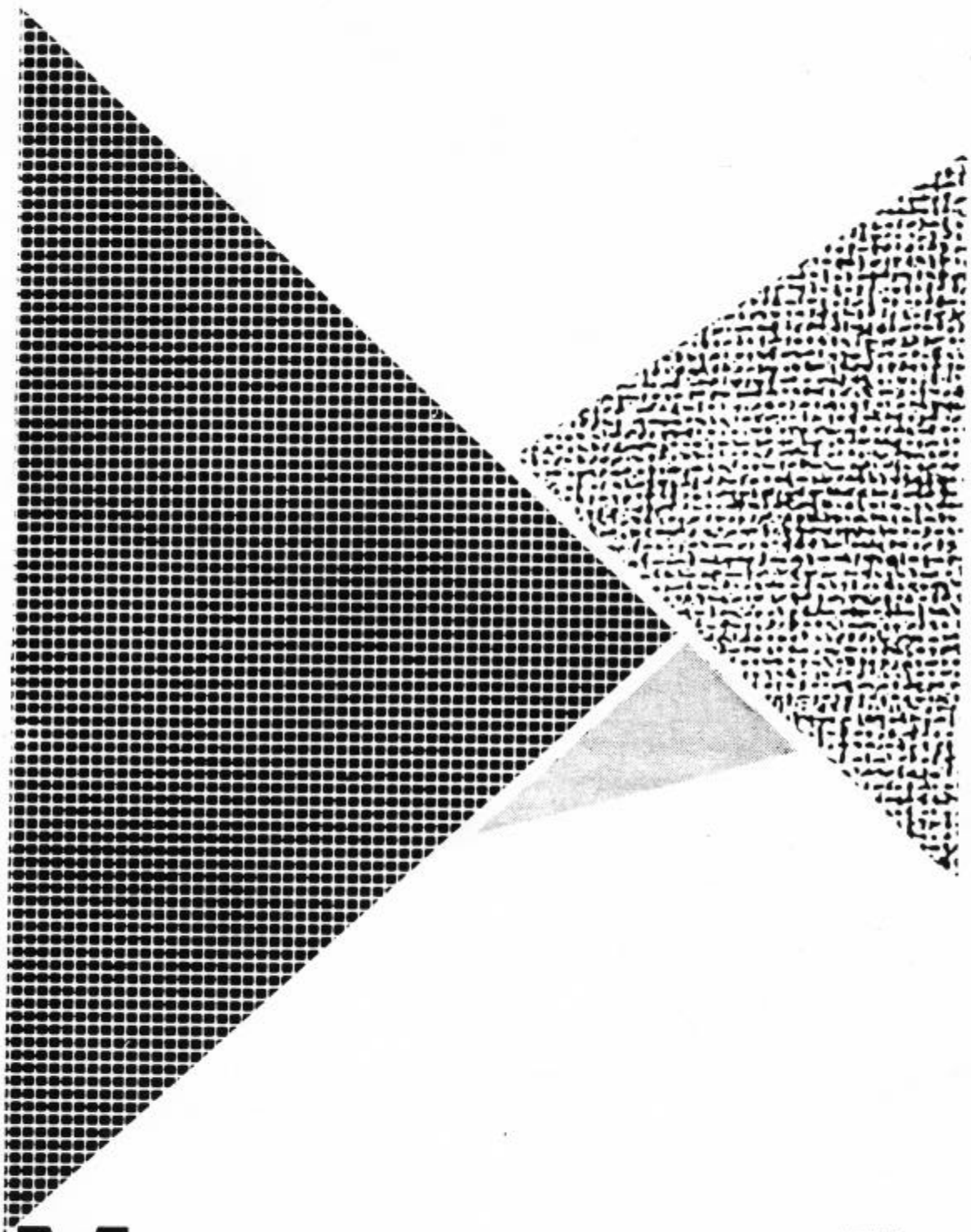
INSTRUCTION MANUAL



Move master II

RM-501 Model

MITSUBISHI ELECTRIC CORPORATION

Introduction

Recently, the Mitsubishi Electric MOVE MASTER II "RM-501" came on the market. The RM-501 is a micro-robot which is being offered to meet the demands for a small, light-weight and entry level industrial robot.
When using this robot, read this Instruction Manual carefully and follow the instructions given.

Caution
Unauthorized publication of whole or part of this manual is prohibited.
The contents of this manual may be changed without notice.
If any errors are found in this manual, please notify us.

Contents

CONSTRUCTION

1.1 ALL TION

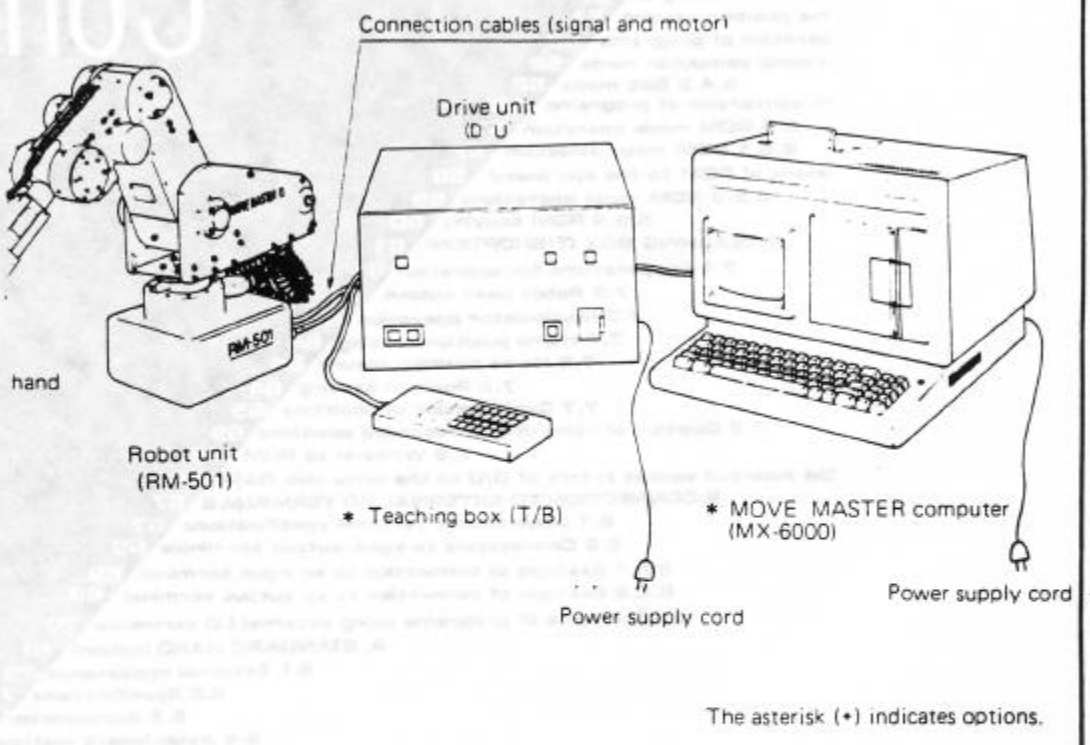
The RM-501 consists of the following main components and options.

1.1.1 MAIN COMPONENTS

(1) Robot unit (RM-501)
(2) Drive unit (DU)
(3) Connection cables (for signals and motor: one 5 m cable each)

1.1.2 OPTIONS

(1) Teaching box (T/B) (with 1.5 m connection cable)
(2) Standard hand
(3) MOVE MASTER computer (MX-6000) (connection cable, power supply cord, 1.5 m each)

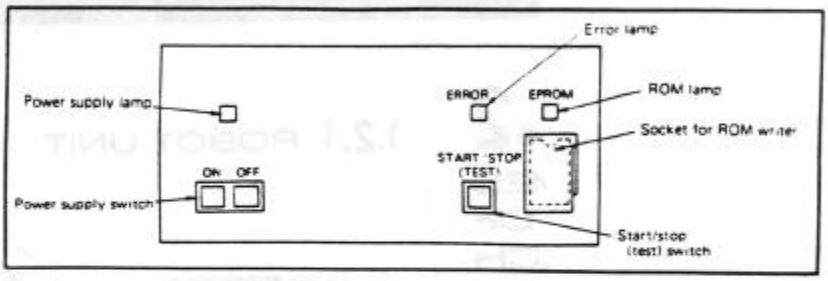


The asterisk (*) indicates options.

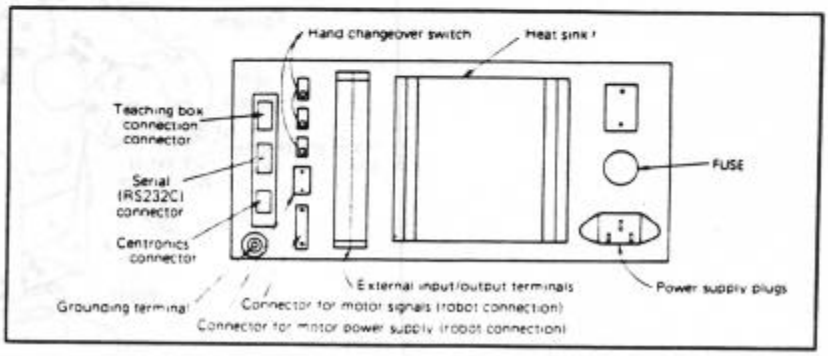
Note: The emergency stop switch must always be provided. For details concerning the emergency stop switch, refer to section 3.5.

