ACER

Turning Center

Model: JG100/150/200

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2010.10.20

PREFACE

Sincerely thank you for using CNC Lathe.

Please be completely note and understand about the installation of machine, all the structures and maintenance stated in the operating manual before using the machine.

Further, the proper program for processing by CNC Lathe is required. The proper arrangement for processing work piece in standardization should be considered completely before operating.

GENERAL SECURITY MEASURES

General security Measures

1. Please read completely the operating manual before running the machine, especially in the related security and maintenance. To operate the machine should accord with the manual after studying.

2. In addition to turn off the operation door and the protective cover, do not approach the U-turn part and movable part when it is running.

3. Forbidden to start the machine when the protective cover, mutual-lock device and other security devices are dismounted.

4. The work piece and machining tools should be fixed exactly; besides, the tools after being used should not be placed on the movable part.

5. For safety operation, please put on the special clothes (such as working clothes, shoes, hat, goggles).

6. To maintain the machine should be done by professionals listed in the operating manual.

Please follow out the security-measures indicated in the manual and the warning slogans pasted up, and do regard safety-operation as "user's duty" to perform. In case that neglecting any kind of warnings will bring damage to anyone as well as to break down the machines.

Please do not tear down and dirty this slogan.

WARNING

△Warning

1. For detailed restrictions concerning chuck function, please refer to Appendix "Description of Chuck Operation."

2. When operation spindle revolve, use max. Rpm allowed for spindle accompanied by low speed of max. Rpm allowed for chuck.

3. Make sure to fasten chuck body and chuck claws.

4. Oil cylinder thrust used for chuck Close/Open should be set under limit (See Description of Chuck Operation for reference.)

5. Working parts should be fastened on chuck. Pay particular attention to unbalanced revolve.

6. When using tail stock core spindle for bar support, pay attention to center hole, shape or center thrust. In supporting heavy-duty parts, any breakage in the center hole front end may result in the danger of flying part.

7. During spindle revolving, avoid activating Open/Close switch (Pad Switch) of chuck claw and tail stock core spindle.

8. For pressure setting of chuck oil cylinder, please refer to setting items specified in "Chuck Clamping Force." Centrifugal force generated by claw overhang under high speed rev. will cause sharp reduction of clamp force.

9. Do not remove or modify stroke switch, various interlock of safety guard device.

10. To avoid error movement caused by major noise interference generated by electric arc welding machine and hoister, additional lining should be connected from converter.

11. Cutting tool should be installed within length range. Interference will result from contacting of tool, safety cover and tail stock core spindle if tool exceeds specified length. Read carefully the Tool Manual and abide strictly by the restrictions.

12. Do not use your hand to grasp working parts.

13. Avoid clamping between processing object and core spindle when tail stock core spindle engages in back and forth movement.

14. All installation of electric device should be entrusted to the hands of a responsible person or safety agent. Close contact should be established between the responsible person and safety agent.

15. All parts used in electric machine should be replaced by those specified by the manufacturer. Under no condition shall overload fuse or bronze wire be allowed to use for the machine.

16. Use only those parts that are under quality guarantee.

17. To avoid any failure and error movement of the machine, be careful not to cause any short circuit in NC device, operation panel or high intensity electric board.

18. The accurate parameter specified in the Parameter List should be adopted for machine test run.

19. Operator shall not change or modify any parameter, size or default setting of electric devices. Please contact our service personnel whenever necessary.

20. Do not press keys randomly. In actual operation, press key with accurate movement.

21. When press "Ready" key on the operation panel, first confirm whether indicator is ON upon completion of Ready function.

22. Confirm that the F value of pressure gauge (hydraulic and air pressure) is correct.

23. When conduct initial run of the machine or when the machine is under Stop condition for long period of time (several days), please apply adequate lubricant on the moving surface of the machine.

24. After Power ON, the machine is ready for operation, use manual mode to reset Home.

25. It is necessary for the spindle and feed spindle to warm run before actual operation starts. First auto run the machine for 20~30 minutes with the max rev. or 1/3 of the feed speed. This warm run program contains lots of various functions. It is worthwhile to first try coordinating them (Refer to test run program.)

26. Make sure chuck pressure is strong enough to make claws execute correctly. Whenever chuck Open/Close in an abnormally slow speed, conform the chuck again. When incomplete clamping occurs, please pay special attention to the clamping position of the ring slot and the shape formed by clamping claws.

27. After tool installation, make sure first if there is any interference caused by tool and chuck. Check program with a low feed speed or use empty car function to test run the machine.

28. Abnormal heat may usually be caused by increased resistance from breakage of tool and drill which in turn result in accidental fire. Please prepare fire extinguisher next to the machine when oil cutting agent is being used.

29. Displacement of turret and work table may be caused by blackout or emergency stop of the machine. After power resume, please activate Offset function by using reference point reset function to restart the machine.

30. When conducting cleaning of the machine or other device, please full stop the machine.

31. When leaving the machine upon finishing daily job, first press Ready key on the panel, then press main power OFF of the intensity electric board. Finally, press cut of the power supple switch in the working site to end your work.

ATTENTION

Attention

1. Do not remove, smear or destroy posters that contain safety instructions. In case of any vagueness of the writing or missing of posters, don't hesitate to place order with us for new replacement.

2. Make sure the pressure hydraulic oil, lubricant and cutting oil have been adequately filled. In case of any insufficiency, refill in according with specified amount stated in Lubrication List.

3. For normal and safe operation after regular maintenance, please consult and maintain close cooperation with your maintenance technician.

4. It is important that you should record the contents and results of each maintenance and inspection for future reference.

CONTENTS

6 Operation

1. Brief outline

1-1 SPECIFICATION

	Model No. Specification Item	JG-100	JG-200
A-0	Processing capacity		
A-1	Max Turning diameter	400mm	670mm
A-2	Standard diameter	200mm	290mm
A-3	Max diameter	200mm	290mm
A-4	Max length	171mm	370mm
B-0	Stroke		
B-1	X-axis stroke	110mm	135mm
B-2	Z-axis stroke	200mm	610mm
C-0	Spindle		
C-1	Rpm of spindle	5000 rpm	3500 rpm
C-2	Variable speed	1	1
C-3	Spindle nose	140mm	A2-8
C-4	Spindle tapered bore	---	75mm 1/20 taper
C-5	Spindle bearing inside dia.	80mm	130mm
C-6	Spindle bore	53mm	86mm
D-0	Tool holder	43mm	52mm
D-1	Turret	8 STA. TURRET	10 STA. TURRET
D-2	Tool installed	8	10
D-3	Outside dia., edge knife handle	□ 20mm	□ 20mm
D-4	Boring tool dia.	φ25mm	φ40mm
E-0	Feed speed		
E-1	Rapid feed	X : 2000mm/min	X : 2000mm/min
		(Automatic)	(Automatic)
		X : 2000mm/min	X : 2400mm/min
		(Automatic)	(Automatic)

	Model No. Specification Item	JG-100	JG-200
E-2	Cutting feed speed	X：0.001-500mm/rev	X：0.001-1260mm/rev
		Z：0.001-500mm/rev	Z：0.001-1260mm/rev
F-0	Tailstock		
F-1	Strock of tailstock	130mm	435mm
F-2	Tailstock sleeve dia.	60mm	90mm
F-3	Taper of tailstock	MT. 3	MT. 5
F-4	Tailstock sleeve stroke	75mm	100mm
G-0	Motor		
G-1	Spindle motor	3.5kw / 5.5kw（β6）	7.5kw / 11kw（β12）
G-2	X，Z axis servo motor	X:1.2kw	X:1.8kw
		Z:1.2kw	Z:2.5kw
G-3	Lubricating oil motor	0.75kw	1.5kw
G-4	Cutting oil motor	0.25kw	0.37kw
H-0	Oil tank capacity		
H-1	Cutting oil	40L	40L
H-2	Motor oil tank	200L	200L
I-0	Machine		
I-1	Length	1700mm	1850mm
I-2	Floor space requirement	2280x1700mm	2370x1600mm
I-3	Weight	2500kgs	4300kgs

1-2 APPEARANCE AND DIMENSION

JG-100 modle

Water Tank

Turret

Tail

Chip Conveyor

Operating Box

Electric Box

Lubricator

Oil Pressure Gauge

Spindle Motor

JG-100 Model

1-4

1591.64

1503

1503

2140

1760

LAYOUT

Electric Box

1591.64

2140

Oil Tank

1503

1587.14

499.3

Operating Box

Chip Conveyor

1760

2338

911

888

2140

1755

Oil Pressure Gauge

Water Tank

Lubricator

Unit:mm

1-6
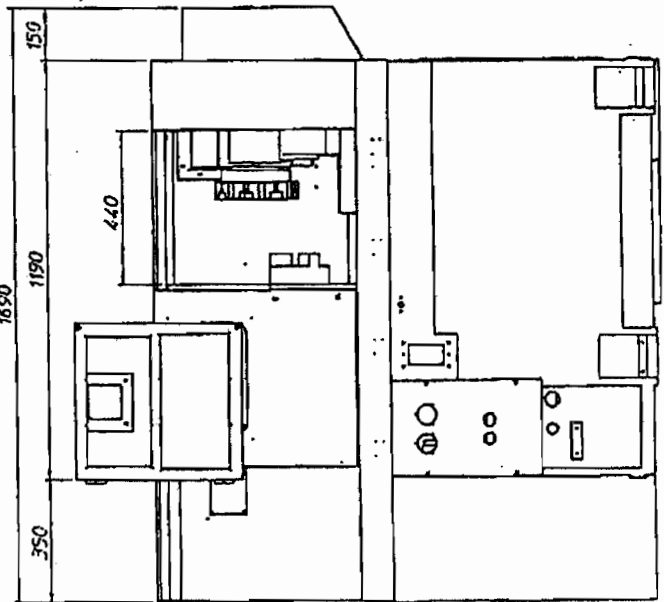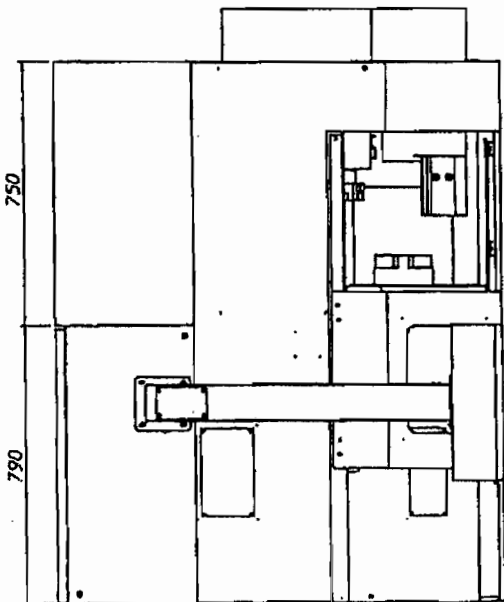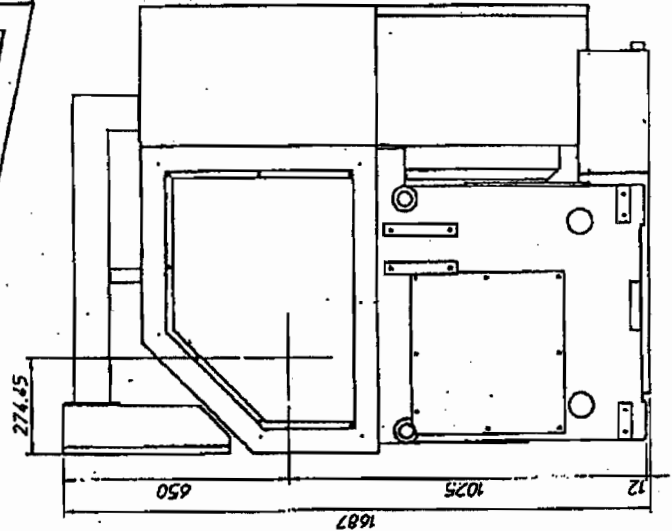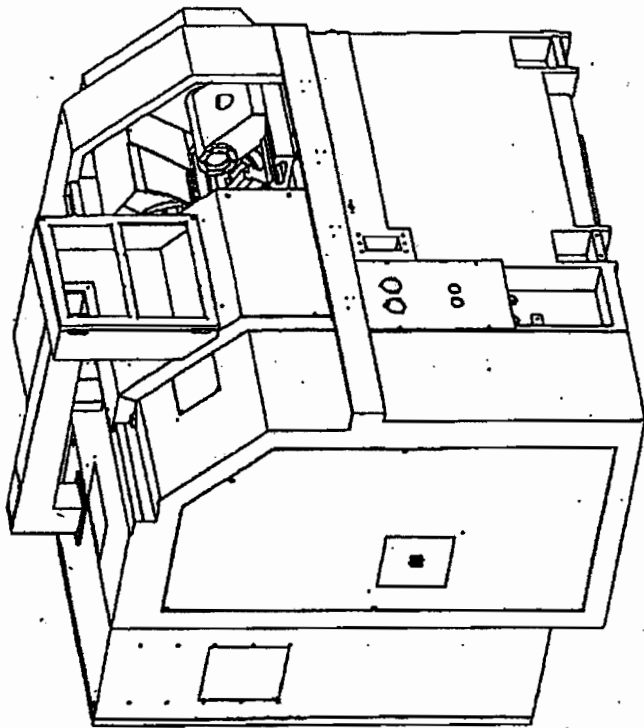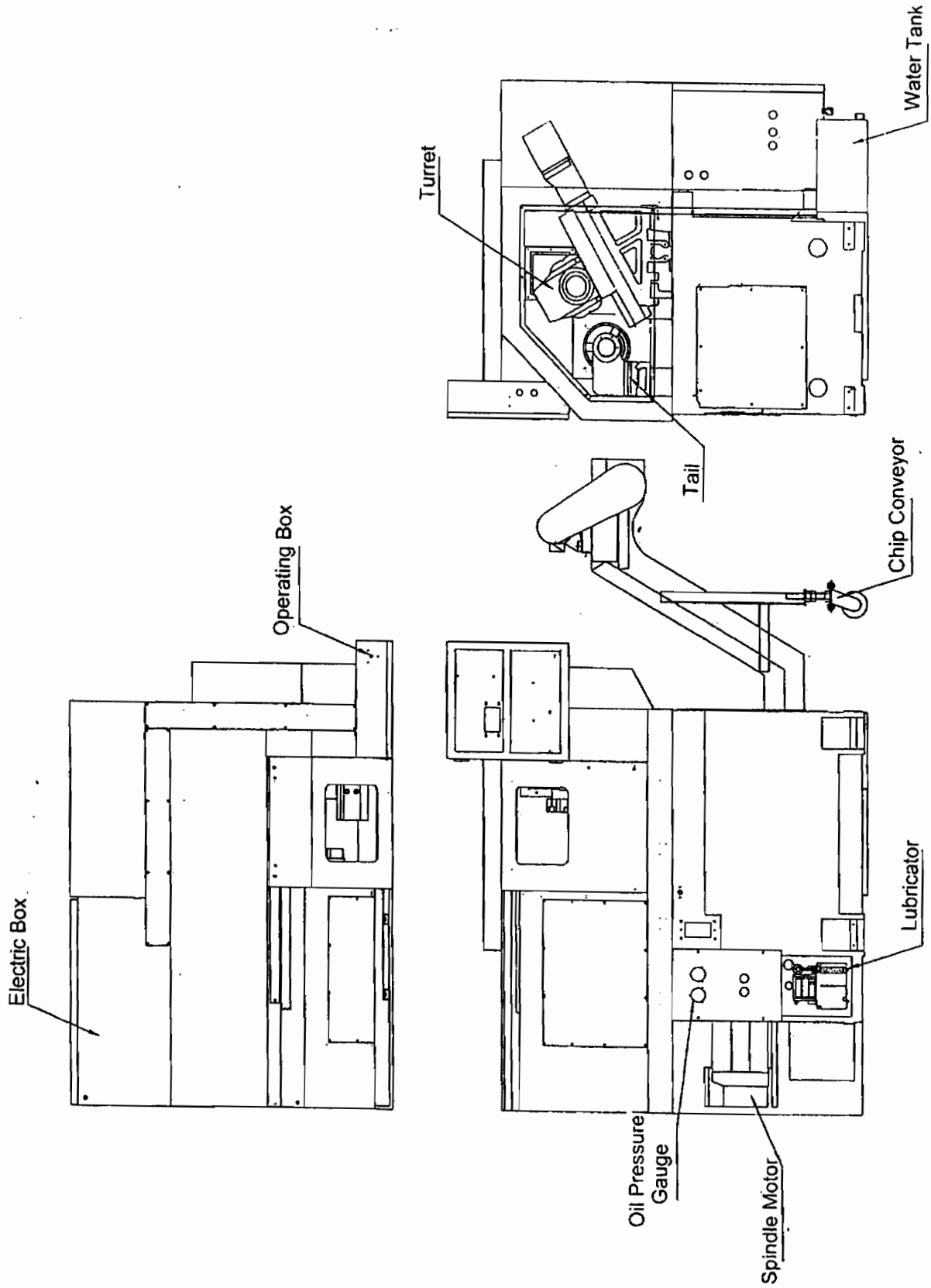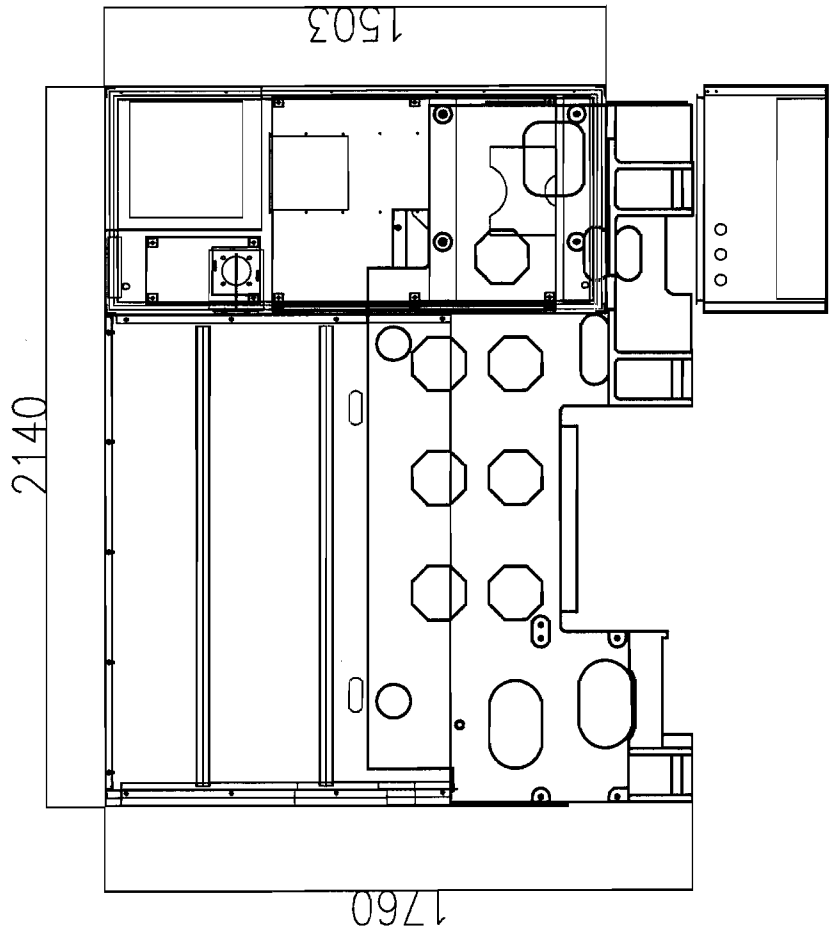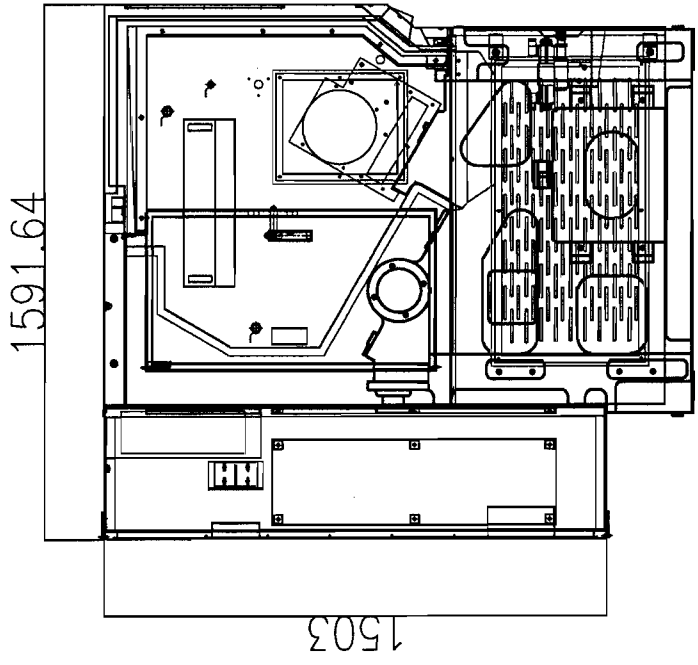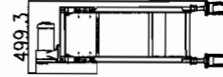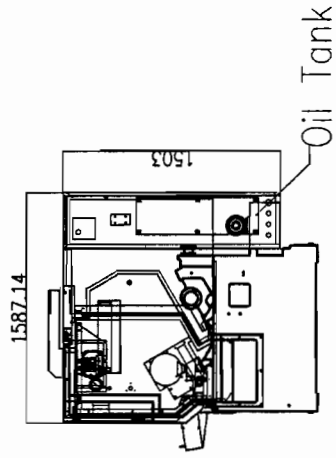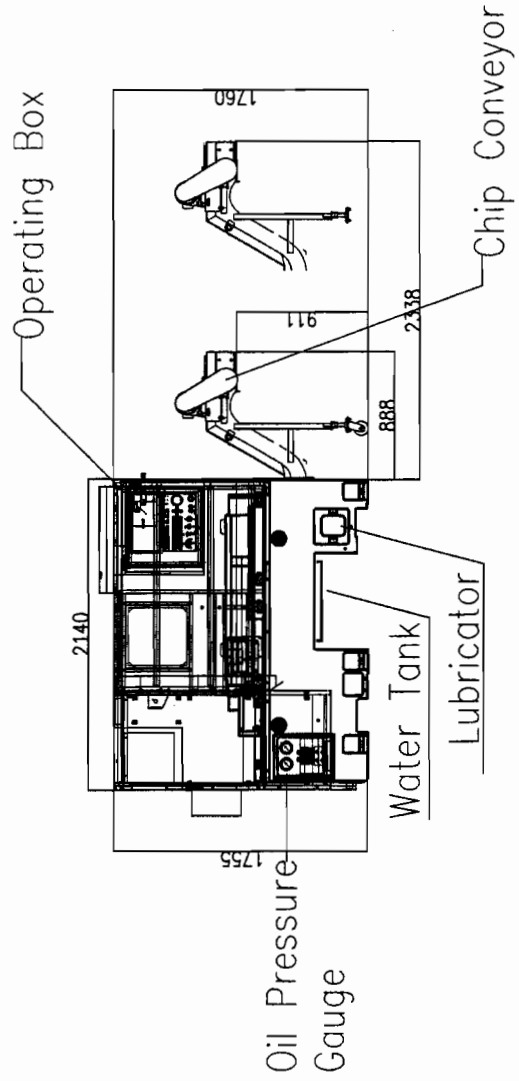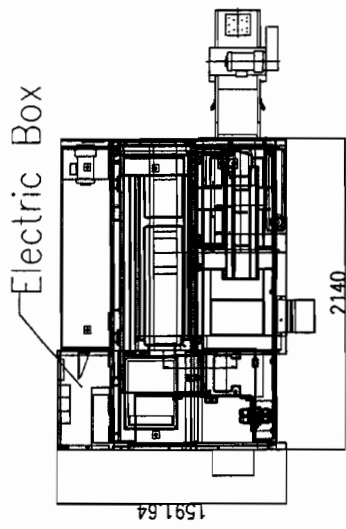
2. Installation

2-1 INSTALLATION

As for the installation of machine, it needs to be carefully to do the base in order to have the best exactness of machining.

An example of the base for installing machine as shown in the Fig. 2-1-1 on the next page. Just note that the machine shall be installed according to the processing method for normal base, because the different geology will have a considerable influence.

Generally, the plant's ground is made of concrete, a thickness of 300mm is quite enough to install.

The space for installation of machine should be based on the peripheral device in order that the operator might not touch the other machines or be disturbed by the wall, because it needs to take apart the cover for maintenance, open/close front door for operation, and move the water tank for taking out chips.

In addition, it's needed to clean the surrounding of the machine and also avoided placing the machine under the sunlight or closing to the heating source (heater).

Some parts of machine deformed will cause its exactness getting worse.

JG-100 MODEL

2-2

電源

300

200

405

1525

1070

50

100

300   580   1170   90

2140

1070

JG-200 MODEL

2-3
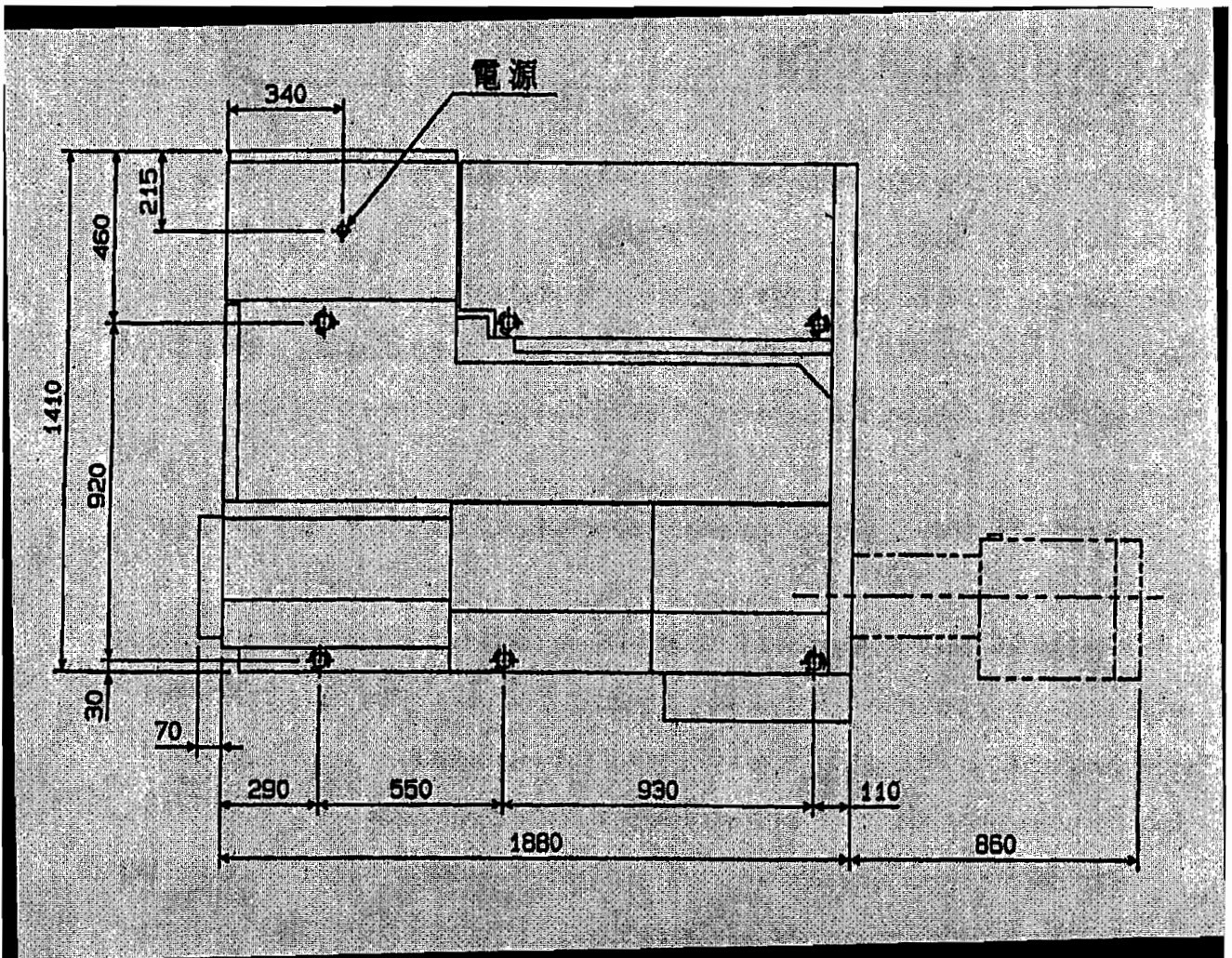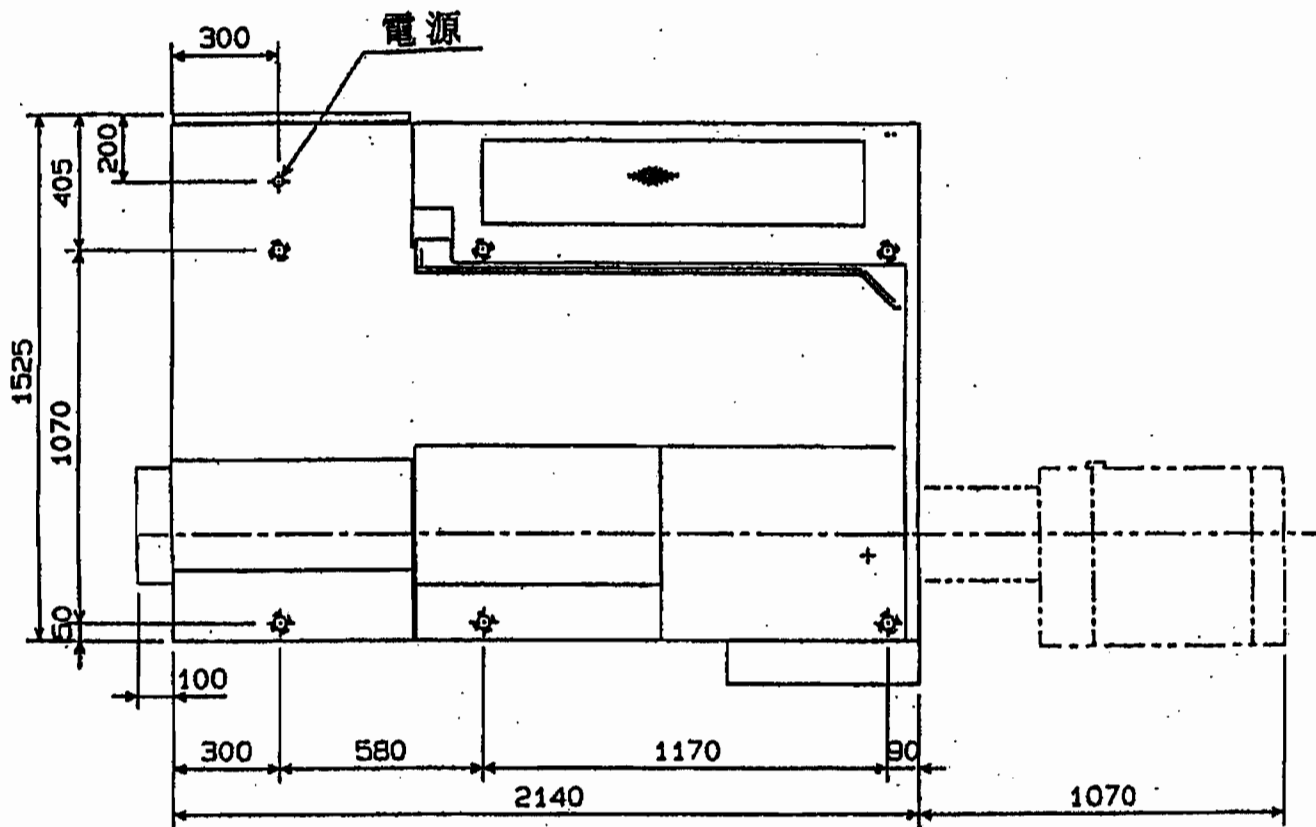
2-2 CRANING UP MACHINE

The company didn't provide the ring for hanging machine.

