to flush out the piping before connecting it.

b) When screwing up the piping and coupling, be careful that metal particles from the pipe thread or particles of sealant do not get into the pipes. When using sealing tape, leave about 1.5 to 2 threads uncovered.

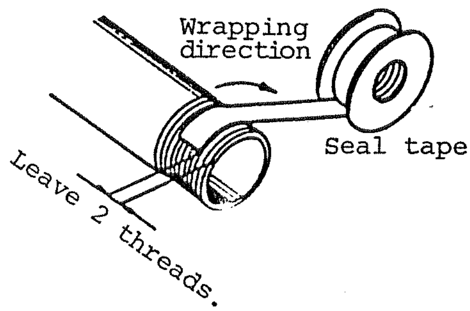


Fig. 8 How To Apply Seal Tape

4) Air Used

Supply clean, filtered air to the rotary actuator. The CRA1 series actuators are oilless types, hence there is no need to use a lubricator. If you do use a lubricator, do not stop using it otherwise you will have to overhaul the actuator and re-grease it. (When lubricating the actuator, use Turbine Oil Class 1 'ISOVG32' or equivalent.)

5. SETTING SWING TIME

Even if the torque generated by the rotary actuator is small, the inertia of the load may cause damage to the shaft or internal parts. When using a rotary actuator, therefore, it is necessary to calculate the moment of inertia of the load and the kinetic energy and then set the swing time accordingly.

1) Moment of Inertia

Moment of inertia is an indication of the difficulty of rotating an object. Stated conversely, it is an indication of the difficulty of stopping an object. When an object is operated by a rotary actuator, the object acquires a moment of inertia. The actuator then stops at the stop end, however because the object has ineritia, it applies a large shock force (kinetic energy) to the actuator. This kinetic energy can be calculated according to the following formula.

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

Where E : Kinetic energy J

I : Moment of inertia $kg \cdot m^2$

ω : Angular velocity rad/s

There is a limit to the kinetic energy which can be applied to a rotary actuator. Consequently, by deriving this moment of inertia, you can derive the limit

value of the swing time.
The method of deriving the moment of inertia is shown below.

The basic equation for moment of inertia is:

$I = mr^2$

Where W : Weight

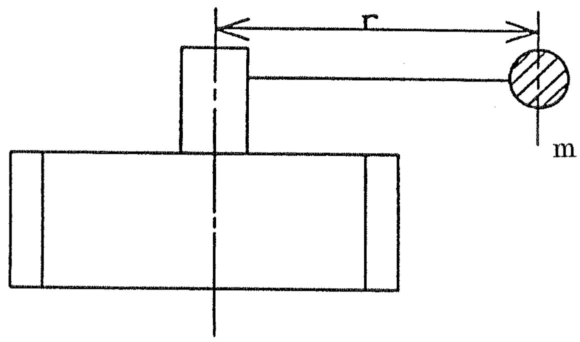


Fig. 9

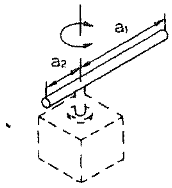
kg

This is the moment of inertia, with respect to a rotating shaft, of a weight located at a distance from the rotating shaft.

The equation for deriving the moment of inertia varies depending upon the shape of the object. Shown below are the equations for calculating the moment of inertia of objects of various shapes.

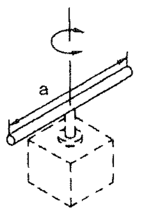
Table for calculation of Inertia moment

① Thin rod
Location of rotation axis: Perpendicular to the rod and passes one end



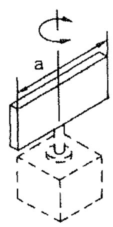
$$I = m_1\frac{a_1^2}{3} + m_2\frac{a_2^2}{3}$$

② Thin rod
Location of rotation axis: Passes the center of gravity of the rod



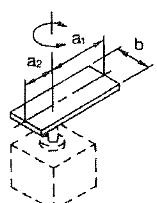
$$I = m\frac{a^2}{12}$$

③ Thin rectangular board (Rectangular parallelopiped)
Location of rotation axis: Passes the center of gravity of the board



