

# **KITAGAWA**

## **NC TILTING ROTARY TABLES OPERATION MANUAL**

MODEL : TTS(M)180  
TTS(M)250  
TTS(M)320

### **IMPORTANT**

Please ensure that these instructions are read and understood by machine operators before using the NC Rotary Indexing Table.

**Please Read and Save This Manual**

**KITAGAWA IRON WORKS CO.,LTD.**



You selected KITAGAWA brand NC tilting rotary table because it has the feature and benefits. All of its specialized features and their operations are described in this manual. Make sure that you are completely familiar with all its features of the table.

## Preface

### 1 SAFETY ALERT SYMBOLS

These are the industry "Safety Alert Symbol". Their symbols are used to call your attention to items or operations that could be dangerous to you or other persons using this equipment. Please read these messages and follow these instructions carefully.

#### Warning terminology



Indicates an imminently hazardous situation which will result in death or serious injury if proper safety procedures and instructions are not adhered to.



Indicates a potentially hazardous situation which could result in death or serious injury if proper safety procedures and instructions are not adhered to.



Indicates a potentially hazardous situation which may result in minor or moderate injury if proper safety procedures and instructions are not adhered to.



Instructions for table performance and avoiding errors or mistakes.

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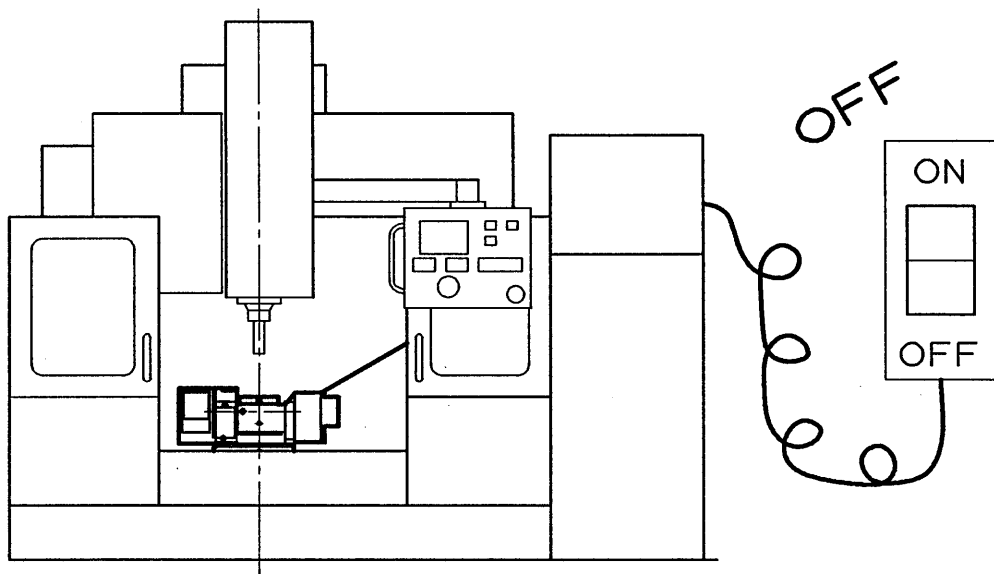
# 1 For Safety Operation

Please read this manual and follow instructions carefully.

We cannot assume responsibility for damage or accidents caused by misuse of the NC Rotary Indexing tables, through non-compliance with the safety instructions.




Turn off the main power of the machine prior to maintenance, check, or repair of the unit. Failure to do so may cause severe injury and/or accident.



There is danger in which fingers or clothes may be caught in the table.

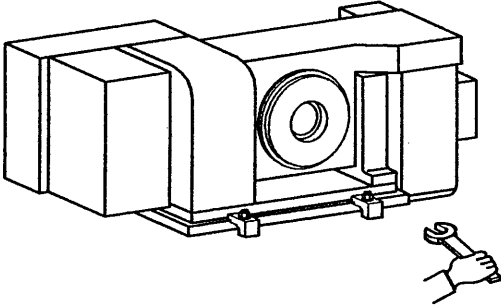
 **WARNING**


 Secure clamp bolts to correct torque.

There is a danger of scattering the work because the table overturns.

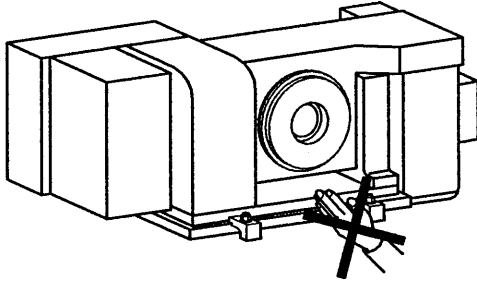
Tighten to correct torque.


Hex.bolt sizes	Tight.trq.(kgf·m)
M10	7.4
M12	11.0
M16	25.5
M20	41.0



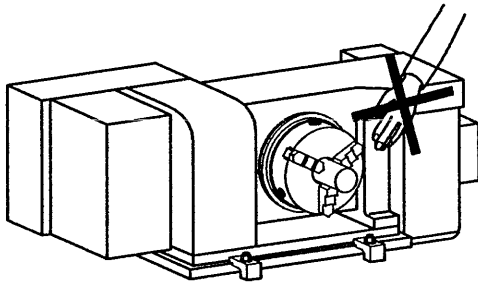
 When rotation the table,ensure your hand is out of the space of tilting area.

There is a danger in which fingers may be caught in rotary member.



 When rotating the table,ensure your hand out of rotating area.

There is a danger in which fingers may be caught in rotary member.

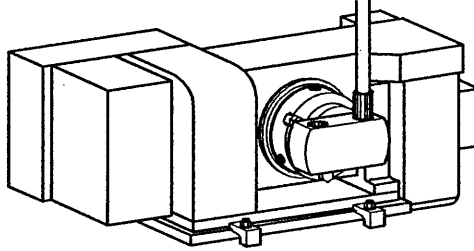


 **WARNING**



Never apply excessive cutting force.

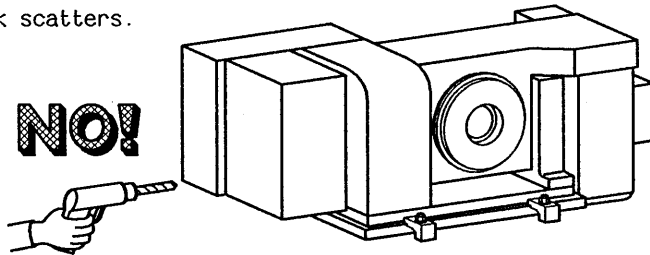
There is danger in which  
NC rotary table damages  
and work scatters.



Do not attempt to modify the NC  
rotary indexing table.

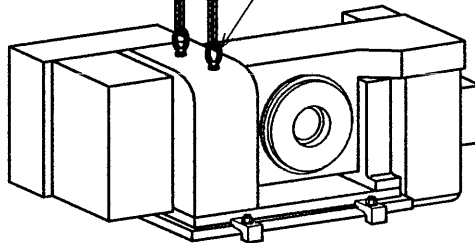
There is danger in which  
NC rotary table damages  
and work scatters.

**NO!**



When lifting the NC rotary table,  
use eye bolts and wire ropes.  
(See page 9.)

Wire rope                      Eye bolt  
There is a danger of falling.





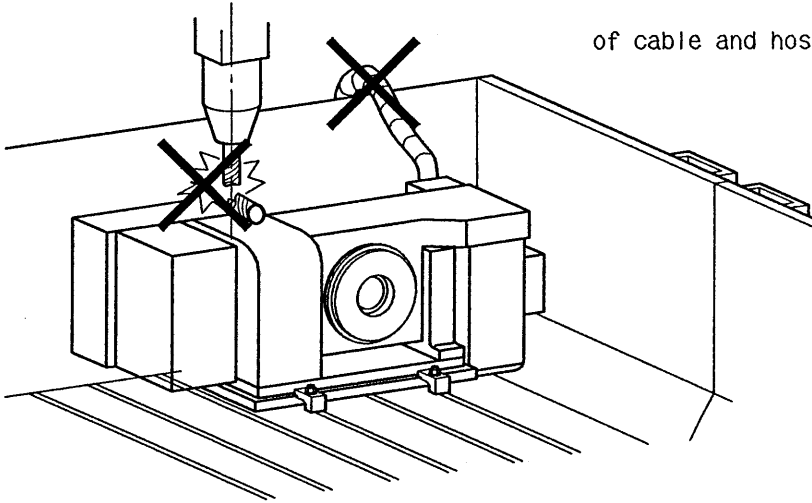
WARNING



Maintain adequate clearance between the unit and any part of the machine.

Danger of scattering  
because of work damage

Interference and extreme bending  
of cable and hose should be avoided.



There is the possibility of electric shock if the cable is damaged.