Please fix the machine with fork lift and put it down gently in order not to damage machine

2-3 POWER SUPPLY

For installation, please distribute cable line from your factory's power supply to the primary power supply of non-fuse breaker in the electric box of the machine.

As shown in the Fig. 2-1-1, have the cable insert into the upper of electric board, then make it connect with the non-fuse breaker after checking L1, L2, L3. Please use electric wire more than $14mm^2 (22mm^2)$ to distribute line.

Besides, it should be bigger than $14mm^2$ electric wire as the ground cable and fix it to the bolt of non-fuse breaker. List 2-3-1 is to show the capacitance of power supply needed for each spindle motor.

Capacitance of power supply
AC3φ
200, 220, 230, 380, 415, 400
460+- 10%   50/60Hz+-1Hz

Unit:KVA

FANUC		
	JG-100	JG200
Spindle motor model	β6 3.5KW / 5.5KW	β12 7.5KW / 11KW
Spindle motor and servo motor	12	16
CNC and Auxiliary device	3	3
Total capacitance	15	19

Capacitance of power supply

3. Lubrication

3-1 LUBRICATION

Before machine running, please follow the indication in Fig. 3-1 and List 3-1-1 to check the lubrication conditions in every part of the machine. From now on, it should be regularly to inspect, lubricate and replace oil according to the list arranged for lubrication.

The following is to indicate the lubrication conditions in every part.

1. Lubrication of spindle

   Generally it is not necessary to replace and supple the lubricant to the bearing of spindle because it uses the grease. Please contact our technician if the grease should be replaced due to special reason.

2. Bearing unit of Ball Screw

   X-axis and Z-axis ball screw bearing unit are enforced on lubricating.

3. Lubrication of X-axis, Z-axis, each sliding surface and the inside turret.

   All of the machine, saddle, surface of slide guide, X-axis, Z-axis ball screws and the inside turret should be lubricated with the lubricating pump at the front leg of machine.

   Please check regularly the oil level of the lubricating pump for supplying.

4. Gear Box

   The gear box is lubricated with oil bath.

   Please check, re-supply, replace according to the lubrication schedule.
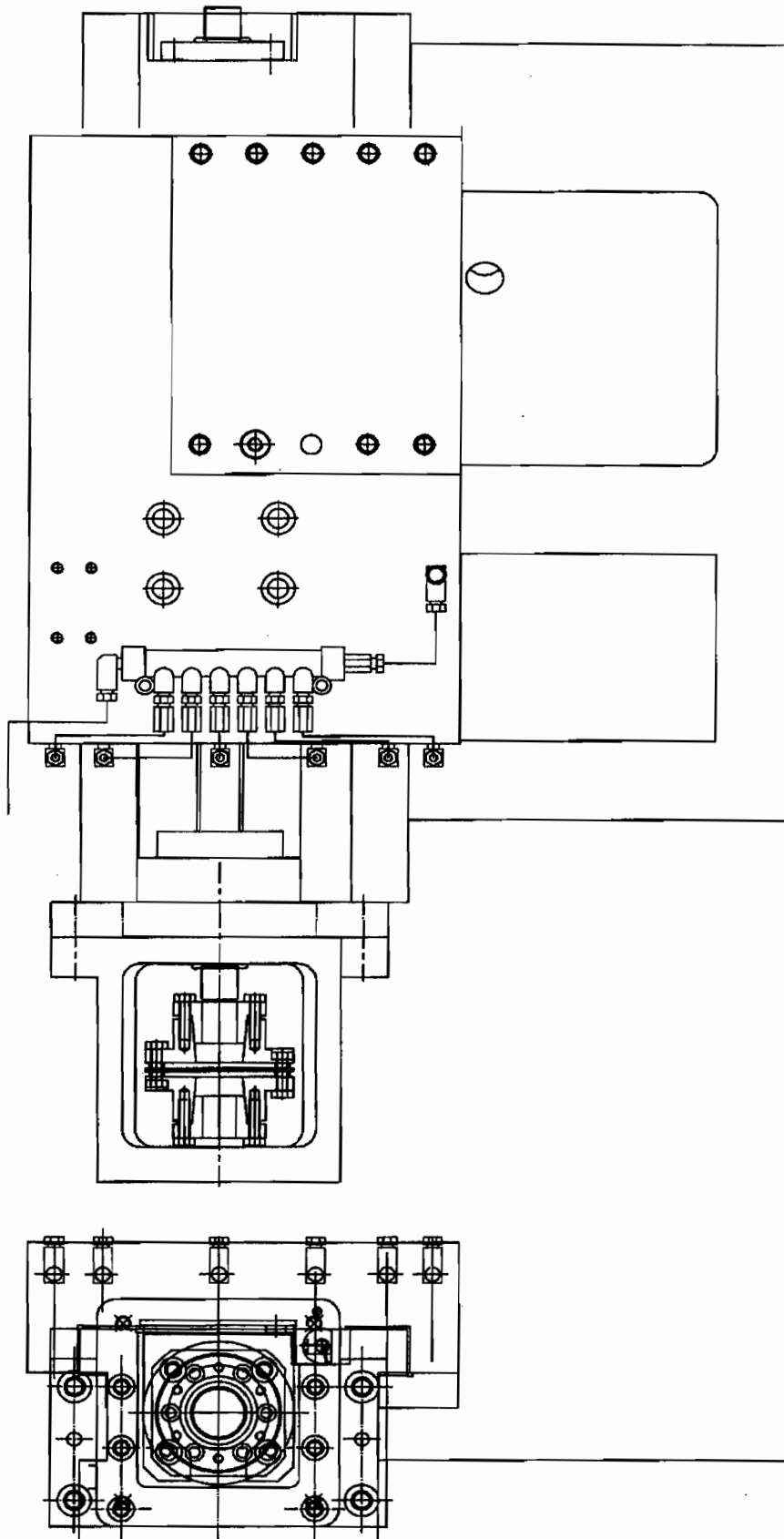
JG-100 OIL HOLE
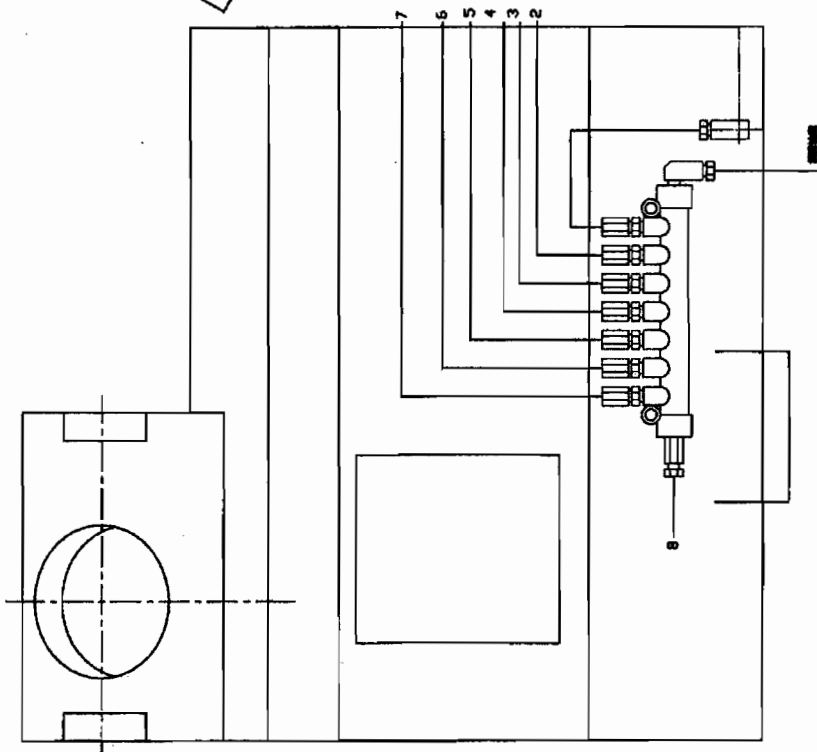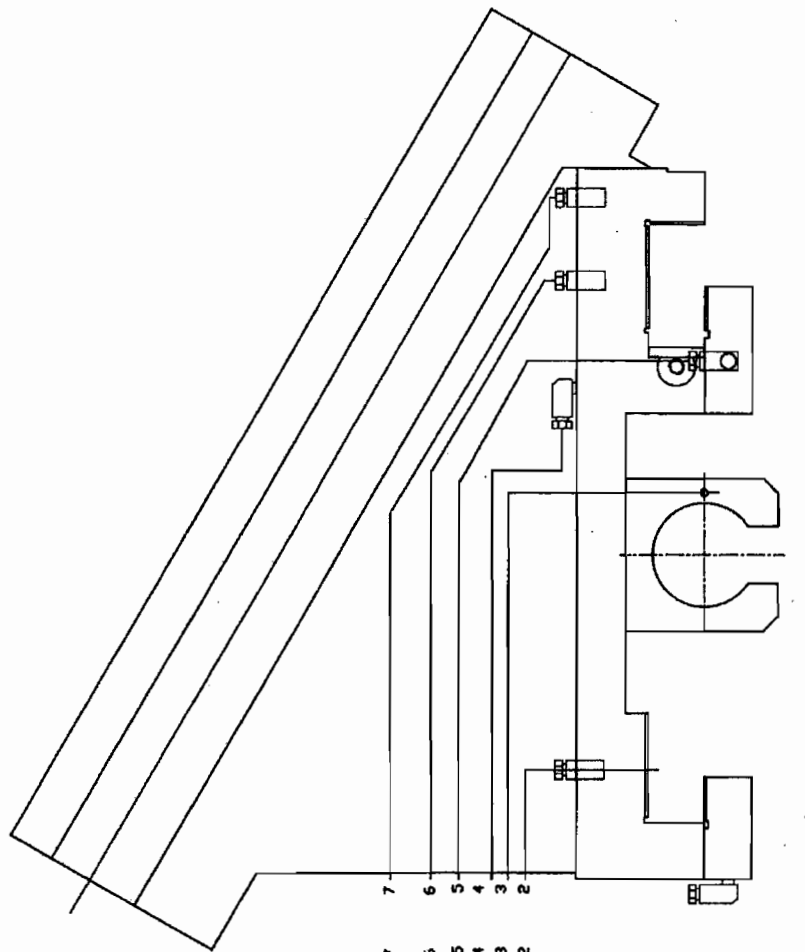
JG-100 OIL HOLE

JG-200 OIL HOLE

3-4
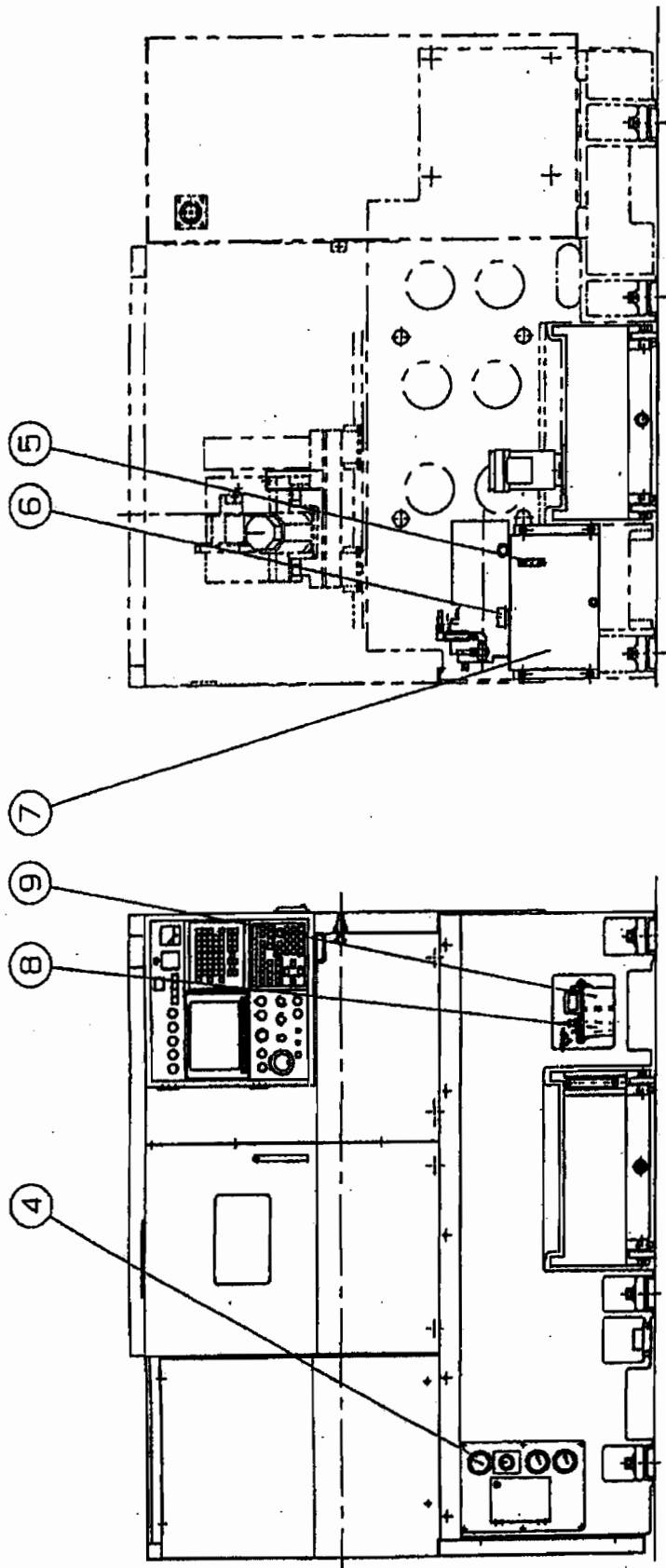
Mark / Name of comapny	FC10	G68	HL32
Mobil oil	Mobil Velocity oil No. 6	Mobil Velocity oil No. 2	Mobil DTE oil Light
Shell oil	Shell Terrus oil C10	Shell Tonna oil T68	Tercsso 32
Esso Standard oil	Sppinesso 10	Fedis K68	Shell Terrus oil C32
Mitsubishi oil	Diamond Lube R010	Diamond Slideway 68	Diamond Lube R032
Nippon oil	Spinox S10	Uniway 68	FBK oil R32
Kyodo oil	Kyosski MS oil 10	Kyoscki Slidus 68	Kyoscki RIX Turbinc 32
Idcmitsu oil	Dephny Mcchanic oil 10	Daphny Multiway 68C	Daphny Hydraulic Fluid 32
Showa oil	Showa J-H32	Showa A-R68	Showa J-R32
China Petroleum Corp.	Spindle Oil R12	Slideway Oil 68	R32 Circulation Oil 32AW Mineral Oil

Note: Please use the above-suggested oil or same grade oil.   List 3-4 Oil List

Avoid making use of the bad lubricant or bad quality grease.

4. Structure of every part and Maintenance

4-1 SPINDLE

4-1-1 Structure and maintenance of spindle
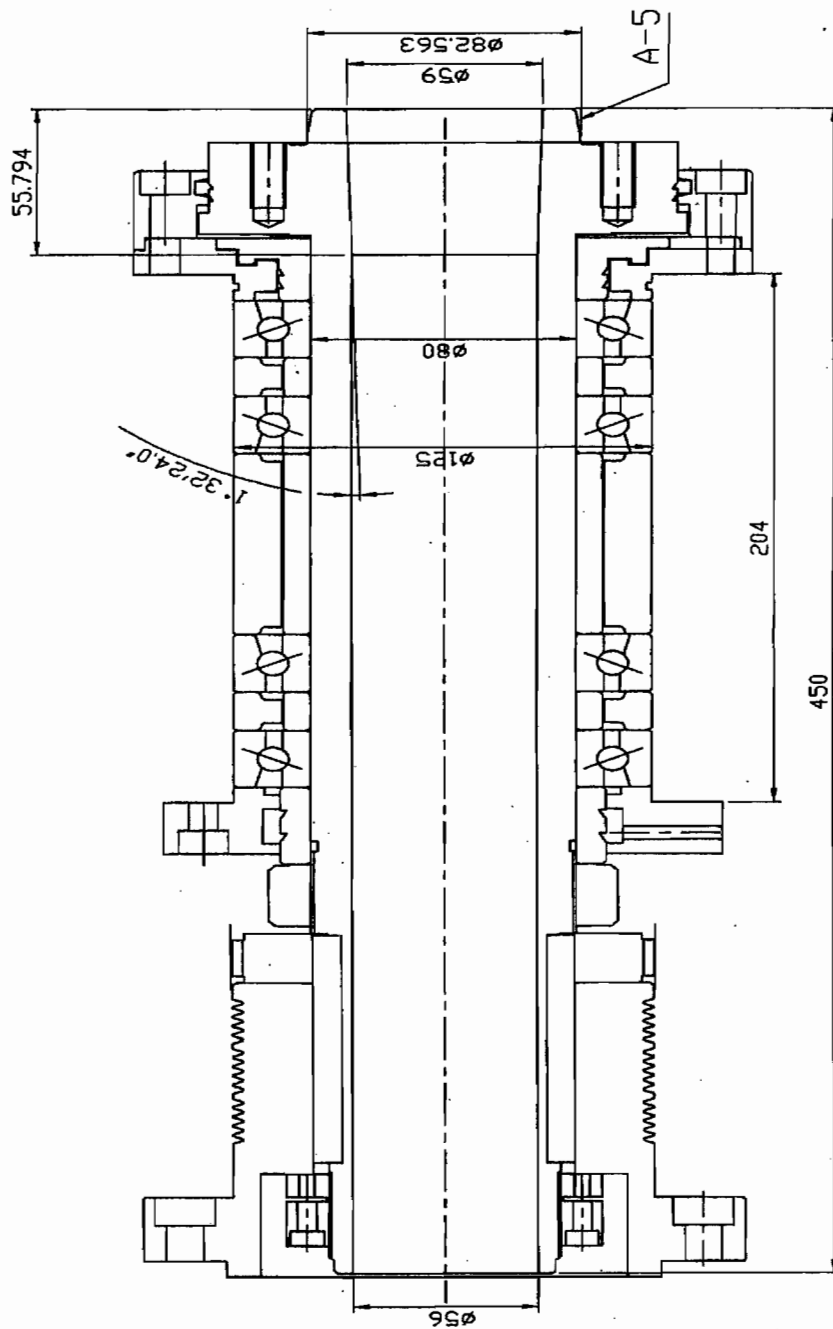
JG-100 size of spindle
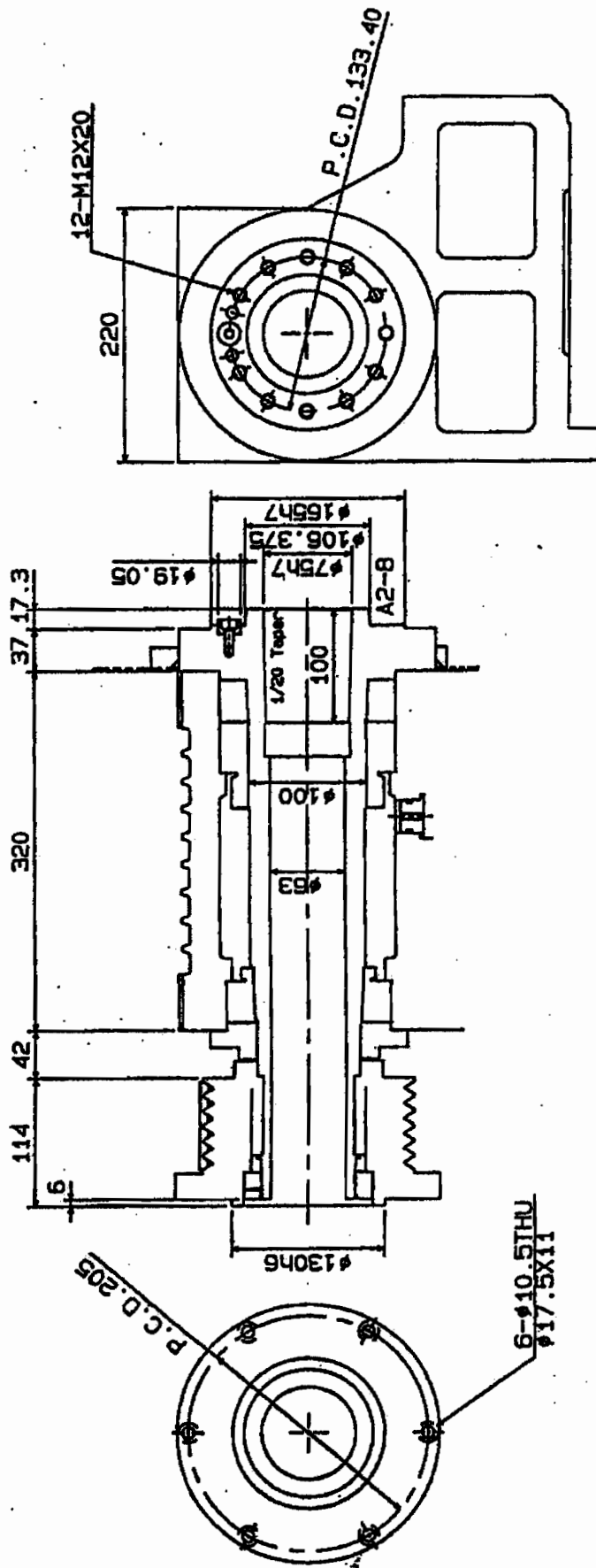
JG-200 size of spindle

4-2
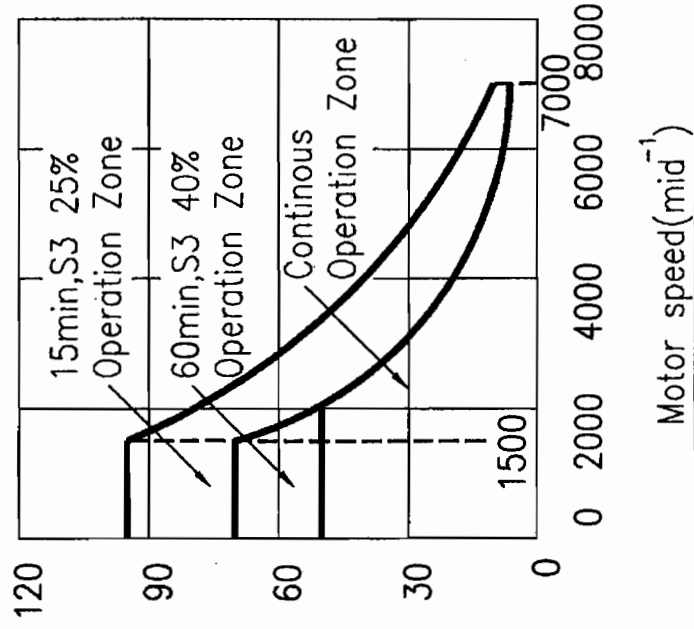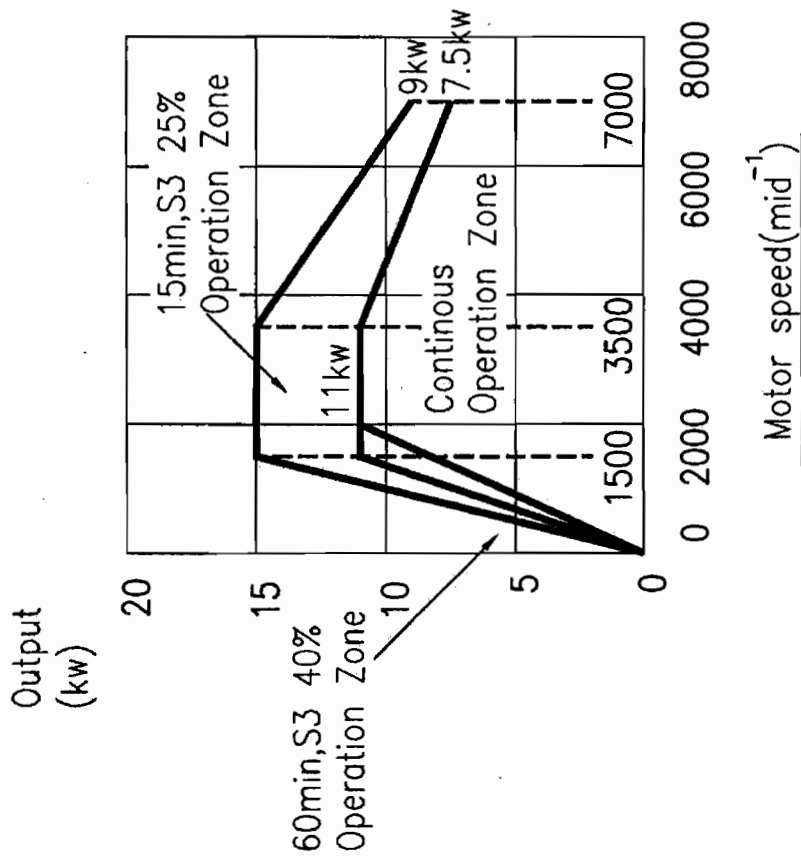
JG-200 RPM of spindle / Thrust curve

4-4

4-1-3 Central spindle regulation

4-1-3 Central spindle regulation

The workpiece becomes as a taper after its outer diameter being cut, or the central height of surface is raised when cutting, please parallel the spindle according to the following items. (Refer to the Fig. 4-1-3).

1. Install the test rod in the spindle, place the dial gauge on the turret, read the deviating value of needle after the saddle having been moved toward the X-axis.
2. If the deviating value of needle is higher, loosen the screws fixed on the spindle, check the indicator and adjust the bolt to parallel the spindle.
3. Tighten the bolt of spindle after regulated, then move the saddle again and read the deviating value of needle.

JG-100 Central spindle regulation

Test Bar

Headstock mounting bolts

Adjusting bolts
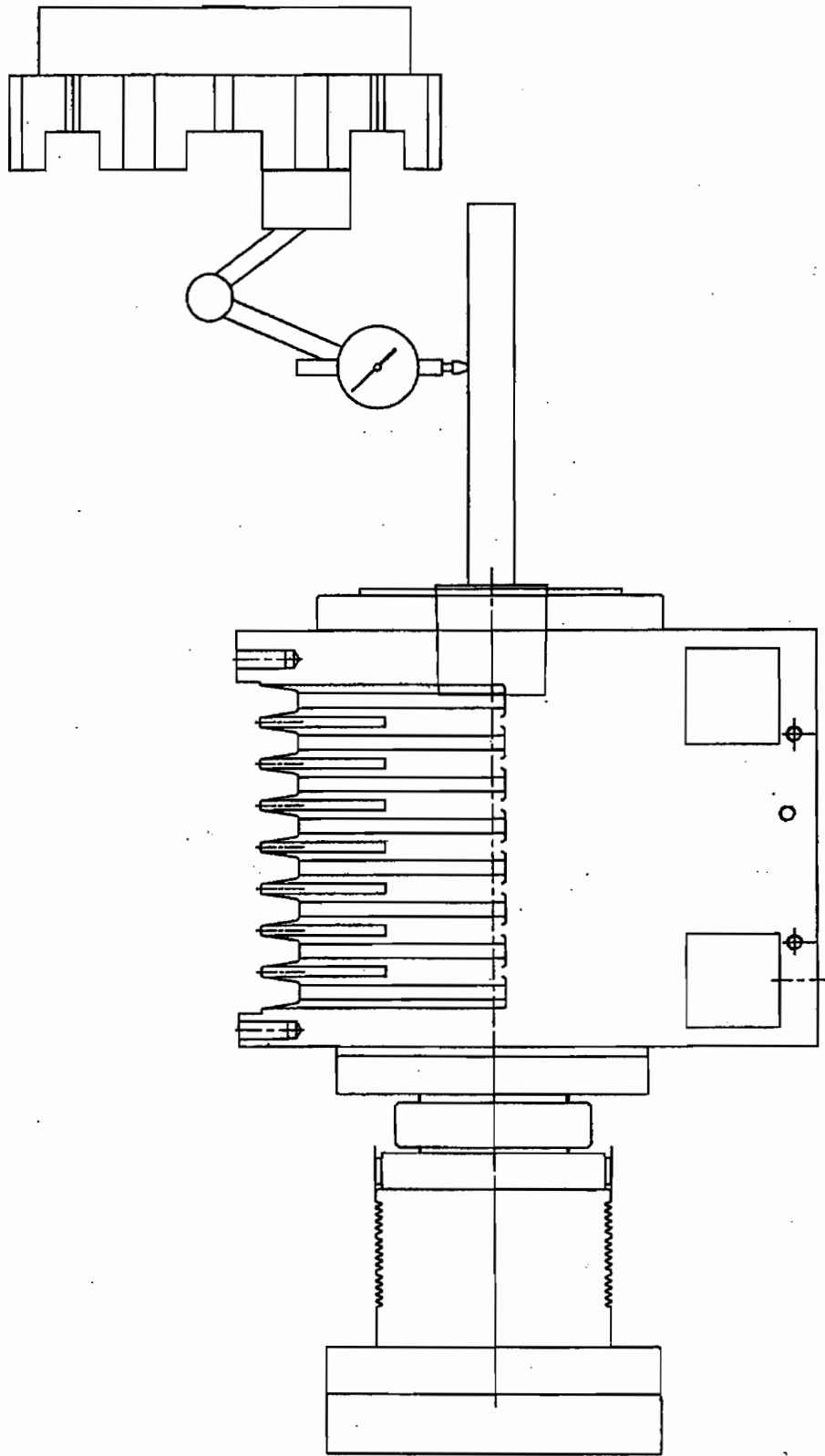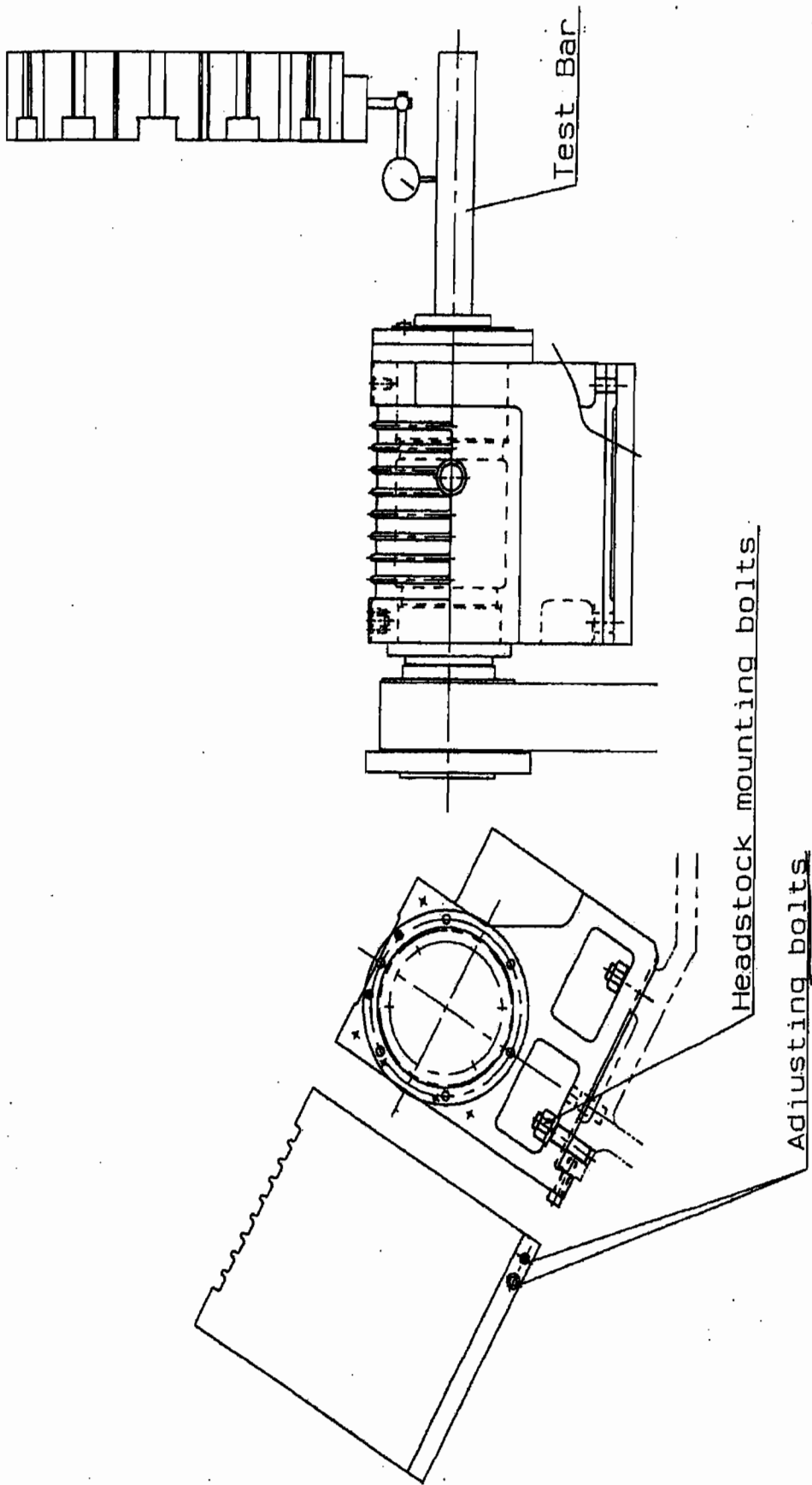
JG-200 Central spindle regulation