1.2.2 DRIVE UNIT

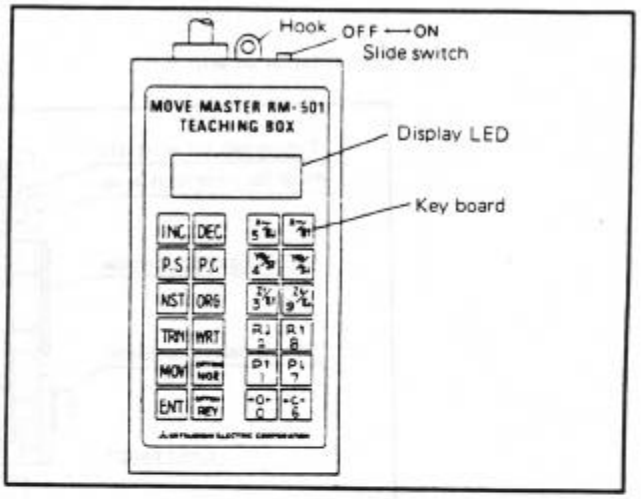
(1) Front



(2) Rear



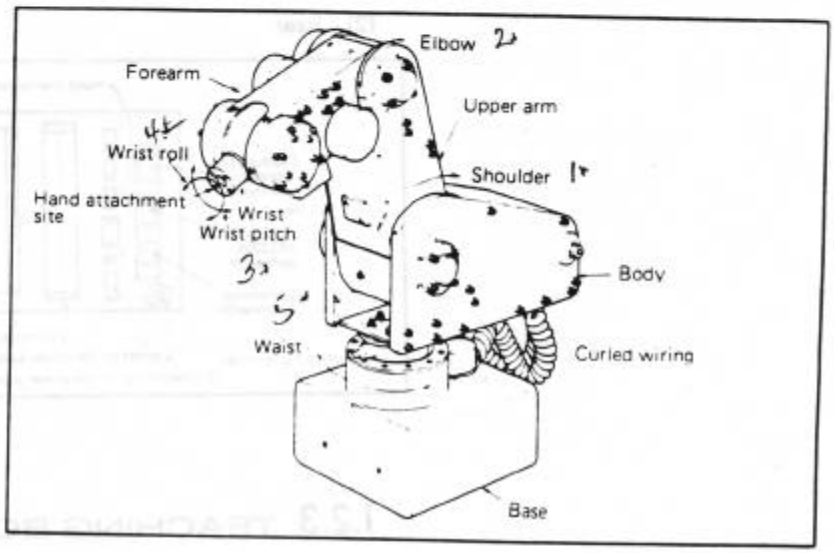
1.2.3 TEACHING BOX (OPTION)



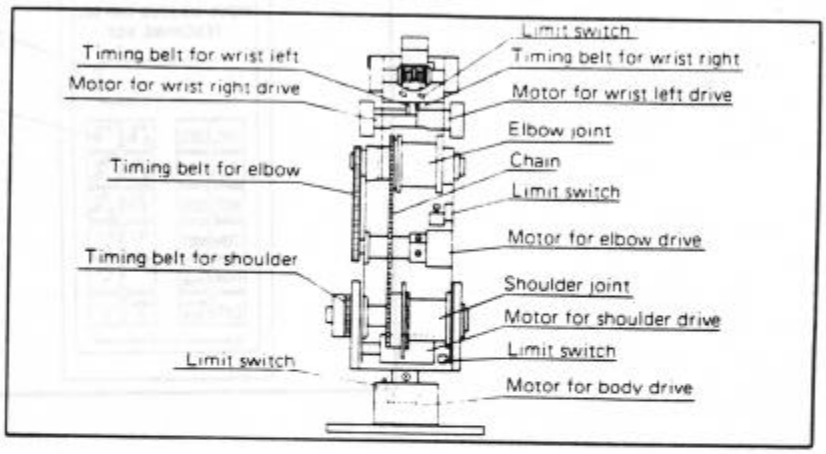
.2 ıES OF .CH ΞNT

1.2.1 ROBOT UNIT

(1) Outer appearance

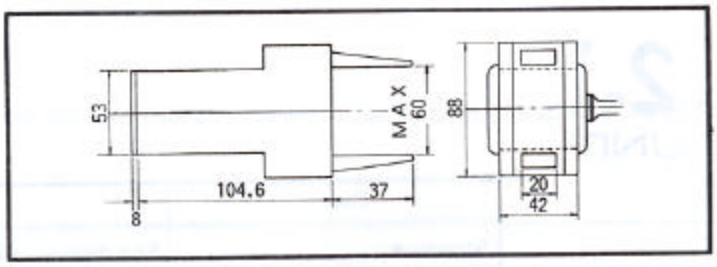


(2) Interior of arm



1.2.4 STANDARD HAND (OPTION)

(1) Outer appearance



(2) Specifications

Motor used	DC servomotor
Rated voltage	DC 24V
Rated output	15W

* For details and attachment of the hand, refer to section 9.

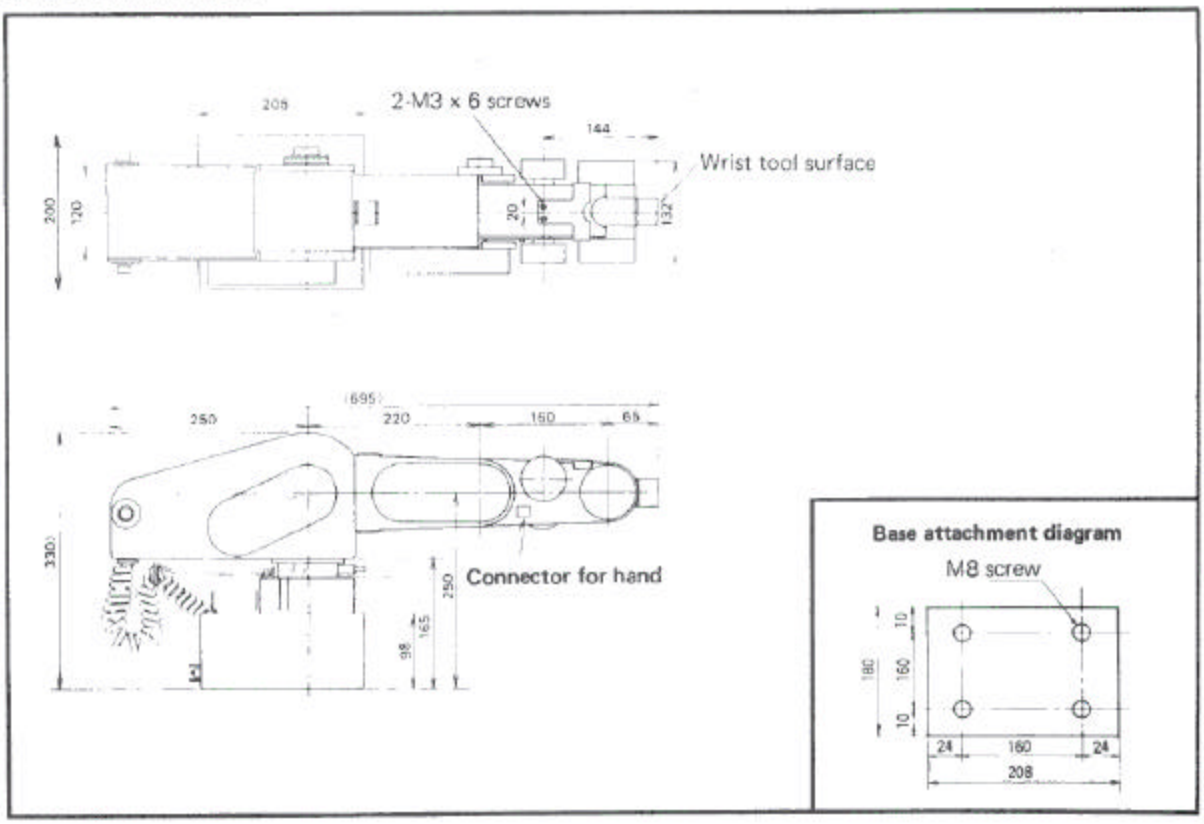
2 SPECIFICATIONS

2.1 ROBOT UNIT

Item		Specification
Structure		Five degrees of freedom Vertical multi-joint type
Range of movement	Waist rotation	300°
	Shoulder rotation	130°
	Elbow rotation	90°
	Wrist pitch	±90°
	Wrist roll	±180°
Permissible handling weight		max. 1.2 kg (includes weight of hand)
Maximum synthesis speed		400 mm/sec (wrist tool surface)
Position repeat accuracy		±0.5 mm (wrist tool surface)
Drive system		Electroservo drive by a DC servomotor
Main unit weight		about 27 kg

Note: The permissible handling weight (1.2 kg) is the value at a point 100 mm from the wrist tool surface.