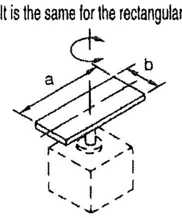
$$I = m\frac{a^2}{12}$$

④ Thin rectangular board (Rectangular parallelopiped)
Location of rotation axis: Perpendicular to the board and passes one end (It is the same for the rectangular parallelopiped made with thicker board)



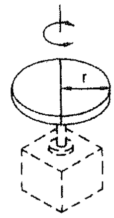
$$I = m_1\frac{4a_1^2 + b^2}{12} + m_2\frac{4a_2^2 + b^2}{12}$$

⑤ Thin rectangular board (Rectangular parallelopiped)
Location of rotation axis: Passes the center of gravity of the board and perpendicular to the board (It is the same for the rectangular parallelopiped made with thicker board)



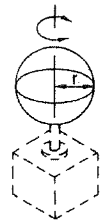
$$I = m\frac{a^2 + b^2}{12}$$

⑥ Column (Including thin round board)
Location of rotation axis: Center axis



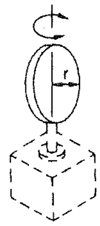
$$I = m\frac{r^2}{2}$$

⑦ Sphere
Location of rotation axis: Diameter



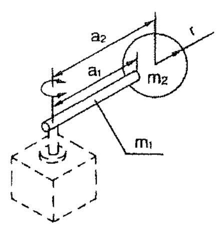
$$I = m\frac{2r^2}{5}$$

⑧ Thin round board
Location of rotation axis: Diameter



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

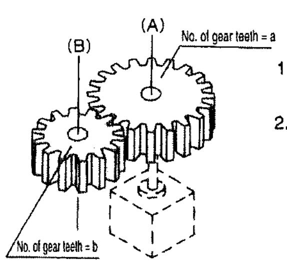
⑨ With a load at the end of the lever



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

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

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.
   $I_A = (\frac{a}{b})^2 I_B$

2) Kinetic Energy

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

Table 8 Allowable Kinetic Energy

Model	Allowable kinetic energy (J)		Cushion angle
	Withdut Cushion	With Cushion	
CRA1BW30	0.01	———	———
CRA1 * 50	0.05	0.98	35°
CRA1 * 63	0.12	1.5	35°
CRA1 * 80	0.16	2.0	35°
CRA1 * 100	0.54	2.9	35°

* The allowable kinetic energy of the actuators with a cushion is the maximum absorbed energy when the cushion needle is properly adjusted.

Because the piston rod of the rotary actuator is short, it may sometimes reach its stroke end while accelerating. The final angular velocity, ω, in such a case can be derived from the following equation.

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

θ: Swing angle rad

ω: Swing time s

The kinetic energy E is derived using the following equation, hence the swing time, t, of the rotary actuator is obtained by means of the following equation.

$$E = \frac{1}{2} \cdot I \cdot \omega^2 \qquad t \geqq \sqrt{\frac{2 \cdot I \cdot \theta^2}{E}}$$

Where E: Allowable kinetic energy J

I: Moment of inertia $kg \cdot m^2$

θ: Swing angle rad

For equiangular acceleration, the angular velocity, ω, and the displacent angle, θ , after t seconds are obtained using the following equations.

$$\omega = \dot{\omega} \times t \qquad \ldots (1)$$

$$\theta = \int \dot{\omega} t dt = \frac{1}{2} \dot{\omega} t^2 + C \qquad \ldots (2)$$

Where C: Integration constant

Because the displacement angle when t = 0 is θ = 0, the integration constant is C = 0.

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

Hence

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

If the swing velocity is extremely low (lower than about $90^{\circ}/2S$) due to the air height specifications, that is, if the operating condition is clearly equiangular velocity, it is permissible to calculate according to the equation $\omega = \theta / t$.

3) External stopper

If the kinetic energy generated by the load exceeds the allowable kinetic energy of the actuator, it is necessary to provide an external shock absorbing mechanism to absorb the shock due to the inertia of the load.