4-7

4-1-4 Confirmation of turret and central height of spindle

After the center of the spindle being set, the center of turret and the central height of spindle should be adjusted according to the following items. (Refer to the Fig. 4-1-4)

1. Take apart the test rod, install the dial gauge on the spindle.
2. Install the round tool holder on the turret.
3. Move the turret toward the X-axis, overlap the round tool holder with the center of spindle.
4. Turn the spindle a round, and get the value of B.C points.
5. According to the item 4-1-3 to move in parallel the spindle for adjusting the value of B.C about +0.02~+0.04.
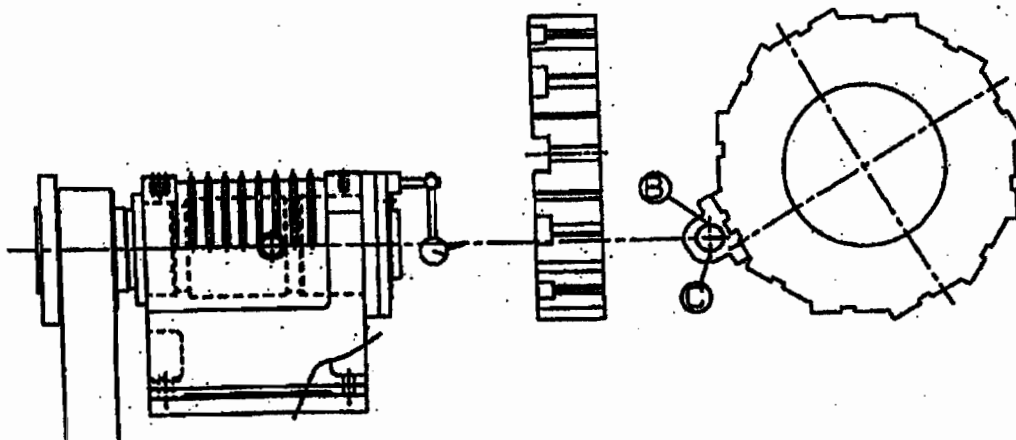
Confirmation of turret and central height of spindle

4-1-5 ADJUSTMENT OF BELT

L(mm)
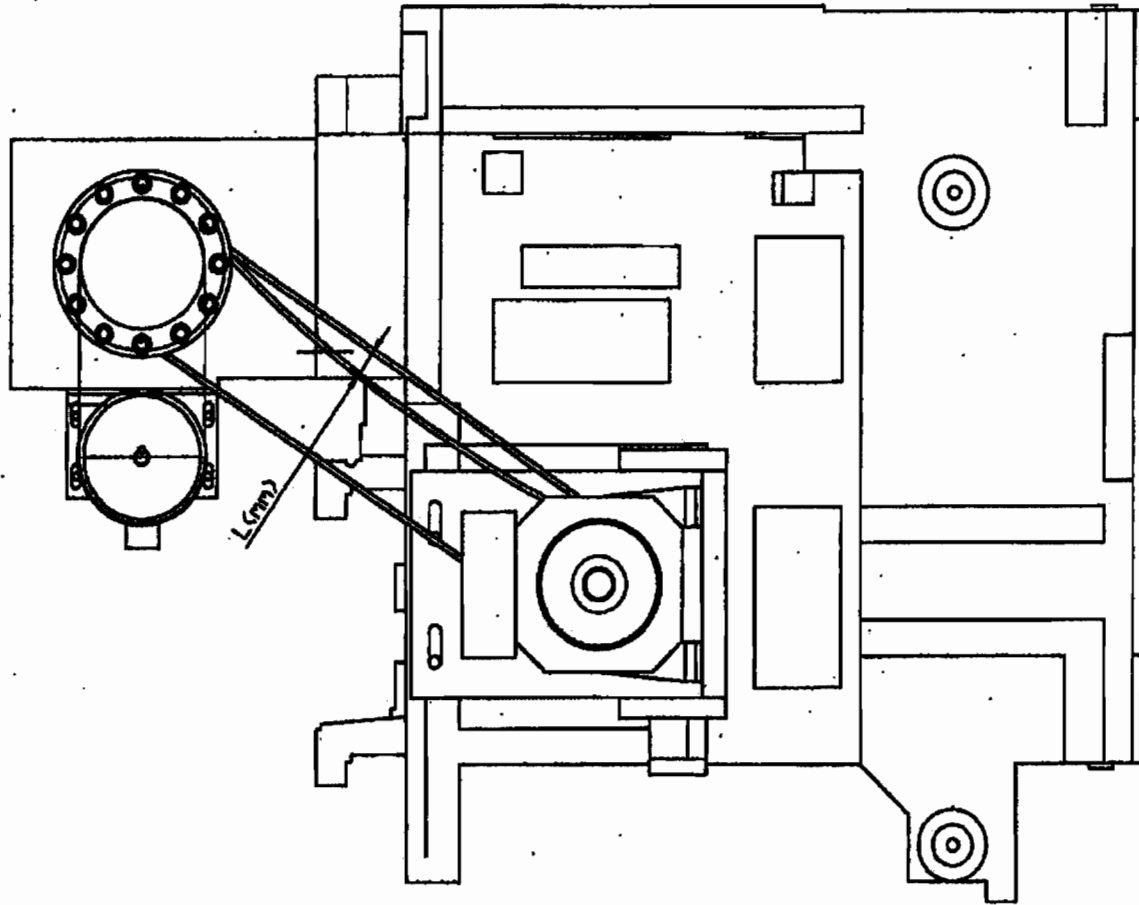
JG-100 Adjustment of belt
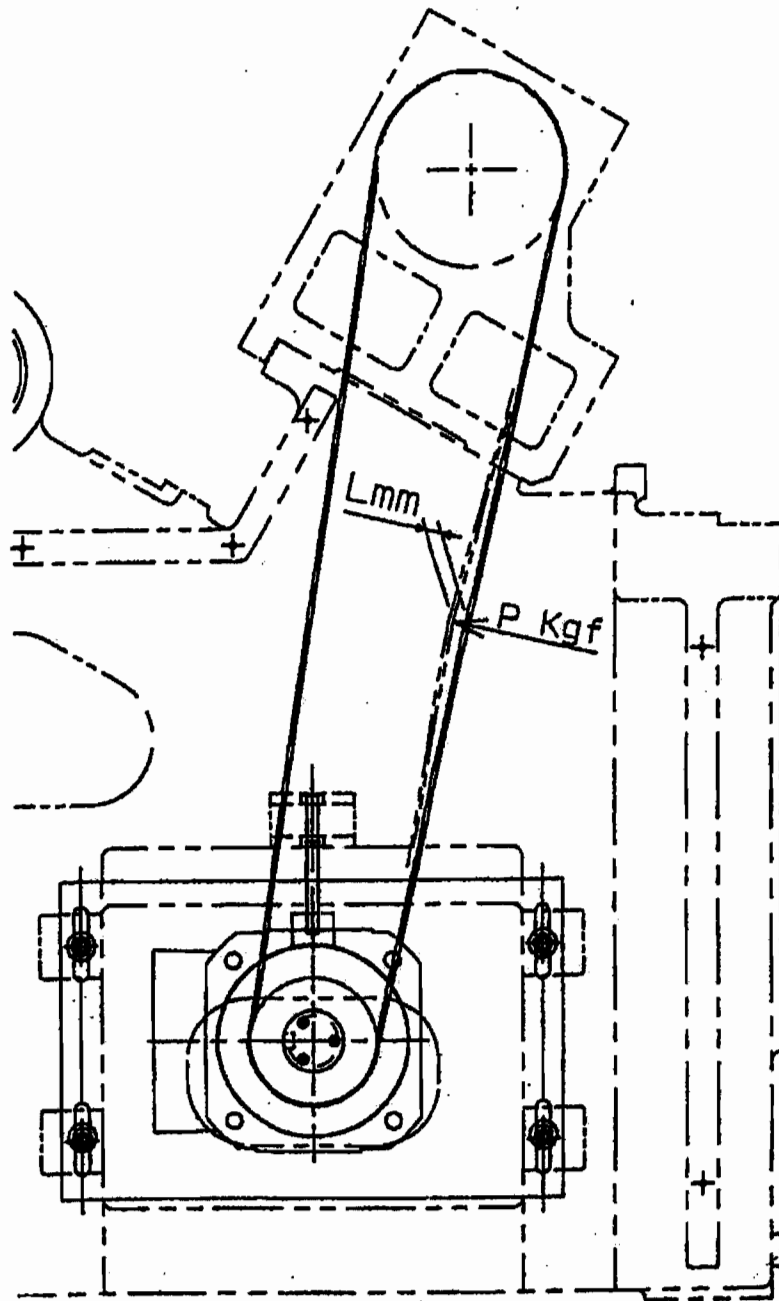
JG-200 Adjustment of belt

4-2 Tailstock

4-2-1 Structure and size of tailstock shaft

Fig. 4-2-1 : Structure and size of tailstock shaft

When taking apart the tailstock shaft, showed as Fig. 4-2-1, just to knock on slightly the attached bars through the rear of the shaft.

At the moment, please note that the taper should not be covered with dust.

Please clean the taper hole with shredded gauze before putting in the shaft.
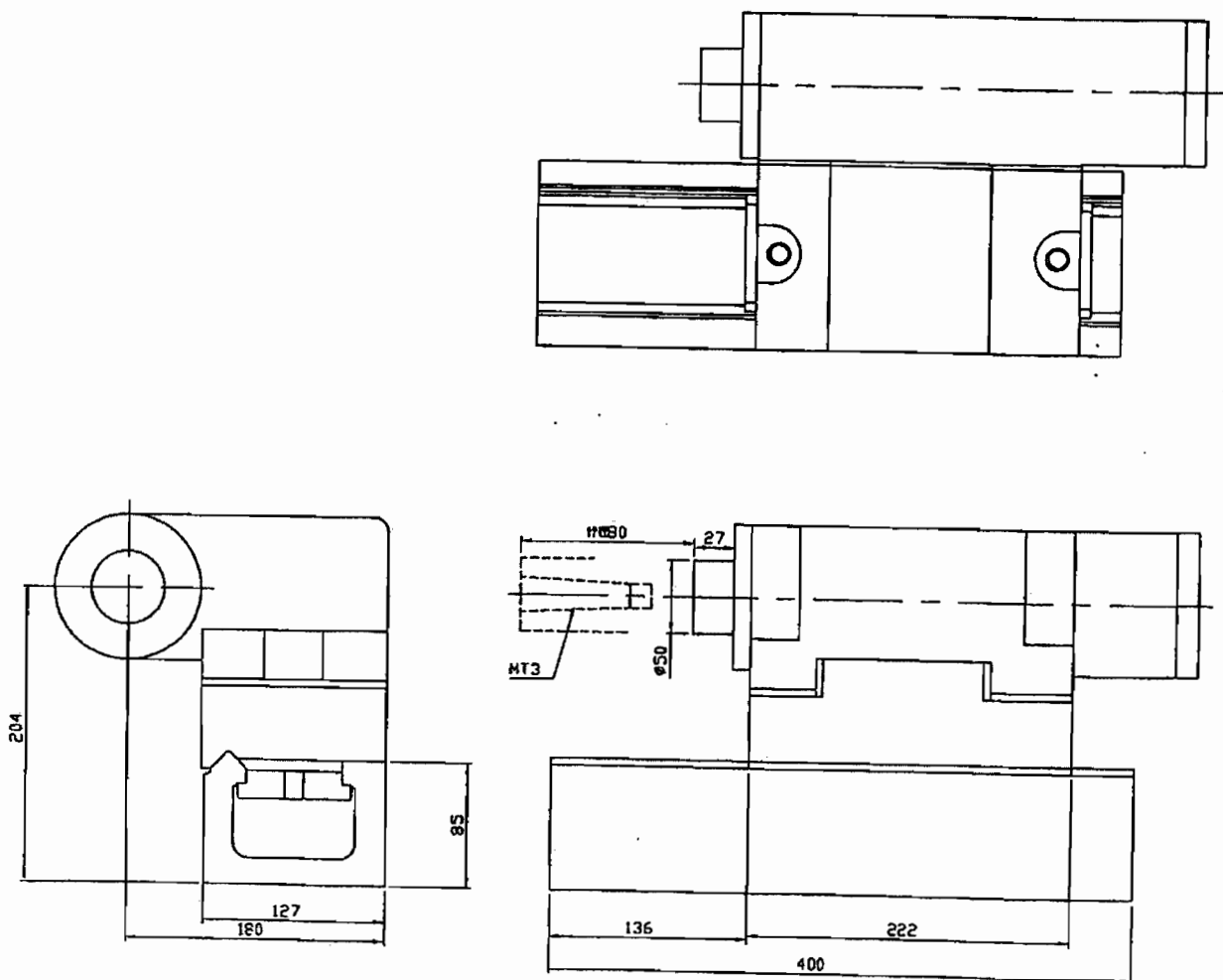
JG-100 structure and size of tailstock shaft
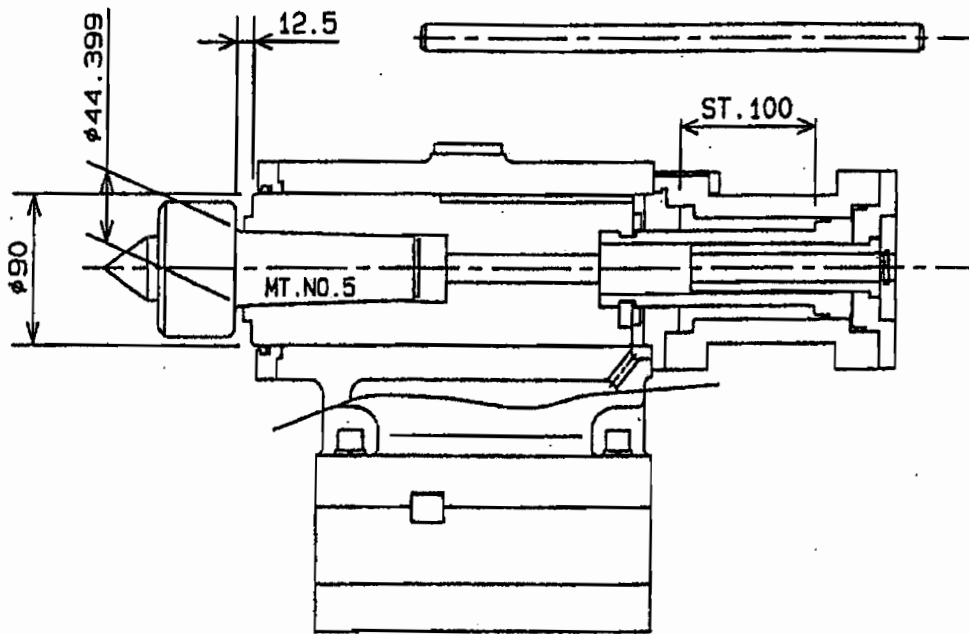
JG-200 structure and size of tailstock shaft

4-2 Tailstock

4-2-2 Thrust of shaft of tailstock

Fig. 4-2-2: Relationship between hydraulic pressure and shaft thrust (excluding the lost thrust caused by tube distribution and friction of oil ring.)
Note: When shaft goes forward, the side of hydraulic cylinder covers an area of $26.7cm^2$.
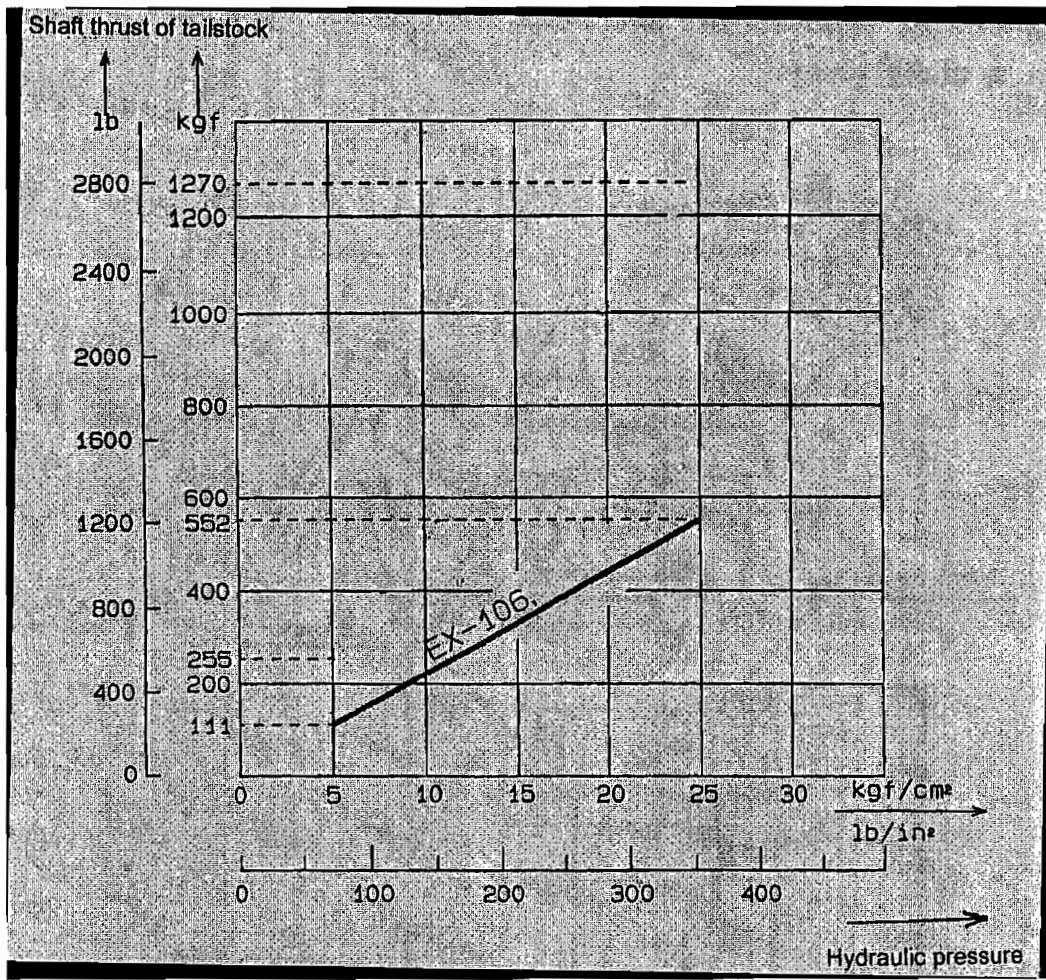
JG-100/200 Thrust of shaft of tailstock

4-2 Tailstock

4-2-3 Regulation of center of tailstock

If the workpiece becomes a taper when it was processed with the shaft thrust of tailstock, please parallel the shaft of tailstock according to the following items.

1. Use the test rod to show two centers, after installing the dial gauge on the turret, move the turret toward the Z-axis, and read the deviating value of needle.

2. After loosening the fixed screws and bolts, adjust the level direction with the adjusting bolts at the both sides.

3. Tighten the fixed screws and bolts, then check again the deviating value of needle of dial gauge.

Tightening screw

Fixed screw
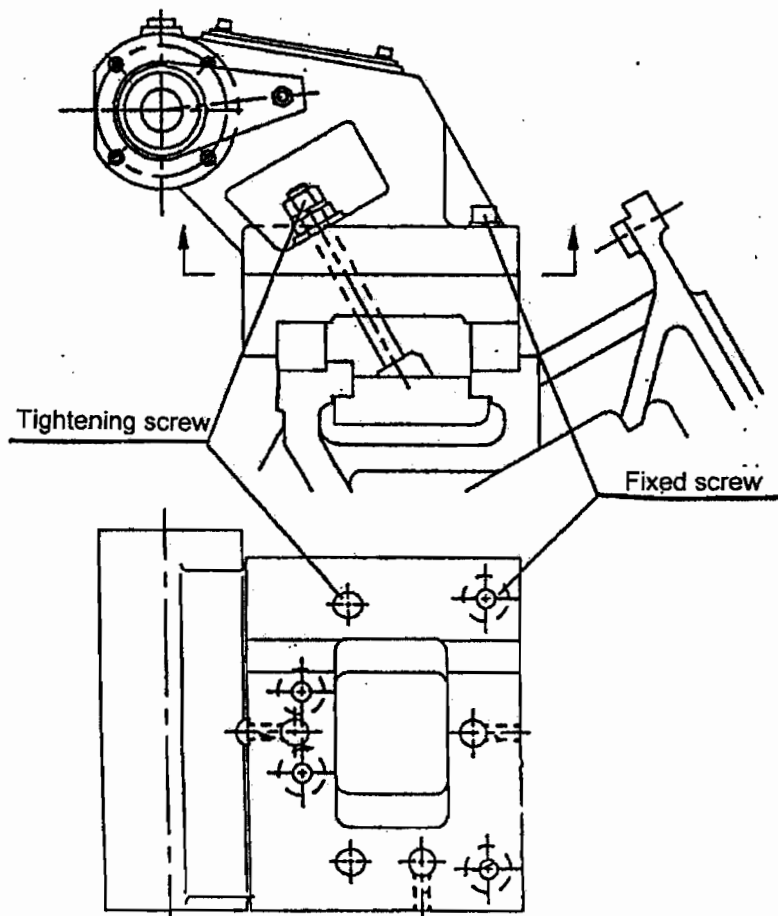
JG-100 Regulation of center of tailstock

JG-100 Regulation of center of tailstock

調整螺絲

鎖緊螺絲

固定螺絲

調整螺絲
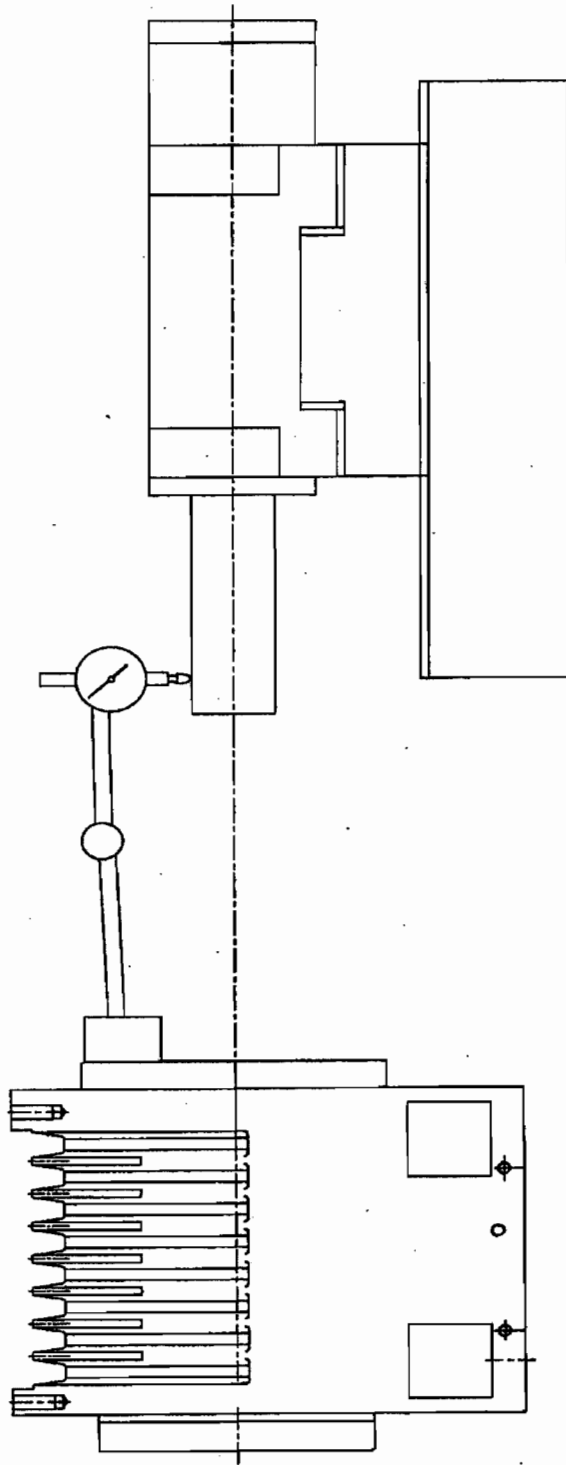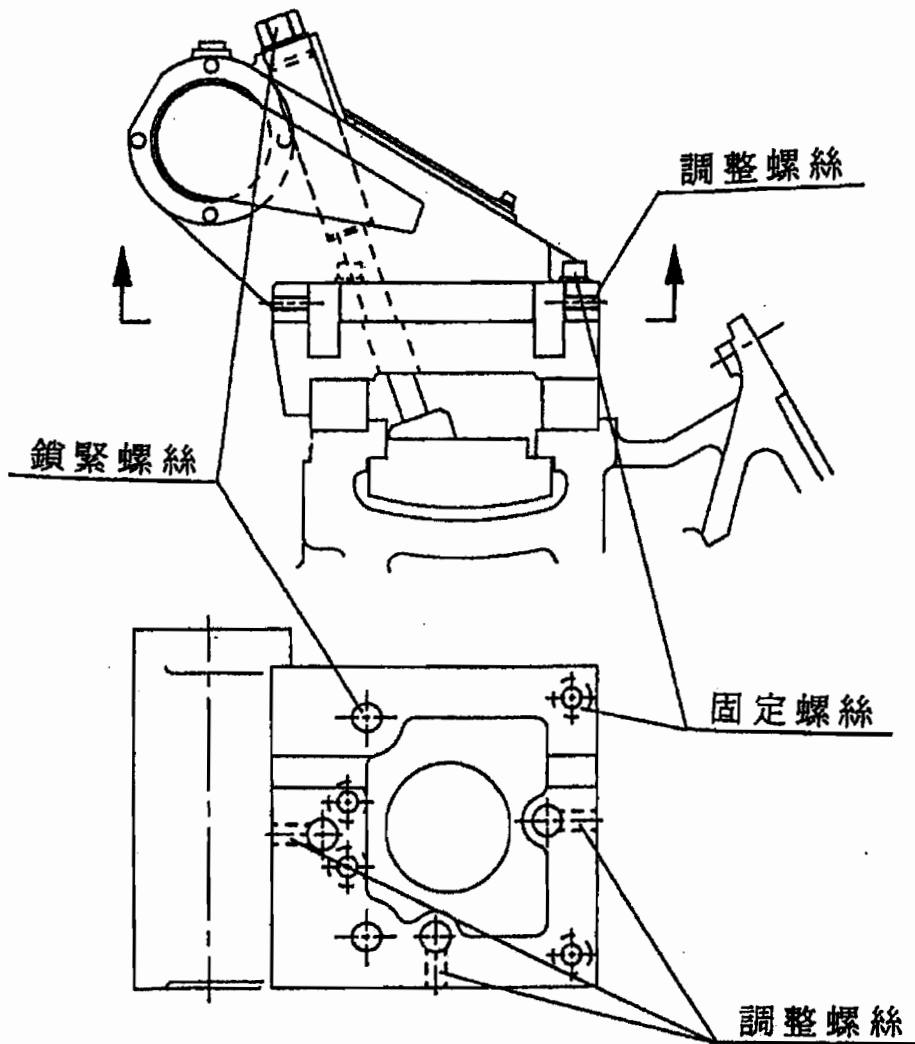
JG-200 Regulation of center of tailstock

4-3 TURRET

4-3-1 Size of turret

Size of turret. As to the tool holder, please refer to the cutting tools list.
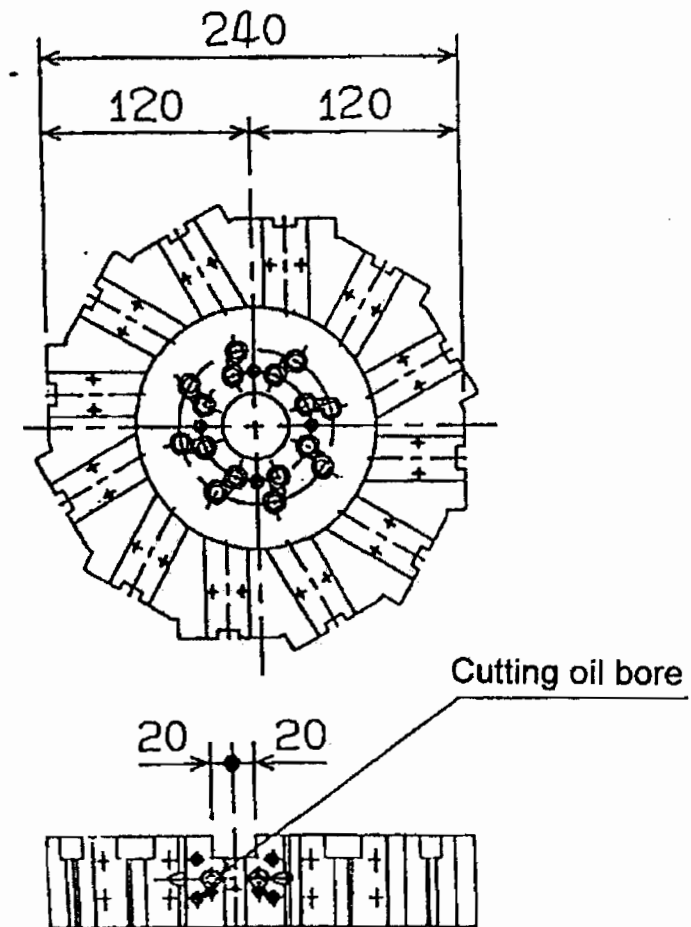
JG-100 Size of turret