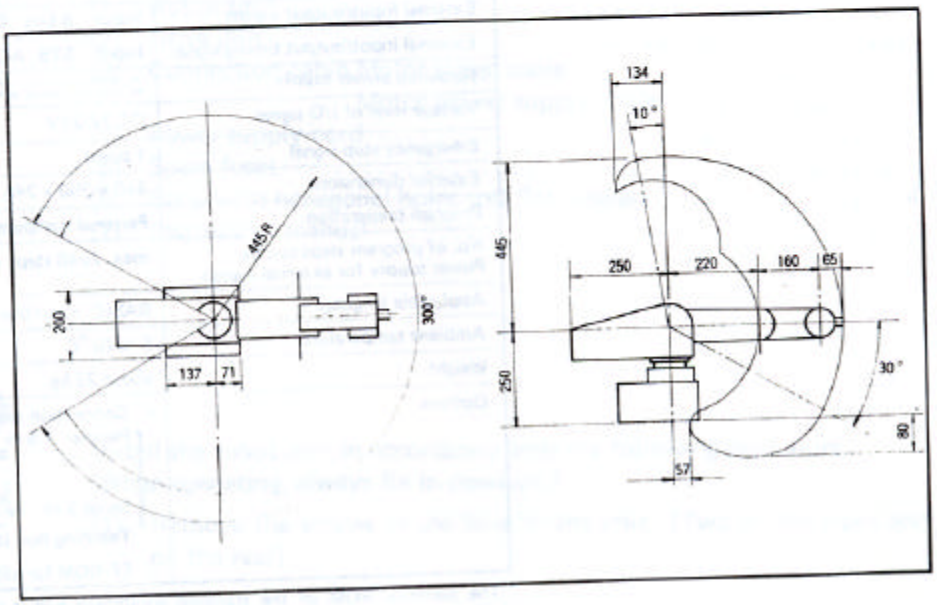
Outer dimension diagram



Base attachment diagram

2.2 RANGE OF MOVEMENTS

The range of movements when the hand is not attached is as follows.



2.3 DRIVE UNIT

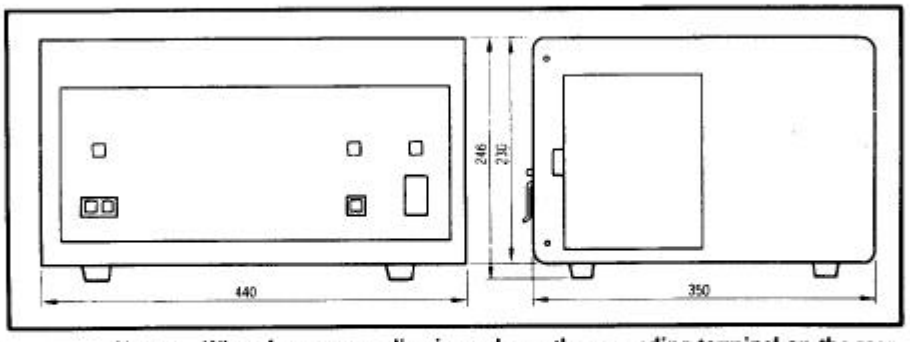
Teaching system	MDI (Manual Data Input) teaching playback
Control system	PTP (Point to Point)
Position detection	Photo encoder
Speed setting	0 ~ 9
No. of position settings	max. 629 points *
Memory	ROM 32kb (System) 8kb (User) RAM 32kb
Origin return function	Yes
Interface	Parallel (centro base) Serial (RS-232c)
External input/output signals	Input 8 bits Output 8 bits
External input/output timing signal	Input STB, ACK Output Busy, RDY
Required power supply	AC 100V (J-Type) AC 115V (A-Type) AC 220V (G-Type) AC 240V (B-Type)
Voltage level of I/O signal	DC 12/24V
Emergency stop signal	1 point
Exterior dimensions	440 x 350 x 246 mm
Program preparation	Personal computer
No. of program steps can be Power supply for external signals	max. 2048 steps *
Applicable language	BASIC, assembler
Ambient temperature	5 ~ 40 °C
Weight	about 23 kg
Options	○ Connection cable with personal computer { Parallel 1.5 m : MX-6000 MULT116 PC8001 Free Cable { Serial 3 m : MX-6000 ○ Teaching box (cable 1.5 m) ○ EP-ROM for expansion

* The memory ROM of the standard equipment had 8 kbytes (4 kbytes program, 4 kbytes position). In the standard equipment, the number of program steps which can be ROM-ized and the number of position settings are as follows:

No. of position settings : 314 points
No. of program steps : 512 steps

(Because the above table is for the full equipment, it is necessary to separately purchase 32 kbits x 4 for a ROM to obtain the above number of steps and number of position settings.)

External dimension diagram



Note: When frame grounding is used, use the grounding terminal on the rear.

3 INSTALLATION AND PREPARATIONS

3.1 CONFIRMATION OF PARTS

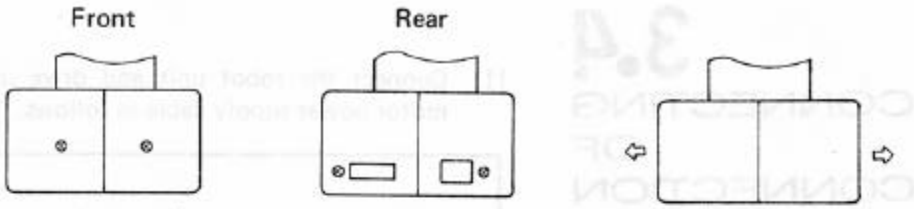
The basic components of the RM-501 which you have purchased are as follows:

(1) Robot unit 1
(2) Drive unit 1
(3) Connection cable Motor signal cable 1
Motor power supply cable 1
(4) Power supply cord 1
(5) Spare fuses 1
(6) Bolts with hexagonal holes and flat washers ..... 4 each
(7) Instruction manual 1

3.2 INSTALLATION OF ROBOT UNIT

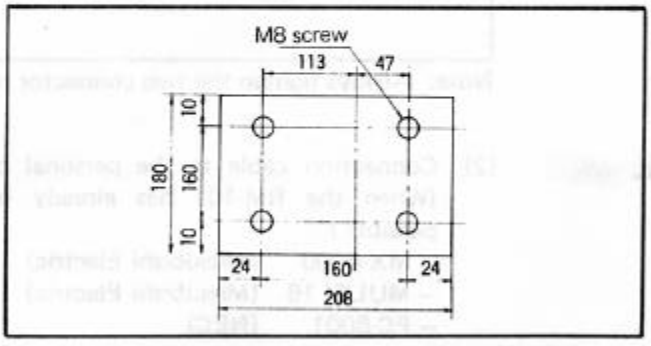
Install the robot unit in accordance with the following procedure.
(When operating, always fix in position.)

(1) Remove the screws in the base of the unit. (Two on the front and two on the rear)



(2) Remove the base cover by pulling the cover to the side.
Since there is wiring by cables, in the base, do not stretch it unnecessarily.

(3) When the cover is removed, the installation dimensions are as follows.



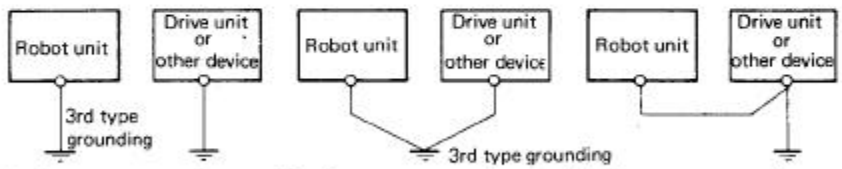
(4) The unevenness of the installation surface must be within 10° of horizontal.

3.3 GROUNDING

(1) If possible, use separate groundings for the robot unit and drive unit (D/U). There is a grounding terminal on the rear of the D/U. Grounding reduces the common mode noise applied between the power supply and input/output wires and the units.

(2) The grounding work is performed by 3rd type grounding (grounding resistance : 100Ω or less). The best is the grounding of each device separate. When separate grounding is not used, use common grounding where the groundings of the devices are connected as shown in (b).

(3) Common grounding with high power devices such as motors must be avoided at all costs. Also avoid grounding points connected to other devices and grounding with iron frames, etc. to prevent electric shocks.



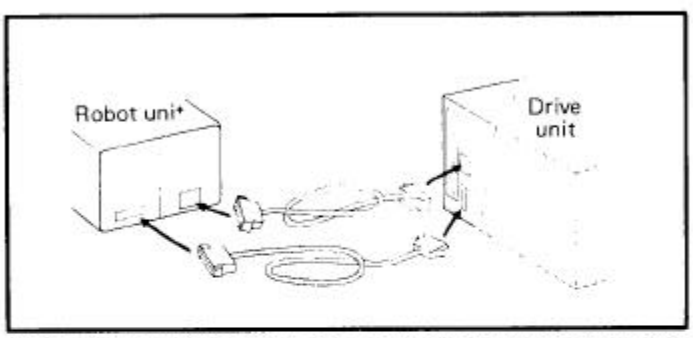
(a) Separate grounding ..... good (b) Common grounding ..... good (c) Common grounding ..... no good

(4) Use at least 2 mm² electric wire for grounding.