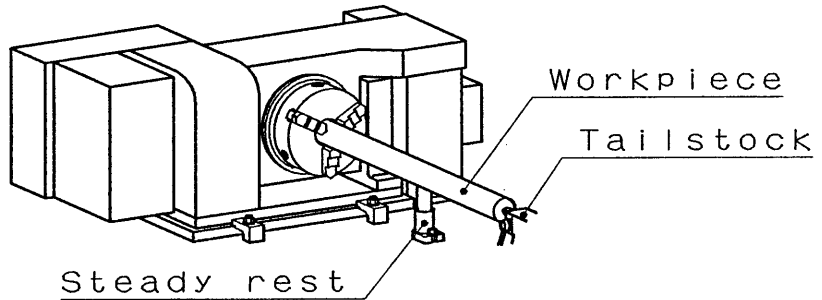


# CAUTION



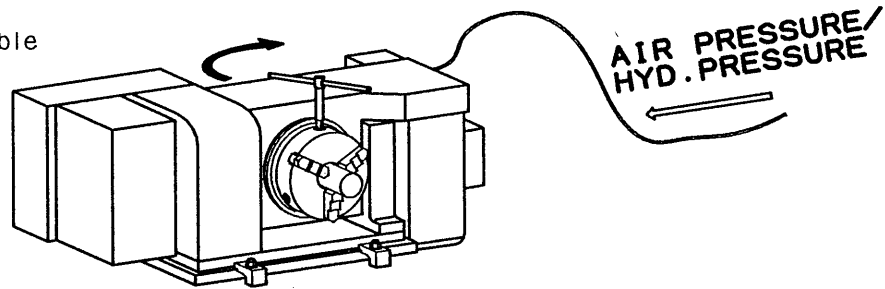
When machining a long or heavy workpiece, support with a tailstock or steady rest.  
(See page 7.)

Danger of scattering  
If work is lengthily  
protruded or heavy.



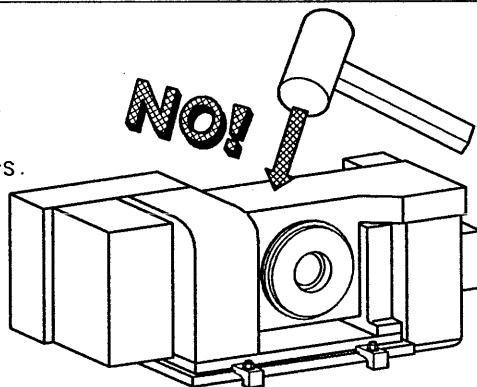
Clamp the table before mounting or removing the work.

Danger because not only  
machining accuracy drops but  
also NC rotary table  
damages or work  
scatters.



Don't apply a shock to each component of NC rotary table.

Danger because NC  
rotary table damages  
and air work scatters.



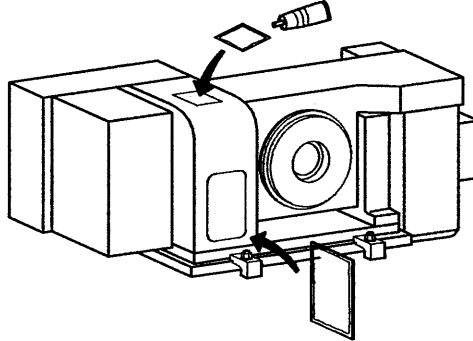


## CAUTION



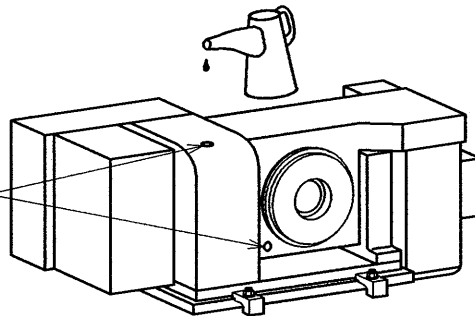
Coat solution packing on the cover mounting face.

Danger by work scattering because NC rotary table will result in misoperation by permeation of coolant, etc.



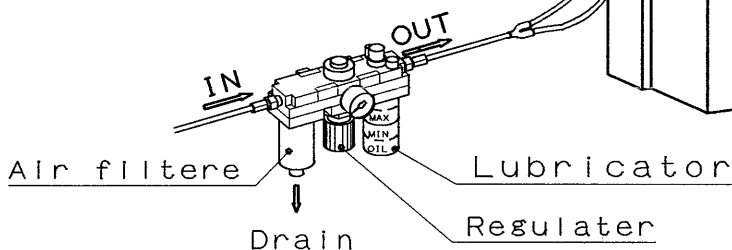
Replace lubricating oil every 6 months (see page 10).

Oil fillers



Supply air through 3-point unit (See page 10)

Apply air purge inside the motor case and be sure to provide dry air (air filtered and regulated).



- Periodically drain the water in air filter.
- Keep the oil capacity in lubricator adequately.
- Use specified oil (ISO-VG68)

## 2 Specifications

NO.	Type		TTS180 TTSM180	TTS250 TTSM250	TTS320 TTSM320	
1	Table diameter	mm	φ180	φ250	φ320	
2	Table height in horizontal	mm	250	300	345	
3	Center height in vertical	mm	180	225	255	
4	Total height	mm	320	380	448	
5	Center through hole	mm	40	70	100	
6	Clamp force [Air pressure (5.1kgf/cm <sup>2</sup> ) ]	(Rotary axis) N·m(kgf·m)	150(15.3)	—	—	
		(Tilting axis) N·m(kgf·m)	200(20.4)	—	—	
	Clamp force [Hyd pressure (35.7kgf/cm <sup>2</sup> ) ]	(Rotary axis) N·m(kgf·m)	—	900(91.8)	1600(163)	
		(Tilting axis) N·m(kgf·m)	—	1200(122)	2000(204)	
7	Allowable work diameter	mm	φ180	φ250	φ320	
8	Allowable work weight	(In horizontal) kg	60	100	150	
		(In tilting) kg	40	60	100	
9	Allowable work inertia	Kg·m <sup>2</sup> (kgf·cm·sec <sup>2</sup> )	0.245(2.5)	0.784(8.0)	1.92(19.6)	
10	Total deced. ratio	(Rotary axis)	Standard min <sup>-1</sup>	1/90	1/90	1/180
			Controller MAC min/A	1/90	1/120	1/180
	(Tilting axis)	Standard min <sup>-1</sup>	1/180	1/180	1/360	
		Controller MAC min/A	1/180	1/240	1/360	
11	Max r.p.m.	(Rotary axis)	Standard min <sup>-1</sup>	33.3	33.3	16.7
			Controller MAC min/A	33.3	12.5	16.7
	(Tilting axis)	Standard min <sup>-1</sup>	7.5	11.1	5.5	
		Controller MAC min/A	7.5	8.3	5.5	
12	Tilting angle	Degree	-20~110	-20~110	-20~110	
13	Weight	kg	About 150	About 275	About 375	

### IMPORTANT

The maximum speed of TTS180,TTSM180 tilting axis is 1350 min<sup>-1</sup>. Other motor revolutions are 2000 min<sup>-1</sup>.

### CAUTION

Be sure to observe the allowable work inertia even if the work weight is within the allowable value.

### CAUTION

There is a possibility to need the tailstock by the work weight, shape, cutting condition, etc.

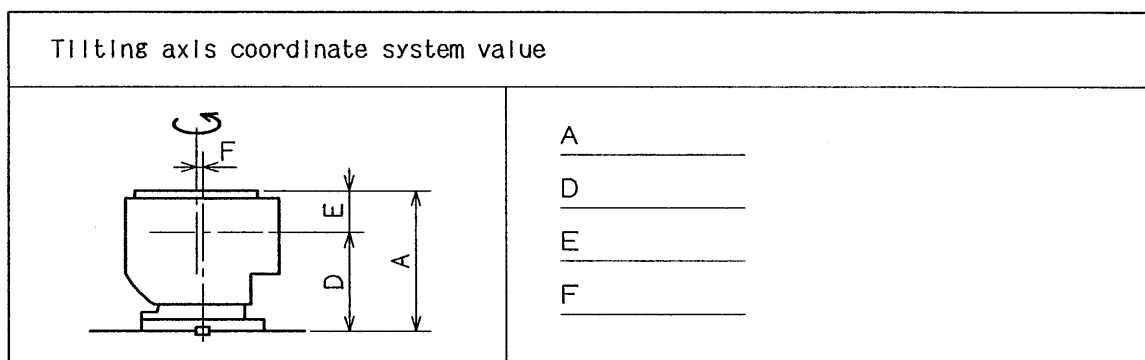
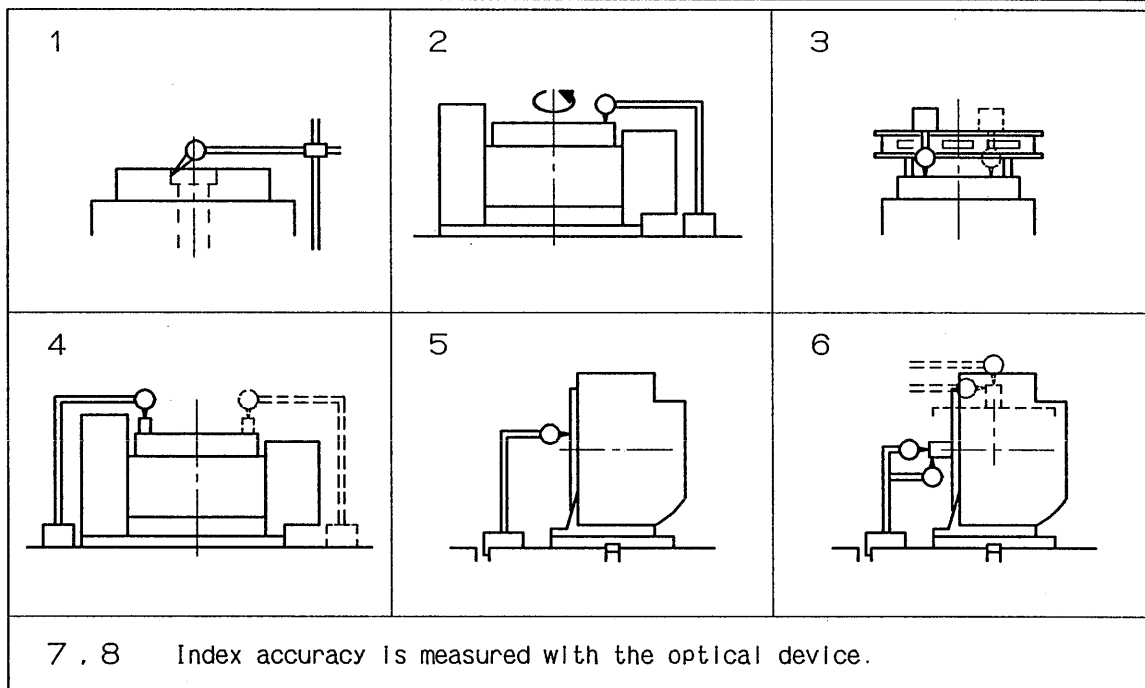
### CAUTION