440

220 220

25 25

切削油口
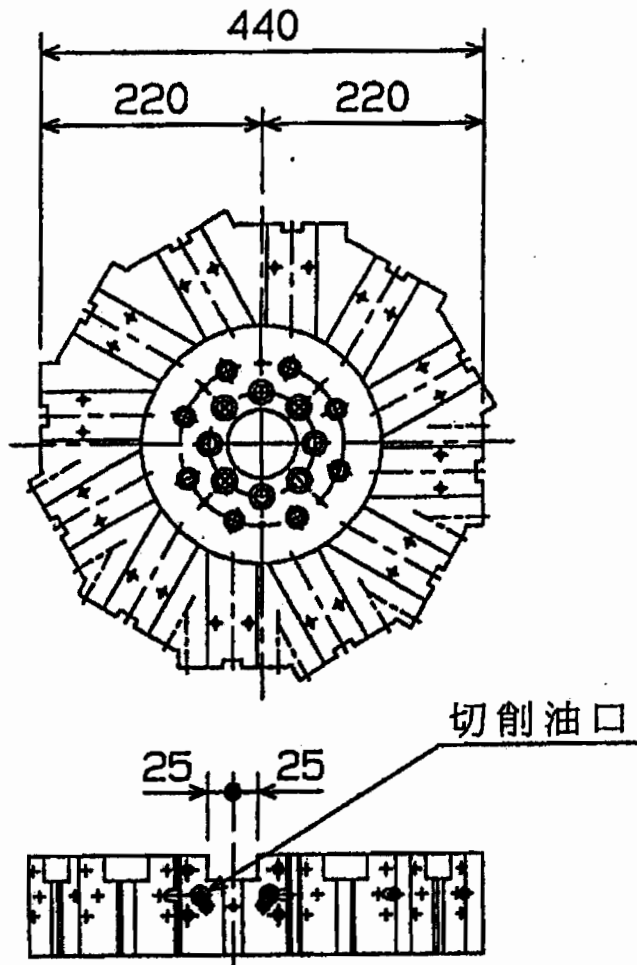
JG-200 Size of turret

4-3 TURRET

4-3-2 Inner structure of turret

Inner structure of turret

Servo motor

Clockwise belt

Proximity switch
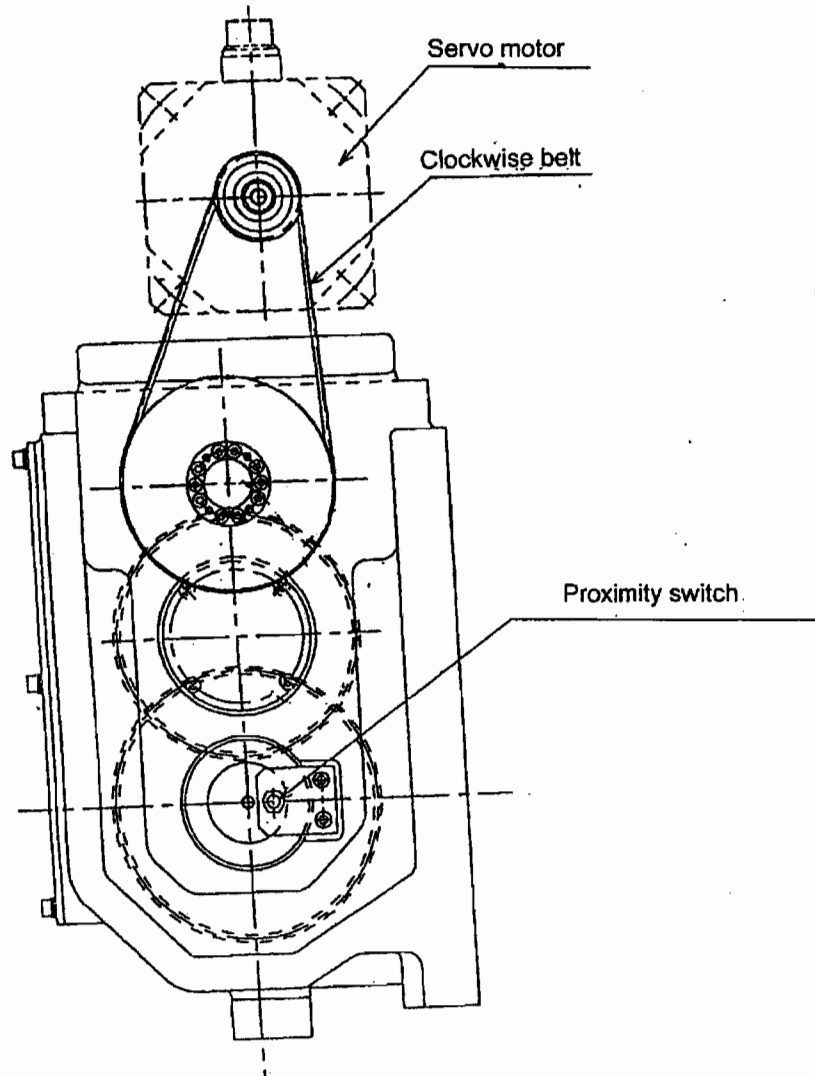
JG-100 Inner structure of turret

伺服馬達

正時皮帶

鎖固檢出近接開關
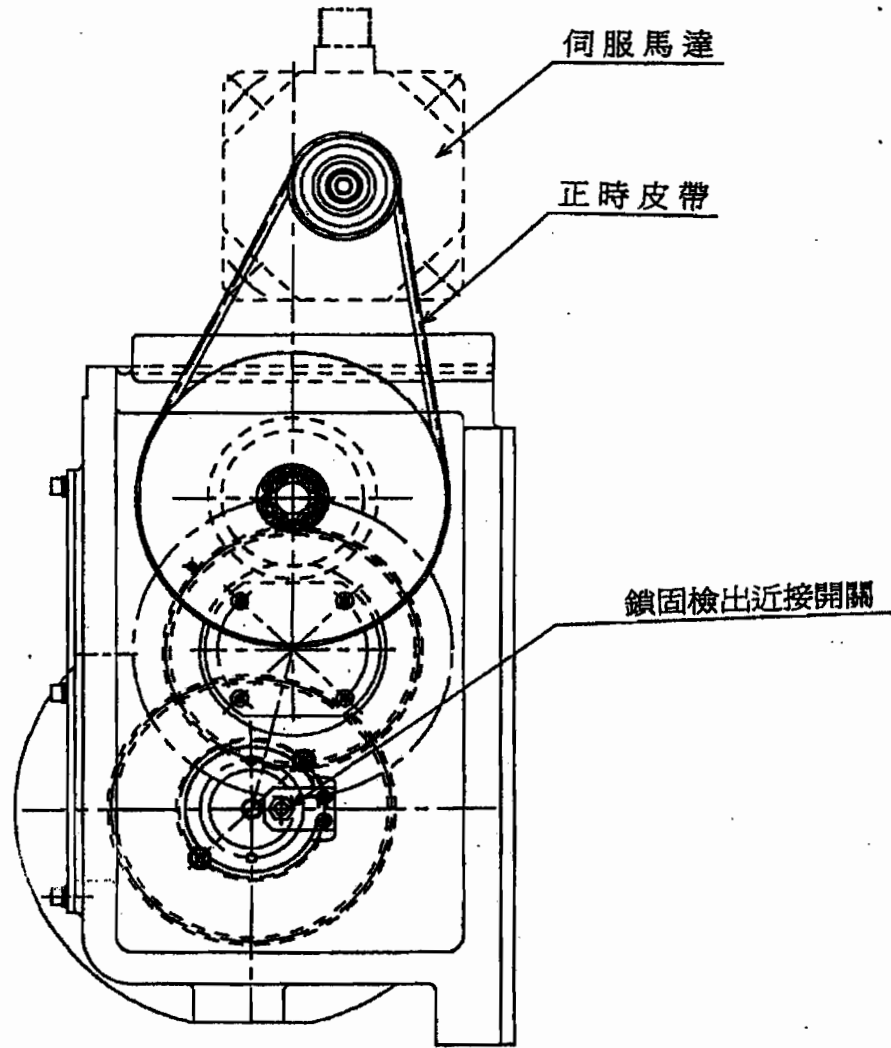
JG-200 Inner structure of turret

4-4 Oil pressure

4-4-1 Oil pressure Unit

Appearance of oil pressure unit used in this machine.
Please refer to the Fig. 3-1-1, List 3-1-1 to replace the hydraulic fluid, clean and replace the filter and inside oil tank.

Please use the hydraulic fluid as list 3-1-2. The volume of oil tank is 40L. The oil level is showed at the yellow line of oil gauge. In normal condition, the oil level should be between the yellow line and red line. Besides, take apart the tap on the hydraulic pump and drip some fluid before running.
Before delivering the machine, the pressure ($30Kgf/cm^2$) of hydraulic pump is already adjusted.

Flow rate regulating bolt
CW: Increase, CCW: Decrease

Please drop some oil before testing run

Pressure regulating bolt
CW: Increase, CCW: Decrease

T-port

P-port

Oil filler point /vent

H: 40L
L : 32L

Oil gauge
Oil discharge bolt
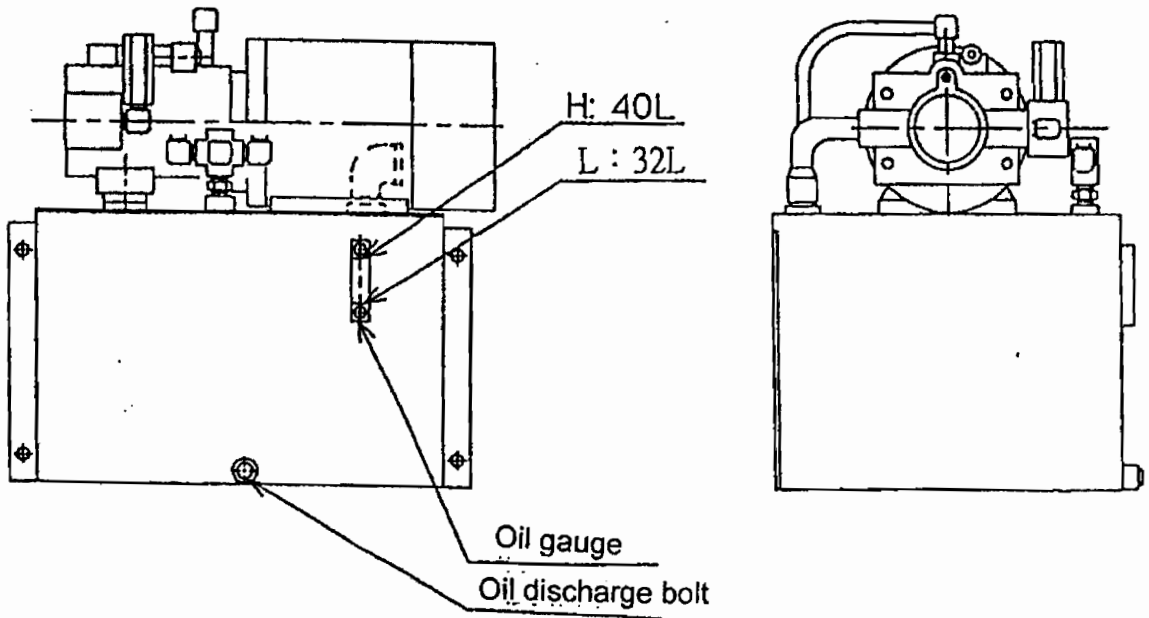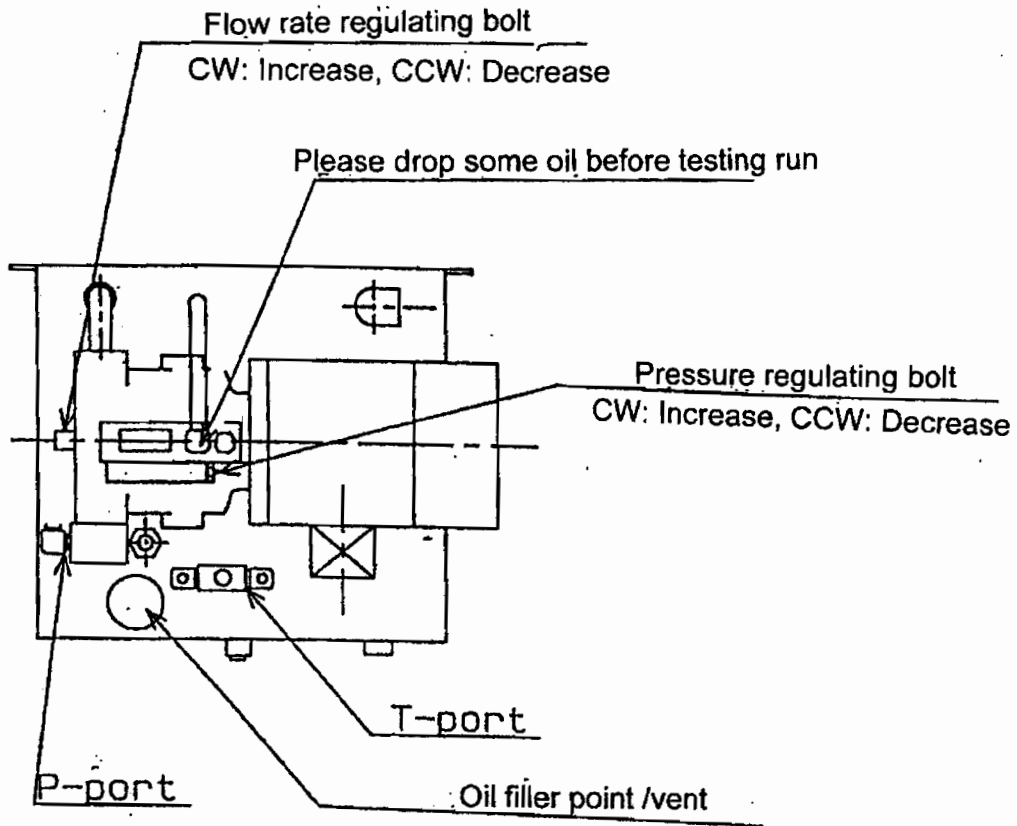
Fig. 4-4-1 Hydraulic Unit

Fig. 4-4-2: Hydraulic circuit, Table 4-4-2: Name and specification (Standard products) of the related parts of Hydraulic circuit.
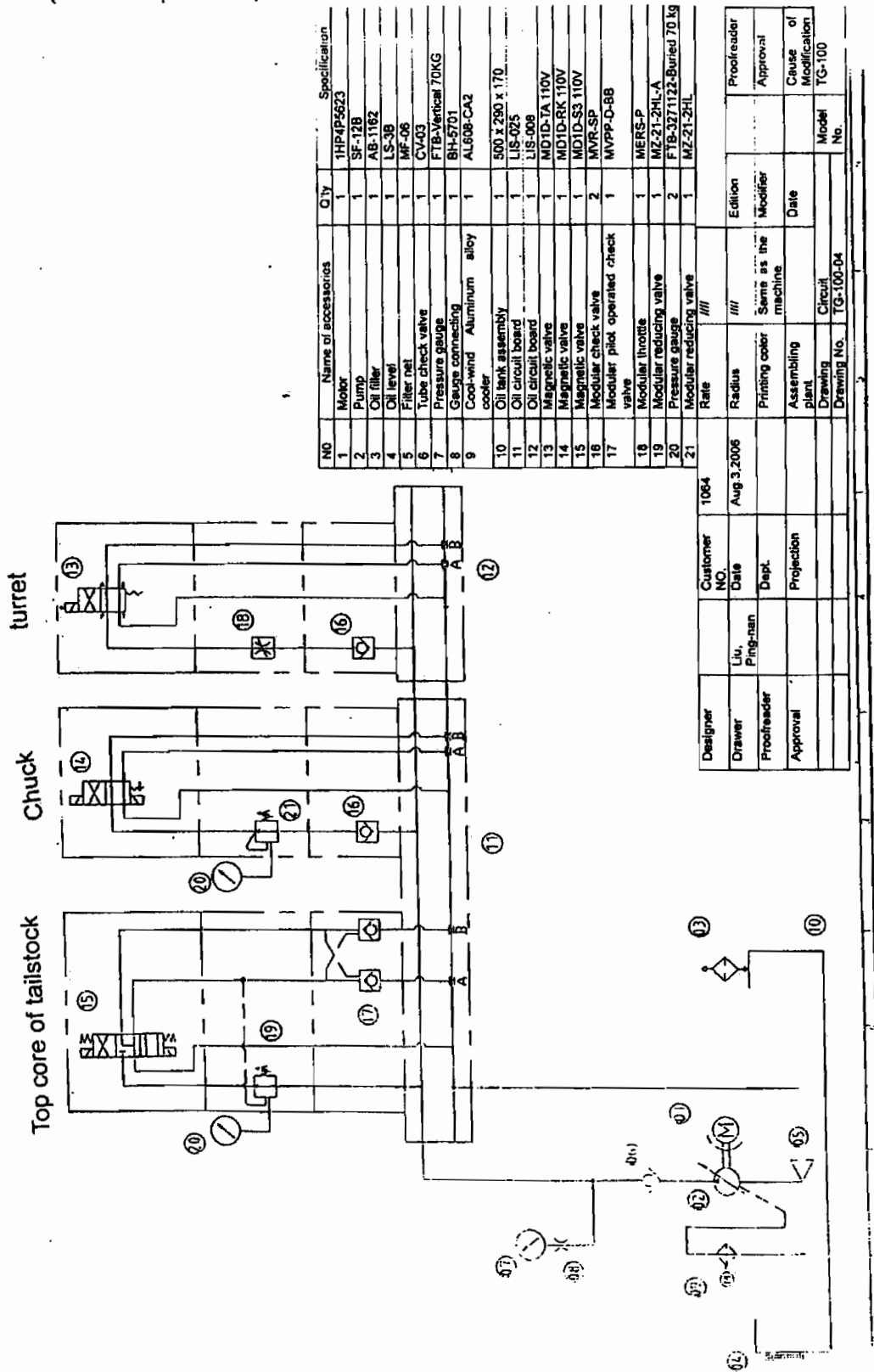
NO	Name of accessories	Qty	Specification
1	Motor	1	1HP4P5623
2	Pump	1	SF-12B
3	Oil filler	1	AB-1162
4	Oil level	1	LS-3B
5	Filter net	1	MF-06
6	Tube check valve	1	CV-03
7	Pressure gauge	1	FTB-Vertical 70KG
8	Gauge connecting	1	BH-5701
9	Cool-wind Aluminum alloy cooler	1	AL608-CA2
10	Oil tank assembly	1	500 x 290 x 170
11	Oil circuit board	1	LIS-025
12	Oil circuit board	1	LIS-008
13	Magnetic valve	1	MD1D-TA 110V
14	Magnetic valve	1	MD1D-RK 110V
15	Magnetic valve	2	MD1D-S3 110V
16	Moduler check valve	1	MVR-SP
17	Moduler pilot operated check valve	1	MVPP-D-88
18	Moduler throttle	1	MERS-P
19	Modular reducing valve	1	MZ-21-2HL-A
20	Pressure gauge	2	FTB-327122-Buried 70 kg
21	Modular reducing valve	1	MZ-21-2HL

Title block:

Designer		Customer NO.	1064	Rate	////	Edition		Proofreader	
Drawer	Liu, Ping-nan	Date	Aug 3,2006	Radius	////	Modifier		Approval	
Proofreader		Dept.		Printing color	Same as the machine	Date		Cause of Modification	TG-100
Approval		Projection		Assembling plant		Drawing	Circuit	Model	
				Drawing No.	TG-100-04			No.	

turret

Chuck

Top core of tailstock

4-4 OIL PRESSURE

4-4-3 Adjustment of hydraulic valve and other pressure parts

1. Main pressure programming

   Shown as Fig. 4-4-1, use the pressure adjusting bolt of hydraulic pump

   to set up the main pressure. (30Kgf/cm2 , 426PSI)

   The turret of this machine is fixed with the main pressure, please do not change.

2. Chucking capacity programming

   Please take use of the reducing valve as Fig. 4-4-2-   to adjust the pressure of

   hydraulic cylinder of chuck.

   Turn the hand-wheel clockwise, the chucking capacity will increase, turn the

   hand-wheel counterclockwise, the chucking capacity will decrease.

   Regarding the connection between chucking capacity and programmed

   pressure, please refer to the Fig. 4-5-1.

3. Adjustment of thrust and speed of tailstock shaft (Special accessories)

   Please refer to the Fig. 4-4-2-12, use the reducing valve to adjust the thrust of

   tailstock shaft.

   Turn the handwheel clockwise, the thrust will increase, turn the handwheel

   counterclockwise, the thrust will decrease.

   Besides, Please refer to the Fig. 4-2-2-   , the forward/backward speed of

   tailstock shaft is adjusted with the regulator.

4. Pressure switch of main pressure (special accessories)

   This pressure switch is a security device which is for the purpose of stopping

   machine immediately in order not to damage the machine because of pressure

   reducing by some reason.   Normally, the pressure is set at 20Kgf/cm2 .

5. Pressure switch of chuck

   This pressure switch is a security device which is for the purpose of stopping

   machine immediately in order not to damage the machine because of chuck

   pressure reducing by some reason.

   To change the setting value of chucking capacity, please change the pressure

   of pressure switch as well.

No.	Name	Model	Manufacturer
1	Oil tank	30L	KAYABA
2	P☐(P port) Reducing valve	MG-02P-03-T-TT	DAIKIN
3	T☐(T port)regulating valve	MT-02T-TT	DAIKIN
4	Magnetic (Solenoid)valve	KSO-G02-4CP-30-N-TT	DAIKIN
5	Magnetic (Solenoid) valve	KSO-G02-2DP-30-N-TT	DAIKIN
6	B☐(B port) regulating valve	MT-02-4CP-30-N-TT	DAIKIN
7	Magnetic (Solenoid) valve	KSO-G02-4CP-30-N-TT	DAIKIN
8	Pressure switch	CQ88-221	NAGANO KEIKI
9	Magnetic (Solenoid)valve	KSO-G02-2DP-30-N-TT	DAIKIN
10	Shockproof & silent valve	SV-618	ASAMI KIKI
11	Pressure gauge	PF-50D	DAIKIN
12	B☐(B port) Pressure reducing valve	MG-02B-03-T-TT	DAIKIN

List 4-4-2   Name and specification of the related parts of oil pressure

4-5 HYDRAULIC CHUCKING CAPACITY

The connection among chucking capacity, hydraulic pressure and rpm of spindle. As returning of the spindle will make centrifugal force increased, therefore, the spindle speed should be considered when calculating the chucking capacity.

The chucking capacity should be programmed very carefully because it will suddenly drop caused by high speed returning of spindle.

To program the chucking capacity, please refer to the curve of chucking capacity, and instruction of chuck made by the manufacturer.

List 4-5-1: Manufacturer and specification of chuck and hydraulic cylinder for Ex-series models

JG-100 Curve of hydraulic chucking capacity
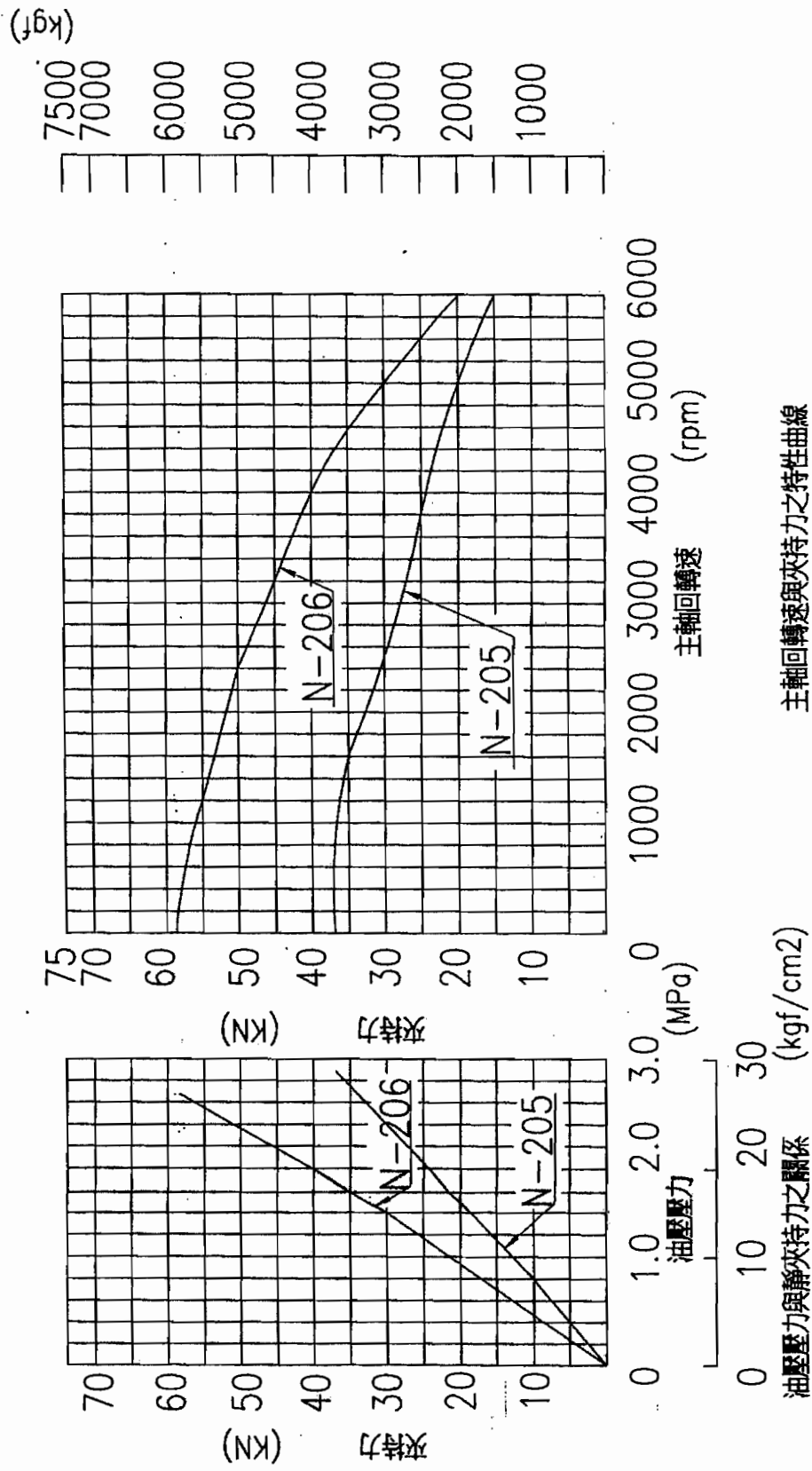
主軸回轉速與夾持力之特性曲線
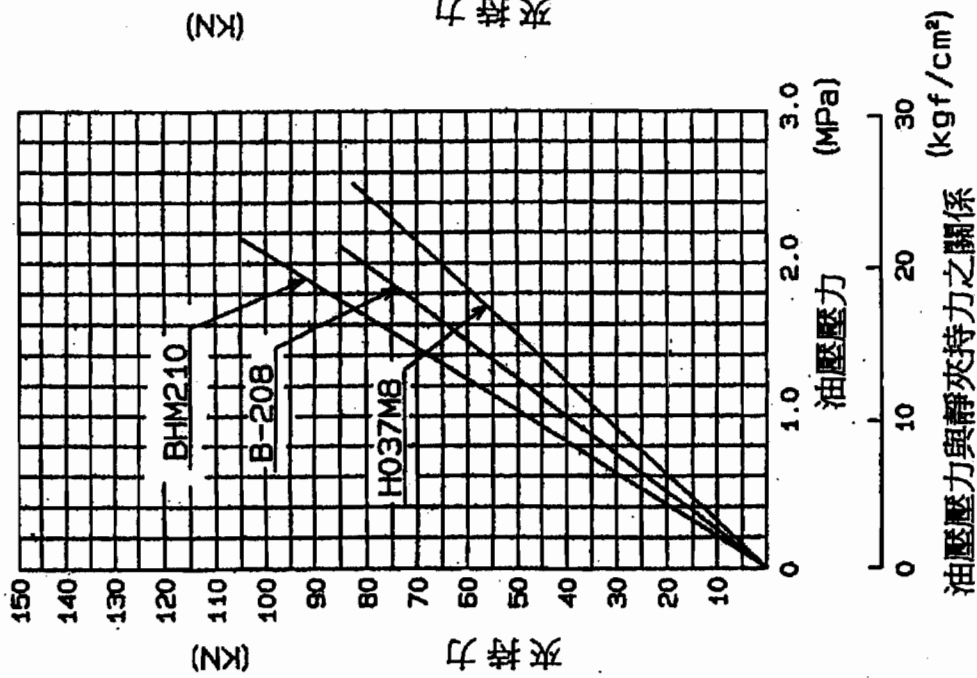
油壓壓力與靜夾持力之關係

JG-200 Curve of hydraulic chucking capacity

4-28
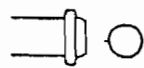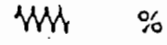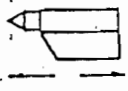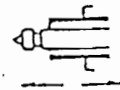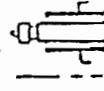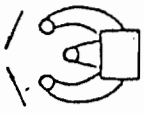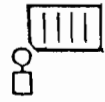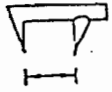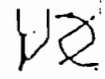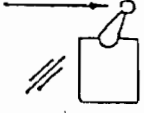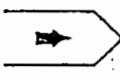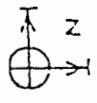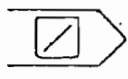
5. Panel

5-1 PANEL MARKS

	Panel marks		
⋀⋀⋀	Feed	⊐)	Spindle counterclockwise
∿	Rapid feed	⊐) ○	Spindle stop
⋀⋀⋀ %	Feed Speed regulation	⊐)	Spindle jog
∿ %	Rapid feed Speed regulation		Tailstock front, back
⊐) %	Speed regulation Spindle speed		Tailstock front, back
⊛	Handwheel feed		Tailstock jog
⫟	Chuck	▮	ON (Ready)
⋏	Tighten	○	Stop, Off, invalid
⋏	Loosen	▭	Cycle start
⊕	Tighten inside diameter	▭	Feed hold
⋏	Tighten outside diameter	⌒	Continuous (stepless) variable regulation
⊐)	Spindle clockwise		Steady rest (open)

5-1

Panel marks			
![Steady rest symbol]	Steady rest (close)	![Dry run symbol]	Dry run
?	Alarm sign	![Home symbol]	Home
![Cutting oil symbol]	Cutting oil	![Door lock symbol]	Door lock
![Position record symbol]	Position record	![Edit symbol]	Edit
![Work lamp symbol]	Work lamp	![Release delete symbol]	Release. Delete
![Chip conveyor symbol]	Chip conveyor belt	![Turret position symbol]	Turret position
![Auto-running symbol]	Auto-running (memory)	![Process release symbol]	Process release
![Single block symbol]	Single block	![Door close symbol]	Door close
![Machine lock symbol]	Machine lock	?//	Alarm sign home
![Optional stop symbol]	Optional stop	![Coordinates symbol]	Coordinates moved (drift)
![Block skip symbol]	Block skip	![Door open close symbol]	Door open, close
![MDI symbol]	Manual Data input (MDI)		

LOAD

51x22.5

EMG

?