(5) The grounding point should be as near as possible to the robot unit and drive unit (D/U). Make the grounding wire as short as possible.

3.4 CONNECTING OF CONNECTION CABLES

(1) Connect the robot unit and drive unit with motor signal cable and motor power supply cable as follows.



Note: Always tighten the two connector screws alternately.

(2) Connection cable to the personal computer is prepared as follows. (When the RM-101 has already been purchased, common use is possible.)

– MX-6000 (Mitsubishi Electric)
– MULTI 16 (Mitsubishi Electric)
– PC-8001 (NEC)

For connection to personal computers other than the above, connector free cable has been prepared and can be purchased separately. (Refer page 10.)

3.5 EMERGENCY STOP SWITCH

The emergency stop switch is installed in a place where it can be operated immediately in a case of emergency. (Always install emergency stop switches for safety.)

(a) As attachment terminals, use the terminal on the rear of the drive unit (D/U) which for emergency display of the external I/O terminals (refer to 3.1).
(b) Remove the short plate provided. (Keep the short plates so that they are not lost.)
(c) Connect the switch normally closed with emergency terminal.
(d) Use wire with a 200V withstand voltage and for at least 10A.
(e) Order the emergency stop switch from Mitsubishi Electric sales agents specifying Mitsubishi OA-MR-1.
Connect between the 1-2 terminals of the switch OA-MR-1.

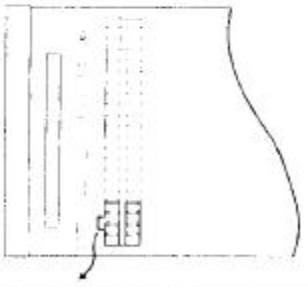
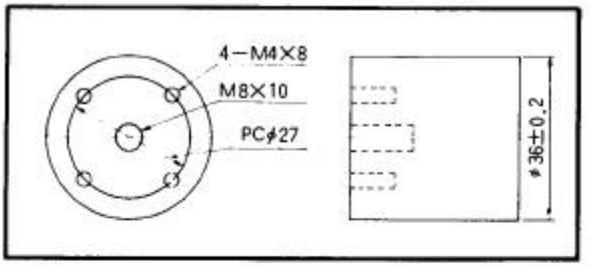


Fig. 3.1 Emergency stop switch terminals (rear of drive unit)

3.6 ATTACHMENT OF HAND

(1) The list part of the robot is as follows.



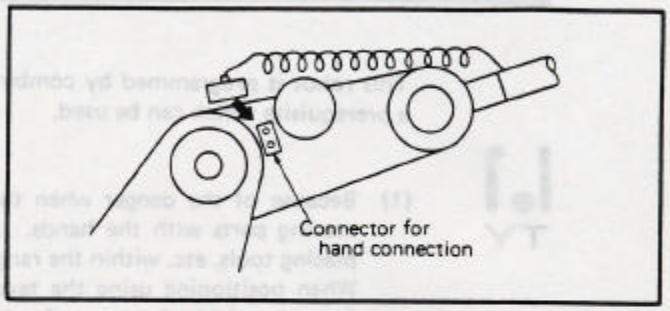
– The hand is attached using 4—M4 x 8 screws. The hand can also be attached using M8 x 10 screws.

* The hand weight arranged by the user should be 1.2 kg or less including the to handle weight.
* The electric type hand arranged by the user should be DC 24V max. 15W

  Solenoid hands are max. AC 100V max. 0.3A when an internal power supply is used and max. AC 200V max. 1A when an external power supply is used.

When air type hands are used, perform opening and closing control of the electromagnetic valve using the hand drive connector pin. In this case, attach the connection wires with the electromagnetic valve so that they are not wrapped around the arm, etc.

(2) Attach the hand as follows.
Fix the manufactured hand in position tightly on the robot wrist part.
(Fix so that there is no eccentricity.)



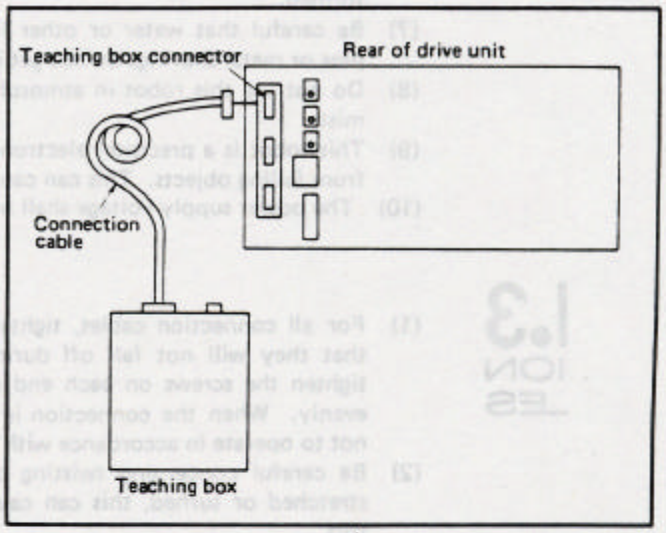
(3) Connect the hand connection terminal to the hand connection connector on the robot unit using the following connectors.

Connection connectors

Manufacturers name	Nihon AMP	
Terminal name	Connector	172165-1
	Contact	170359-1

3.7 CTION CHING BOX

Connect the cables of the teaching box as shown below.



PRECAUTIONS FOR USE

This robot is programmed by combining with a personal computer which is a prerequisite which can be used.

1.1 TY

(1) Because of the danger when the robot is operating, never touch the moving parts with the hands. Be very careful concerning working or placing tools, etc. within the range of movement (refer to 2.2).
When positioning using the teaching box, be careful not to bring the face, etc. within the range of movement of the robot.
(2) Always provide an emergency stop switch and if possible, take double or triple safety measures.

.2 ON NG

(1) Install the robot unit and drive unit as we mentioned before, refer to 3.2.4.
(2) Avoid using at high temperatures (40° C or higher) or low temperatures (5° C or less).
(3) Be careful that the ventilation holes of the drive unit do not become clogged.
(4) Do not turn the joints by hand or stop (restrain) them unnecessarily during operation. This can cause damage.
(5) Do not place the robot in places exposed to direct sunlight or near hot equipment such as heaters.
(6) Disassembling and reassembling can cause damage and must be performed.
(7) Be careful that water or other liquids or metal objects such as nails, pins or metal shavings do not get into the robot unit or drive unit.
(8) Do not use this robot in atmospheres containing explosive gas, dust or mist.
(9) This robot is a precision electronic device. Do not subject it to shocks from falling objects. This can cause damage.
(10) The power supply voltage shall not exceed the rated voltage.

1.3 ION _ES

(1) For all connection cables, tighten the screws at both ends firmly so that they will not fall off during use. When tightening the screws, tighten the screws on each end alternately and insert the connectors evenly. When the connection is incomplete, it might cause the robot not to operate in accordance with the input program.
(2) Be careful concerning twisting of the cables. When the cables are stretched or turned, this can cause damage to the cables and connectors.
(3) When removing the power supply cord, always hold the plug and pull it out.

1.4 ND

When using electric hands, be careful since there is no gripping power when the power supply is OFF.

4.5 POWER INTERRUPTIONS

(1) When restarting in cases of power interrupti
power interruptions for 20mS or more) or c
stop switch, execute the operation program
to the point of origin of the machine system)

(2) In case of power interruptions during teachin
and teaching must be performed again.

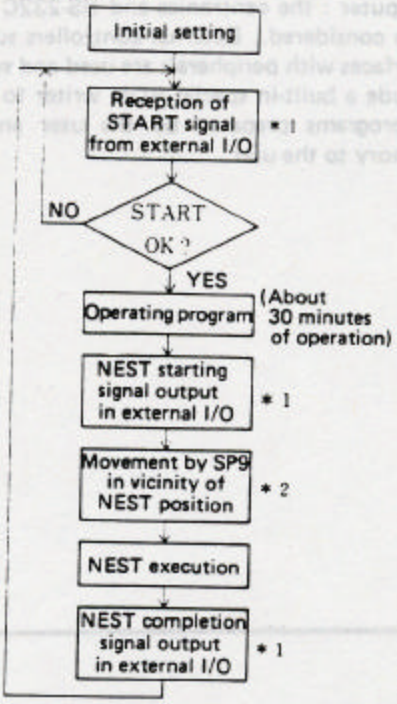
4.6 COUNTERMEA- -SURES AGAINST NOISE

(1) When the robot is used near a radio or TV
radio or TV. Since the robot might be affe
TV which generates a strong magnetic fie
devices.

(2) This robot is designed so that external surg
problem with respect to use, but there are cas
such as positional discrepancies due to unexp
as lightning surges 1 μs, 1,000 V or more at
modes in the primary power supply). Therefo
at appropriate intervals (once every 30 minu
ram, give the point of origin of the mechani
positional discrepancy.