Also, because the CRA1 type rotary actuator is a rack and pinion type, there is backlash from the rack and pinion (within 1° at the swing end), hence it is necessary to provide an external stopper in order to accurately determine the angle.

The method of correctly installing an external stopper is described below using drawings.

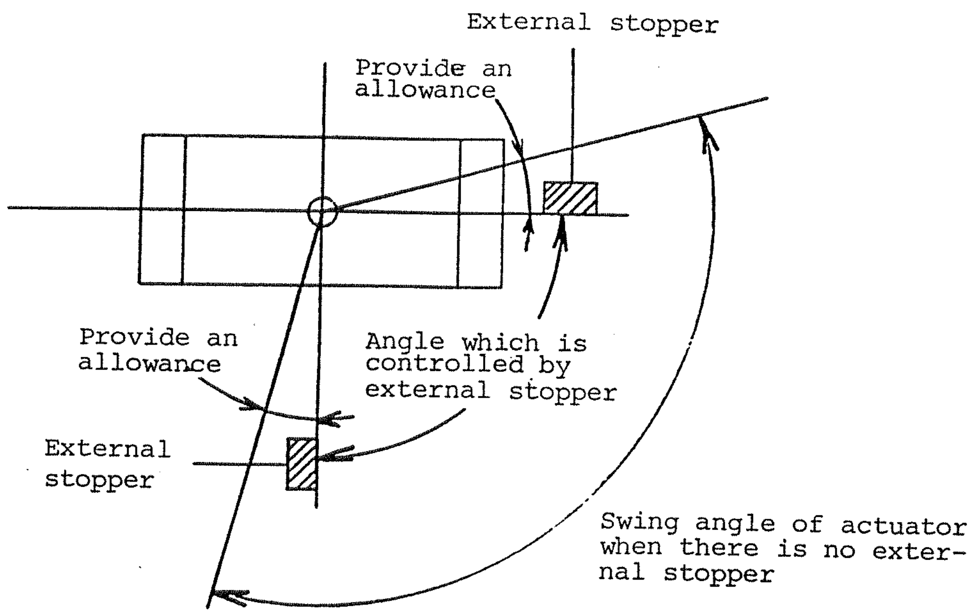
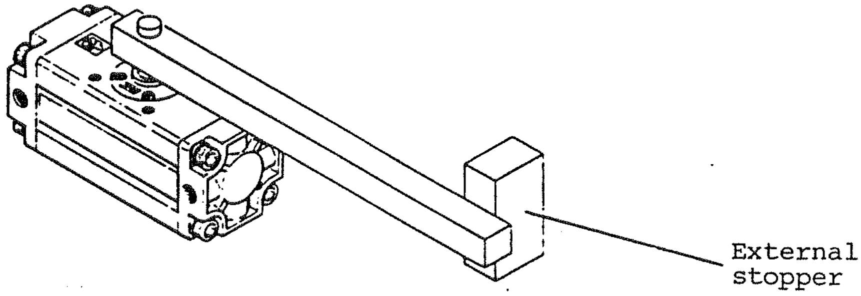


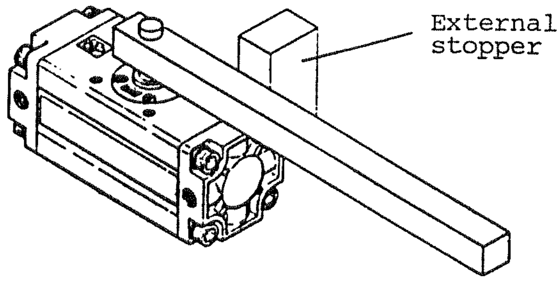
Fig. 10

Actuators are available with stoppers having swing angles of 100° and 190°, respectively.