Ø62

+Z −Z +X −X

RAPID TRAVERSE

EMG STOP

Ø22

FEED HOLD   CYCLE START

16   16

NC READY

16

DNC	AUTO	EDIT	MDI	MPG	JOG	HOME

		CHIP CCW	CHIP STOP	CHIP CW	MACHINE LOCK	AUX LOCK	M.S.T%	DRY RUN	BLOCK SKIP	OPTION STOP	SINGLE BLOCK

	QUILL IN	TAIL STOCK FRONT	TAIL STOCK BACK	SPINDLE DEC	SPINDLE INC	COOLANT MANUAL	DOOR OPEN

SPINDLE 100%

TOOL SETTER	STEADY REST CL	STEADY REST UNCL	SPINDLE JOG	SPINDLE CW	SPINDLE CCW	COOLANT AUTO	TURRET START

TURRET SELECT

1 2 3 4 5 6 7 8 9 10 11 12   9.2

MANUAL SPINDLE   9.2

RAPID

X1 F0%   X10 25%   X100 50%   X1000 100%   9.2

%

FEED

2.0 3.2 5.0 7.9 12.6 20 32 50 60 70 80 90 100 110 120 130 140 150 126 200 320 500 790 1260

0 10 20 30 40 50

%

5-3

6. Operation

6-1 POWER ON AND OFF

Electric Box rear main power switch "ON"	Machine stops
Operation Box right power switch "ON"	Operation Panel Press "Ready" button
Operation Panel (3) "Operation Ready" button release	Operation Box right power switch "OFF"
Operation Panel connects NC start	CRT display OFF
CRT initial display X 0.000 "NOT READY"; Z 0.000 then shows as indicated on the left	Electric Box rear main power switch "OFF"
Manual reset to reference points of each axis.	
Ready completed	

Note: 1. Machine cannot operate normally when under "NOT READY" status.

2. It is essential to reset to reference points of each axis before power reconnection or release of emergency stop, since displacement of each axis has been caused by previous power disconnection or emergency stop.

6-2-2 Rapid Feeding

Press "⌇" (Rapid Feed) of the Mode Select Buttons.

Press Select Feed Direction Button, movement starts toward arrow direction; movement stops when release.

Use Feed Speed Ratio Select Switch to select desired feed speed.
Both X and Z axes speeds are 400 mm/min when switch points to F0.

Note: The "⌇% min"(feed speed) F may be used to select both feeding speeds of "⌇ Rapid Feed" and "⌇Feed" before reset to reference points.

6-2-3 Feed

Press " 〰 Feed" of the Mode Select Buttons.

Press Select Feed Direction Button, movement starts

towards arrow direction.

Release button, movement stops.

Feed speed may be selected by using Regulate Feed

Speed Rate Switch.

Feed stops at "0."
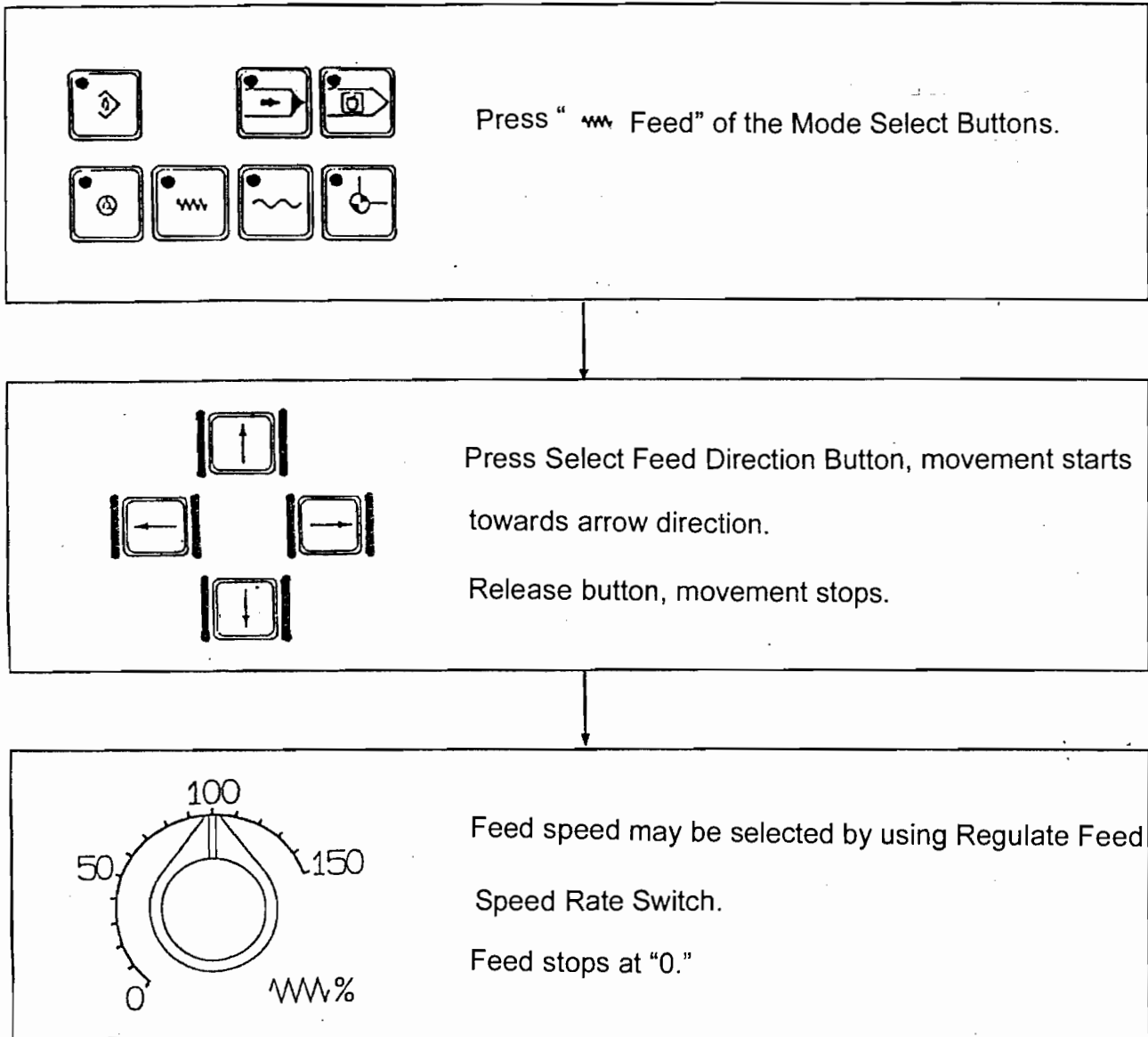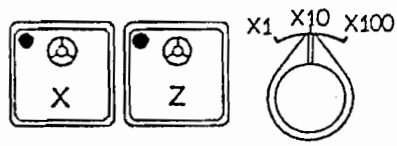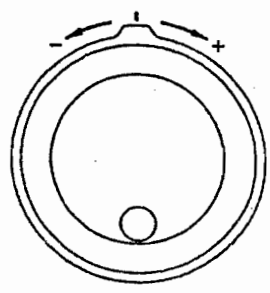
6-2-4 Handwheel Feed

Press ⊕ (Handwheel Feed) of Mode Select Buttons.

First select axis with Handwheel Axis Select Button, then select the X1 ratio with Handwheel Feed Ratio Button.

Handwheel Impulse Generator, feed speed will move in proportion to handwheel Rpm (One handwheel rotation equals to 100 degrees.)

Handwheel feed ratio	One degree	One rotation
×1	0.001mm	0.10mm
×10	0.01mm	1.00mm
×100	0.10mm	10.00mm

6-2-5 Turret Positioning

Press either ⊘ ⋙ of Mode Select Buttons.

Press Turret Position Button to execute turret positioning.

Repeat execution of this command until desired position is reached.
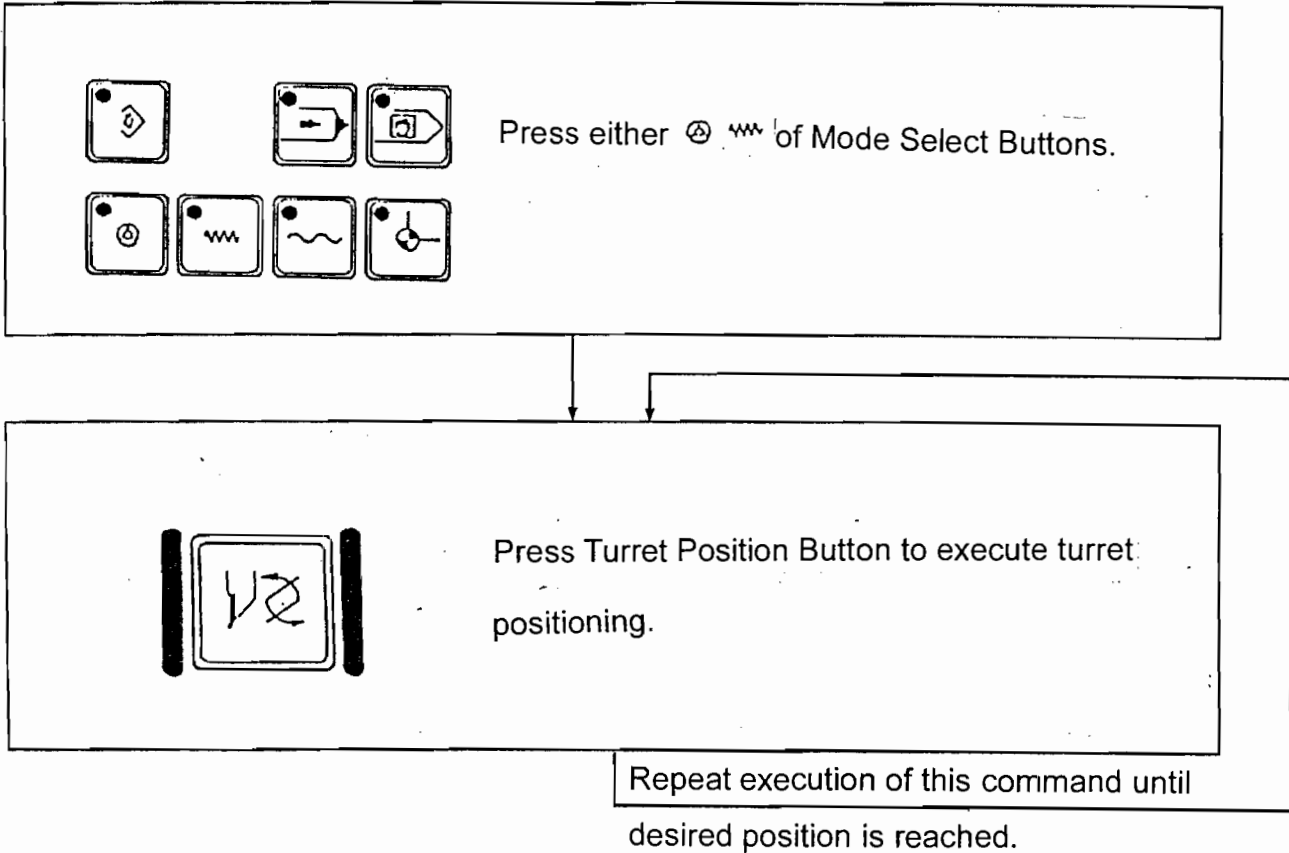
(2) Conditions of turret positioning

When turret fails to reach desired position, please confirm:

(i) Has oil pressure reached the designated value?

6-2-6 Spindle Start

(1) Spindle Start

Press 「 ⊘ , ⋁⋁⋀ , ⟜⊸ 」 of Mode Select Buttons.

	Press ──────▶	CW
	Press ──────▶	Stop
	Press ──────▶	CCW
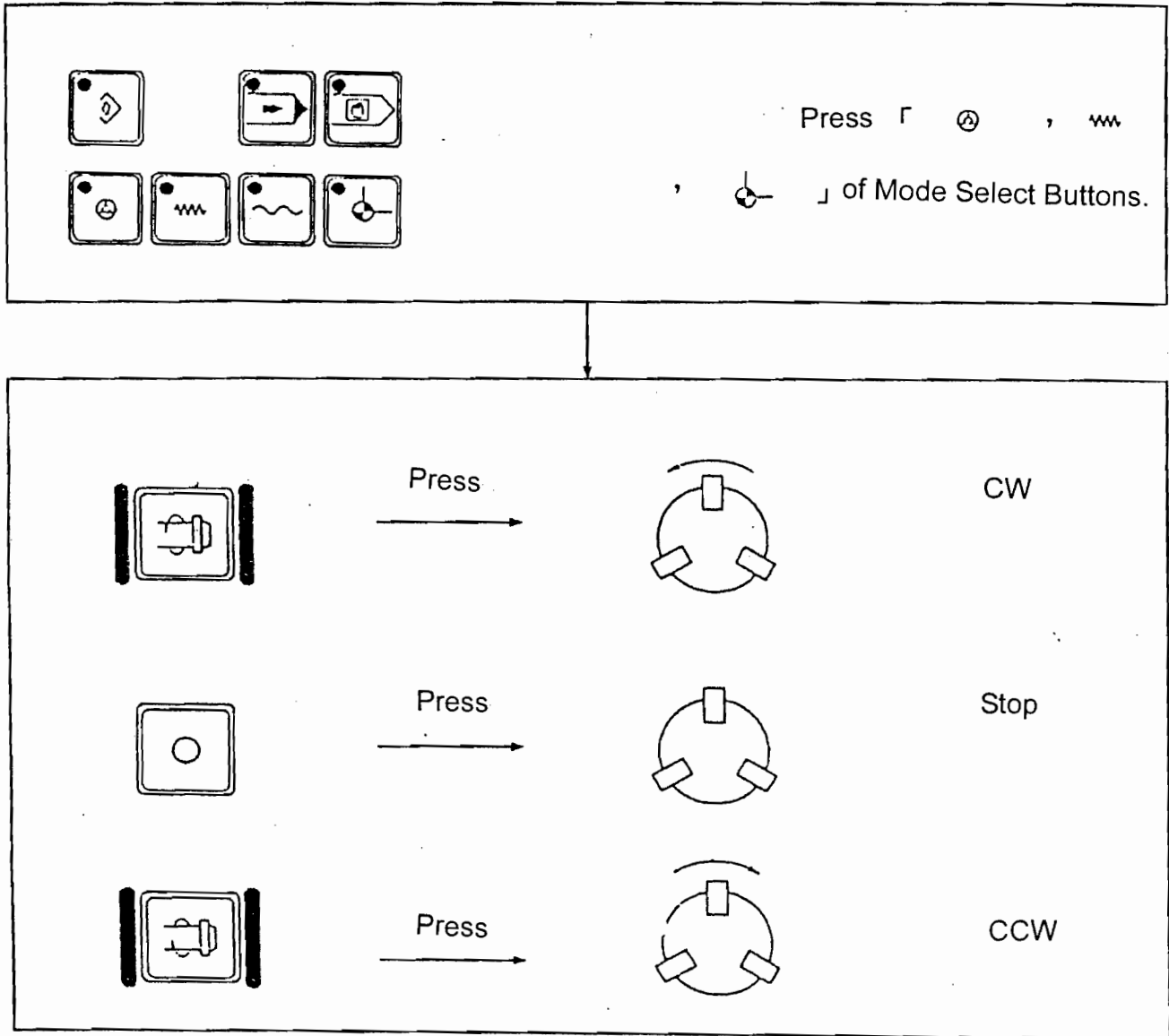
Note: Before manual switch of spindle CW or CCW, please first stop spindle, then give command.

(2) Spindle Rpm
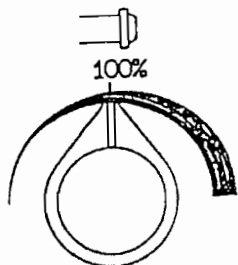
Using Regulate Spindle Speed Ratio Switch to select desired spindle Rpm.
Spindle Rpm will display on CRT.

(3) Conditions of spindle start

Spindle won't start under the following conditions:

(i) Emergency stop;

(ii) During reset movement;

(iii) Loosen chuck;

(iv) During program stops or on optional stop;

(v) Gear ratio is not selected when gear variable is available;

(vi) When previous door lock was set as a precondition for spindle disable (Refer to 3-5-6).

Nevertheless, difference may exist when various special appendix are added to this Manual.

6-3 Auto Run

6-3-1 Auto run starts

> Program memory is stored in NC mainframe.
>
> For details, please refer to the Operation Manual published by NC Manufacturer.
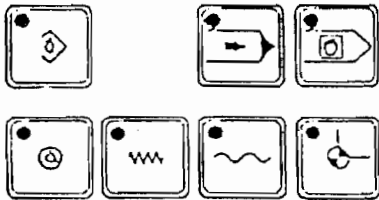
Press ⌐ ➡) (Auto Run) of Mode Select Buttons.
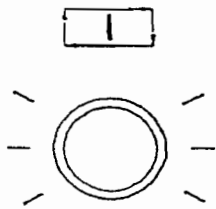
Press Cycle Start Button, Cycle Start Button indicator is on and auto run starts executing.
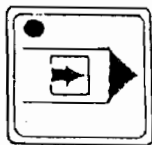
Execution will begin by one single block when Single Block Execution Button is effective.

Note: Single block run is effective only when Mode Select Button is set on ➡) (Auto Run) or ◌⟩ (Manual Data Input).

6-3-2 Discontinuing of Auto Run

Program is executing.

Press Feed Hold Button, feed stops
(Program execution discontinues.)
Additionally, Feed Hold Button indicator will be ON.
Thread cutting becomes invalid.
Please be noticed that spindle won't stop.
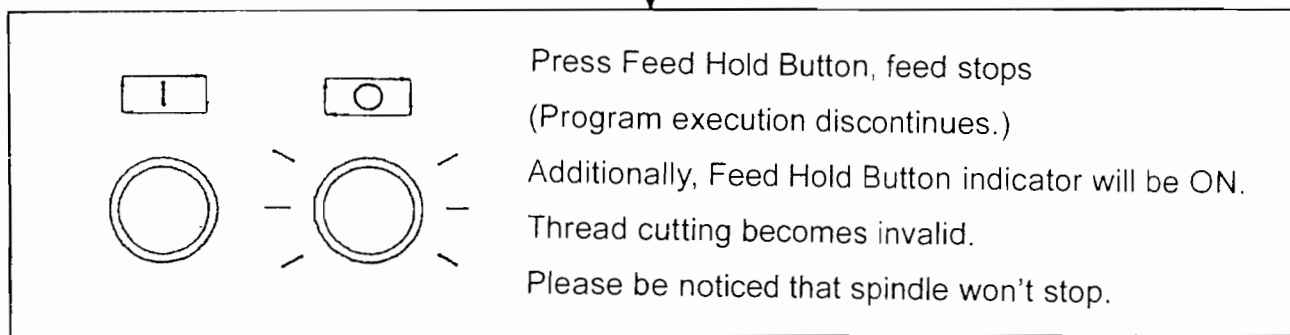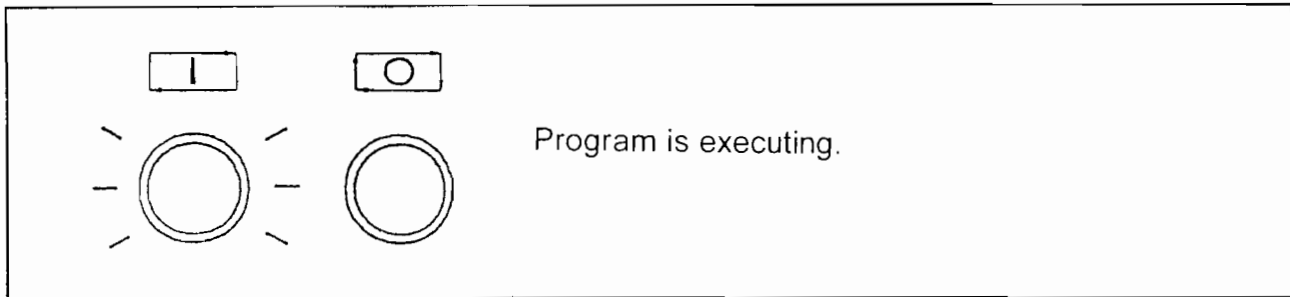
6-3-3 Termination of Auto Run

Auto Run is ON.

Upon completion of single block execution containing
M02 or M03, Cycle Start Button indicator will turn OFF
and auto run will end.

6-3-4 MDI Run

Press ⬡ (Manual Data Input) of Mode

Select Buttons.

Input desired data on MDI panel.

When press Cycle Start Button, Cycle Start Button

indicator is ON and MDI starts executing.

Upon completion of program execution, Cycle Start Button

indicator is OFF.

6-3-5 Various Switches Used During Auto Run

(1) Optional Block Skip

Block Delete
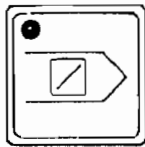
Indicator ON: Program containing single block with "/" sign won't execute.

Indicator OFF: Program containing single block with "/" sign will execute.

(2) Program check

Indicator ON: Programmed feed speed F is invalid, execution will based on selected speed by Regulate Feed Speed Ratio Switch. Furthermore, spindle won't rotate.
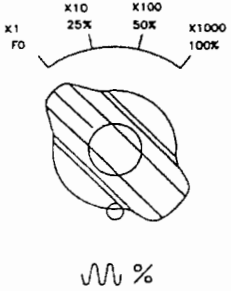
Indicator OFF: Execution will base on programmed feed speed F.

(3) Regulating feed ratio
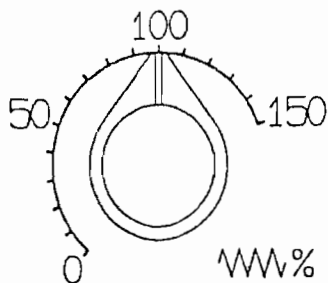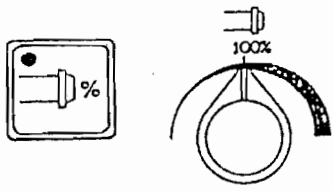
Programmed feed speed may be switched within the range of 0~150%. 100% setting equals to F value.

(4) Regulating rapid feed ratio

Rapid feed ratio may be switched among F0, 25%, 50% and 100%.

(5) Regulating spindle speed ratio

Indicator ON: Programmed spindle speed may be regulated within 70~120% range according to switch volume.

Indicator OFF: Switch volume invalid, switch fixed on 100% as programmed F.

6-3-6 Inserting Handwheel Run during Auto Run

(1) Inserting method

Press Feed Hold Button, Feed Hold Button indicator is ON.

Press either ⊕ , ᴡᴡ of Mode Select Buttons.

All handwheel functions may be executed.

(2) Continuing of Auto Run

Press ━▶ (Auto Run) of Mode Select Buttons.

Press Cycle Start Button, Cycle Start Button indicator is ON and program continues.
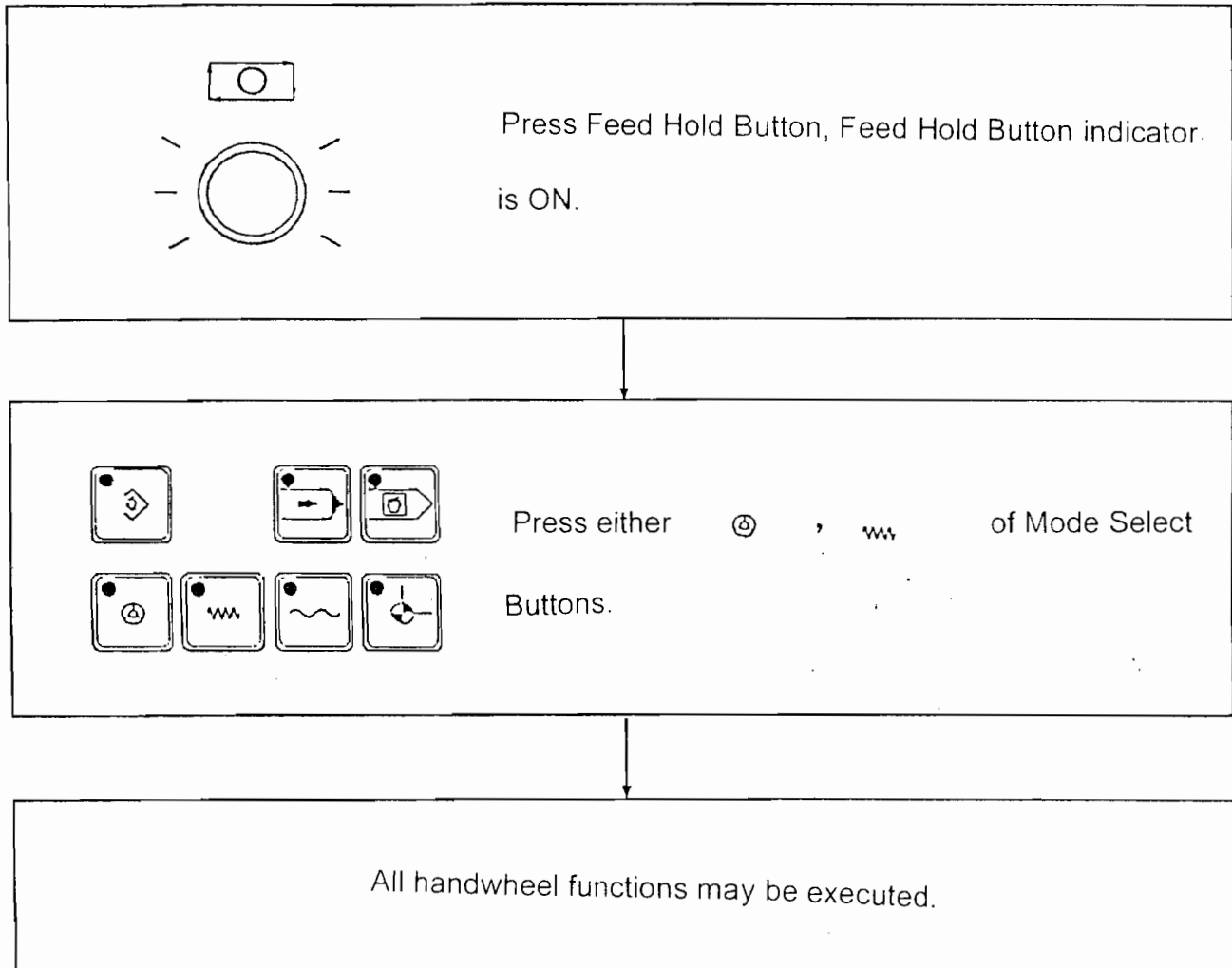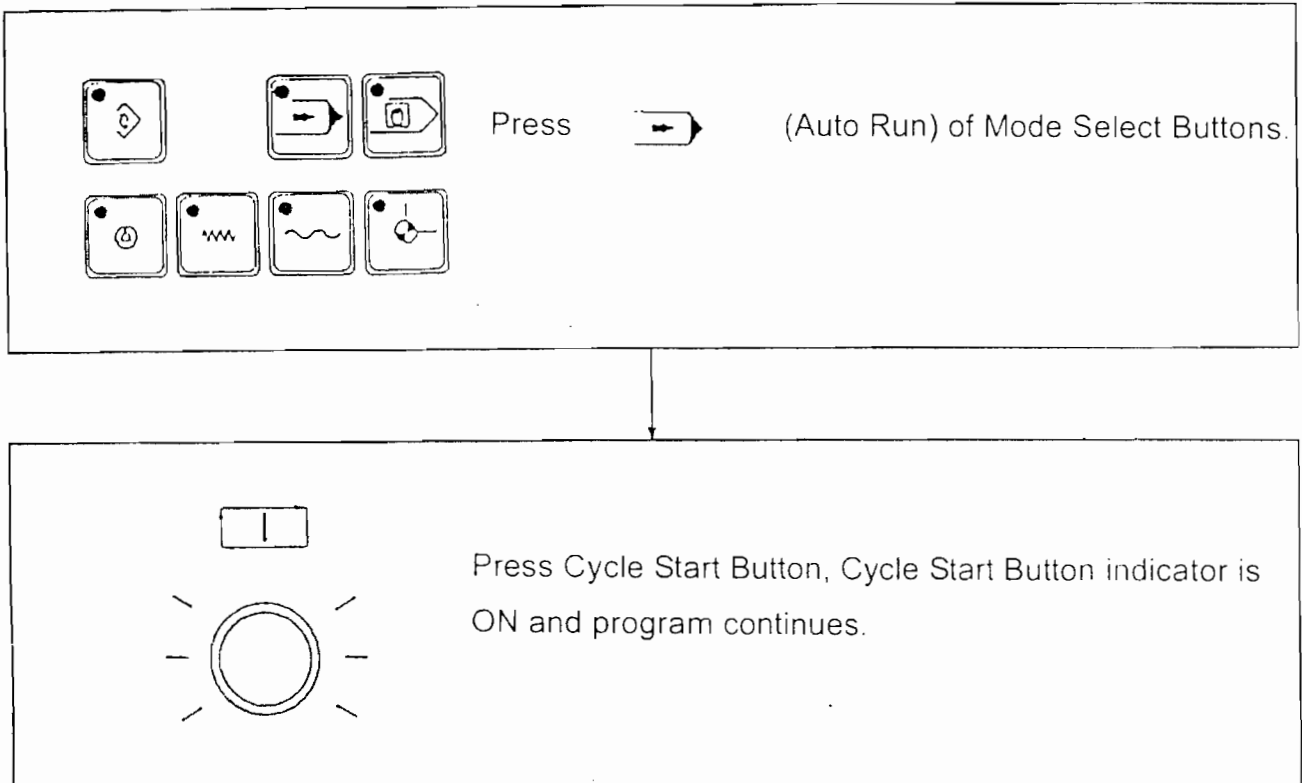
Note:
(i) Please return to previous spindle rotation direction and speed before inserting handwheel run to start machine.

(ii) Spindle will activate from Stop status and follow inserted handwheel run command. When press Cycle Start Button, spindle will continue rotate in according to the previously programmed command.

6-3-7 Program Stop and Optional Stop
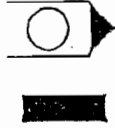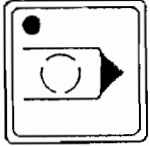
Upon completion of single block execution containing M00 or M01 (M01 represents effective optional stop), Program Stop Button indicator will be ON and program stops.