(Example of operating program)

a. Flowchart



b. Program

```
1   NT
2   SP 7
3   ID
4   TB + 0,6
5   GT 3
6   RC 10
7   MO 1
8   GC
    }
200 NX
201 GS 300 ....
202 SP 7 .......
203 GT 3
300 OD 2 ......
301 SP 9 .......
302 MO 150 ....
303 NT
304 OD 0 ......
305 RT
```

Note: *1: Necessary only when connected to ex
*2: To shorten the NEST execution tim
the NEST position at as high a speed
hand curl code must always be as sh

CONTROL OUTLINE

5.1 OUTLINE

The composition of the basic system of the control equipment is shown in Fig. 5.1.

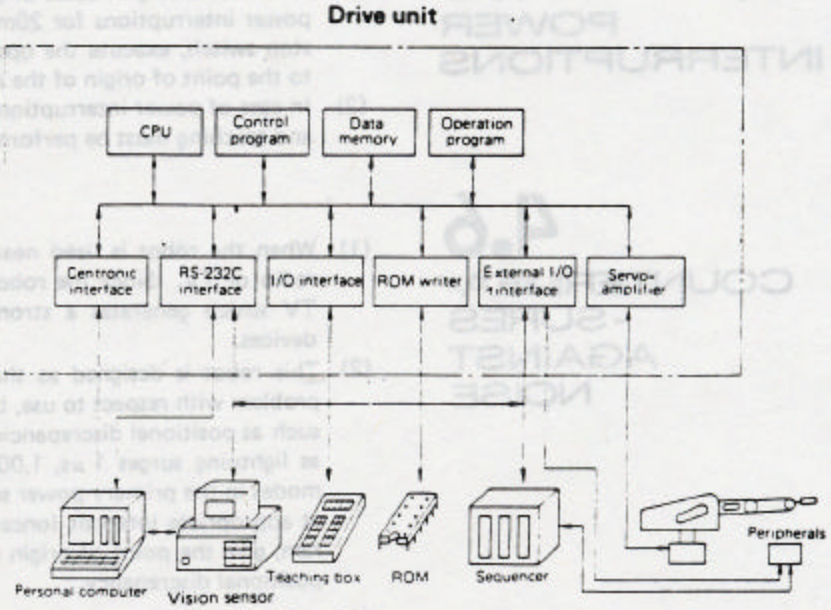


Fig. 5.1 Main system components

Two interfaces are used in the drive unit as interfaces for the personal computer : the centronics and RS-232C interfaces, and simplicity of use has been considered. External controllers such as a sequencer and external I/O interfaces with peripherals are used and systemization is easy. Other features include a built-in special ROM writer to facilitate for easy ROM conversion of programs prepared by the user and the opening of a large capacity memory to the user.

5.2 HAND CTION CHES

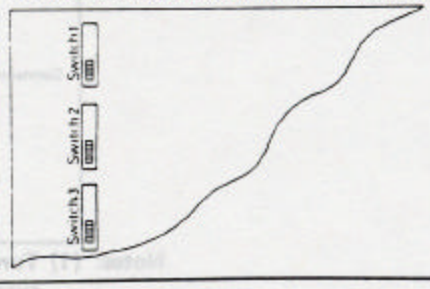
Select the DC motor or solenoid by the switch on the back of the drive unit. However, when using electromagnetic valves for opening and closing control of air-type hands, select the interior or exterior power supply by switch 2.

Table 5.1 Hand selection switches

Switch No.	
Switch 3 Solenoid Motor	○ Selection of the DC motor (DC 24V) or solenoid. ○ When the DC motor is selected, switch 2 and switch 1 have no relation. DC 24V max. 15W max. (Note 2)
When solenoid is used Switch 2 (Power supply changeover switch) Exterior Interior	When the "interior" power supply is used, ○ an interior power supply insulated with a transformer is selected. ○ The same voltage as the AC power supply input is applied. AC 100V max. 0.3A max. When the "exterior" power supply is used, ○ an exterior power supply insulated by a transformer is selected. AC 200V max. 1A max. ○ Perform wiring to the external I/O terminals with wire with a withstand voltage of AC 200V.
Switch 1 Reverse Forward	○ Grip opening and closing corresponding to the intelligence command (GO, GC) or the teaching box opening and closing operation. ○ When the changeover switch "forward" is selected, opening is by GO and closing by GC. When "reverse" is selected, opening is by GC and closing by GO.

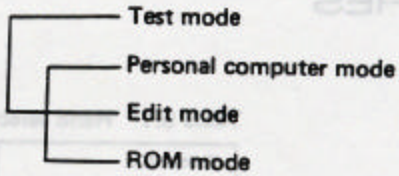
Note: About overseasversion, see the attached sheet.

Notes: (1) Feed in the insulated power supply to the external I/O external power supply terminal via the 1A fuse.
(2) Be careful when changing the switch since erroneous selection of switch 3 can cause damage.
(3) When shipped from the factory, the hand selection switches are as follows:



.3 OL ES

The following means of using the control modes can be selected using the intelligence command. Use the proper method in accordance with the application.



5.3.1 TEST MODE

(Before operation, confirm the safety of the peripherals.)
Confirm the operation of each of the shafts by the test mode operation in Table 5.2.

(1) Move the teaching box slide switch to OFF.
(2) Push the START/STOP switch of the drive unit and turn the power supply switch to ON.
(3) When pushing of the START/STOP is continued, the robot operates in the test mode as indicated in Table 5.2 after NEST execution.
Be careful since the operating speed at this time is set at the highest speed.
(4) When the START/STOP switch is pushed again, the robot is stopped after completion of the command currently being executed.
(5) When the START/STOP switch is next pushed again, execution is continued from the subsequent operation.
(6) Each time the switch is pushed thereafter, stopping and continued execution are repeated.
(7) During test operation, there is a one-second stopping time for each operation breakpoint and two-second stopping time at the completion of each cycle.
(8) To cancel the test mode, turn the power supply OFF.

Table 5.2 Test mode operation

External I/O	External I/O input side		External I/O output side		Operation
No connected	—		—		Combined operation of all joints
Connected	All SW	OFF	All LED	OFF	Combined operation of all joints
	SW1	ON	LED1	ON	Rotation of body
	SW2	ON	LED2	ON	Rotation of shoulder
	SW3	ON	LED3	ON	Rotation of wrist
	SW4	ON	LED4	ON	Raising and lowering of elbow
	SW5	ON	LED5	ON	Rotation of elbow
	SW6	ON	LED6	ON	Opening and closing of grip
	SW7	ON	LED7	ON	Optional forward and reverse directions
	SW8	ON	LED8	ON	No movement

Notes: (1) Turn one switch ON at one time among the switches on the external I/O input side. When two or more switches are turned on at the same time, the lowest bit has a priority.
(2) When the test circuit is connected to the external I/O terminals, prepare the test circuit as in the connection diagram in section 8.2 after carefully reading that section.

5.3.2 PERSONAL COMPUTER MODE

When the intelligence command is used, the robot can be moved by the BASIC language, etc. commonly used by the user via personal computer interfaces such as the centronics and RS-232C interface. When programs are prepared in these mode, the advantage is that all commands of the BASIC language, etc. can be used without restriction. For details of the program, refer to section 6.4.1.

5.3.3 EDIT MODE

Program debugging, editing, simulation, etc. is performed before ROM conversion. After the program is transferred to the RAM of the drive unit, the personal computer is released from control of the robot. For details of the program, refer to section 6.4.2.

5.3.4 ROM MODE

This mode is for operation by the ROM converted programs. The robot is completely controlled by the CPU in the drive unit. Therefore, it is not necessary to connect a personal computer. For details of the ROM converted programs and the ROM mode operation, refer to sections 6.4.3 and 6.5 respectively.

5.4 ERROR DISPLAY

There are two types of error modes. When there is an error, the robot does not operate.

- This error can be output by the ERROR FLAG command using the external I/O terminal.
- When starting again, move the robot into a safe position and execute the origin output operation program.

5.4.1 ERROR MODE I

(1) The error lamp is extinguished and the robot stops.
(2) The power supply is OFF and resetting is performed.
(3) Error mode I occurs in the following cases.
  (a) No connection of the signal cables of the robot unit and the drive unit.
  (b) Excessive servo error : signal cable disconnection, no connection or disconnection of the motor power supply connection cable, overload, high speed operation by a single axle (refer to SP command).

5.4.2 ERROR MODE II

(1) The error lamp remains lit and the robot immediately stops.
(2) Resetting is performed by the RS (reset) command. After resetting, the condition becomes a command stand-by condition.
(3) Error mode II occurs in the following cases.
  (a) Input of an undefined command
  (b) Erroneous input format
  (c) Exceeding of specified range of parameters
  (d) Input of instruction which exceeds drive limit values
  (e) Input for operation in an unrecorded position number
  (f) Defective ROM read-in and read-out

5.5 INTELLIGENCE COMMANDS AND THEIR OPERATION

All operations of the RM-501 are controlled by intelligence commands. The intelligence commands are in a robot language close to the human language (will) and make it possible for the users to execute commands concerning robot operation and commands such as condition evaluation. There are 38 types of intelligence commands and they can be divided into the three main types:

Intelligence	Operation control	16 types
	I/O control	6 types
	Program control	16 types

5.5.1 COMMAND FORMATS

There are two types of commands : those which function only by commands and those which function by commands and parameters.