For conditions for using the table, refer to the above specifications and caution items. Set each cutting condition so as not to exceed the allowable value.

### 3 Accuracy Standard

(Unit:mm)

Inspection items		TTS180 TSM180	TTS250 TSM180	TTS320 TSM180	
1	Run out of table center hole		0.010		
2	Run out of upper face during table rotation		0.015		
3	Straightness of upper face of table(center low)	Total length	0.010		
4	Parallelism of upper face of table and lower face of base(tilting axis direction)	Total length	0.020		
5	Parallelism of upper face on table and center line of guide block (tilting angle 90°)	Total length	0.020		
6	Parallelism of tilting axis center line and lower face of base	Total length	0.020		
7	Index accuracy	Rotary table	Standard	Accumulation	20sec
			Controller MAC miniA	Accumulation	30sec
		Tilting axis		Accumulation	60sec 45sec 45sec
8	Reproducibility	Standard			4sec
		Controller MAC miniA			10sec



## 4 Preparation

Unpack the unit and remove the packing material.

### 4-1 Installation

- 1) When lifting the unit, securely screw in the eye bolts provided. Use wire loop which provided sufficient strength to lift the unit.
- 2) Clean the unit thoroughly with an adequate clean agent. When installing the unit on the machine table, make sure there is no foreign material nor damage such as nicks and burrs on the mating faces. Use an oil stone for correction if necessary.
- 3) Locate and set the unit at the most suitable location for the operation. In case of a vertical unit, the guide blocks will fit into the slotted groove on the machine. If there is any play between the guide block and the T-slot, place the unit against one side of the T-slot to eliminate the gap.
- 4) Firmly clamp down the unit to the machine with the furnished clamping fixtures.



When mounting the NC rotary table to the machine tool, check the mounting space. Especially, take care so that the NC rotary table, cable and air hose will not interfere with the splash guide, ATC device, spindle head, etc., of the machine tool when moving the machine tool table or spindle head, etc.



Don't damage the cable by applying unreasonable stress, placing a heavy thing or pinching it. If damaged, there is a danger of electric shock.

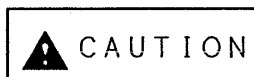


Effectively use mounting seats and tighten clamping bolts at the specified torque. (See page 2.)

### 4-2 Lubrication

Lubricant has been already filled in the NC rotary table body before shipping. Check the lubricant is filled to the center line of the gauge before operating the machine.

(See Fig.1.)



Replace all lubricant with new one every 6 months. Completely drain before replacing the oil. When filling the oil, wipe the oil filler so that chips and foreign matter are not entered into the tank. If the chips or foreign matter are entered, the important part such as bearings, etc., are seized or machining accuracy drops. Use recommended oil in the following table.

Recommended Lubricant(Viscosity grade ISO VG68)

Maker	Oil Name	Maker	Oil Name
Mobil	Vactra Oil No.2	Cosmo	Dinaway S68
Nisseki	Uniway 68	Idemitsu	Dufni Mutiway 68C
Kyouseki	Kyouseki Slidus 68	Esso	Fyelvis K68
Mitsubishi	Diamond Slideway 68	Shell	Shell Tona Oil T68

Required Oil

(Liter)

Part \ Type	TTS180	TTS250	TTS320
	TTSM180	TTSM250	TTSM320
Tilting axis body	0.6	1.0	1.5
Gear case of tilting table	0.5	0.6	0.6
Rotary table body	0.8	1.5	3.0
Gear case of rotary table	0.6	0.8	1.0

★ Vactra Oil No.2 has already been filled before shipping.

#### 4-3 Air/hydraulic pressure supply for clamp

##### 4-3-1 Specification for air pressure clamping

- 1) Supply air through 3-point unit(air filter,regulator,lubricator)(see page 6).
- 2) Connect the air pressure hose to the connection(Rc 1/4)shown in Fig.1.
- 3) Use the air pressure at the range of 0.5~0.6MPa(5.1~6.1kgf/cm<sup>2</sup>).
- 4) In the case of air pressure specification,the solenoid valves are incorporated.  
The piping is as follows with the standard specification. Take care when the electric wires are routed.

Solenoid ON — Unclamp

Solenoid OFF — Clamp

##### 4-3-2 Specifications for hydraulic pressure clamping

- 1) Connect the hydraulic pressure hose to the connection(Rc 1/4)shown in Fig.1.
- 2) Use the hydraulic pressure at the range of 3.5~3.7 MPa(35.7~37.7kgf/cm<sup>2</sup>).
- 3) In the case of hydraulic pressure specifications, since the solenoid valve is not incorporated, provide the solenoid valves on the external portion and route the same wiring as the air pressure specifications.

### 4-3-3 Clamp - Unclamp check

The set up pressure of the switch for both pneumatic and hydraulic systems are as follows:

	Clamp Signal (SP1.SP3)	Unclamp Signal (SP2.SP4)
Pneumatic	0.3 MPa (3.0kgf/cm <sup>2</sup> )	0.05 MPa (0.5kgf/cm <sup>2</sup> )
Hydraulic	2.7 MPa (28.0kgf/cm <sup>2</sup> )	0.2 MPa (2.0kgf/cm <sup>2</sup> )

### 4-3-4 Clamp - Unclamp caution



Rotate the table and move the tilting axis with the chuck unclamped. After positioning, machine the work with the chuck clumped. Take care because the worm wheel will be damaged by misuse.



Avoid the machining more than the clamp force shown in the specification table. The clamped part is worn and the worm wheel is damaged.



Completely escape pressure when the unit is unclamped. If remained, the worm gear and clamper will be seized and damaged. therefore, take care of back pressure.