Single block will be on stop status when M00 or M01 is executed. To continue executing the program, please resume to previous status with applicable M command.
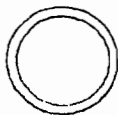
Press Cycle Start Button, program will continue executing.

6-4 Program Editing

6-4-1 Program memory

Please refer to official FANUC Operation Manual.

6-4-2 Program editing

Press ◊ (Edit) of Mode Select Buttons.

Switch ⇒ (Edit) to ❘ (ON) side.
A key (Dex) is attached to this switch.

Use MDI to conduct program editing.

Upon completion of editing, return ⇒ (Edit) to
⊃ (Invalid) position. When writing screen saver program,
take out Dex key on ⊃ (Invalid) side and hand over to the
care of computer administrator.
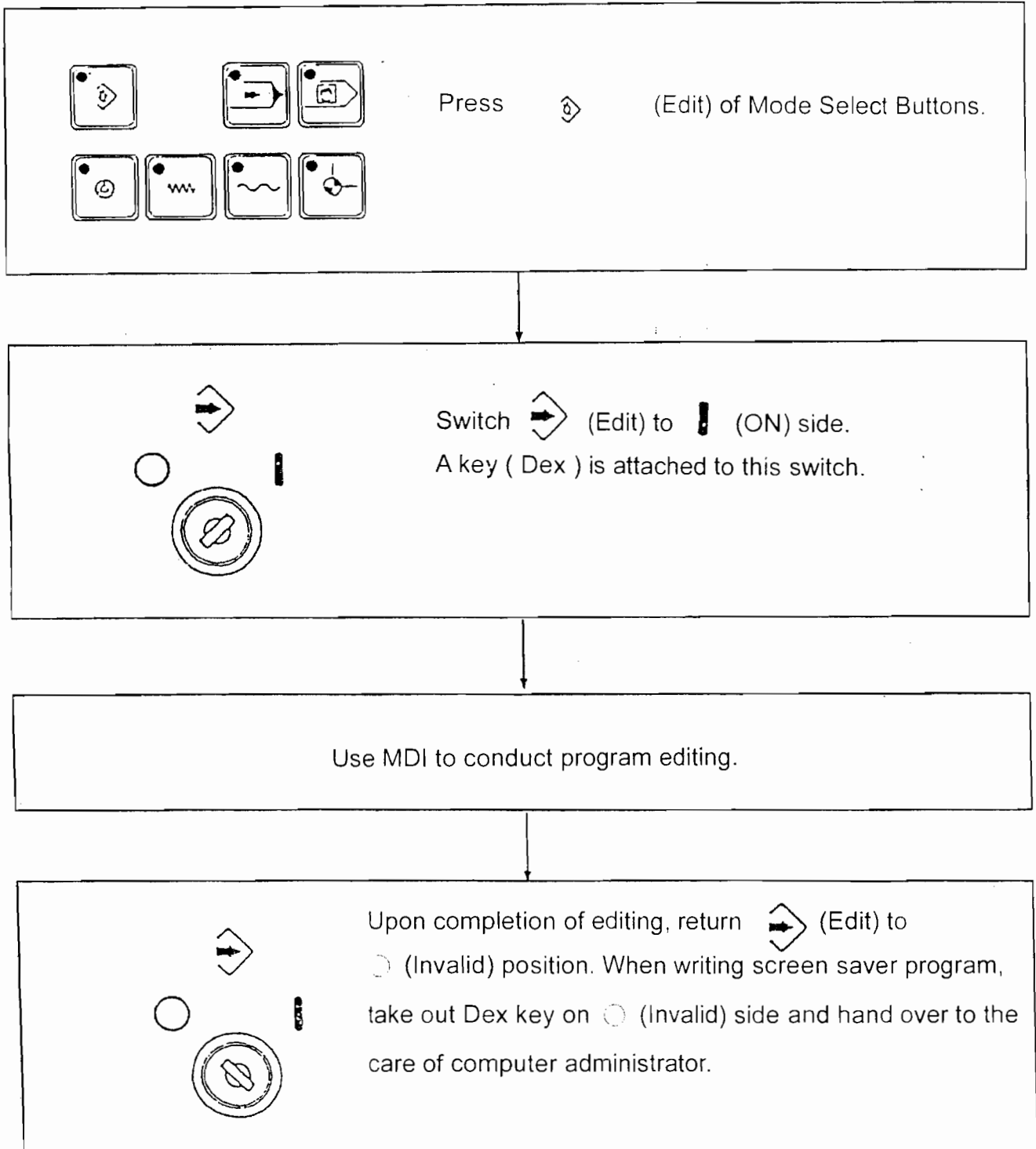
6-5 Other Switches and Their Designation

6-5-1 Emergency Stop
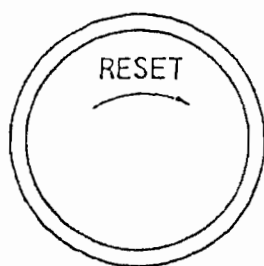
RESET

RESET----Press Emergency Stop to activate.
Rotate RESET switch in arrow direction to relief
Emergency Stop.

Note: To reset the machine, press Ready after release of Emergency Stop. It is also essential to execute resetting reference points since displacement of each axis has been caused by Emergency Stop.

6-5-2 Reset

RESET

Press Reset button on MDI panel to execute resetting.

6-5-3 Locking Inside and Outside Diameters of Chuck

M10: Select chuck locking direction.

M11: Use MDI mode to command switch.

Don't execute program during Auto Run.

6-5-4 Cutting Oil
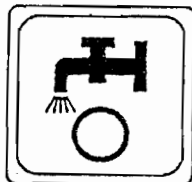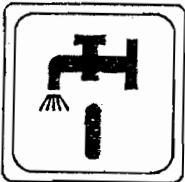
Cutting Oil will hold during Program Stop, Optional Stop,

Test Run and Program Check.

6-5-5 Fastening and Loosening of Chuck
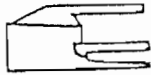
Step on pedal switch to control open and close
of chuck claws.

If the chuck is open, one step on the pedal switch to
close chuck, step again, the chuck will open. Chuck
lock indicator will be ON when chuck is on close status.
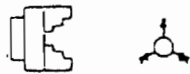
6-5-6 Front Door Locking
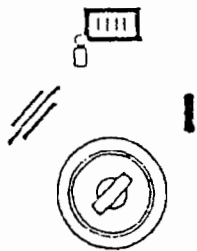
Switch to engage and disengage front door lock.
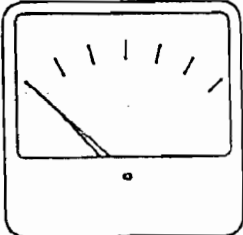
Front door lock disengaged.
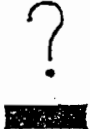
Front door lock engaged.

Turn the additional key attached to this switch to
computer administrator for proper care.

6-5-7 Spindle Motor Load Chart (Special Appendix)

Represents Spindle Motor load value.

6-5-8 Alarm Sign Indicator

?

In case of alarming condition, this indicator will be ON.

7. Handling of Alarm Signs

7-1 NC Alarm Signs

Alarm signs status displaying on CRT can be processed and resolved in accordance with description stated in the officially published operation manual of NC manufacturer.

7-2 Alarm Signs Related to Motors

7-2-1 Spindle Motor

Please refer to alarm signs instructions attached on spindle motor and handle in accordance with description stated in the officially published operation manual of NC manufacturer.

7-2-2 Non-Spindle Motor

For over heat of auxiliary motor, please check thermal relay in the electric box.

7-3 Reset of Alarm Sign

When Alarm Sign Reset Button indicator is ON, first eliminate cause of alarm sign, then, press Alarm Sign Reset Button to lift alarm sign.

When machine is on Feed Hold status, NC Reset Button on MDI panel should be pressed before press Alarm Sign Reset Button to lift alarm sign.
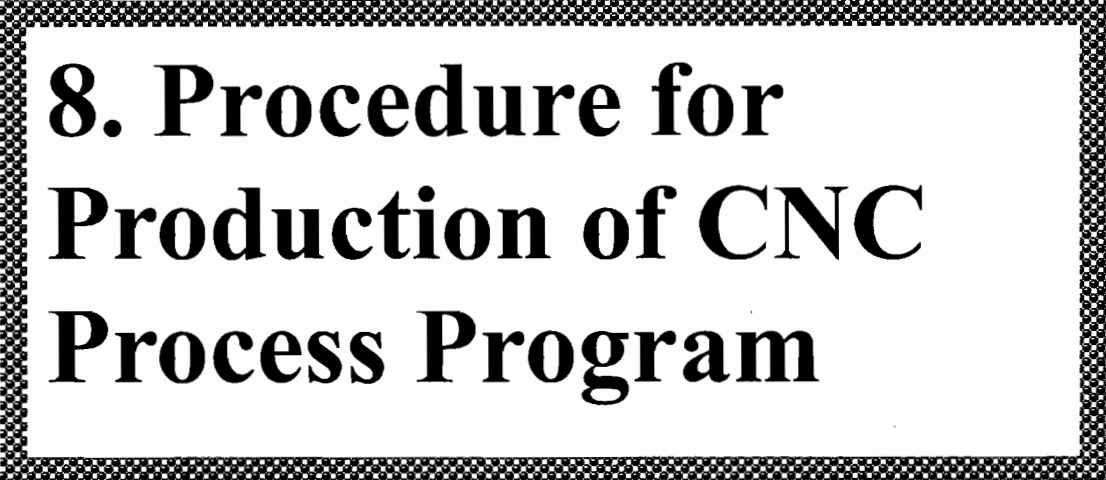
Note: To silence the buzz sound issuing upon failure occur, first press Alarm Sign Reset Button and press this button again after eliminating failure cause to lift alarm sign.

Alarm List

Alarm No.	Description	Remark
1000	Tool No. > Reset First input Home Tool, then Rest.	
1001	Soft Limit 2 Over Travel X/Z axes travel CCW.	
1002	Soft Limit 3 Over Travel X/Z axes travel CCW.	
1003	Turret Mis-Index Check tool number for accuracy.	
1004	Soft Limit 4 Over Travel X/Z axes travel CCW.	
1005	Door Not Close Close front door.	
1006	SP#1Chuck Unclamp Use pedal to close chuck.	
1007	Chuck End Stroke Check to confirm that chuck is clamping tight.	
1008	X-Axis Not Home X Use Home mode to reset X axis.	
1009	X, Z Axis Not Home X/Z Use Home mode to reset X/Z axis.	
10011	Turret Not Orientated Orientate turret clamp by manual or compulsory mode.	
10016	Spindle #1 Amplifier Detect Error Please contact manufacturer for consultation.	
10017	Hydraulic Fail Check if Oil Pressure Motor is running or Pressure Valve switch is normal.	

8. Procedure for Production of CNC Process Program

This manual aims to provide fundamentals and smooth operating of regular NC machine. For those who want to produce general process program, this manual may be utilized as a useful guide. It is advised that users should refer to the operation manual published by NC assembler and manufacturer for more advanced processing program or if detailed description is needed.

```
┌─────────────────┐  ┌──────────┐
│  Raw Materials  │  │ Drawing  │
└────────┬────────┘  └────┬─────┘
         │                │
         ▼                ▼
┌──────────────────────┐
│ Processing Drawings  │──→ All sizes are revised to absolute value, e.g.,
└──────────┬───────────┘        setting processing coordination.
           │
           ▼
┌──────────────────────┐
│ Processing Planning  │──→ Review and record high efficient processing
└──────────┬───────────┘        method.
           │
           ▼
┌──────────────────────┐        ┌─── Soft jaw or hard jaw
│ Deciding Chuck Shape │────────┤─── Clamping width
└──────────┬───────────┘        ├─── Production of necessary chuck tools
           │                    └─── Other special chucks
           │
           ▼
┌──────────────────────┐        ┌─── Tool type to be used
│   Tool Selection     │────────┤─── Number of tool
└──────────┬───────────┘        └─── Type of tool tip
           │
           │
           ▼
┌──────────────────────┐        ┌─── Determining Rpm
│ Selection of Cutting │────────┤─── Determining feed speed
└──────────┬───────────┘        ├─── Determining feed depth
           │                    └─── Whether cutting oil is needed
           ▼
```

```
┌─────────────────────────────────┐
│ G50 setting for individual blade │ → Tool drawings
└─────────────────────────────────┘
            │
            ▼
┌─────────────────────────────────────┐
│ Production of Processing Program Chart │ → Record tool paths and machine
└─────────────────────────────────────┘     movements in accordance with NC
            │                                specification.
            ▼
┌─────────────────────────────┐
│ Production of NC Program     │ → Program Inspection and Testing Use Production
└─────────────────────────────┘     of Processing Program Chart and indication on
            │                        Current Position Indicator and by comparison
            │                        between various M.S.T. of the machine to
            │                        conduct program inspection and testing.
```

→ Program Inspection and Testing Use Production of Processing Program Chart and indication on Current Position Indicator and by comparison between various M.S.T. of the machine to conduct program inspection and testing.

(1) Press Program Inspection and Testing Button

(2) Travel from origin point along positive direction of X and Z axes, that is to start from safe position.

(3) Conduct single block mode run.

(4) Cancel all tool offset status.

(5) Conduct assumed cutting before determining offset of each tool (Refer to Part 4 for method of setting coordination and tools).

(6) Use MDI to key-in tool offset according to tool number.

(7) Upon completion of determining origin point and inputting of tool offset, conduct test run to check for interference (Special attention should be paid to chuck clamp).

```
┌─────────────────────┐
│ Machine Activation   │ → After testing of each component, correction should be
└─────────────────────┘     repeated whenever needed.
```

8-1 Main Functions and Description of Marks (XZUW)

X or Z represents a command mark of absolute value. In a coordinates, they are used to register code numbers of X axis and Z axis respectively (X axis is a diameter command).

U and W are marks used for relative command.

U→travel distance of X axis.

W→travel distance of Z axis. / Registered code number
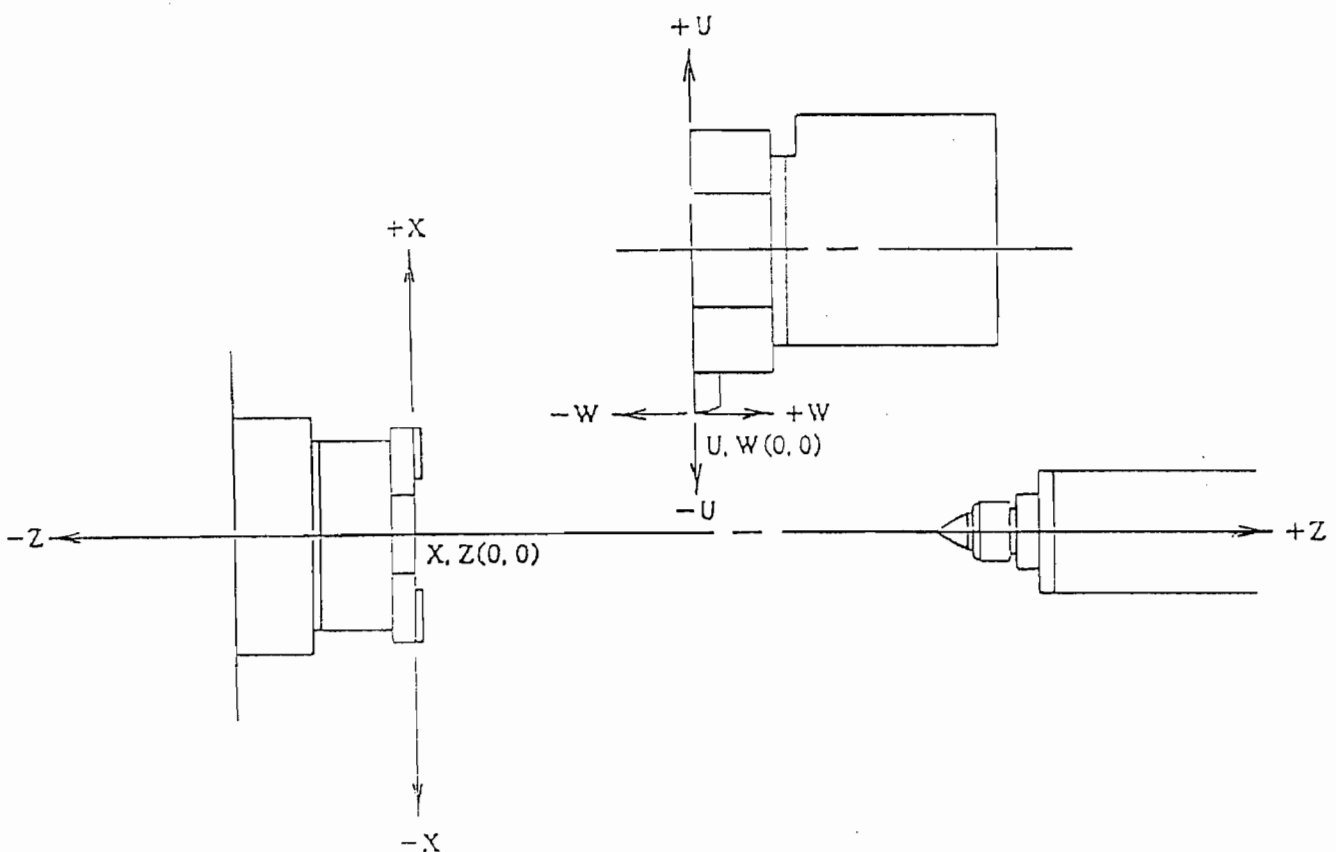
When claw end face and center of spindle are used as origin points, all range covered by ⊕⊖ of X and Z are shown as drawing.

Nevertheless, when current position of U and W is (0,0), ⊕⊖ should be determined by turret direction.

- X and U are commanded by diameter value.
- Both absolute and relative values may combined in the same program.
- General or regular lathe should adopt relative value.

8-2 Frequent used G functions

G00

When used for coordination (Rapid feed)

May also be used when M.S.T. functions are in use.

Attention should be paid to interference from tail stock, material, chuck and tool. (Travel paths are not necessarily linear.)

G00 X___Z___

G00 U___W___

G00   M___

G01

Linear travel under F speed command.

G01 X___F0.3

⤷ Feed volume 0.3 mm/rev

G01 X___Z___F___

When X, Z or U, W exists in the same single block, a taper shape may be formed. Special functions like chamfer and fillet (R) are also included to facilitate processing production. In processing of fillet (R) (R=designated radius)

G01   Z___R___ from Z direction to X direction

G01   Z___R___ from X direction to Z direction

In processing of chamfer (C=designated radius)

G01   Z___C

G01   X___C

C is determined by direction mark of cutting axis.

Example: Direction marks of R, C become ⊕ when cutting axis travels in Z direction.

G02

Fillet cutting (in CW direction)

G02X(U)___Z(W)___R___F___

or I___K___F___

| G03 | Fillet cutting (in CCW direction) |

G03X (U) ___ Z (W) ___R___F___
                    or I___K___F___

X.Z.: End position of fillet

U.W.: Distance between starting point to end point of fillet

R.: Radius of fillet

I.K.: Distance between starting point to center of fillet

X axis/end point/designated diameter/starting point/Z axis
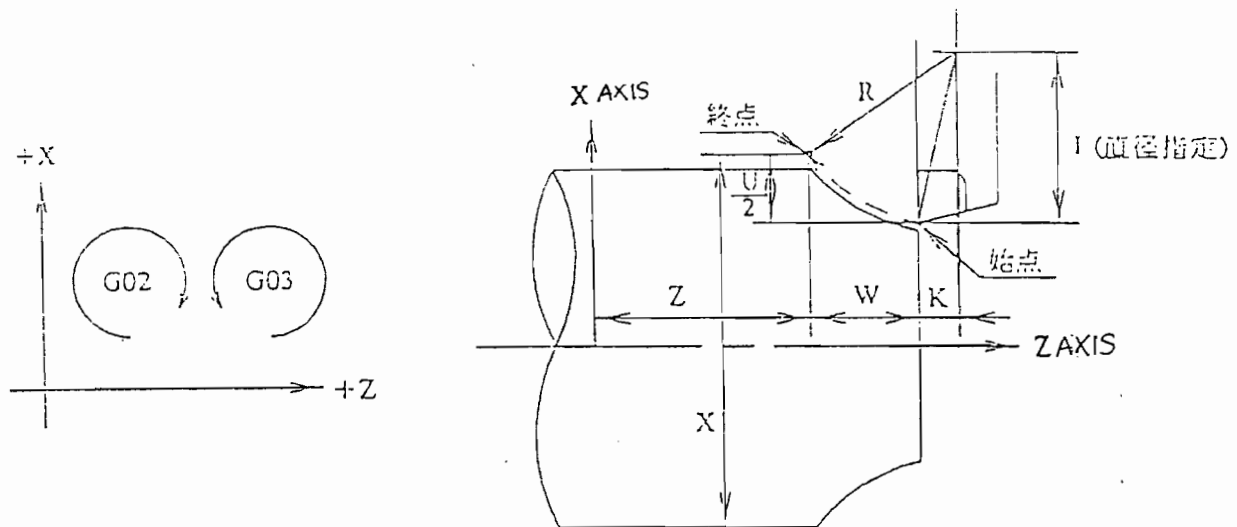
| G04 | Dwell |

G04 X (t)

Upon completion of a single block execution, a pause of (t) seconds should be followed by the subsequent single block.

Thread Cutting

| G32 | G32 X___Z___F___ |

F: Lead directly designate for thread cutting

| G50 | Coordinate Setting |

G50 X___ Z___

- ◆ Determined by the coordinates on which tools travel under absolute value command. This is not the actual travel command. Notify the Position between X=0, Z=0 and tool tip as indicated in the following drawing to NC device.
- ◆ Input the size calculating from tool tip, starting point, to X=0, Z=0.
- ◆ Operator needs to find out X, Z starting position of G50 manually before begin processing (Programmed X, Z coordinates of G50 corresponds with that of tool tip.)
- ◆ Normally, X=0 is spindle center position.
  Z=0 may be set at any position, provided that
  Z=0 position is normally set at chuck end face, material left end face or right end face.
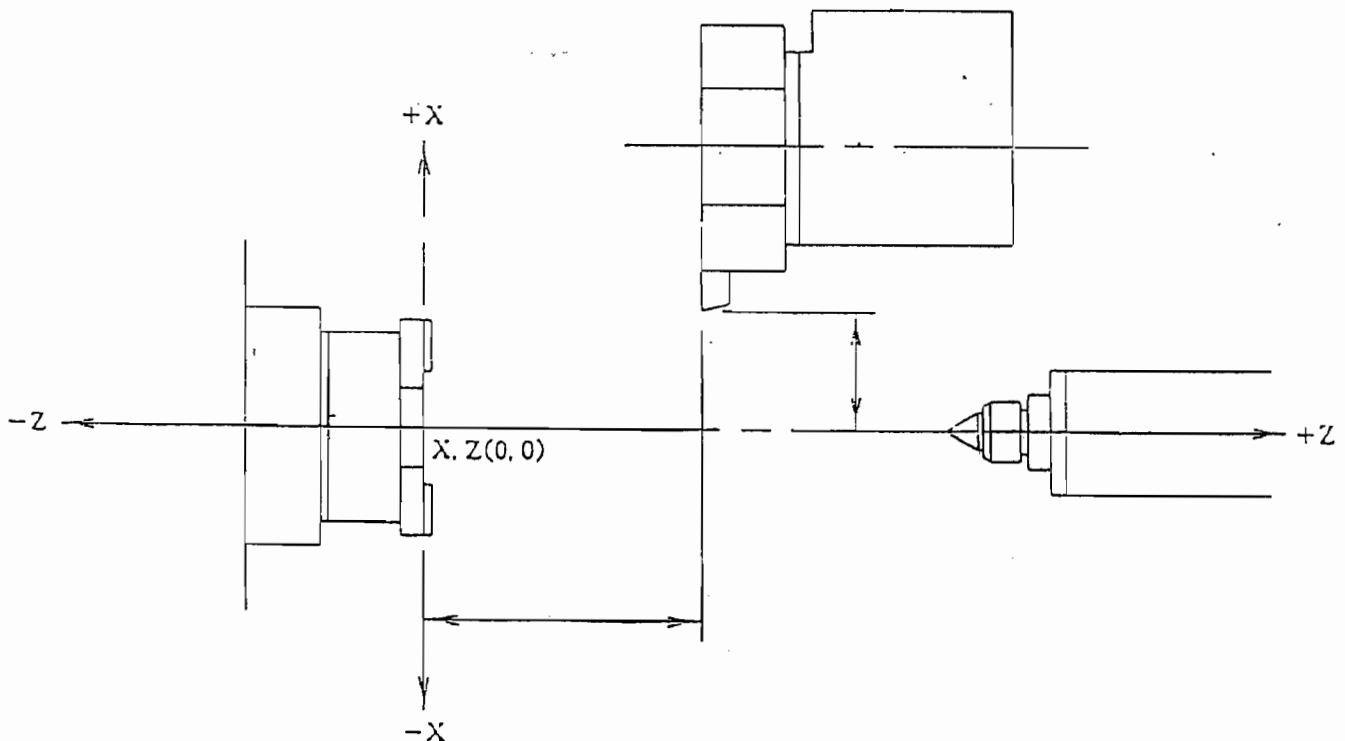
| G92 | Thread Cutting Cycle |

Thread Cutting Cycle

G92 X___Z___R___F___

X: X coordinates at end point

Z: Z coordinates at end point

R: Incremental value of X axis

F: Threading lead

R value is not needed in linear threading operation.

| G96 | G97 | Constant Cycle Speed Control |
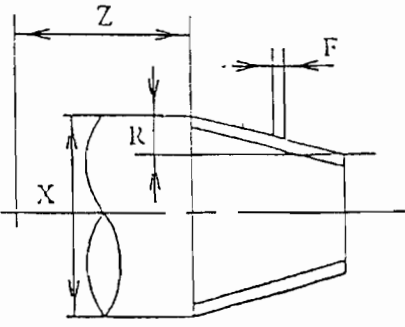
Constant Cycle Speed Control

For machine equipped with DC motor or AC variable motor to drive spindle, G96 stands for power ON of constant cycle speed control, while G97 stands for constant revolving speed control.

G96 S200 cycle speed   200m/min

G97 S200 revolution speed 200min^{-1}

8-2-1 Constant Cycle Speed Control

Constant cycle speed control means to revolve spindle under acquired accurate cycle speed status by calculating spindle revolve speed with variable cycle speed F of working part's position and send out corresponding voltage to spindle control part when give cycle speed command (relative speed between tool and working part.)

Unit for calculating cycle speed are as follows:

Input unit	Cycle speed unit
Metric	m/min
English	Feet/min

G Code	Meaning	Unit
G96	Execution of constant cycle speed control	m/min, feet/min
G97	Designate spindle revolution speed	Min^{-1}

When executing constant cycle speed control, coordinates of working part must be set by revolving back to X axis (X=0).
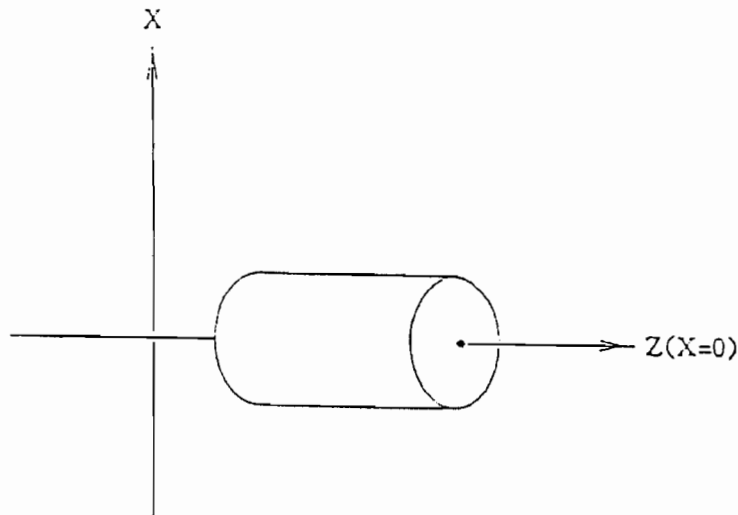
1. Clamping on Max. Rpm of Spindle

   Max. Rpm of spindle may be controlled by giving min⁻¹ command while conducting constant cycle speed control of G50S

   G50S___;

   Clamping on max. Rpm of spindle will activate when spindle revolution speed exceeds the above programmed speed.

2. Rapid feed speed (G00)

   When G00 is used to command rapid feed speed, constant cycle speed control may not only be calculated in accordance with tool position changes but also coordinates with distance changes between starting point and end point. This is the calculation of rapid feed speed before non-cutting operation.

Note:

(1) When power ON, unsetting status of spindle max. Revolution speed equals to unclamping status.

(2) Clamping status applies only to G96 mode.

(3) G50S0*0min^{-1} represents the meaning of clamping.

(4) The designated value in G96 mode will be saved in G97 mode, and will be auto reset when operation returns to G96 mode.

   G96S50; (50m/m or 50 feet/min)

   G97S1000; (1000min^{-1})

   G96X1000; (50m/mm or 50 feet/min)

(5) Cycle speed commanded by control cycle speed control designates cycle speed of program path not for program path after offset.

(6) When clamping is effective, machine will calculate constant cycle speed bases on X axis coordinates changes although there is no movement.

(7) Constant cycle speed control is still valid during thread cutting. Constant cycle speed control under G97 command becomes invalid during linear or slant thread cutting. Nevertheless, it has no effect on servo reaction and the changes of spindle revolution speed.

(8) Although it is meaningless, G96 command may be given during G98 (feed/min) command.

(9) Final revolution speed of G96 will be based on S (min^{-1}) of G97 code if S (min^{-1}) is not adopted by G97 upon transfer of G96 to G97.

N111G97S800;   800min^{-1}

N222G96S100;   100m/min

N333G97;   Xmin

X is revolving speed Xmin^{-1} of the previous single block before N333.

During G97→G96 transfer, S value in G96 is effective.