Table 5.3 Command formats

Item	Format
Command	English alphabet
Parameter a	Decimal (integers)
Parameter b	Hexadecimal
, (Comma)	ASC II code 2 C
↵ (Terminator)	ASC II code 0 D

5.5.2 INPUT FORMATS FOR EACH COMMAND

Table 5.4 Input formats for each command

Type	No.	Name	Input format	Function	ROM conversion	Remarks
	1	Nest	NT	Mechanical point of origin output	Yes	
	2	Home	HO	Setting of basic operation position	Yes	
	3	Origin	OG	Return to basic position	Yes	
Operation control	4	Move I	MIa$_1$, a$_2$, a$_3$, a$_4$, a$_5$, a$_6$	The individual joints move the number of steps specified by parameters a$_1$ to a$_5$.	No	Operating range after execution of NEST $-12000 \leq a_1 \leq 0$ $-5200 \leq a_2 \leq 0$ $0 \leq a_3 \leq 3600$ Bending $0 \leq (a_4 - a_5) \leq 4800$ Rotation $-9600 \leq (a_4 + a_5) \leq 9600$
	5	Move	MOa	The robot moves to the point cataloged in the teaching box or set by the PS command.	Yes	$1 \leq a \leq 629$ (or a=0)
	6	Increment	IP	Move the robot to the position one step ahead of the current position.	Yes	
	7	Decrement	DP	Move the robot to the position one step behind the current position.	Yes	
	8	Position set	PS a$_0$, a$_1$, a$_2$, a$_3$, a$_4$, a$_5$, a$_6$	Define a position determined by the number of steps from the origin of operation, together with the position number.	Yes	$1 \leq a_0 \leq 629$ (or a_0=0) $a_1 \sim a_6$ same as MI command.
	9	Here	HEa	Store a position of operation specified by an "MI" command, etc., together with the position number.	Yes	$1 \leq a \leq 629$ (or a=0)
	10	Position clear	PC a$_1$, a$_2$	Delete position numbers between a$_1$ and a$_2$.	No	$a_1 \leq a_2$ $1 \leq (a_1, a_2) \leq 629$ (or a_1=0)
Hand control	11	Grip set	GP a$_1$, a$_2$, a$_3$	Increase or decrease the pressure.	Yes	$0 \leq (a_1, a_2) \leq 7$ $0 \leq a_3 \leq 99$
	12	Grip opened	GO	Open the grip.	Yes	
	13	Grip closed	GC	Close the grip.	Yes	
	14	Grip flag	GFa	Used when setting grip open/close condition during execution of the PS command.	Yes	a=0 or 1
	15	Speed	SPa	Set the operation speed (0: low speed, 9: high speed)	Yes	$0 \leq a \leq 9$
	16	Time	TIa	Stop the operation for the during specified by the parameter (in increments of 0.1 sec).	Yes	$0 \leq a \leq 99$
I/O control	17	Input controller	IN	Fetch external signal at a specified timing.	Yes	
	18	Input data	ID	Fetch external signal.	Yes	
	19	Output controller	OTa(&b)	Output signal specified by the parameter at a timing.	Yes	$0 \leq a \leq 255$ or $00 \leq b \leq FF$
	20	Output data	ODa(&b)	Output signal specified by the parameter.	Yes	
	21	Test bit	TB a$_1$, a$_2$	Judge the status of signal fetched from the input terminal specified by a$_1$ and cause a jump to the line specified by a$_2$.	Yes	a_1 ; $\pm 0 \sim \pm 7$ $1 \leq a_2 \leq 2048$
	22	Error flag	EFa	Output error signal.	Yes	a=0 or 1

Table 5.5 Input formats for each command

Type	No.	Name	Input format	Function	ROM conversion	Remarks
	23	If larger	LG a_1 (&b), a_2	Compare input signal from exterior with the parameter specified by a_1 for equality, and cause a jump to the line specified by a_2.	Yes	$0 \leq a_1 \leq 255$ or $00 \leq b \leq FF$ $1 \leq a \leq 2048$
	24	If equal	EQ a_1 (&b), a_2			
	25	If smaller	SM a_1 (&b), a_2			
	26	If not equal	NE a_1 (&b), a_2			
	27	Go subroutine	GS a	Cause a jump to a sub routine specified by the parameter, and cause a return to the main routine after the subroutine is executed.	Yes	$1 \leq a \leq 2048$
	28	Return	RT		Yes	
	29	Repeat	RC a	Repeat the execution of a program between RC and NX by the number of times specified by the parameter.	Yes	$1 \leq a \leq 99$
	30	Next	NX		Yes	
	31	Go to	GT a	Cause a jump to line a.	Yes	$1 \leq a \leq 2048$
	32	End	ED	Indicate the end of a program.	Yes	
	33	New	NW	Clear all data stored in the RAM area.	No	
	34	Delete	DL a_1, a_2	Delete programs from line a_1 to line a_2.	No	$a_1 \leq a_2$ $1 \leq (a_1, a_2) \leq 2048$
	35	Run	RN a	Execute the program from the line specified by the parameter.	No	$1 \leq a \leq 2048$
	36	Write	WR a	Write the content of RAM area specified by the parameter to ROM.	No	$0 \leq a \leq 5$
	37	Transfer	TR a	Transfer the content of ROM to the RAM area specified by the parameter.	No	
	38	Reset	RS	Reset the error mode II.	No	

○ Table 5.6 shows the relation between the parameters $a_1 \sim a_6$ in the move I and position set commands and the operating angle.

Table 5.6 Relation between parameters and operating angles

Parameter	Joint	Operating angle/pulse
a_1	Waist	0.025°
a_2	Shoulder	0.025°
a_3	Elbow	0.025°
a_4 , a_5	Wrist	0.075°

5.5.3 EXPLANATION OF INTELLIGENCE COMMANDS

An asterisk (*) in the input format column in the explanation of each command indicated that ROM conversion is impossible.

NEST

[Input format]

NT

[Functions]

(a) This is the command for origin output of the mechanical system of the robot.

(b) The operation sequence is as follows:
Shoulder → elbow → wrist pitch → wrist roll → waist
Each of the joints move until operating of the limit switch.

(c) When the command is not executed, the power supply closing condition indicates the mechanical origin (NEST position). Therefore, always execute NEST.

(d) The grip is in the open position.

Note: If the hand is already attached when the command is executed, check the following two points to determine if the relation between the wires to the hand and the hand attachment part are as shown in Fig. 5.2.

(i) Can the knob of the limit switch be seen on the right from the front surface ?

(ii) Is the wiring to the hand twisted or stretched ?

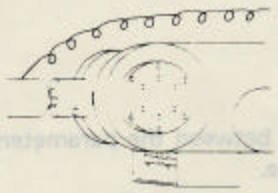


Fig. 5.2 Limit switch knob

If the condition is not as shown in Fig. 5.2, correct the position to that in Fig. 5.2 using the MI (move immediate) command or the teaching box.

Note: Do not touch the limit switch during NEST execution.
Execute NEST after moving the robot into a safer position when power is restored.
Example: LPRINT "NT"
LPRINT is a basic command given from the personal computer to the printer, etc. Since there are differences in accordance with the personal computer used, care is necessary and this is the same for the following sections.

HOME POSITION SET

[Input format]

HO

[Functions]

(a) This is the command for setting the basic position in robot operation.
(b) When this command is executed, the robot becomes in the home position.
(c) When this command is not executed, the mechanical origin (NEST position) is set as the home position.
(d) When the home position is set in an optional position, there are two procedures as follows.
  (i) The robot is moved to the desired position using the PS, MO or MI commands and the HO command is executed.
  (ii) The robot is moved to the desired position by manipulator operation of the optional teaching box and this position is stored as position No. 000. For details, refer to section 7.)
(e) This command is effective up to the subsequent revision.

[Example]

```
LPRINT "MI-1000, 0, 0, 0, 0, 0" ↵
LPRINT "HO" ↵
```

ORIGIN

OG

[Functions]

(a) The command returns to robot to the home position.
(b) When the HO command is not executed, the robot returns to the mechanical origin (NEST position).

[Example]

```
10      LPRINT "MI-1000, 0, 0, 0, 0, 0"
20      LPRINT "HO"
30      LPRINT "MI-2000, 0, 500, 400, 400, 0"
40      LPRINT  "OG"
```

By means of origin execution at number 40, there is a return to position 10.

MOVE IMMEDIATE

[Input format]

MI a_1, a_2, a_3, a_4, a_5, a_6 *

[Functions]

(a) The command rotates each joint only by the amount specified by the parameters.
(b) The parameter 0 i.e. no movement, but to conclude the instruction, there is a need to have 5 commas.
(c) Input 0 for a_6 .