Correct

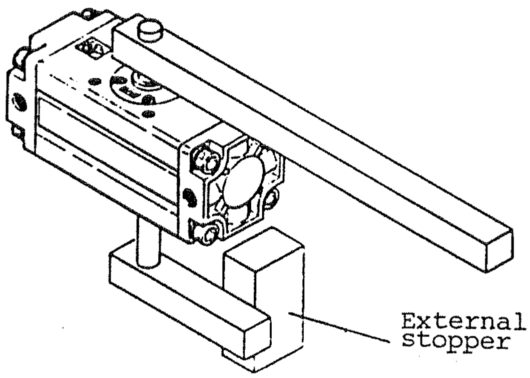


Incorrect



The external stopper becomes a pivot, and the inertial force of the load acts on the shaft as a bending moment

Incorrect



When the external stopper is installed on the shaftoppositethe load, the inertial force generated by the load is applied directly to the shaft.

6. MAINTENANCE AND INSPECTION

To ensure that the actuator is used under optimum conditions, it is necessary to periodically inspect it according to the conditions of use. Generally, it is desirable to inspect the actuator once a year. Also, the seal should be replaced every 3 years, even if there is no abnormality.

1) Periodic Inspection

The check points for periodic inspection are as follows:

(1) Looseness of actuator mounting bolts

(2) Looseness of actuator mounting frame

(3) Is the operating condition smooth?

(4) External leakage

(5) Has the backlash of the rack and pinion become abnormally large?

Check the actuator in respect of the above points. If any abnormalities are found, tighten up bolts, or disassemble and repair the actuator as necessary.

2) Method of Disassembly and Reassembly

2-1 Precautions for disassembly

(1) When disassembling the actuator, work in a clean location which has adequate space.

(2) After removing the actuator, be sure to protect the end of the pipes and rubber hoses to prevent the ingress of dirt.

(3) When disassembling the actuator, be very careful not to damage it internally.

(4) If you come across something which you are not sure about when disassembling or inspecting the actuator, be sure to consult us.

2-2 Disassembly procedure

(1) Loosen small pan-head screw ⑬ and remove the shaft from the main unit. Also, remove bearing ⑨ from the housing.

(2) Loosen hexagonal socket head bolt ⑪ and remove covers ②. (Remove both the left and right covers.)

(3) The piston will be visible inside main unit ①. Push the piston from one side and remove piston assembly ③ from the main unit.

Because the rack has directivity, note its direction when removing it from the main unit. (If you install the rack in reverse when reassembling the rotary actuator, the engagement between the gears will be imperfect, resulting in an error in the swing range of the key groove.)

2-3 Reassembly procedure

(1) Before reassembling the rotary actuator, thoroughly wash each part to ensure that no dirt adheres to it.

(2) Coat each part with grease.
When installing the piston packing in the piston, be careful not to damage the packing.

(3) The letters R and L, which represent left and right, respectively, are marked on the inside of covers ②. First, install the left cover (L).

(4) Insert piston assembly ③ into the main unit, then push the piston until it strikes left cover (L) ②. At this time, the piston packing will pass through the bearing housing. Be sure, therefore, not to damage the packing.

(5) Install bearing ⑨ in the housing of the main unit, and assemble the shaft so that the direction of the key groove is the same as the direction of the right

cover. If the key groove does not face the right side, this means that rack is assembled in reverse. In this case, correctly reassemble the rack.