S=0m/min (feet/min) when no S value is designated.
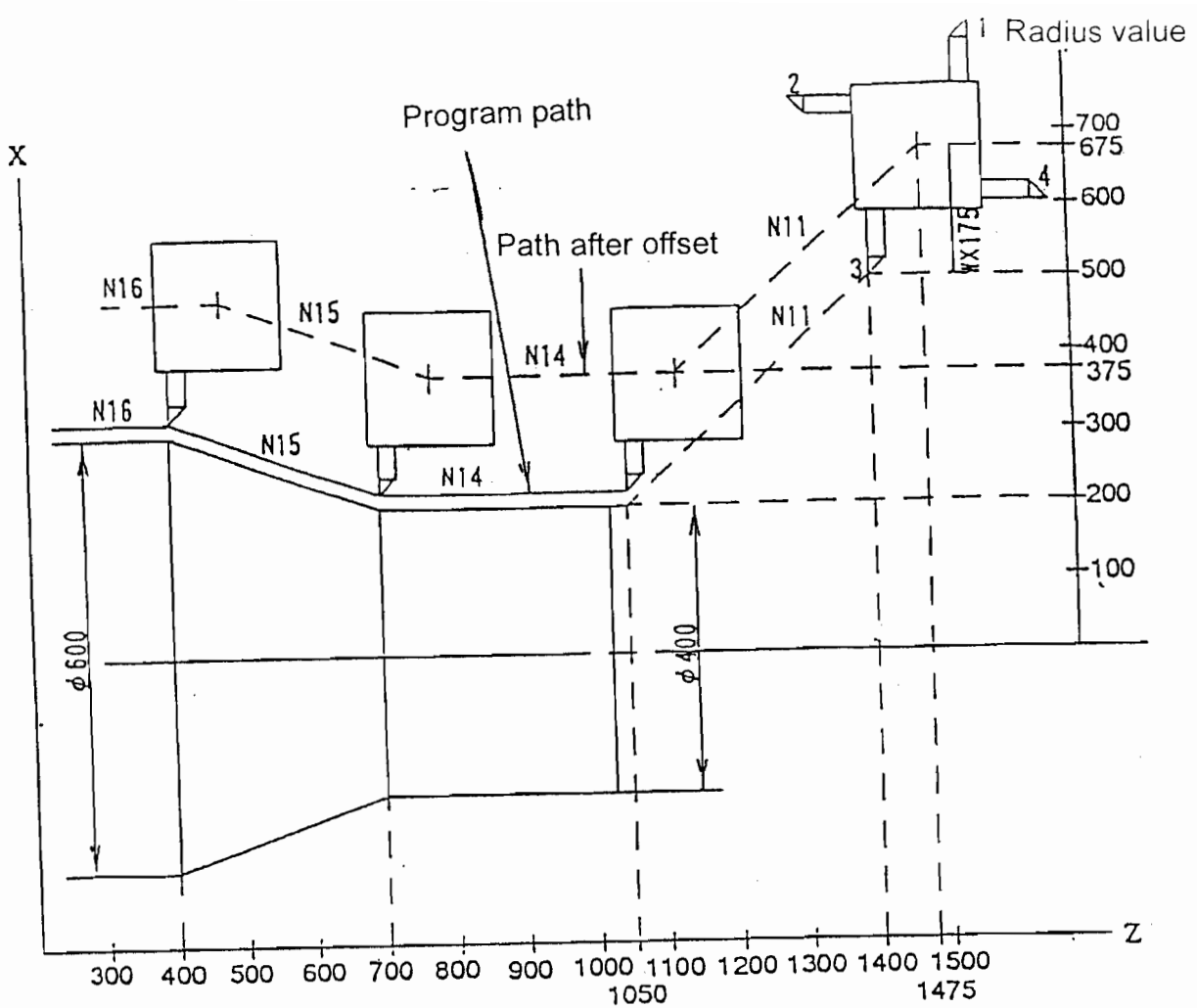
Fig. 3-2-1 Example of Program Embodiment

(Diameter Commands)

```
N8    G00   X1000.   Z1400.              ;
N9                            T0303 ;
N11         X400.    Z1050.              ;
N12   G50                     S3000 .;   (Designation of max. revolve speed)
N13   G96                     S200   ;   (Cycle speed 200m/min)
N14   G01            Z700.  F1000   ;
N15         X600.    Z400.              ;
N16                  Z...              ;
```

NC calculates designated cycle speed with programmed X coordinates position.
As such, NC has an additional way of calculation besides using X value of path after offset. As shown in the above drawing, end point of N15 is not the center of turret but the front end of turret, e.g., cycle speed of ϕ 600 equals 200m/min.

Calculation should be based on absolute when X value is negative.

Note: T function should be commanded with a four-digit when constant cycle speed function is available.
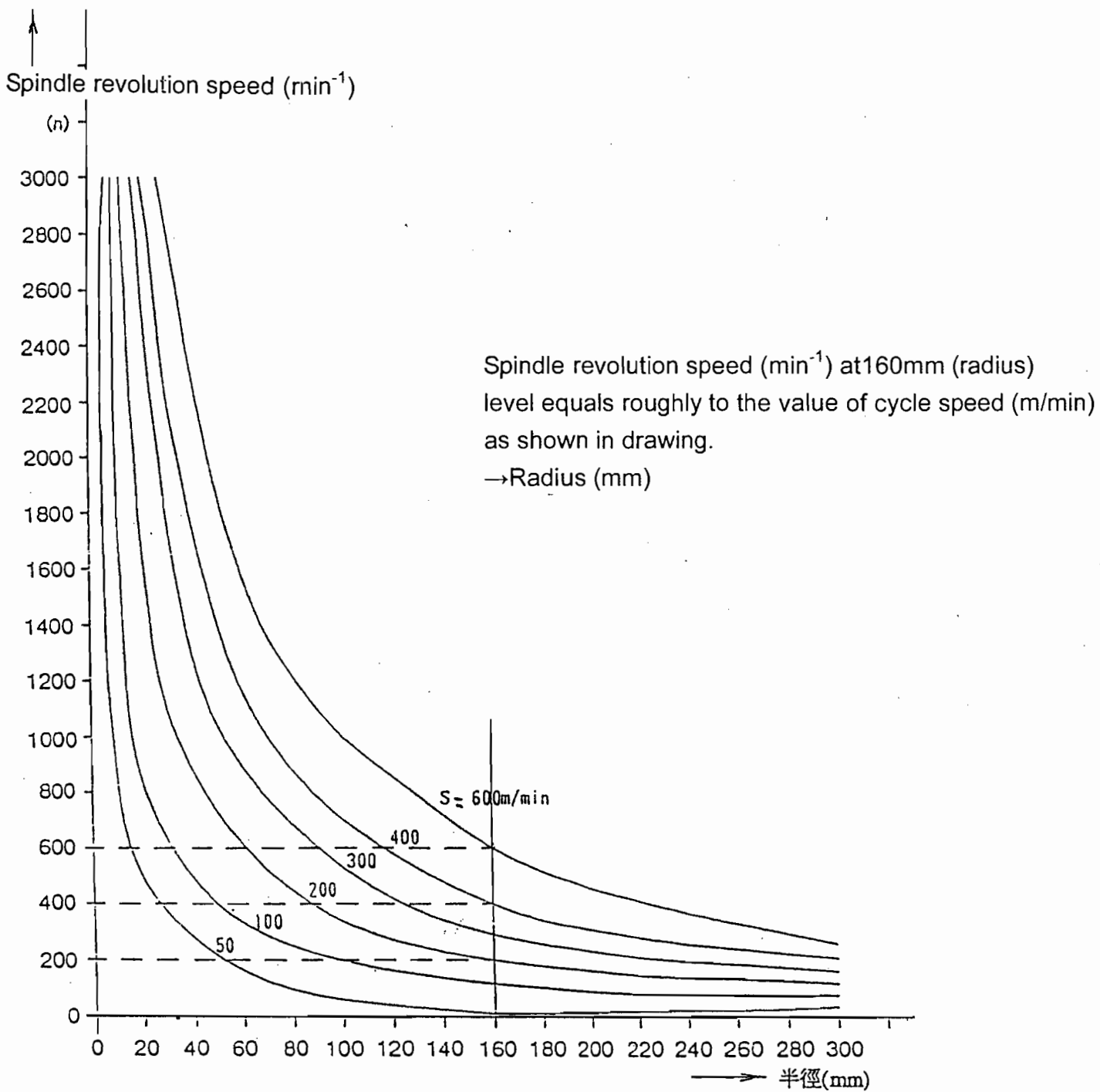
Figure 3-2-2 Relations between spindle Rpm and cycle speed

8-2-2 List of G Code

B: Standard   O: Special function

Standard G		Function	Classification
▶ G00		Rapid coordinating	B
G01		Linear interpolation	B
G02	01	Fillet interpolation (CW)	B
G03		Fillet interpolation (CCW)	B
G04	00	Dwell	B
G10		Setting offset volume	B
G20	06	Input of English system	B
G21		Input of metric system	B
G27	00	Testing of reference point reset	B
G28		Reset of reference point	B
G32	01	Thread cutting	B
G50	00	Thread cutting	B
G68	04	Turret mirror image function ON	O
▶ G69		Cancel mirror image function	B
G90		Cutting cycle A	B
G92	01	Thread cutting cycle	B
G94		Cutting cycle B	B
G96	02	Constant cycle speed control	O
▶ G97		Cancel constant cycle speed control	O
G98	05	Feed/min	B
▶ G99		Feed/rev.	B

Note:

1. All G codes with " ▶ " sign indicate status of G codes when power ON.

2. G codes belong to "00" group represent non-patterned G codes which only effect when single block code is activated.

3. Alarm sign (No.010) will be issued when G code not included in the list is given.

4. An unlimited number of G codes may be given in a single block if those codes don't belong to the same group. When two G codes are given in a single block, only the latter given G code is effective.

5. Each G codes may be indicated by its group number.

8-3 M Functions

All M functions of this machine are listed as follows. Please be noticed that M functions of other machines with different specifications are excluded.

M00	Program Stop
M01	Program Optional Stop
M02	End of Program
M03	Spindle CW
M04	Spindle CCW
M05	Spindle Stop
M08	Coolant ON
M09	Coolant OFF
M10	Spindle#1 Chuck Clamp
M11	Spindle#1 Chuck Unclamp
M12	Quill OUT
M13	Quill IN
M17	Auto Door Close
M18	Auto Door Open
M21	Door Interlock Bypass ON
M22	Door Interlock Bypass OFF
M23	Chamfering ON
M24	Chamfering OFF
M30	Program Rewind
M31	Spindle#1 Chuck Bypass ON
M32	Spindle#1 Chuck Bypass OFF
M33	Block Skip ON
M34	Block Skip OFF
M37	Chip Conveyor CW
M38	Chip Conveyor Stop
M40	Low Gear Change
M41	Middle Gear Change
M42	High Gear Change
M47	Chuck Soft Limit 2 Valid
M48	Tail Stock Soft Limit 3 Valid
M49	Soft Limit 2&3 Invalid
M51	Error Detect OFF

M52	Error Detect ON
M55	Tail Stock Clamp
M56	Tail Stock Unclamp
M57	Spindle#1 Air Blow ON
M58	Spindle#1 Air Blow OFF
M71	Mirror Image X ON
M97	Parts Counter
M98	Calling of Subprogram
M99	Main Program Return

Note:

1. Classification B and O in the list stand for standard specification and special function respectively.

2. M02 and M03 may be used for number counting in machine equipped with various counter and processing completion lamp (special specification.)

3. When press Reset button of M02 or M03, machine will return to program ER.

8-4 S Functions

S4 Codes

G97 <u>S1500</u>

↳ Rpm. may be directly commanded by a four-digit figure.
Speed at this command is 1500 rev. (without constant cycle speed
control function.)

G50 <u>S1400</u>

↳ Max. Rpm. is clamped on 1400 rev. when constant cycle speed
control function is available.

G96 <u>S120</u>

↳ To execute 120m/min constant cycle speed control.

8-15 T Functions

T4 Codes

T01 Tool

         └➤ Number (Turret number)

└➤ 01 Tool offset number
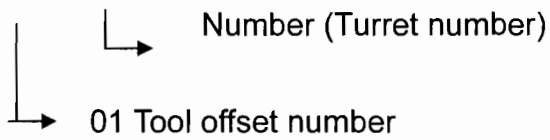
1. Tool offset number

    A total of nine sets of number are used to offset displacement or wearing of tool.

    Max. value: ±999.999

    Offset may be set for each individual number (OFX, OFZ).

Offset	OFX (X Offset)	OFZ (Z Offset)
1	0.010	0.020
2	0.000	0.000
∫	∫	∫
9	0.100	1.340

T0000

Offset number starts with "00" means cancel offset.

8-6 Coordinates Setting
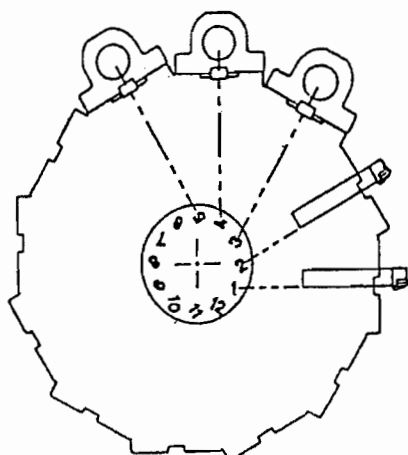
Example: Tool Installation

No.1 Outside diameter tool (base tool)

No.2 Outside diameter tool

No.3 Inside diameter tool

No.4 Inside diameter tool

No.5 Drill head

※ All values of X axis (direction) are

diameter values.

1. Auto Coordinates Setting

Coordinates shown in the following drawing may be set by auto coordinates setting for manual or auto reference point reset.

Spindle end face
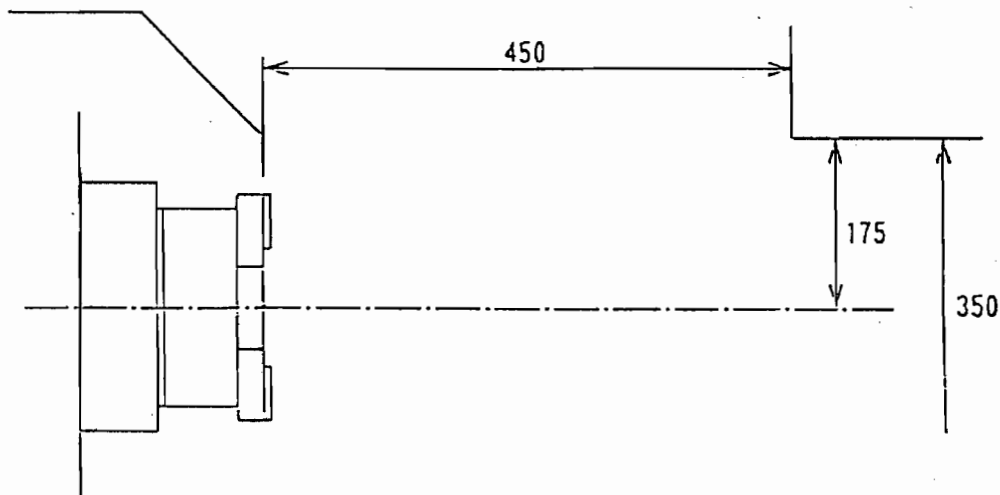
PRM ＊＊＊=350000

PRM ＊＊＊=450000

Upon completion of auto coordinates setting, first execute reference point reset (the result will be the same as executing G50×350Z 450 EDB), then execute pre-set POS (indicating position).

2. Drift of Working Coordinates

In actual practice, it is necessary to conduct drift of parts clamping coordinates, as shown in the preceding page, after tool installation.

Select base tool No.1 for optional surface cutting while conducting actual measuring by disengaging from spindle under the condition of Z axis not moving.

Example:

When program origin, as shown in the following drawing, is 60mm away from left side, position of cutting end face is 62mm from left side, which is expressed as Z2.0.

When distance to program origin is 60mm, equation equals to 0. 2mm should be added for actual measuring value of 62mm; minus 1mm for 59rnm.

Program origin
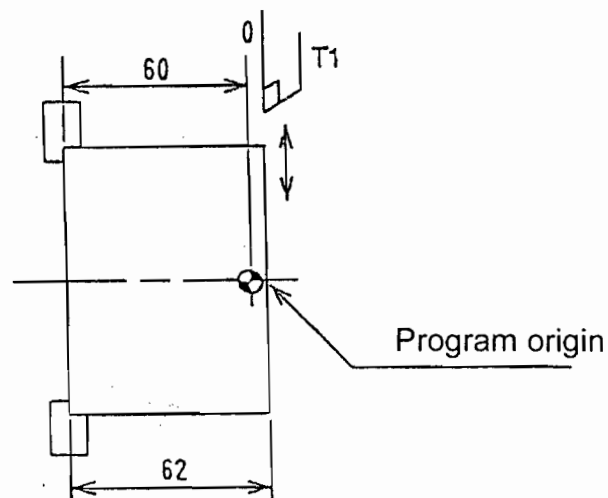
Operation procedures are shown as follows:

1. Repeatedly press OFFSET/SETTING button several times until displaying of OFFSET screen.
2. Press Select Chapter Button to display |workpiece| Drift screen.

```
┌─────────────────────────────────────────────────────────────┐
│   Workpiece Drift                                             │
│   (Drift Value)                        (Measuring Value)      │
│       X   0                                 X                 │
│       Z                                     Z                 │
│   Current Position (Relative Coordinates)                     │
│       U                                     W                 │
│                                                               │
│   【        】【Workpiece Drift】【      】【      】【(Operation)】│
└─────────────────────────────────────────────────────────────┘
 ◁  ▭   ▭   ▭   ▭   ▭   ▷
```
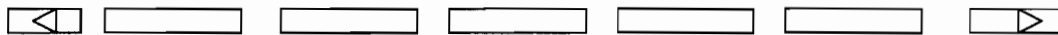
Move cursor to value corresponding to Z, key-in 2.0 then press| Enter.|
(Key-in -1.0 if measuring value is -1m/m.)

```
┌─────────────────────────────────────────────────────────────┐
│   Workpiece Drift                                             │
│   (Drift Value)                        (Measuring Value)      │
│       X   0                                 X                 │
│       Z                                     Z                 │
│   Current Position (Relative Coordinates)                     │
│       U                                     W                 │
│                                                               │
│   【      】【      】【      】【  +Enter  】【 +Enter 】          │
└─────────────────────────────────────────────────────────────┘
 ◁  ▭   ▭   ▭   ▭   ▭   ▷
```

Note: Make sure that drift volume for X axis is zero.

When drift volume for X axis is not zero, move cursor to value corresponding to X, then, press |Enter|.

Upon completion of reference point reset, both drifted coordinates setting and current position pre-setting are also completed.

Value may be input by press |Enter| after moving cursor to correspond with drift volume of X or Z.

Before press |Enter|, previous drift volume should be added to input value.

8-7 Tool Calibrating

Select base tool No.1 to execute optional outside diameter cutting. Disengage working part with X axis not moving. Stop spindle, measure outside diameter value.

Example: When outside diameter is 50m/m.
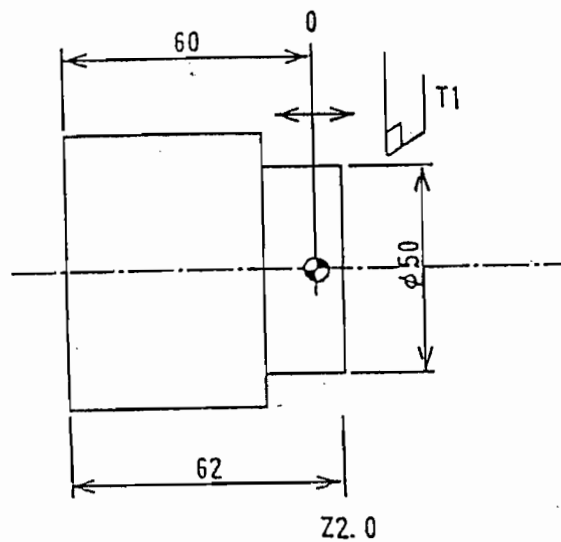
Operation sequence should be as follows:

(1) Press functions key—Offset/Setting to call out offset screen.

(2) Press Offset key

Offset/Setting
【 Offset 】【 Setting 】【   】【   】【Operation】
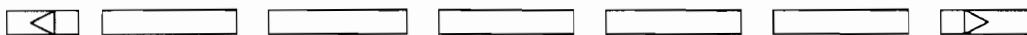
(3) Press Shape key

(4) Move cursor to Offset number

```
Tool Offset/Shape
G01 ___



     ●
     ●
     ●


【 No. Search】【 Measure 】【C Enter 】【+ Enter】【 Enter 】
```

◁ ▭ ▭ ▭ ▭ ▭ ▷

(5) Press Operation key

```
Tool Offset/Shape
G01 ___



     ●
     ●
     ●

【 Wearing 】【 Shape 】【        】【          】【Operation】
```
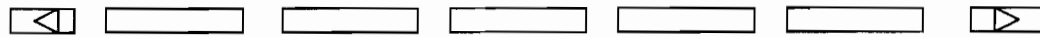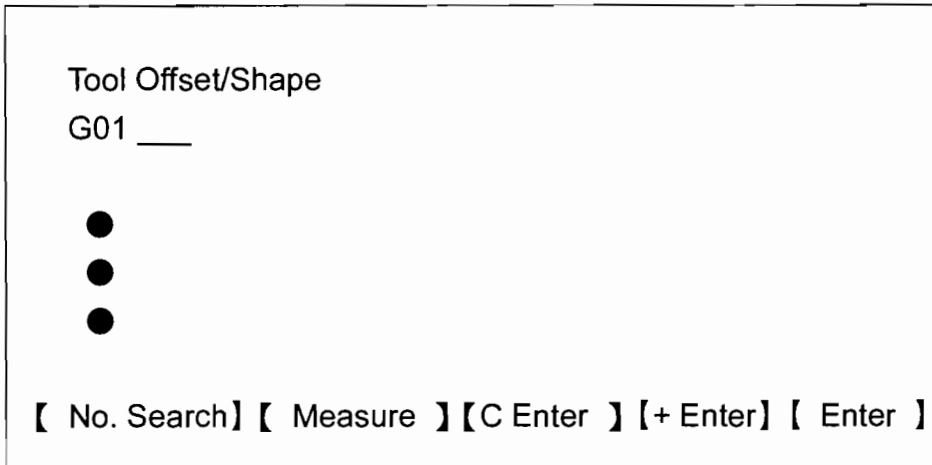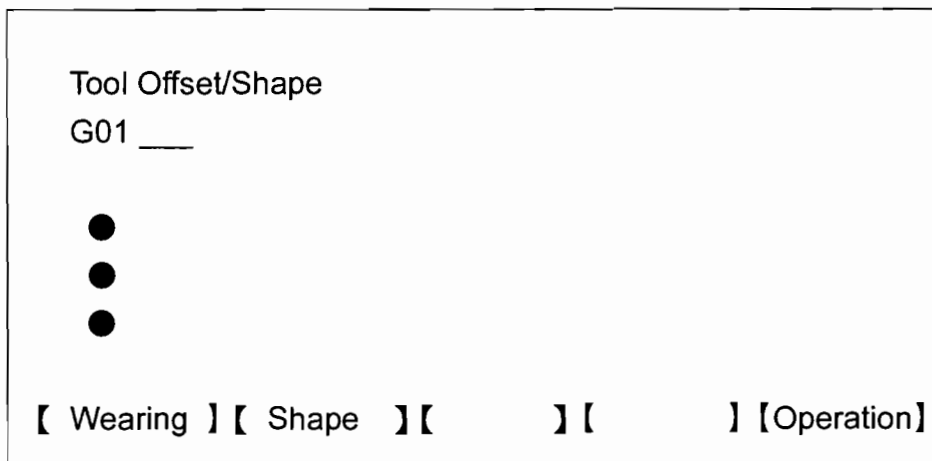
Input X50, press No. Search, X value of Offset No.1 will automatically count in.

Note: Z value of Offset No.1 is zero.

When Z value is not zero, first move cursor to correspond with Z value and input 0,

then press Enter to change value to 0.

1. Calibrating of outside diameter tool
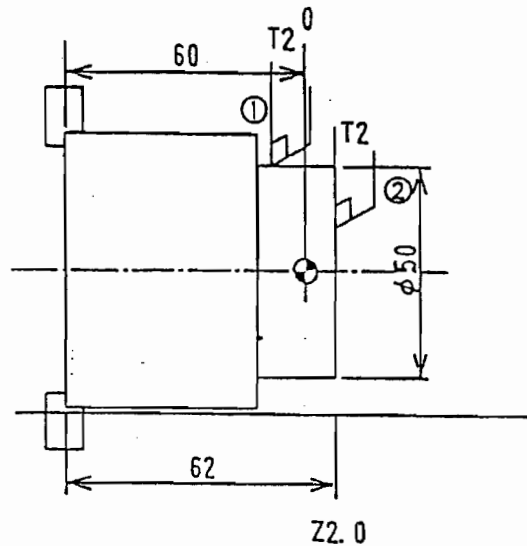
(1) Cut outside diameter face with calibrated base tool, and use No.2 tool to conduct test.

Do not move X axis.

Move cursor on Operation Sequence (5) screen to call out Offset number.

Input X50, press soft key— ⌐ Test. ⌐

Under Auto Coordinates setting, display offset to X movement of pre-set coordinates.

(2) Drift cutting end face with parts coordinates, conduct test with No.2 tool.

Do not move Z axis.

Always match value with cursor.

First input Z2.0, then press soft key—⌐ Test. ⌐

Input offset volume displayed by Z movement of base tool No.1.

2. Calibrating of inside diameter tool
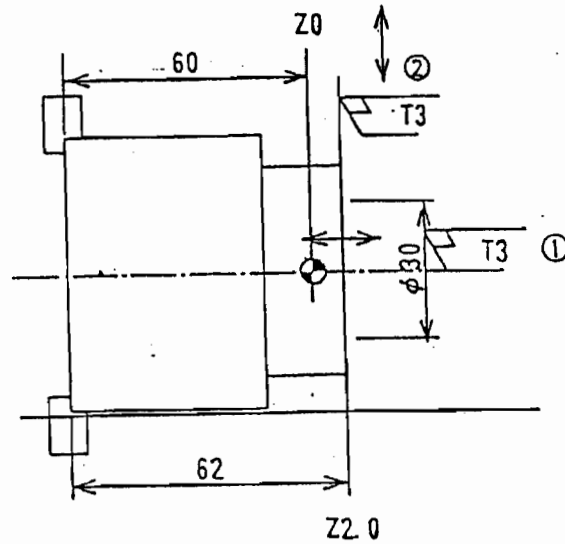
(1) Cut inside diameter face with calibrated base tool No.3, and disengage with X axis not moving.

Stop spindle and conduct inside diameter value test.

Move cursor on Operation Sequence (5) screen to call out Offset number.

Input X30.0, press soft key—Test.

Under Auto Coordinates setting, display offset to X movement of pre-set coordinates.

(2) Drift cutting end face with parts coordinates, conduct test with No.3 tool.

Do not move Z axis.

Always call out offset number with cursor.

First input Z2.0, then press soft key—Test.

Input offset volume displayed by Z movement of base tool No.1.

3. Inside tool B
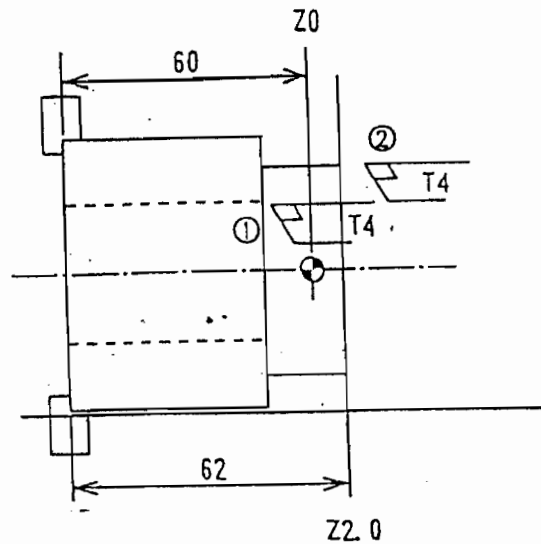
(1) Cut inside diameter face with inside diameter tool, and use No.4 tool to conduct
test.

Do not move X axis.

Move cursor to call out offset number.

Input X30.0, press soft key—|Test.|

Under Auto Coordinates setting, display offset to X movement of pre-set
coordinates.

(2) Drift cutting end face with parts coordinates, conduct test with No.4 tool.

Do not move Z axis.

Always call out offset number with cursor.

First input Z2.0, then press soft key—|Test.|

Offset value to Z movement of base tool No.1 is now displaying.