Table 5.7 Parameters and movement directions of each joint

Parameter	Joint	+	−
a_1	Body	Clockwise direction	Counterclockwise direction
a_2	Shoulder	Upward direction	Downward direction
a_3	Elbow	Upward direction	Downward direction
a_6	—	—	—

Table 5.8 Parameter and wrist movement direction

a_4	a_5	Wrist movement
+	+	Clockwise direction
−	−	Counterclockwise direction
+	−	Upward direction
−	+	Downward direction

[Example]

```
LPRINT "MI-1000, -100, 100, 300, 300, 0"
```

MOVE

[Input format]

```
MO a
```

(a) $1 \leqq a \leqq 629$

[Functions]

(a) This command moves the robot to the position recorded by the PS or HE command. Parameter a shows the recorded position.

(b) When the position is set by the teaching box, it is the same as in (a). When the position is recorded by the teaching box, the grip opening and closing condition is also recorded.
When the position is moved and the grip opening and closing condition is changed, the grip opening and closing is performed first.

(c) a = 0 is not an error, but care is necessary since the operation is the same as for the OG command.

(d) If a is not recorded, error mode II occurs (refer to 5.4).

[Example]

```
10    LPRINT "PS 1, -100, 0, 0, 0, 0, 0" ↵
20    LPRINT "MO 1" ↵
```

INCREMENT OF POSITION

[Input format]

IP

[Functions]

(a) This command moves the robot from the current position No. to the next recorded position No.

(b) When the recorded position has no No., error mode II occurs.

[Example 1]

```
10      LPRINT "MO  1"
11      LPRINT "IP"  ..... Moved to position 2.
```

[Example 2]

```
10      LPRINT "MO 1"
20      LPRINT "RC 10"
30      LPRINT  "IP"
40      LPRINT  "NX"
```

Eleven positions are necessary with this program. It is necessary that the II positions be set beforehand by the PS command or Teaching Box.

DECREMENT OF POSITION

[Input format]

DP

[Functions]

(a) This command moves the robot from the current position No. to the previous recorded position No.

(b) When the recorded position has no No., error mode II occurs.

[Example 1]

```
10      LPRINT "MO 5"
20      LPRINT "DP" ..... Moved to position 4
```

[Example 2]

```
10      LPRINT "MO 5"
20      LPRINT "RC 4"
30      LPRINT "DP"
40      LPRINT "NX"
```

It is necessary that 5 positions be set beforehand by the PS command or Teaching Box.

POSITION SET

[Input format]

PS a_0, a_1, a_2, a_3, a_4, a_5, a_6

(a) $1 \leqq a_0 \leqq 629$
(b) For $a_1 \sim a_6$, refer to Table 5.9.

[Functions]

(a) This command sets the standard home position together with position No. a_0 and the movement amounts $a_1 \sim a_6$.
(b) After the commanded position is set and the home position is changed by the HO command, there is a relative effect on the positions set by this command previously (shift function) and care is necessary (example 2).
(c) Care is necessary since $a_0 = 0$ becomes the home position setting.
(d) The parameter part (recorded position No., position data) can be converted to ROM.
(e) Command and parameter errors are in error mode II.

[Example 1]

```
        LPRINT "NT"
10      LPRINT "PS 1, -100, -200, 300, 400, -400, 0"
20      LPRINT "MO 1"
30      LPRINT "OG" ..... Since the home position is not specified,
                          the robot returns to the position speci-
                          fied by NT.
```

[Example 2]

```
        LPRINT "NT"
10      LPRINT "MI-6000, -2600, 1800, 1200, -1200, 0"
15      LPRINT "HO"
20      LPRINT "PS 1, -3000, -1000, 1000, 1000, -1000, 1000, 0"
30      LPRINT "PS 2, 3000, 1000, -1000, -1000, -1000, 0"
60      LPRINT "MO 1"
80      LPRINT "MI-2000, -3600, 2800, 2200, -2200, 0"
90      LPRINT "HO" ..... The position to which the robot is
                          moved from position 1 by the MI com-
                          mand is assumed as the home position.
                          Thereafter, this home position is used as
                          the base for other positions.
110     LPRINT "MO 1"
120     LPRINT "MO 2"
```

Position Nos. 110 and 80 are shifted as home positions.

[Relation between home positions and parameters]

(a) Parameters after NEST execution can be used in the range shown in Table 5.9.

Table 5.9 Range of parameters after NEST

Parameter	Parameter range
a_1	$-12000 \leqq a_1 \leqq 0$
a_2	$-5200 \leqq a_2 \leqq 0$
a_3	$0 \leqq a_3 \leqq 3600$
a_4	$0 \leqq (a_4 - a_5) \leqq 4800$
a_5	$-9600 \leqq (a_4 + a_5) \leqq 9600$

(b) When the home position is changed by input of LPRINT "MI-6000, -2600, 1800, 1200, -1200, 0" ↵ after NEST execution, the range of parameters is as shown in Table 5.10.

Table 5.10 Range of parameters after change in home position

Parameter	Parameter range
a_1	$-6000 \leqq a_1 \leqq 6000$
a_2	$-2600 \leqq a_2 \leqq 2600$
a_3	$-1800 \leqq a_3 \leqq 1800$
a_4	$-2400 \leqq (a_4 - a_5) \leqq 2400$
a_5	$-9600 \leqq (a_4 + a_5) \leqq 9600$

Note: In the example in Table 5.10, the home positions are set in the actual range of possible mechanical movement.

HERE

[Input format]

HE a

(a) $1 \leqq a \leqq 629$

[Functions]

(a) This command stores the relative positional relation between the current position and the home position together with the position No.
(b) When the home position is changed after the position decided by this command, care is necessary since there is a relative effect on positions set by this command previously.
(c) Care is necessary since a = 0 becomes the home position setting.
(d) The position No. is handled the same as the position No. in the PS command and position numbers input thereafter are stored first.
(e) Command and parameter errors are in error mode II.

[Example]

```
        LPRINT "NT"
10      LPRINT "MI-100, 0, 0, 0, 0, 0"
20      LPRINT "HE 1"
25      LPRINT "MI-3000, 0, 0, 0, 0, 0"
30      LPRINT "MO 1" ..... Move to the position of line number 10.
```

POSITION CLEAR

[Input format]

PC a_1 [, a_2]

(a) $a_1 \leqq a_2$ $\quad 1 \leqq (a_1, a_2) \leqq 629$
(b) Parameters in brackets can be omitted but if omitted, all positions after those set by a_1 are deleted.

[Functions]

(a) This command deletes positions recorded previously in parameters a_1 – a_2.
(b) When $a_1 = 0$ is executed, care is necessary because the set home position is deleted and the home position becomes the same as the mechanical origin (NEST position).
(c) The positions recorded from the teaching box can be cleared from the personal computer.

[Example]

```
10      LPRINT "PS 1, 100, 0, 0, 0, 0, 0"
20      LPRINT "PS 2, 0, 200, -200, 500, -500, 0"
30      LPRINT "PS 3, -200, 0, 0, -500, 500, 0"
        LPRINT "PC 2, 3"  .....  The position data in lines 20 and 30 is
                                 deleted.
```

GRIP PRESSURE SET

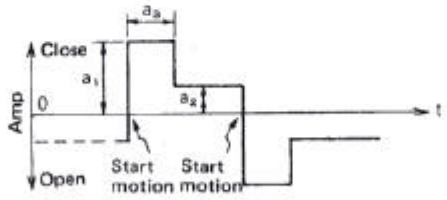
[Input format]

GP a_1, a_2, a_3

(a) $0 \leqq (a_1, a_2) \leqq 7$
(b) $0 \leqq a_3 \leqq 99$

[Functions]

(a) This command controls the current fed to the motor and the time when a DC motor driven hand is used.



(b) The current limiting parameters a_1 and a_2 show a maximum grip power at 7 and minimum at 0, and there is basically proportional distribution.
(c) a_3 can set the time of duration of current parameter a_1 in units of 0.1 sec. The time required for grip opening and closing is a minimum of a_3 x 0.1 sec.
(d) When the power supply is closed, the settings are $a_1 = 7$, $a_2 = 1$ and $a_3 = 15$. Therefore, when hands operated at high speeds by solenoid drive, etc. are used, a_3 is set at a smaller value to shorten the waiting time from after grip opening and closing until moving to the next operation.
(e) When the solenoid is selected by SW_3 on the rear of the drive unit, parameters a_1 and a_2 are disregarded.
(f) This command is effective until a change to the next parameter.
(g) Command and parameter errors are in error mode II.

[Example]

```
10      LPRINT "GP 5, 3, 10" ↵
20      LPRINT "GC" ↵
```

GRIP OPEN

[Input format]

GO

[Functions]

(a) This command opens the grip according to the current waveform set by the GP command.
(b) This command can not maintain this condition, and becomes ineffective (open) in the next step. Care is necessary when the program is prepared.
(c) This command is disregarded from the 2nd time even when executed continuously twice or more.
(d) Command errors are in error mode II.

[Example]

```
LPRINT "GO" ↵
```

GRIP CLOSE

[Input format]

GC

[Functions]

(a) This command closes the grip according to the current waveform set by the GP command.
(b) For other items, refer to the GO command.