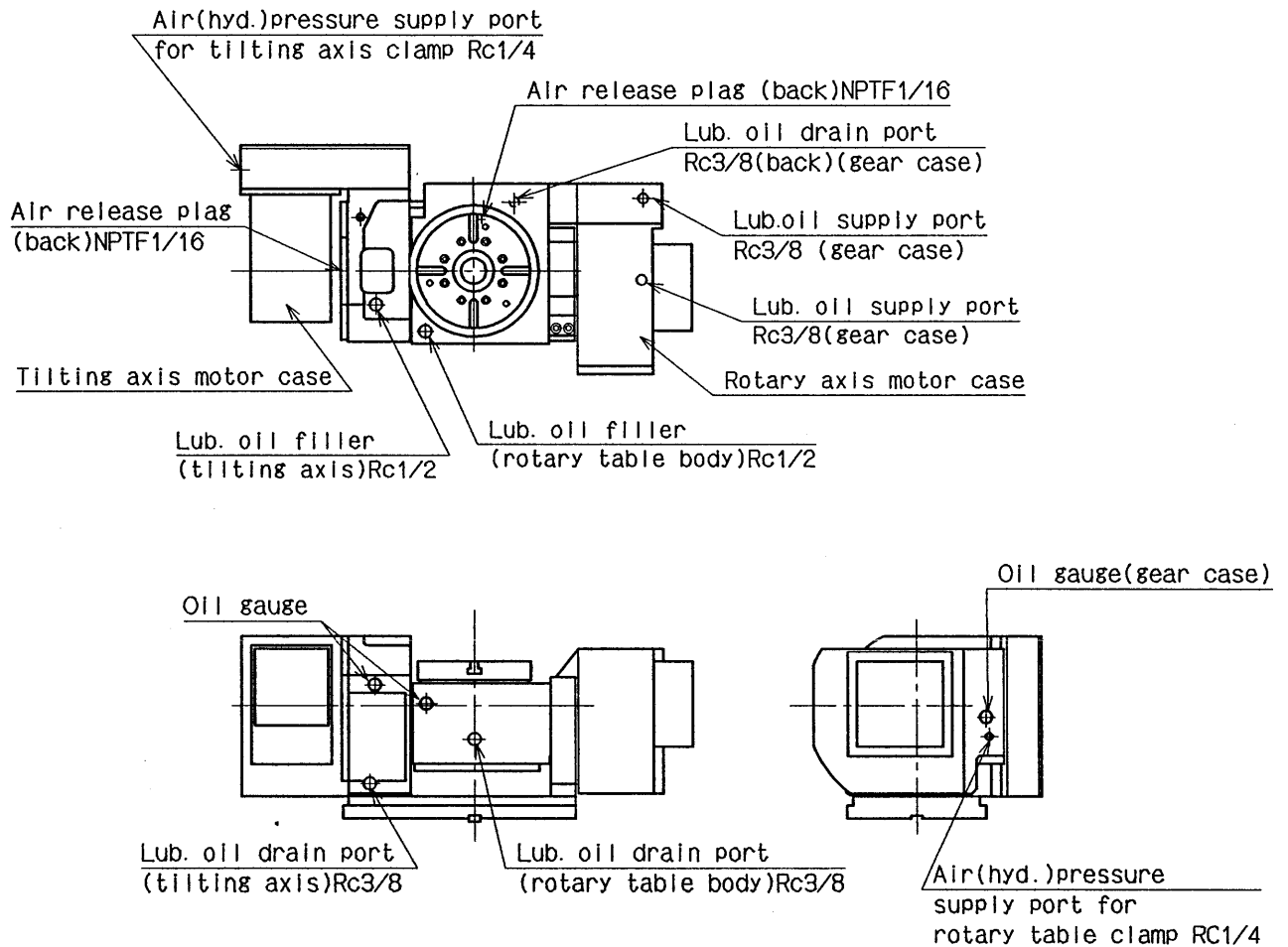


Fig 1

#### 4-4 Trial run, accuracy check

- 1) Perform the trial run under no load in which no work is mounted on the table.
- 2) Check there is no noise and vibration during the operation of axis LOW,

HIGH, FORWARD and REVERSE. Perform the running-in of rotary axis by two slowly increase the forward and reverse directions at 1 rpm at first. After that, slowly increase the speed in high speed.

Perform the running-in of the tilting axis by two strokes at the feed of 1 RPM, paying attention so as not to enter in the over travel area and slowly increase the speed.

- 3) During the above operation, check there are the working sound and exhaust sound from the solenoid valves and silencer incorporated in the NC table.

(In air clamp of use)

- 4) Check accuracy, referring to the inspection result table and the accuracy standard in the manual.

#### 4-5 Setting of ZRN and shift value to machine datum

- 1) After checking the above operation, when there is no alarm, return each axis to machine datum. For the ZRN of each axis, the axis rotates at high speed in the fixed direction and decelerates with the sensor (proximity switch) of the incorporated ZRN decelerating dog before stopping by receiving the standard signal of motor detector.
- 2) The tilting axis datum (0°) is where the table face is horizontal and +90° where the table face is vertical. The standard ZRN direction of tilting axis is set from - (minus) direction to 0°.
- 3) The ZRN direction of rotary table is right.
- 4) Individually perform ZRN for the tilting axis and the rotary table to find the angle difference between the actual stopping position and the machine datum. To compensate this angle difference, set the parameter value of datum shift volume of control unit. If the compensating value exceeds the setting range, it is necessary to adjust the ZRN deceleration dog position (See Item 6-3).



## 4-6 Work mounting

Securely mount the work for a high accuracy machining.



If the work is not securely mounted, not only accuracy is wrong but also the machine and tool are damaged. In the worst case, it will result in serious injury.



If the work which is not flatness and straightness is mounted as is, the work or rotary table is distorted, thus causing accuracy drop or unevenness rotation. In this case, insert shim in the gap between the work and the rotary table.



Clamp the work in equipartition on the rotary table as much as possible.

## 5 Daily Inspection

Inspect the following items before starting the machine.

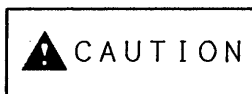
1. Check the fixing condition of the NC rotary table(including jig).
2. Check the electric connection cables and houses are not damaged  
and also check the air pressure and hydraulic pressure.
3. Check each ZRN operation, index operation and position.

## 6 Each Component and Maintenance. Adjustment

This chapter explains the structure and maintenance, adjustment about worm gear, spur gear drive mechanism, ZRN device, tilting axis emergency stop device and motor case.

### 6-1 Backlash adjustment of worm gear

The worm and worm wheel are made of the special material and accurately machined. Though the backlash of the worm gear has already been adequately adjusted before shipping, it may be necessary to adjust it after using for a long period of time. The adequate values of backlash are as follows. These values were measured when the machine is cooled. Thus, values are measured after interrupting for a long period of time. Consequently, when operating the machine for a long period of time, the backlash values become smaller than the following table due to thermal expansion.



If backlash is too small, the worm gear will be seized.

#### Adequate backlash

Type	Circular arc length at peripheral table position( $\mu\text{m}$ ) Angle(sec.)In [ ]		
	TTS180 TTSM180	TTS250 TTSM250	TTS320 TTSM320
Rotary table	12~31 [28~71]	14~42 [23~69]	15~45 [19~63]
Tilting axis	6~10 [15~23]	6~10 [8~14]	6~10 [7~11]

When adjusting the backlash, measure the current backlash with the following method before adjusting it.

### 6-1-1 Measuring method of backlash of worm gear on table

- 1) Set the dial gauge to the peripheral part of the T-groove on the upper face of table.
- 2) Slowly turn the table with the flat steel or round bar inserted in the T-groove on the upper face of table and release your hand when the worm wheel tooth is touched before reading the value of dial gauge. Next, turn the table at the same condition in the reverse direction and read the value of dial gauge. At this time, the difference of measuring values is the backlash.
- 3) Perform the above measurement at 8 equipartition of outer periphery by turning the table and compare them with the above adequate values. (See Fig.2.)

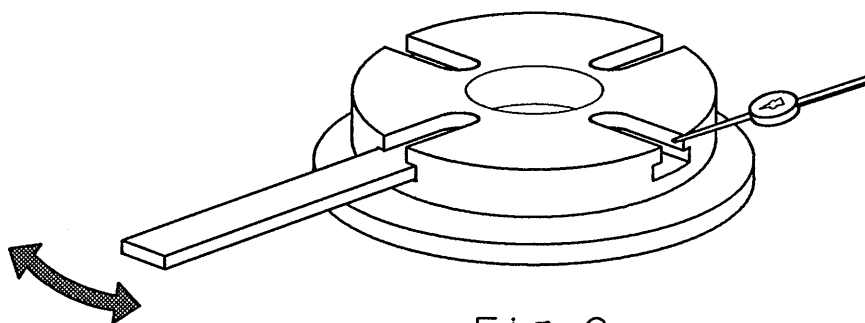


Fig 2

### 6-1-2 Backlash measuring method of tilting worm gear

- 1) Set the dial gauge around the outer periphery on the upper face of table.
- 2) After turning the tilting body at about 10kg in the minus direction, loosen force and read the value of dial gauge with the body maintained at the force of 2~3kg in the same direction. Similarly turn the body in the reverse direction and read the value of dial gauge. This difference of measuring values is the backlash.

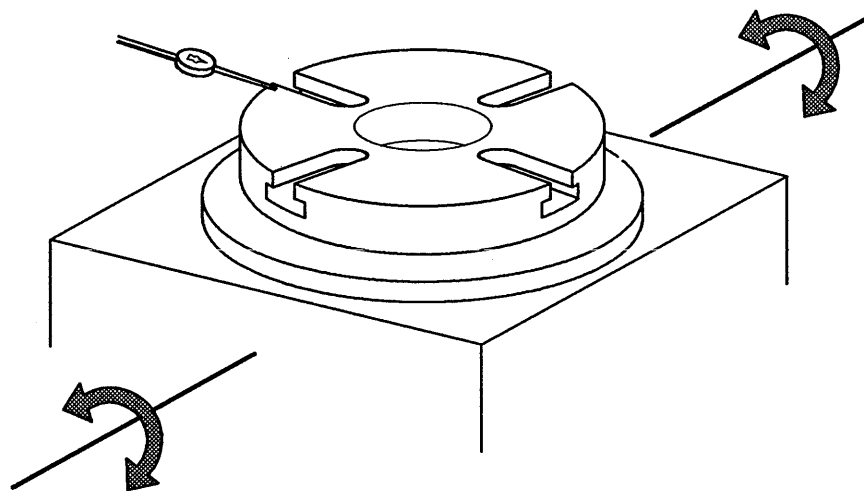


Fig 3

### 6-1-3 Backlash adjusting method of worm gear on table(Fig.4)

- 1) Remove the cover ①.
- 2) The bearing case ② is positioned with the tightening bolts ③ and the hexagon socket head set screw ④.
- 3) Slightly loosen the tightening bolts.
- 4) Loosen four hexagon socket head set screws by the same quantity and retighten their bolts. At this time, the bearing case moves forward and the backlash becomes small.

#### IMPORTANT

Each turning angle of the hexagon socket head set screw to reduce the backlash 0.01mm is shown in the following table.

Type	TTS180 TTSM180	TTS250 TTSM250	TTS320 TTSM320
Turning angle of screw	110°	170°	170°

#### CAUTION

Uniformly and securely tighten the tightening bolts and hexagon socket head set screws. Don't adjust the backlash once. Slowly and carefully adjust it.

After assembling, measure the backlash on the outer periphery of table at the same position as the measuring before adjusting and check that the its value is adequate.