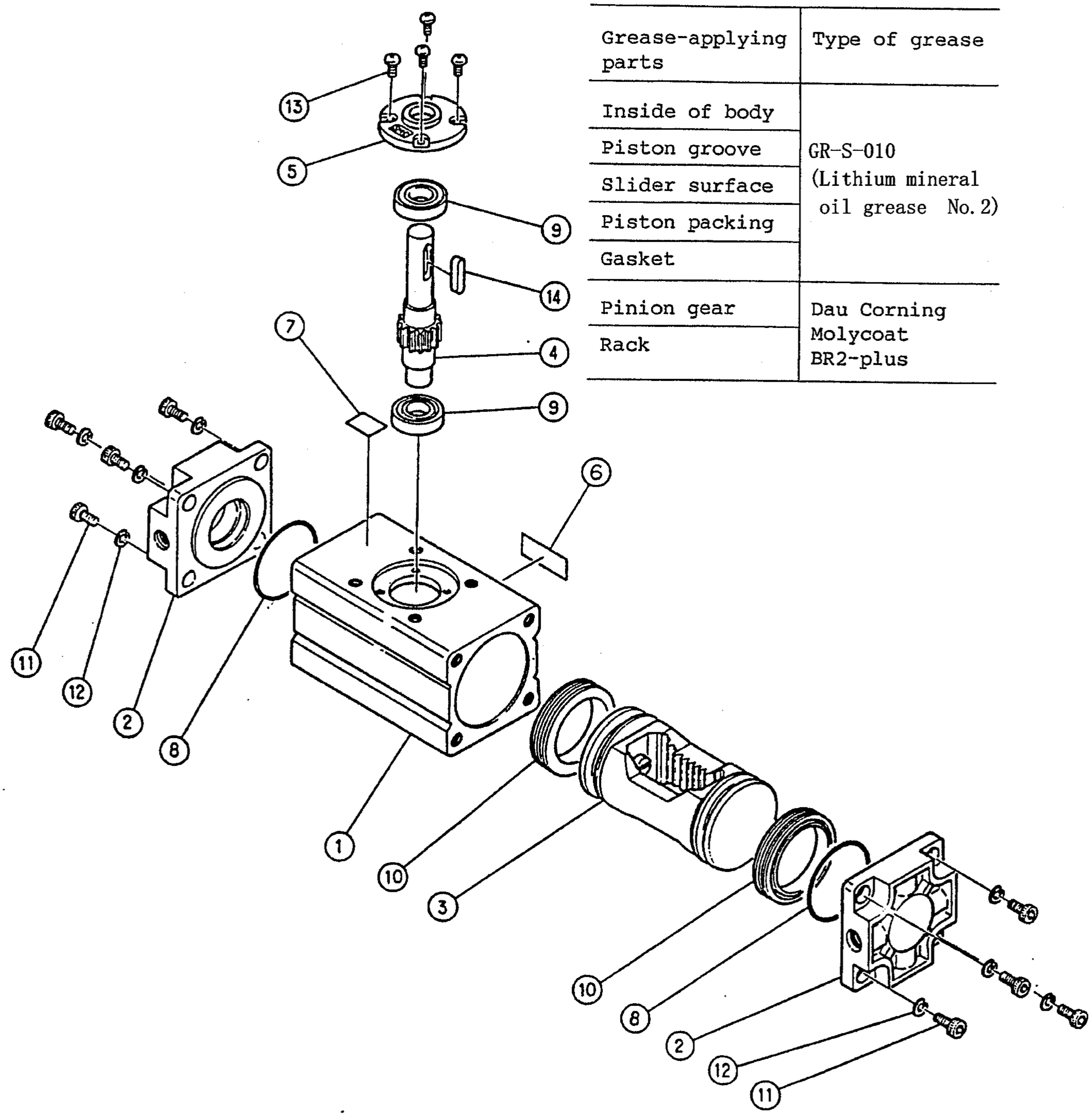
(6) Install cover (R) ②.

(7) After assembling the rotary actuator, perform an operating test and also check the actuator to ensure that there is no air leakage.

3) Disassembly Drawing

Table 9 Grease-applying Parts

Grease-applying parts	Type of grease
Inside of body	GR-S-010 (Lithium mineral oil grease No. 2)
Piston groove	
Slider surface	
Piston packing	
Gasket	
Pinion gear	Dau Corning Molycoat BR2-plus
Rack	