9. List of Cutting Speed

9-1 List of Cutting Speed
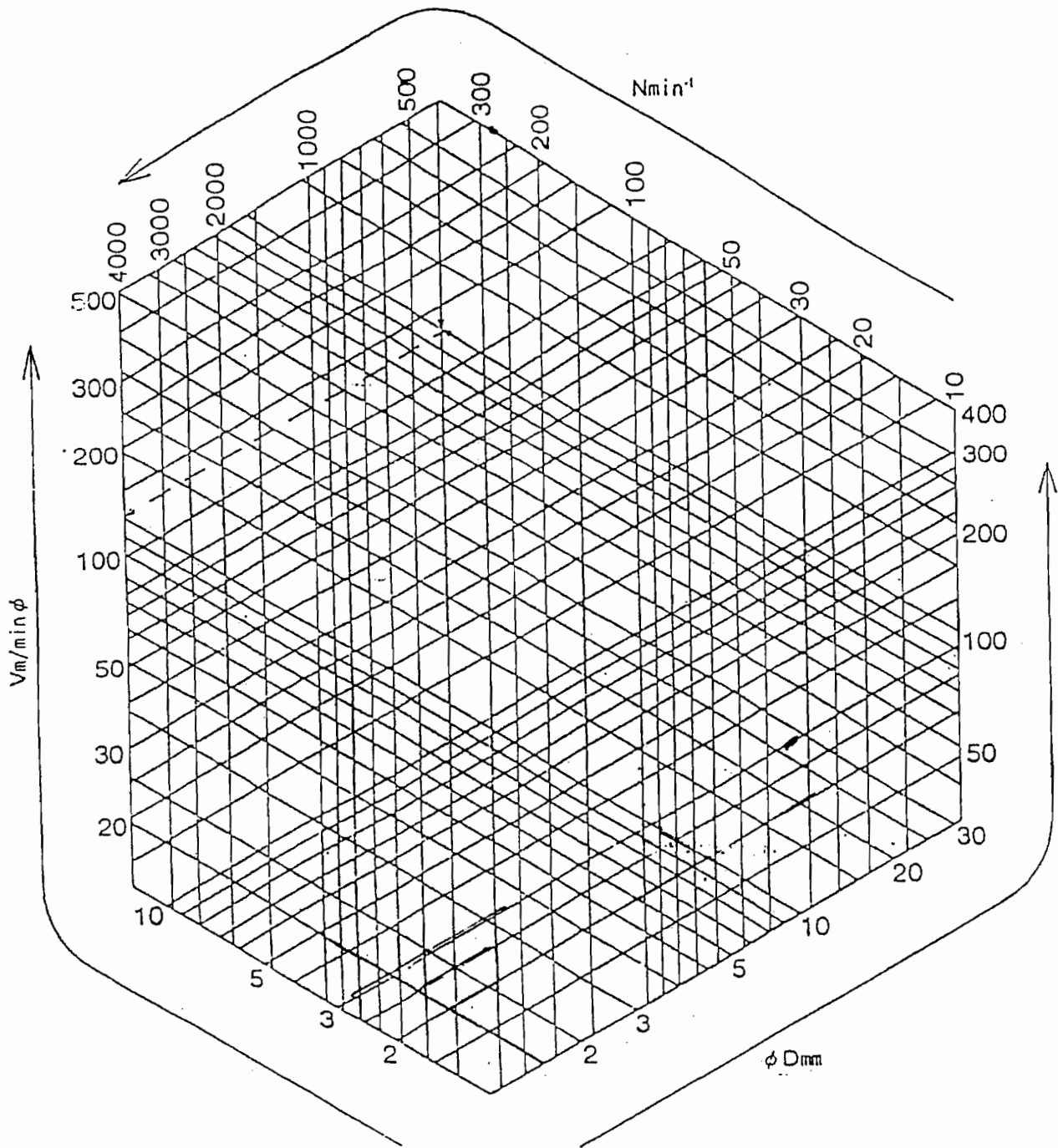
$$V = \frac{\pi \cdot D \cdot N}{1000}$$

V = Cutting speed   m/min

D = Workpiece diameter   m/min

N = Revolution speed   min⁻¹

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9-2 Standard Cutting Conditions for Tungsten Carbide Tool

Material Name	Material Mark	Feed: 0.2~0.5mm/rev		Feed: 0.05~0.2mm/rev	
		Cutting Speed Vm/min	cutting tool	Cutting Speed Vm/min	Cutting tool
Carbon steel for mechanical structure	S20C ~ 30C	140 ~ 180	P20	150 ~ 230	P10
	S35C ~ 45C	100 ~ 140		120 ~ 190	
	S50C	70 ~ 100		80 ~ 140	
Polished steel bar	S20CD ~ S50CD	70 ~ 100		80 ~ 140	
Steel alloys	SNC1 ~ SNC3	70 ~ 100	P10	80 ~ 140	M10
Stainless steel	SUS24	60 ~ 100	M10	80 ~ 140	
	SUS27 ~ SUS33	40 ~ 70	M20	80 ~ 140	
Heat-resistance steel	SEH1 ~ SEH5	40 ~ 70	P40	70 ~ 100	
Forged carbon steel	SF40 ~ SF50	140 ~ 180	P20	150 ~ 230	P10
	SF55 ~ SF60	100 ~ 140	P30	120 ~ 190	
Cast steel	SC42 ~ SC49	100 ~ 120	P20	120 ~ 180	P10
Cast steel alloys	SCA1 ~ SCA23	60 ~ 100		70 ~ 120	
	SCA31	50 ~ 80		70 ~ 100	
	SCA41 ~ SCA52	60 ~ 100		70 ~ 120	
Stainless cast steel	SCS1 ~ SCS15	50 ~ 80	M20	70 ~ 140	M20
Heat-resistance cast steel	SCH1 ~ SCH2	60 ~ 90		70 ~ 120	
	SCH11 ~ SCH13	50 ~ 80		60 ~ 100	

Material Name	Material Mark	Feed: 0.2~0.5mm/rev		Feed: 0.05~0.2mm/rev	
		Cutting Speed Vm/min	cutting tool	Cutting Speed Vm/min	Cutting tool
Gray cast iron	FC20	70 ~ 110	K10	80 ~ 130	K10
	FC25 ~ FC30	60 ~ 100		80 ~ 130	
Bronze castings	BC2 ~ BC7	100 ~ 200		200 ~ 350	
Aluminum	AC3A ~ F	200 ~ 400		300 ~ 500	
Alloy castings	AC4A-F-AC7B-T4	800 ~ 900		800 ~ 1200	
Synthetic leather, Wood		300 ~ 600	K10 K20	350 ~ 600	K10 K20

9-3 Standards of Drill Head Cutting Speed

Material		Cutting Speed (m/min)	Material	Cutting Speed (m/min)
Carbon steel	below 0.4C	24 ~ 33	Aluminum; Aluminum alloys	60 ~ 90
	0.4C ~ 0.7C	18 ~ 24	Bronze with average	45 ~ 75
	above 0.7C	12 ~ 18	tension-resistance	22.5 ~ 45
Steel alloys	$60kg/mm^2$	15 ~ 18	Mg; Mg alloys	60 ~ 120
	$60 \sim 80kg/mm^2$	9 ~ 15	Rapid cutting metals	9 ~ 15
	$80kg/mm^2$	5 ~ 9	Nickel steel	9 ~ 15
Stainless steel	マルテンサイト	10 ~ 20	Zinc alloys	45 ~ 80
	フエライト	15 ~ 18	Brass	45 ~ 90
	オーステナイト	5 ~ 15	Gold	60 ~ 75
Manganese steel	12 ~ 14%	3.5 ~ 4.5	Cutting steel	8 ~ 22
Plastics		30 ~ 90	Cast alloys	6 ~ 9

9-4 Feed Standard for Drill Head Cutting

Drill head diameter	Feed (mm/rev)	
	General steel	Stainless steel
1.6 ~ 3	0.05 ~ 0.06	0.05 ~ 0.08
3 ~ 4	0.05 ~ 0.1	0.06 ~ 0.15
4 ~ 5.5	0.08 ~ 0.15	0.1 ~ 0.23
5.5 ~ 8	0.1 ~ 0.2	0.13 ~ 0.3
8 ~ 11	0.15 ~ 0.25	0.19 ~ 0.35
11 ~ 14.5	0.2 ~ 0.3	0.25 ~ 0.45
14.5 ~ 17.5	0.23 ~ 0.33	0.28 ~ 0.6
17.5 ~ 20.5	0.25 ~ 0.36	0.31 ~ 0.53
20.5 ~ 24	0.28 ~ 0.38	0.34 ~ 0.56
24 ~ 28.5	0.3 ~ 0.4	0.38 ~ 0.6
28.5 ~ 38	0.35 ~ 0.45	0.44 ~ 0.68
38 以上	0.4 ~ 0.5	0.5 ~ 0.7

10. Program Examples
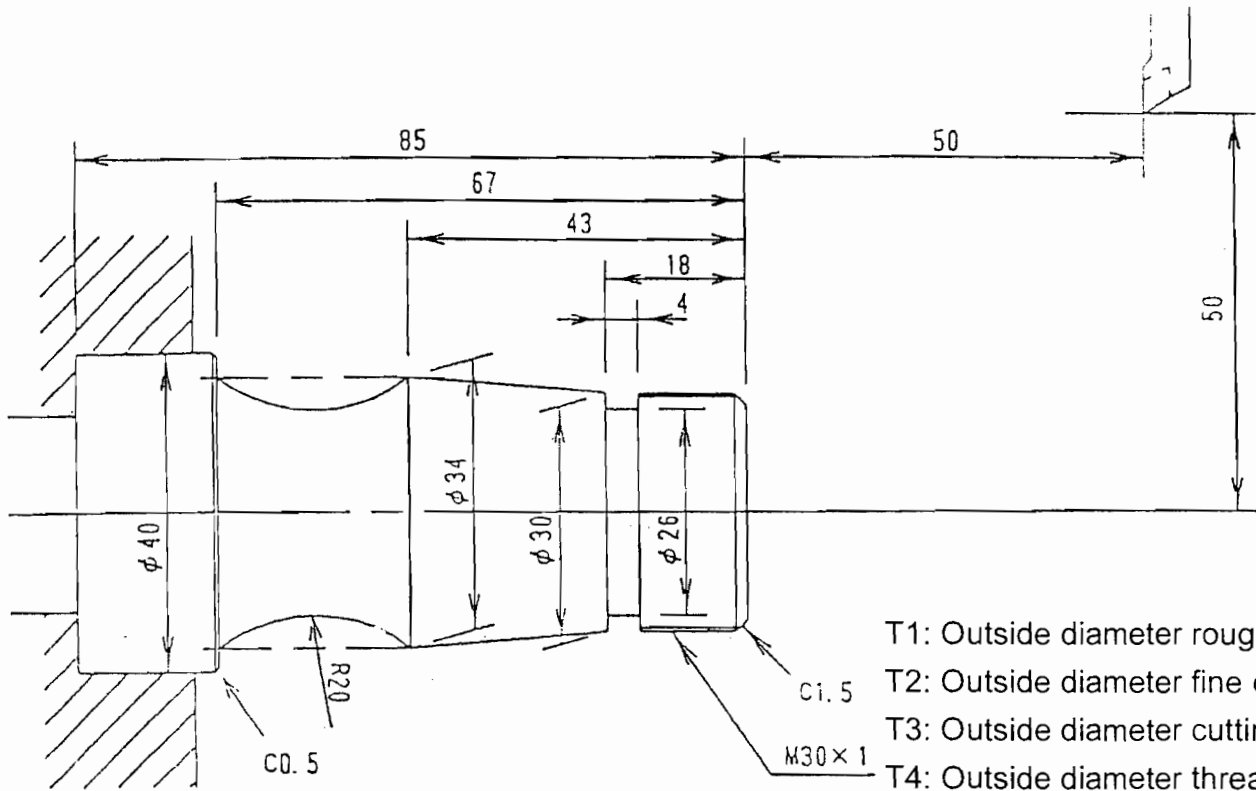
T1: Outside diameter rough cutting
T2: Outside diameter fine cutting
T3: Outside diameter cutting slot
T4: Outside diameter threading
Material: S45C

No.1	G00	X100.0 Z50.0 ;
	G50	S1800 ;
	G96	S140 M03 T0101 ;
		X35.0 Z2.0 T01 M08 ;
	G01	Z-66.9 F0.4 ;
		X44.0 ;
	G00	Z2.0 ;
		X23.5 ;
	G01	X30.5 Z-1.5 ;
		Z-18.0 ;
		X34.5 Z-43.0 ;
	G02	X33.751 Z-66.9 R20.0 ;
	G01	X44.0 ;
	G00	X100.0 Z50.0 T00 ;
		M01 ;

No.2   G00   X100.0   Z50.0 ;
       G96   S200   M03   T0202 ;
             X23.0   Z2.0 ;
       G01   X30.0   Z-1.5   F0.15 ;
                     Z-18.0 ;
             X34.0   Z-43.0   F01 ;
       G02   X34.0   Z-67.0   R20.0 ;
       G01   X39.0 ;
             X41.0   Z-68.0 ;
             X44.0 ;
       G00   X100.0   Z50.0   T00 ;
                     M01 ;

No.3   G00   X100.0   Z50.0 ;
       G96   S130   M03   T0303 ;
             X34.0   Z-18.0 ;
       G01   X26.0   F0.08 ;
       G04   U0.1 ;
       G01   X34.0   F0.5 ;
       G00   X100.0   Z50.0   T00 ;
                     M0 ; 1
No.4   G00   X100.0   Z50.0 ;
       G97   S1300   M03   T0404 ;
             40.0   Z2.0 ;
       G92   X29.4   Z-16.0   F1.0 ;
             X29.0 ;
             X28.8 ;
             X28.7 ;
       G00   X100.0   Z50.0   T00   M09 ;
                                 M05 ;
                                 M30 ;

Note: Conduct parts drift setting with auto coordinates when G50 is replaced by G00.

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11. Appendix

11-1 Feed Volume and Feed Times of Threading

Example of male thread
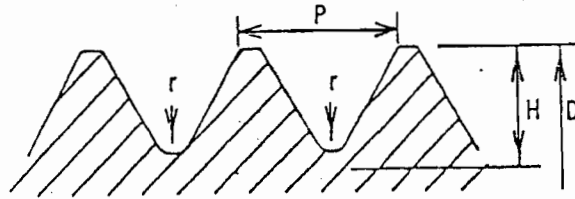
P: Thread pitch
D: Outside diameter
H: Thread height
r: Fillet at thread bottom

Metric system

P		1.00	1.25	1.50	1.75	2.00	2.50	3.00	3.50	4.00
H		0.65	0.81	0.97	1.13	1.30	1.62	1.95	2.27	2.60
r		0.11	0.14	0.16	0.19	0.22	0.27	0.33	0.38	0.43
Cutting times and feed volume	1	0.30	0.30	0.35	0.40	0.40	0.40	0.40	0.40	0.40
	2	0.20	0.20	0.20	0.25	0.15	0.30	0.30	0.30	0.30
	3	0.10	0.20	0.20	0.25	0.25	0.25	0.25	0.25	0.30
	4	0.05	0.06	0.10	0.10	0.20	0.25	0.25	0.25	0.25
	5		0.05	0.07	0.08	0.10	0.15	0.25	0.25	0.25
	6			0.05	0.05	0.05	0.15	0.20	0.20	0.25
	7					0.05	0.07	0.10	0.20	0.25
	8						0.05	0.10	0.15	0.20
	9							0.05	0.15	0.20
	10							0.05	0.07	0.10
	11								0.05	0.05
	12									0.05

Whitworth thread

Thread number		24	20	18	16	14	12	10	8	6
P		1.058	1.270	1.411	1.588	1.814	2.117	2.540	3.175	4.233
H		0.68	0.81	0.90	1.02	1.16	1.36	1.63	2.03	2.71
r		0.15	0.17	0.19	0.22	0.25	0.29	0.35	0.44	0.58
Cutting times and feed volume	1	0.30	0.30	0.35	0.35	0.40	0.40	0.40	0.40	0.40
	2	0.20	0.20	0.20	0.25	0.25	0.25	0.30	0.30	0.30
	3	0.10	0.20	0.20	0.20	0.25	0.25	0.25	0.25	0.30
	4	0.08	0.06	0.10	0.10	0.10	0.20	0.25	0.25	0.25
	5		0.05	0.05	0.07	0.10	0.15	0.15	0.25	0.25
	6				0.05	0.06	0.06	0.15	0.20	0.25
	7						0.05	0.08	0.15	0.25
	8							0.05	0.10	0.20
	9								0.08	0.20
	10								0.05	0.10
	11									0.10
	12									0.06
	13									0.05

11-2 Error Caused by Nose Radius (R) of Tool
(Arc Cutting)

Setting position
of cutting tool

Fillet cutting with tool nose set as shown in right Figure
usually causes the same error.

To execute actual cutting path and the sizes specified
in the drawing, please follow the procedures below:
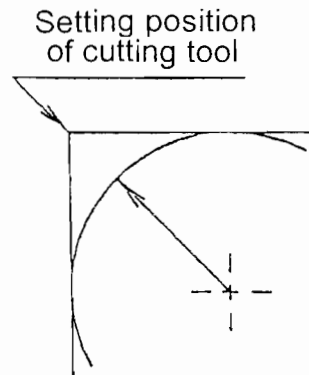
(1) Inside cutting

Programmed arc radius(R) = arc radius (R') specified in the drawing − nose
radius (r)

(2) Outside cutting

Programmed arc radius(R) = arc radius (R') specified in the drawing + nose
radius (r)

Program path

Cutting path

$R+r=R'$

$R-r=R'$
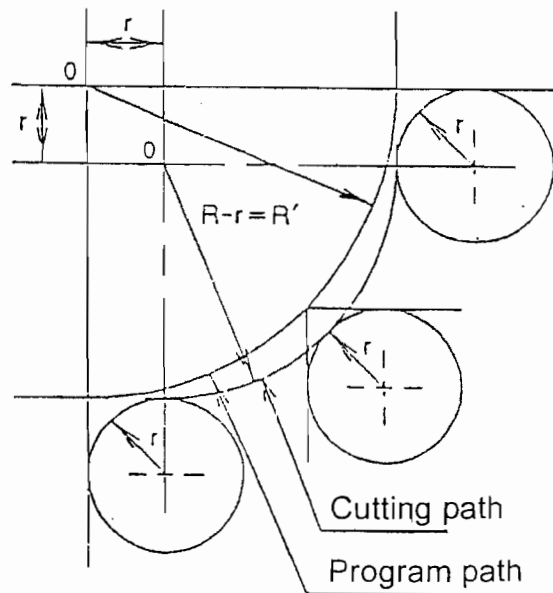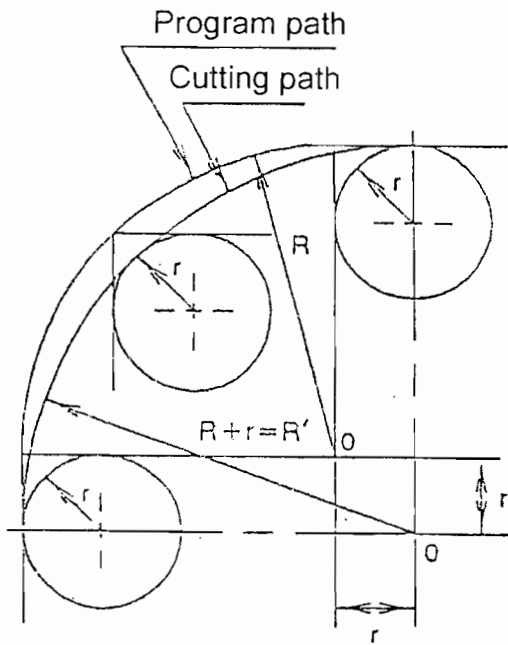
(1) Inside cutting

$$R + r = R'$$

$$R = R' - r$$

(2) Outside cutting

$$R - r = R'$$

$$R = R' + r$$

Cutting path

Program path

$11-3$

11-3 List of Nose Radius (R) Correction

Application of the list should be based on min. setting unit of the machine.

							List	1-1
θ	R	0.2	0.4	0.5	0.6	0.8	1.0	1.2
1°	X	.0035	.0069	.0087	.0104	.0138	.0173	.0208
	Z	.1983	.3965	.4956	.5948	.7930	.9913	1.1895
1° 30′	X	.0052	.0103	.0129	.0155	.0207	.0258	.0310
	Z	.1974	.3948	.4935	.5921	.7895	.9868	1.1843
2°	X	.0069	.0137	.0172	.0206	.0274	.0343	.0412
	Z	.1965	.3930	.4913	.5895	.7860	.9825	1.1791
2° 30′	X	.0085	.0171	.0214	.0256	.0342	.0427	.0512
	Z	.1956	.3913	.4891	.5869	.7825	.9782	1.1738
3°	X	.0102	.0204	.0255	.0306	.0408	.0510	.0612
	Z	.1948	.3895	.4869	.5843	.7791	.9738	1.1686
3° 30′	X	.0119	.0237	.0296	.0356	.0474	.0593	.0712
	Z	.1939	.3878	.4847	.5817	.7756	.9694	1.1633
4°	X	.0135	.0270	.0337	.0405	.0540	.0675	.0810
	Z	.1930	.3860	.4825	.5790	.7721	.9651	1.1581
4° 30′	X	.0151	.0302	.0378	.0454	.0605	.0756	.0907
	Z	.1921	.3843	.4804	.5764	.7686	.9607	1.1529
5°	X	.0167	.0335	.0418	.0502	.0669	.0837	.1004
	Z	.1913	.3825	.4782	.5738	.7651	.9222	1.1476
5° 30′	X	.0183	.0367	.0458	.0550	.0733	.0917	.1100
	Z	.1904	.3808	.4760	.5712	.7616	.9520	1.1424
6°	X	.0199	.0398	.0498	.0598	.0797	.0996	.1195
	Z	.1895	.3790	.4738	.5686	.7581	.9476	1.1371
6° 30′	X	.0215	.0430	.0537	.0645	.0860	.1075	.1290
	Z	.1886	.3773	.4716	.5659	.7546	.9432	1.1319
7°	X	.0231	.0461	.0576	.0692	.0922	.1153	.1383
	Z	.1878	.3755	.4694	.5633	.7511	.9388	1.1266
7° 30′	X	.0246	.0492	.0615	.0738	.0984	.1230	.1476
	Z	.1869	.3738	.4672	.5607	.7476	.9345	1.1213

θ \ R		0.2	0.4	0.5	0.6	0.8	1.0	1.2
8°	X	.0261	.0523	.0654	.0784	.1046	.1307	.1569
	Z	.1860	.3720	.4650	.5580	.7441	.9301	1.1161
8° 30′	X	.0277	.0553	.0692	.0830	.1107	.1383	.1660
	Z	.1851	.3703	.4628	.5554	.7405	.9257	1.1108
9°	X	.0292	.0584	.0730	.0876	.1167	.1459	.1751
	Z	.1843	.3685	.4606	.5528	.7370	.9213	1.1056
9° 30′	X	.0307	.0614	.0767	.0921	.1227	.1534	.1841
	Z	.1834	.3668	.4585	.5501	.7335	.9169	1.1003
10°	X	.0322	.0644	.0805	.0965	.1287	.1609	.1931
	Z	.1825	.3650	.4563	.5475	.7300	.9125	1.0950
10° 30′	X	.0337	.0673	.0842	.1010	.1346	.1683	.2020
	Z	.1816	.3632	.4541	.5449	.7265	.9081	1.0897
11°	X	.0351	.0703	.0878	.1054	.1405	.1757	.2108
	Z	.1807	.3615	.4519	.5422	.7230	.9037	1.0845
11° 30′	X	.0366	.0732	.0915	.1098	.1464	.1830	.2196
	Z	.1799	.3597	.4497	.5396	.7194	.8993	1.0792
12°	X	.0380	.0761	.0951	.1141	.1522	.1902	.2283
	Z	.1790	.3580	.4474	.5369	.7159	.8949	1.0739
12° 30′	X	.0395	.0790	.0987	.1184	.1579	.1974	.2369
	Z	.1781	.3562	.4452	.5343	.7124	.8905	1.0686
13°	X	.0409	.0818	.1023	.1227	.1637	.2046	.2455
	Z	.1772	.3544	.4430	.5316	.7089	.8861	1.0633
13° 30′	X	.0423	.0847	.1058	.1270	.1693	.2117	.2540
	Z	.1763	.3527	.4408	.5290	.7053	.8816	1.0580
14°	X	.0437	.0875	.1094	.1312	.1750	.2187	.2625
	Z	.1754	.3509	.4386	.5263	.7018	.8772	1.0527
14° 30′	X	.0451	.0903	.1129	.1354	.1806	.2257	.2709
	Z	.1746	.3491	.4364	.5237	.6982	.8728	1.0473
15°	X	.0465	.0931	.1163	.1396	.1861	.2327	.2792
	Z	.1737	.3473	.4342	.5210	.6947	.8683	1.0420
15° 30′	X	.0479	.0958	.1198	.1437	.1917	.2396	.2875
	Z	.1728	.3456	.4320	.5183	.6911	.8639	1.0367

θ \ R		0.2	0.4	0.5	0.6	0.8	1.0	1.2
16°	X	.0493	.0986	.1232	.1479	.1972	.2464	.2957
	Z	.1719	.3438	.4297	.5157	.6876	.8595	1.0314
16° 30′	X	.0507	.1013	.1266	.1520	.2026	.2533	.3039
	Z	.1710	.3420	.4275	.5130	.6840	.8550	1.0260
17°	X	.0520	.1040	.1300	.1560	.2080	.2600	.3120
	Z	.1701	.3402	.4253	.5103	.6804	.8505	1.0207
17° 30′	X	.0534	.1067	.1334	.1601	.2134	.2668	.3201
	Z	.1692	.3384	.4230	.5077	.6769	.8461	1.0153
18°	X	.0547	.1094	.1367	.1641	.2188	.2735	.3281
	Z	.1683	.3366	.4208	.5050	.6733	.8416	1.0099
18° 30′	X	.0560	.1120	.1401	.1681	.2241	.2801	.3361
	Z	.1674	.3349	.4186	.5023	.6697	.8371	1.0046
19°	X	.0573	.1147	.1434	.1720	.2294	.2867	.3440
	Z	.1665	.3331	.4163	.4996	.6661	.8327	.9992
19° 30′	X	.0587	.1173	.1466	.1760	.2346	.2933	.3519
	Z	.1656	.3313	.4141	.4969	.6625	.8282	.9938
20°	X	.0600	.1199	.1499	.1799	.2398	.2998	.3598
	Z	.1647	.3295	.4118	.4942	.6589	.8237	.9884
20° 30′	X	.0613	.1225	.1531	.1838	.2450	.3063	.3675
	Z	.1638	.3277	.4096	.4915	.6553	.8192	.9830
21°	X	.0625	.1251	.1564	.1876	.2502	.3127	.3753
	Z	.1629	.3259	.4073	.4888	.6517	.8147	.9776
21° 30′	X	.0638	.1276	.1596	.1915	.2553	.3191	.3829
	Z	.1620	.3241	.4051	.4861	.6481	.8101	.9722
22°	X	.0651	.1302	.1627	.1953	.2604	.3255	.3906
	Z	.1611	.3222	.4028	.4834	.6445	.8056	.9667
22° 30′	X	.0664	.1327	.1659	.1991	.2655	.3318	.3982
	Z	.1602	.3204	.4005	.4807	.6409	.8011	.9613
23°	X	.0676	.1352	.1691	.2029	.2705	.3381	.4057
	Z	.1593	.3186	.3983	.4779	.6372	.7965	.9559
23° 30′	X	.0689	.1377	.1722	.2066	.2755	.3444	.4132
	Z	.1584	.3168	.3960	.4752	.6336	.7920	.9504

θ \ R		0.2	0.4	0.5	0.6	0.8	1.0	1.2
24°	X	.0701	.1402	.1753	.2104	.2805	.3506	.4207
	Z	.1575	.3150	.3937	.4725	.6300	.7874	.9449
24° 30′	X	.0714	.1427	.1784	.2141	.2854	.3568	.4281
	Z	.1566	.3132	.3914	.4697	.6263	.7829	.9395
25°	X	.0726	.1452	.1815	.2178	.2903	.3629	.4355
	Z	.1557	.3113	.3892	.4670	.6226	.7783	.9230
25° 30′	X	.0738	.1476	.1845	.2214	.2952	.3690	.4429
	Z	.1547	.3095	.3869	.4642	.6190	.7737	.9285
26°	X	.0750	.1501	.1876	.2251	.3001	.3751	.4502
	Z	.1538	.3077	.3846	.4615	.6153	.7691	.9230
26° 30′	X	.0762	.1525	.1906	.2287	.3049	.3812	.4574
	Z	.1529	.3058	.3823	.4587	.6116	.7645	.9174
27°	X	.0774	.1549	.1936	.2323	.3098	.3872	.4646
	Z	.1520	.3040	.3800	.4560	.6079	.7599	.9119
27° 30′	X	.0786	.1573	.1966	.2359	.3145	.3932	.4718
	Z	.1511	.3021	.3777	.4532	.6042	.7553	.9064
28°	X	.0798	.1597	.1996	.2395	.3193	.3991	.4790
	Z	.1501	.3003	.3753	.4504	.6005	.7507	.9008
28° 30′	X	.0810	.1620	.2025	.2430	.3240	.4051	.4861
	Z	.1492	.2984	.3730	.4476	.5968	.7460	.8952
29°	X	.0822	.1644	.2055	.2466	.3288	.4110	.4931
	Z	.1483	.2966	.3707	.4448	.5931	.7414	.8897
29° 30′	X	.0834	.1667	.2084	.2501	.3335	.4168	.5002
	Z	.1473	.2947	.3684	.4420	.5894	.7367	.8841
30°	X	.0845	.1691	.2113	.2536	.3381	.4226	.5072
	Z	.1464	.2928	.3660	.4392	.5856	.7321	.8785
30° 30′	X	.0857	.1714	.2142	.2571	.3428	.4285	.5141
	Z	.1455	.2909	.3637	.4364	.5819	.7274	.8728
31°	X	.0868	.1737	.2171	.2605	.3474	.4342	.5211
	Z	.1445	.2891	.3613	.4336	.5781	.7227	.8672
31° 30′	X	.0880	.1760	.2200	.2640	.3520	.4400	.5280
	Z	.1436	.2872	.3590	.4308	.5744	.7180	.8616

θ \ R		0.2	0.4	0.5	0.6	0.8	1.0	1.2
32°	X	.0891	.1783	.2228	.2674	.3566	.4457	.5348
	Z	.1427	.2853	.3566	.4280	.5706	.7133	.8559
32° 30′	X	.0903	.1806	.2257	.2708	.3611	.4514	.5417
	Z	.1417	.2834	.3543	.4251	.5668	.7085	.8502
33°	X	.0914	.1828	.2285	.2742	.3656	.4570	.5485
	Z	.1408	.2815	.3519	.4223	.5630	.7038	.8445
33° 30′	X	.0925	.1851	.2313	.2776	.3701	.4627	.5552
	Z	.1398	.2796	.3495	.4194	.5592	.6990	.8388
34°	X	.0937	.1873	.2341	.2810	.3746	.4683	.5619
	Z	.1389	.2777	.3471	.4166	.5554	.6943	.8331
34° 30′	X	.0948	.2895	.2369	.2843	.3791	.4739	.5686
	Z	.1379	.2758	.3447	.4137	.5516	.6895	.8274
35°	X	.0959	.1918	.2397	.2877	.3835	.4794	.5753
	Z	.1369	.2739	.3424	.4108	.5478	.6847	.8216
35° 30′	X	.0970	.1940	.2425	.2910	.3880	.4850	.5820
	Z	.1360	.2720	.3399	.4079	.5439	.6799	.8159
36°	X	.0981	.1962	.2452	.2943	.3924	.4905	.5886
	Z	.1350	.2700	.3375	.4050	.5401	.6751	.8101
36° 30′	X	.0992	.1984	.2480	.2976	.3968	.4960	.5952
	Z	.1340	.2681	.3351	.4021	.5362	.6702	.8043
37°	X	.1003	.2006	.2507	.3009	.4011	.5014	.6017
	Z	.1331	.2662	.3327	.3992	.5323	.6654	.7985
37° 30′	X	.1014	.2027	.2534	.3041	.4055	.5069	.6082
	Z	.1321	.2642	.3303	.3963	.5284	.6605	.7927
38°	X	.1025	.2049	.2561	.3074	.4098	.5123	.6147
	Z	.1311	.2623	.3278	.3934	.5245	.6557	.7868
38° 30′	X	.1035	.2071	.2588	.3106	.4141	.5177	.6212
	Z	.1302	.2603	.3254	.3905	.5206	.6508	.7809
39°	X	.1046	.2092	.2615	.3138	.4184	.5230	.6276
	Z	.1292	.2584	.3229	.3875	.5167	.6459	.7751
39° 30′	X	.1057	.2113	.2642	.3170	.4227	.5284	.6340
	Z	.1282	.2564	.3205	.3846	.5128	.6410	.7692

θ \ R		0.2	0.4	0.5	0.6	0.8	1.0	1.2
40°	X	.1067	.2135	.2668	.3202	.4270	.5337	.6404
	Z	.1272	.2544	.3180	.3816	.5088	.6360	.7632
40° 30′	X	.1078	.2156	.2695	.3234	.4312	.5390	.6468
	Z	.1262	.2524	.3155	.3786	.5049	.6311	.6573
41°	X	.1089	.2177	.2721	.3266	.4354	.5443	.6531
	Z	.1252	.2504	.3131	.3757	.5009	.6261	.7513
41° 30′	X	.1099	.2198	.2748	.3297	.4396	.5495	.6594
	Z	.1242	.2485	.3106	.3927	.4969	.6211	.7454
42°	X	.1110	.2219	.2774	.3329	.4438	.5548	.6657
	Z	.1232	.2465	.3081	.3697	.4929	.6161	.7394
42° 30′	X	.1120	.2240	.2800	.3360	.4480	.5600	.6720
	Z	.1222	.2444	.3056	.3667	.4889	.6111	.7333
43°	X	.1130	.2261	.2826	.3391	.4522	.5652	.6782
	Z	.1212	.2424	.3030	.3637	.4849	.6061	.7273
43° 30′	X	.1141	.2281	.3852	.3422	.4563	.5704	.6844
	Z	.1202	.2404	.3005	.3606	.4808	.6010	.7212
44°	X	.1151	.2302	.2878	.3453	.4604	.5755	.6906
	Z	.1192	.2384	.2980	.3576	.4768	.5960	.7152
44° 30′	X	.1161	.2323	.2903	.3504	.4645	.5807	.6968
	Z	.1182	.2364	.2954	.3545	.4727	.5909	.7091
45°	X	.1172	.2343	.2929	.3515	.4686	.5858	.7029
	Z	.1172	.2343	.2929	.3515	.4686	.5858	.7029