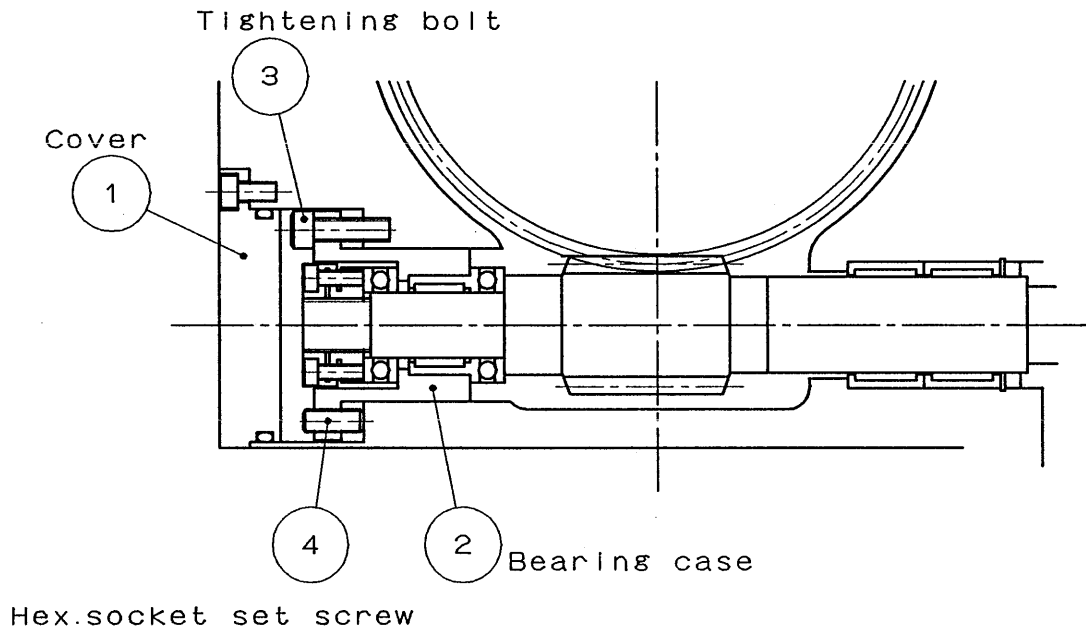


Fig 4

#### 6-1-4 Backlash adjusting method of tilting axis worm gear (Fig.5)

- 1) Remove the work, jig, etc., on the table before adjusting and level the table.
- 2) Drain lubricating oil from the drain port.
- 3) Remove the tilting axis motor case ⑥ and also remove in the order of the servo motor and the flange ⑦.
- 4) Remove the gear ⑨ from the worm shaft by loosening the spun ring which fixes gear ⑨ to the worm shaft after loosening the bolt ⑧.
- 5) Remove the cover ①.
- 6) Remove the hexagon socket head bolt which fixes the bearing case ④ and slowly turn the worm shaft ⑤ by using the hole of lock nut ② before removing the bearing case ④.
- 7) Remove the spacer ③ and reduce its thickness by grinding before reassembling.  
As a result, the backlash becomes small.

#### IMPORTANT

The spacer grinding quantity to reduce the backlash 0.01mm is shown in the following table.

Type	TTS180 TTSM180	TTS250 TTSM250	TTS320 TTSM320
Grinding quantity	0.314	0.466	0.466

#### CAUTION

Grind the spacer so that both faces become parallel. Don't adjust the backlash once.

Slowly and carefully adjust it.

After adjusting, reassemble the worm gear by the reverse procedure of the above and securely tighten the bolts. After reassembling, measure the backlash again at the outer periphery of the table and at the same position. Check that the backlash is proper.

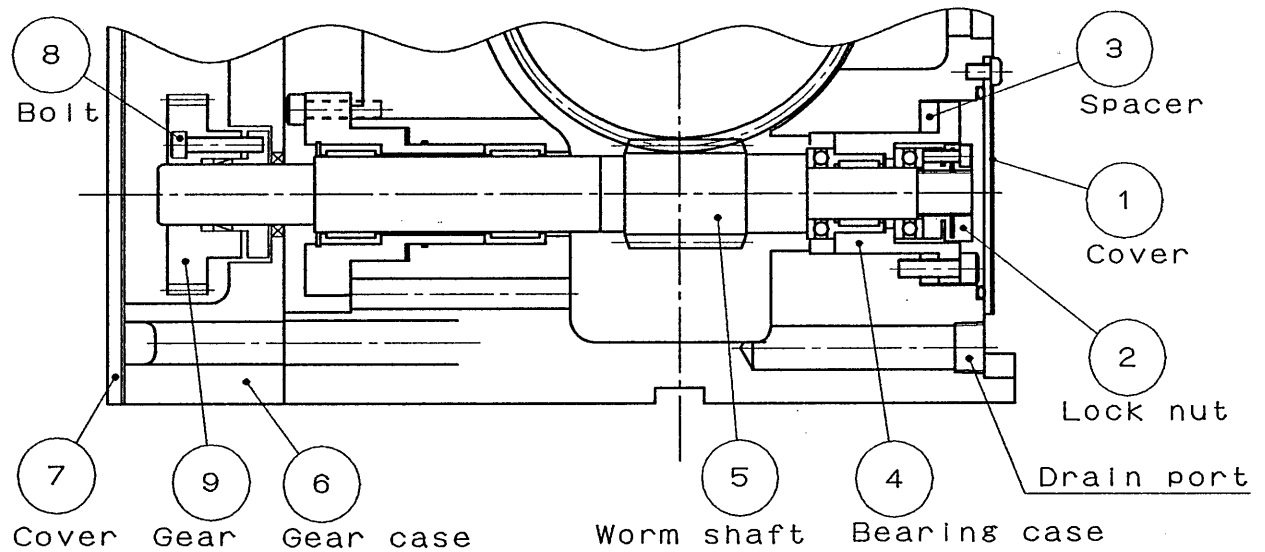


Fig 5

## 6-2 Backlash adjustment of spur gear

The adequate backlash of the spur gear is 0.02~0.04mm. If it is far removed from the adequate value, it is necessary to adjust the backlash.

### 6-2-1 Backlash adjusting method of table drive spur gear (Fig.6)

#### A) Spur gear Z1 and spur gear Z2.

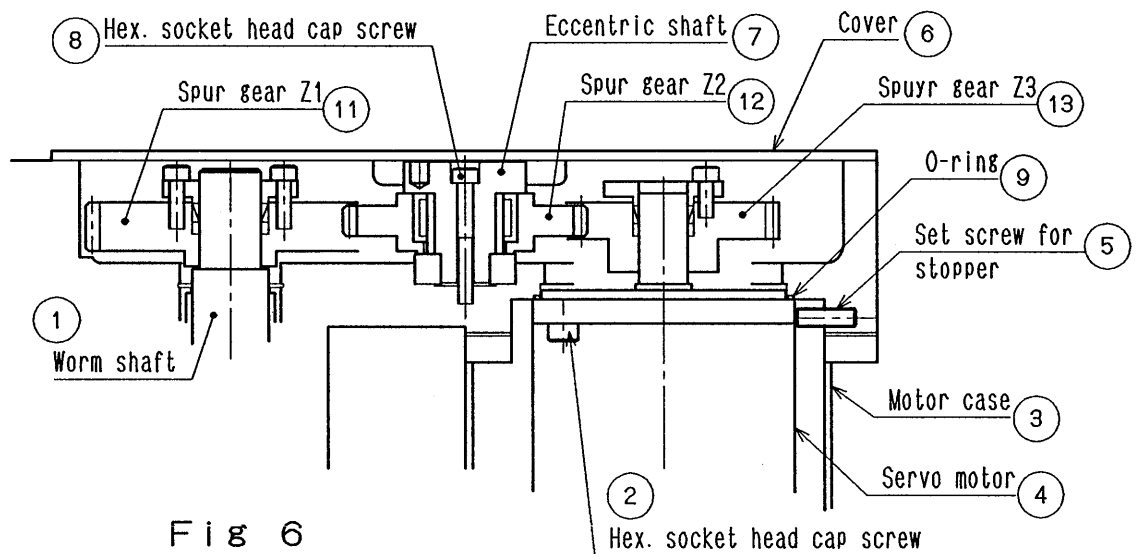
The backlash between spur gears of Z1 (11) and Z2 (12) is adjusted by turning the eccentric shaft and by varying the distance between axes.

- 1) Drain the lubricant from the drain port.
- 2) Remove the cover (6).
- 3) Fix the spur gear Z2 and touch the dial gauge to the tooth face of the spur gear Z1 to measure the backlash.
- 4) Since the eccentric shaft (7) is fixed with the hexagon socket head set bolt (8), loosen this bolt and turn the eccentric shaft to adjust the center distance between the spur gear Z1 and the spur gear Z2 checking the backlash with the dial gauge.
- 5) The backlash has already been adjusted to the adequate value and the alignment mark of the gear case has been aligned to that of the eccentric shaft before shipping.

## B) Spur gear Z2 and spur gear Z3

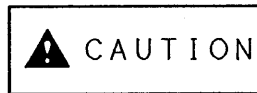
The backlash between spur gears of Z2 (12) and Z3 (13) is adjusted by touching the set screw (5) for stopper to the side face of the servo motor (4) and by varying the distance between axes after adjusting the motor position.