4) Troubleshooting

Symptom	Likely cause	Remedy	Ref. Page
Actuator does not operate	Supply pressure is not normal	Correctly adjust setting of pressure reduction valve on supply pressure side	1
	Direction switch-valve (solenoid valve, etc.) does not switch	Correctly apply signal to direction switching valve (solenoid valve, etc.)	6
	Air leakage from piping	Inspect piping and stop leakage	6
	Throttle valve in cover board is clogged	Remove cover and clean throttle valve. Also, carry out the following. a) Re-flush piping b) Inspect air filter	10 11
Actuator does not operate smoothly	Localized friction acts on load	Take steps to reduce frictional resistance	8
	Centers of actuator shaft and mating shaft are misaligned	Use flexible coupling at joints	9
Actuator does not operate smoothly	Insufficient output due to reduced supply pressure	To ensure stable operation, adjust supply pressure so that load factor is less than 50%	4
	Speed controller is excessively throttled	Because speed adjustment range of actuator is determined by each bore diameter, readjust speed controller	2

Symptom	Likely cause	Remedy	Ref. Page
Swing angle varies markedly	Internal parts damaged	Replace actuator with new one. Also, take the following action. a) Calculate kinetic energy applied to actuator, and adjust speed controller so that correct swing time is obtained. b) Install external shock absorber to absorb shock being applied to actuator. c) Install external stopper to prevent shock from being applied to actuator In this case, provide margin of actuator stroke (use 100° actuator in the case of 90° stroke so that actuator positively strikes external stopper.	12 to 15
Leakage from shaft	Piston packing friction	clean inside of cylinder then check whether or not inside of cylinder wall is damaged. Also,take the following action. a) If inside of cylinder is undamaged, replace packing. b) If inside of cylinder ia damaged, replace actuator with new one. c) If inside of cylinder is very dirty, inspect filter and flush piping.	10 20 to 24 29

Symptom	Likely cause	Remedy	Ref. Page
Damaged gears	Excessive kinetic energy is applied to actuator, causing damage to gears.	Replace actuator with new one. Also, take the following action a) Measure kinetic energy applied to actuator and adjust speed controller so that correct swing time is obtained b) Install external shock absorber to absorb shock being applied to actuator. c) Install external stopper to prevent shock from being applied to actuator In this case, provide margin of actuator stroke (use 100^{o} actuator in the case of 90^{o} stroke) so that actuator positively strikes external stopper.	12 to 19
Damaged gears	(For actuator provided with cushion) Cushion needle not optimally adjusted, hence cushion does not absorb kinetic energy.	Replace actuator with new one. Also, take the following action. a) Adjust cushion needle to obtain optimum cushioning b) Check to see if kinetic energy generated by load is less than energy which can be absorbed by cushion	16 17

Symptom	Likely cause	Remedy	Ref. Page
Insufficient swing angle	There is no margin on swing angle of actuator, hence swing range of actuator is unsymmetrical with respect to external stopper.	Remove external stopper and check full swing range of actuator, then install external stopper in correct position. When using external stopper, the use of 100° actuator for 90° stroke, or 190° actuator for 180° stroke is recommended.	18 19
	(For actuator provided with cushion) Cushion needle is closed	Adjust cushion needle	

5) Spare Parts Lists

Table 10 Spare Parts List (1)

Parts name \ Bore diameter		CRA1○30		CRA1○50		CRA1○63	
		Parts NO.	Qty	Parts NO.	Qty	Parts NO.	Qty
Piston packing	Press. gauge	PGY-30	2	PGY-50	2	PGY-63	2
	Air-hydro	———	——	OSY-50	2	OSY-63	2
Tube gasket		31.9 X 29.5 X 1.2	2	CA50-1602	2	CA63-1603	2
Slider		P2940194 (90°)	2	P2940257	2	P2940357	2
		P2940195 (180°)	2				
Spring pin		JISB2808 2 X 5 W	8	JISB2808 2 X 5 W	4	JISB2808 2 X 5 W	4

Table 11 Spare Parts List (2)

Parts name \ Bore diameter		CRA1○80		CRA1○100	
		Parts NO.	Qty	Parts NO.	Qty
Piston packing	Press. gauge	PGY-80	2	PGY-100	2
	Air-hydro	OSY-80	2	OSY-100	2
Tube gasket		CA80-1604	2	CA100-1605	2
Slider		P2940457	2	P2940558	2
			2		
Spring pin		JISB2808 3 X 8 W	4	JISB2808 3 X 8 W	4