- 1) Fix the spur gear Z2 and touch the dial gauge to the tooth face of the spur gear Z3 to measure the backlash.
- 2) Remove the cover (3).
- 3) Slightly loosen four bolts (2) which fix the servo motor.
- 4) Slowly shift the servo motor by turning the set screw for stopper.
- 5) Since the screw pitch of the set screw for stopper is 1.0mm, when turning the set screw  $10^\circ$  (1/36turn), the backlash varies 0.02mm.
- 6) After securely tightening four hexagon head bolts with the servo motor certainly touched to the set screw for stopper, check the backlash with the dial gauge again.



## 6-2-2 Backlash adjusting method of tilting axis drive spur gear [TTS180,TTS250] (Fig.7)

Adjusting steps are the same as the table rotary axis ,refer to Item 6-2-1.



When remounting the motor, be sure to carefully set O-ring ④.

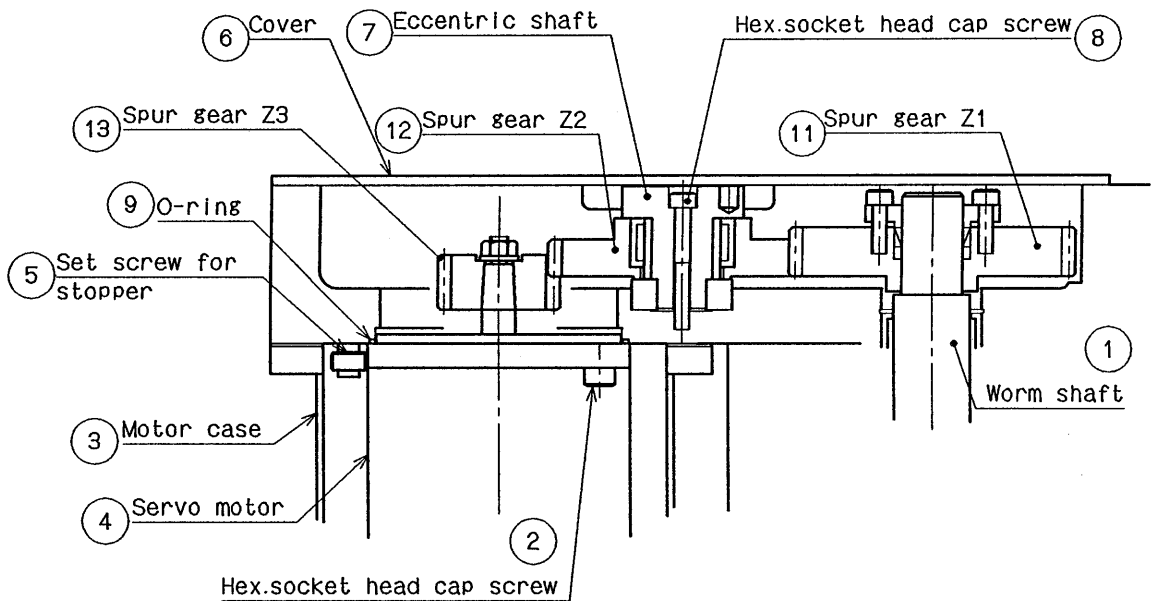


Fig 7

## 6-2-3 Backlash adjusting method of tilting axis drive spur gear [TTS320] (Fig.8)

- 1) The backlash between spur gears of Z1 ⑪ and Z2 ⑫ is adjusted by varying the distance between axes after turning the eccentric shaft ⑦.
- 2) The backlash between spur gears of Z2 ⑬ and Z3 ⑭ is adjusted by touching the hex. sockethead cap screw ⑤ for stopper to the side face of the servo motor ④ and by varying the distance between axes after adjusting the motor position.



3) Adjusting steps are the same as the table drive part, refer to Item 6-2-1.

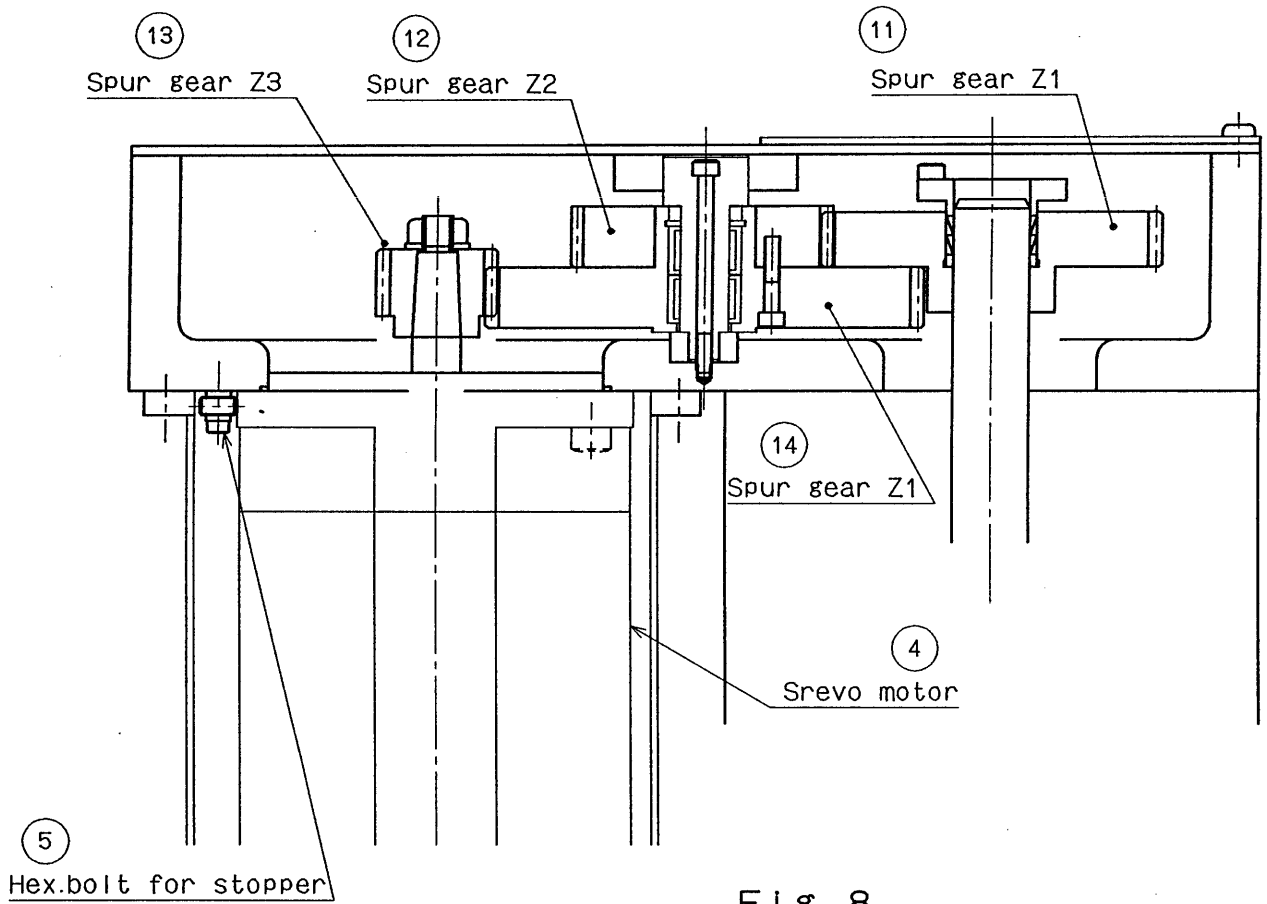


Fig 8

## 6-3 ZRN device

### 6-3-1 ZRN device on table (Fig.9)

The ZRN device rotates clockwise (CW) on the standard specification. The ZRN deceleration dog is mounted in the table and it can be mounted on the optional position of outer periphery. When changing the ZRN position or ZRN rotary direction counterclockwise, the dog position can be changed by the following procedure.

- 1) Drain the lubricating oil in the table body and gear case.
- 2) Remove the cover ①.
- 3) Loosen the set screws ③ which fix the dog ②.
- 4) Shift the dog to the proper position.
- 5) After adjusting the position, securely tighten the set screws.



When setting the cover again after adjusting the dog position, be sure to evenly coat seal agent on the cover. (The seal agent 1215 made by Three Bond Co., has already been coated on the cover before shipping.)

The proximity switch is provided as the sensor for detecting the dog. The gap between the dog and the switch is set to about 1mm. (The thread pitch for mounting the proximity switch is 1mm.) The proximity switch is equipped with the lamp.

Since the lamp goes out when the dog is detected, use it when the dog is adjusted.

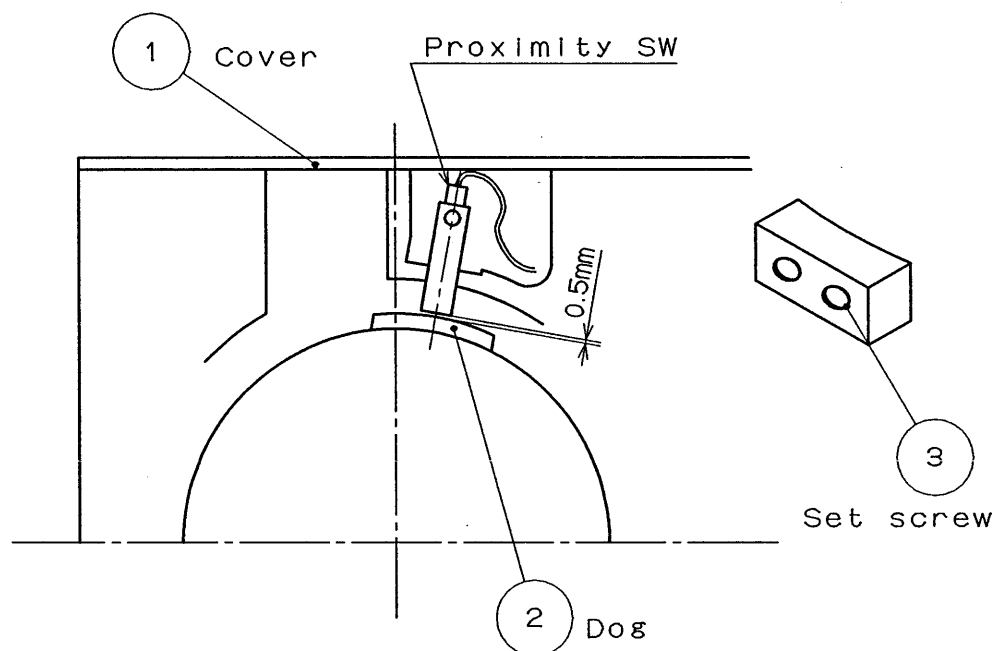


Fig 9

## 6-3-2 Tilting axis ZRN device (Fig.10, Fig.11)

- 1) The ZRN decelerating dog and the proximity switch are located in the tilting axis body.
- 2) The horizontal table face is the datum as the standard specification. The dog A ① in is detected with the proximity switch A ②.



In the case of TTS180, TTS250, since the dog A is commonly used for emergency stop, when each is shifted for ZRN adjustment, make sure that it is detected with the proximity switch C ⑤.

- 3) When determining the vertical table face position to the datum the dog B ③ with the proximity switch B ④. (It is necessary to reconnect the wiring with the terminal block in the tilting axis motor case.)

## 6-4 Emergency stop device for tilting axis

### 6-4-1 TTS180, TTS250 (Fig.10)

- 1) The dog A ① of Fig.10 (used together with ZRN decelerating dog) located on the stroke limit on the horizontal table face position is detected with the proximity switch C ⑤.
- 2) The dog B ③ located on the stroke limit on the vertical table face position is detected with the proximity switch D ⑥.
- 3) The angle of 25° is provided until the emergency stop is applied from the horizontal and vertical positions of table face. Provide the soft limit by the work shape, etc.

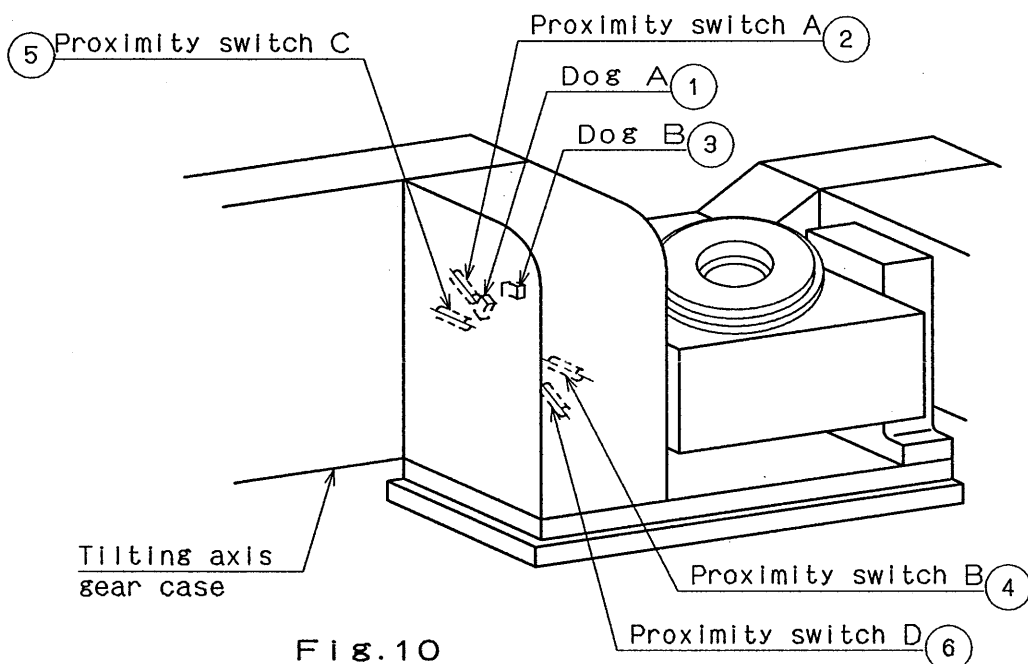


Fig. 10  
(TTS180, TTS250)

## 6-4-2 TTS320 (Fig.11)

- 1) The stroke limit on the horizontal table face position side detects the dog C ⑤ with the proximity switch C ⑥ and the stroke limit on the vertical table face position detects it with the proximity switch D ⑦
- 2) The angle of 25° is provided until each emergency stop is applied from the horizontal position and vertical position of table face. Provide the soft limit by the work shape, etc.

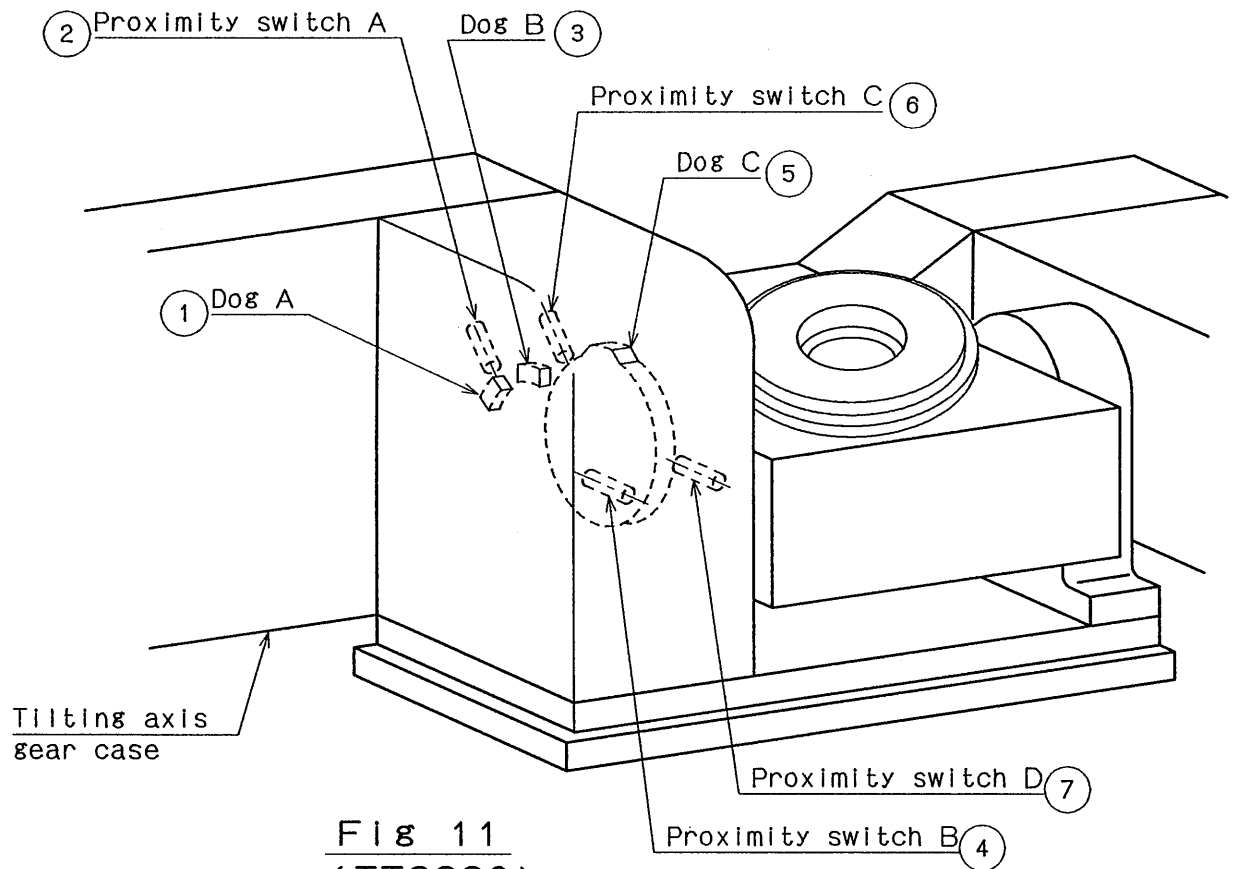
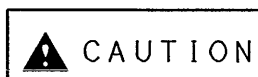


Fig 11  
(TTS320)

## ➤ Strage



When storing the NC rotary table after removing it from the machine tool, place it on the stable wooden base for maintaining accuracy after removing chips or coolant, etc. Coat the table with rust prevention oil and case or lap it with the wooden cover or vinyl cover, etc. when using the wooden base and box, avoid the green wood. Since the green wood is not chemically neutral, use the wood moistened with paraffin.

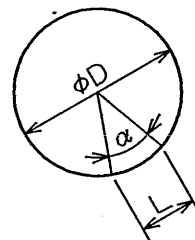
## 8 Reference Material

### 8-1 Conversion of peripheral length and angle

#### IMPORTANT

When understanding 'How long at periphery is accumulation index accuracy 30 seconds?' or 'How angle is the accumulation pitch error 0.05?', use the following formula from the relationship between the angle and the periphery length.

D : Work diameter (mm)  
 $\alpha$  : Angle (sec)  
 L : Periphery length (mm)



$$\frac{L}{\pi \times D} = \frac{\alpha}{360(\text{sec}) \times 60(\text{min}) \times 60(\text{sec})} \quad \text{----- (1)}$$

From (1)

$$\alpha = \frac{360 \times 60 \times 60 \times L}{\pi \times D} = \frac{4.125 \times L \times 10^5}{D} \quad \text{----- (2)}$$

or

$$L = \frac{\alpha \times \pi \times D}{360 \times 60 \times 60} = 2.424 \times 10^{-6} \times \alpha \times D \quad \text{----- (3)}$$

(Example)

When the work diameter is regarded as 100mm, the following is formulated by 'Accumulation accuracy of 30 sec. is indicated with periphery length.' and formula (3).

$$L = 2.424 \times 30 \times 100 \times 10^{-6} = 0.007272\text{mm} = 7.3\mu\text{m}$$

Consequently, the periphery length is about 0.0073mm or 7.3 $\mu$ m.

The following is formulated by 'Accumulation pitch error is indicated with angle of 0.05.' and formula (2).

$$\alpha = \frac{4.125 \times 0.05 \times 10^5}{100} = 206.25 \text{ sec}$$

Therefore, the angle is 206 seconds or 3 minutes and 26 seconds. As shown above, the periphery length and angle are converted by formulas of (2) and (3).

## 8-2 Coordinate calculation of table center for tilting angle

The calculation which finds the table center coordinate when tilted  $\theta$ 's shown as follows. For values of E and F, use values entered in the inspection table.

$$X = F \cos \theta - E \sin \theta - F$$

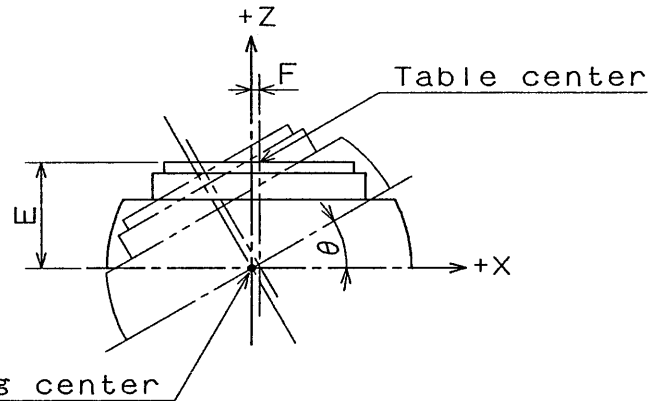
$$Z = E \cos \theta + F \sin \theta - E$$

(Example)

In case of  $E=70, F=0$ :

$$X = -70 \sin \theta$$

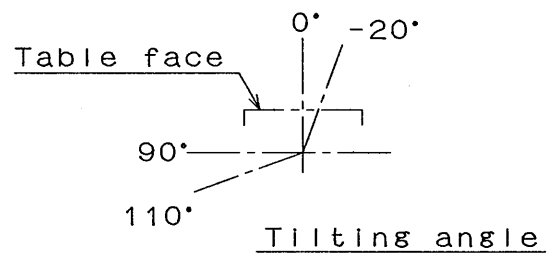
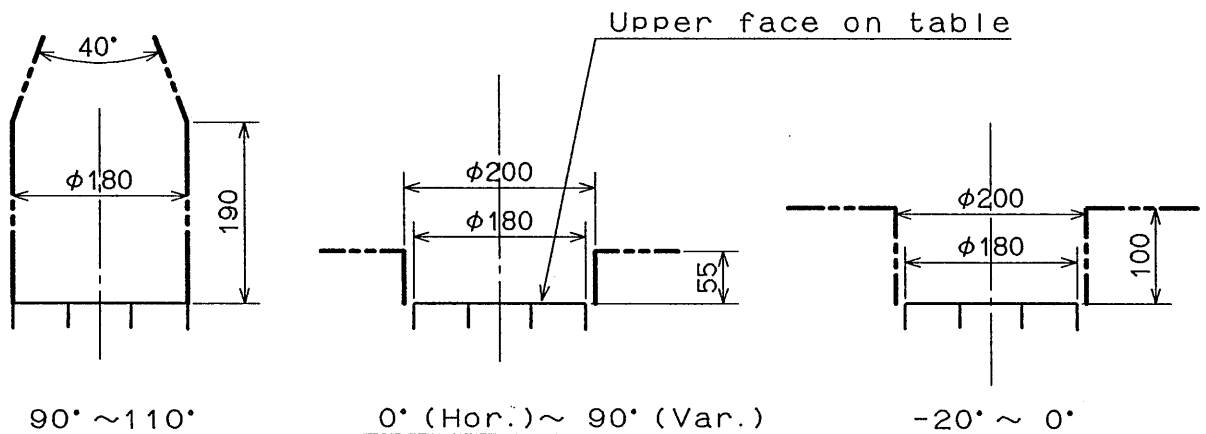
$$Z = 70 \cos \theta - 70$$



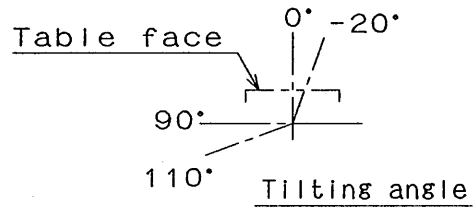
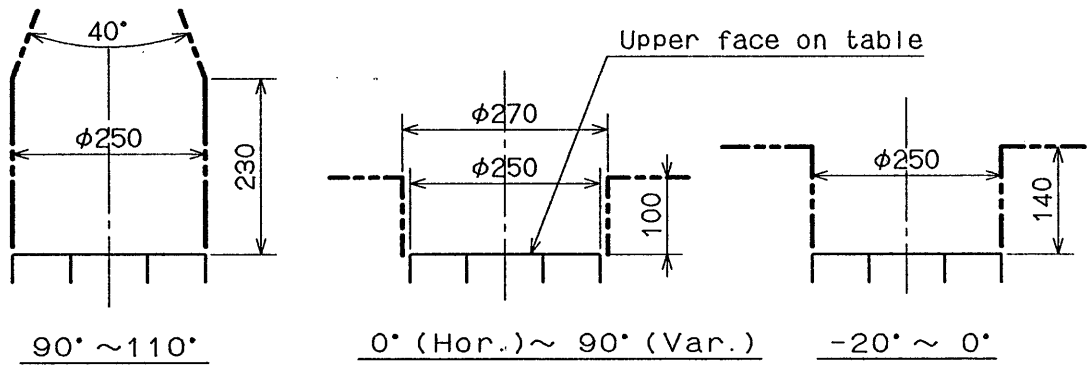
## 8-3 Work Interference area

Since the following shows the standard specifications, take care in the case of special specifications. The interference with the clamper is not considered.

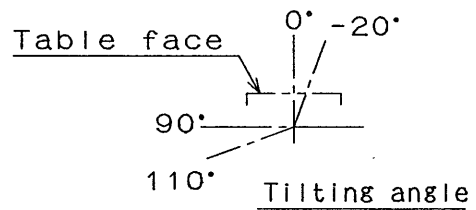
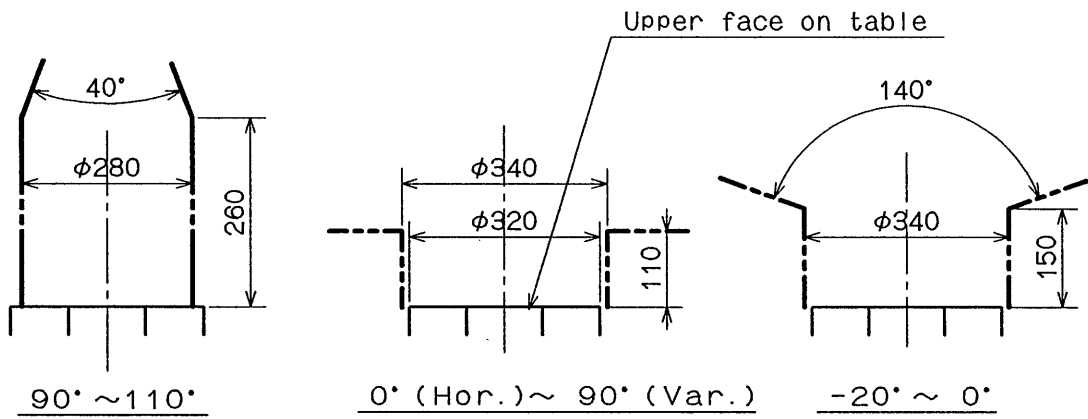
### 8-3-1 TTS180 · TTSM180



8-3-2 TTS250 · TTSM250



8-3-3 TTS320 · TTSM320









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