[Example]

```
LPRINT "GC"
```

GRIP FLAG

[Input format]

GF a

(a) a = 0 or 1

[Functions]

(a) This command sets the grip opening and closing conditions when the PS command is executed.
(b) a = 0 is grip open and a = 1 is grip closed.
(c) The same conditions are maintained until parameter a is changed.
(d) a = 0 is set when the power supply is closed.
(e) Command and parameter errors are in error mode II.

[Example]

```
5     LPRINT "GC"
10    LPRINT "GF 1"
20    LPRINT "PS 1, -1000, 0, 0, 0, 0, 0"
30    LPRINT "PS 2, 0, -1000, 0, 0, 0, 0"
35    LPRINT "GO"
40    LPRINT "GF 0"
50    LPRINT "PS 3, 0, 0, 100, 0, 0, 0"
```

Positions 1 and 2 are set as the grip open condition and position 3 as the grip closed condition.

SPEED SET

[Input format]

SP a

(a) $0 \leqq a \leqq 9$

[Functions]

(a) The command sets the operating speed in 10 stages.

(b) In cases of combined operations, the operating speed is that of the joint with with the maximum operating pulse number. The speeds are about 40 mm/sec at a = 0 and about 400 mm/sec at a = 9 with approximately proportional distribution between.

(c) The speed at the time of starting and stopping are controlled automatically to obtain the optimum speed variation curves in accordance with the operating speed, but finer control is possible when the parameters are set in accordance with the load weights.
For example, in cases of operation at high loads with rapid changes in the movement direction, use while confirming actual operation by dropping the speed before changing the direction, etc.
- The upper limit of the SP command parameters are set so that the robots will show maximum functions during combined operation.
When parameters are set at high speeds during single axle operation, there are cases where interpolation of the approximately linear curves becomes disrupted because of such conditions as the operating range and load, and where error mode I occurs because of excessive servo errors. In such cases, set the parameters at low speeds.

(d) a = 4 is set when the power supplied.

(e) This command remains effective until a change to the next command.

(f) Command and parameter errors are in error mode II.

[Example]

```
10      LPRINT "SP 5"
20      LPRINT "MI 1000, 100, 200, 300, 300, 0"
30      LPRINT "SP 9"
40      LPRINT "MI-1000, -100, -200, -300, -300, 0"
```

TIME SET

[Input format]

TI a

(a) $0 \leqq a \leqq 99$

[Functions]

(a) This command stops operation in a x 0.1 sec.
(b) When a time of 9.9 sec. or more is desired, repeatedly execute this command or use it together with the RC and NX commands. (For details, refer to the section on RC commands.
(c) Command and parameter errors are in error mode II.

[Example]

```
10    LPRINT "MI-1000, -100, 200, 300, 300, 0"
20    LPRINT "TI 10"
30    LPRINT "MI 1000, 100, -200, -300, -300, 0"
```

INPUT DATA FROM EXTERNAL CONTROLLER

[Input format]

ID

[Functions]

(a) This command is used in cases of input for timing of signals from an external controller such as a sequencer via the external I/O terminals.
(b) For details of the connections, timing, etc., refer to section 8.
(c) Command errors are in error mode II.

INPUT DATA

[Input format]

ID

[Functions]

(a) This command is used for unconditional input of signals from external devices via the external I/O terminals.
(b) This command is used for input of conditions of limit switches, etc. For details concerning connections, refer to section 8.
(c) Command errors are in error mode II.

[Example]

```
10      LPRINT "NT"
20      LPRINT "SP 7"
30      LPRINT "ID"
40      LPRINT "TB + 0.6"
```

OUTPUT DATA TO EXTERNAL CONTROLLER

[Input format]

OT a (decimal) or OT & b (hexadecimal)

(a) $0 \leqq a \leqq 255$
(b) $00 \leqq b \leqq FF$

[Functions]

(a) This command is used in cases of output for timing to an external controller such as a sequencer via the external I/O terminals.
(b) For details of connections, timing, etc., refer to section 8.
(c) The parameters are decimal or hexadecimal. Always add & in hexadecimal cases.
(d) Command and parameter errors are in error mode II.

OUTPUT DATA

[Input format]

OD a (decimal) or OD & b (hexadecimal)

(a) $0 \leqq a \leqq 255$ or $00 \leqq b \leqq FF$

[Functions]

(a) This command is used for unconditional output of signals set by parameters via the external I/O terminals.
(b) For connections, refer to section 8.
(c) The parameters are decimal or hexadecimal. Always add & in hexadecimal cases.
(d) Command and parameter errors are in error mode II.

[Example]

```
10      LPRINT "OD 2"
20      LPRINT "SP 9"
30      LPRINT "MO 100"
```

IF INPUT DATA LARGER THAN a_1 THEN GOTO a_2

[Input format]

LG a_1, a_2(decimal) or
LG & b_1, a_2(hexadecimal)

(a) $0 \leqq a_1 \leqq 255$, $1 \leqq a_2 \leqq 2048$
(b) $00 \leqq b_1 \leqq FF$

[Functions]

(a) This command jumps to the next program step set by a_2 if data input from the external I/O terminals are larger than the specified parameter (condition is realized) and if the data are not larger (condition not realized), execution is from the next step.
(b) When data are input by IN or ID, this command does not necessarily require continued execution. Conditions are evaluated from the initially input data.
(c) The parameters are specified as decimal or hexadecimal. In hexadecimal cases, always add &.
(d) When there is a command or parameter error or step set by a_2, error mode II occurs.

[Example]

```
10      LPRINT "13 IN"
20      LPRINT "15 LG 124, 30"
30      LPRINT "18 MO 73"
.              .
.              .
.              .
.              .
.              .
100     LPRINT "30 MO 15"
```

Not realized
Realized

(Care is necessary since BASIC step 30 in the above example does not affect condition branching.)

IF INPUT DATA NOT EQUAL a_1 THEN GOTO a_2

[Input format]

EQ a_1, a_2(decimal) or
EQ & b_1, a_2(hexadecimal)

(a) $0 \leqq a_1 \leqq 255$, $1 \leqq a_2 \leqq 2048$
(b) $00 \leqq b_1 \leqq FF$

[Functions]

(a) This command jumps to step a_2 is the condition is realized or executes the next step if it is not realized.
(b) Other conditions are the same as b – d of the LG command.
(c) In hexadecimal cases, always add &.

[Example]

```
10      LPRINT "13 IN"
20      LPRINT "15 EQ 124, 30"
30      LPRINT "18 MO 50"
.              .
.              .
.              .
.              .
.              .
100     LPRINT "30 MO 15"
```

Not realized

Realized

(Care is necessary since BASIC step 30 in the above example does not affect condition branching.)

IF INPUT DATA SMALLER THAN a_1 THEN GOTO a_2

[Input format]

SM a_1, a_2(decimal) or
SM & b_1, a_2(hexadecimal)

(a) $0 \leqq a_1 \leqq 255$, $1 \leqq a_2 \leqq 2048$
(b) $00 \leqq b_1 \leqq FF$

[Functions]

(a) If the condition is realized, the command jumps to step a_1 and if it is not realized, the next step is executed.
(b) The other conditions are the same as b – d of the LG command.
(c) In hexadecimal cases, always add &.

IF INPUT DATA NOT EQAUL a_1 THEN GOTO a_2

[Input format]

NE a_1, a_2(decimal) or
NE & b_1, a_2(hexadecimal)

(a) $0 \leqq a_1 \leqq 255$, $1 \leqq a_2 \leqq 2048$
$00 \leqq b_1 \leqq FF$

[Functions]

(a) If the condition is realized, the command jumps to step a_2 and if it is not realized, the next step is executed.
(b) The other conditions are the same as b – d of the LG command.
(c) In hexadecimal cases, always add &.

TEST BIT

[Input format]

TB a_1, a_2

(a) $\pm 0 \leqq a_1 \leqq \pm 7$
(b) $1 \leqq a_2 \leqq 2048$

[Functions]

(a) There is an investigated to determine if the bit set by parameter a_1 of data input from external I/O terminals is established or 0 is established. As a result, if the condition is realized, step a_2 is executed and if it is not realized, the next step is executed.

— The sign of parameter a_1 can be checked by using, for a contact signal for example, ON for minus and OFF for plus. For an example of wiring, see page 70. (For European specifications, see the attached sheet.)

[Example 1]

```
10      LPRINT "15 TB +5, 50"
```

— There is an investigation to determine if the 5th bit of the input data is one or not.
— If it is one, step 50 is executed and if it is zero, the next step is executed.

[Example 2]

```
10      LPRINT "15 TB -5, 50"
```

— There is an investigation to determine if the 5th bit of the input data is 0 or note.
— If it is 0, step 50 is executed and if it is one, the next step is executed.

GO SUBROUTINE

[Input format]

GS a

(a) $1 \leqq a \leqq 2048$

[Functions]

(a) This command jumps to the step specified by a and returns to the main program by the RT command.
(b) CALL of the subroutine in the subroutine is impossible.
(c) In the following case, error mode II occurs. — command or parameter error

[Example]

```
10      LPRINT "1 GS 100"
20
30
 .
 .
 .
100     LPRINT "100 MO 10"
210
 .
 .
 .
250     LPRINT "150 RT"
```

RETURN

[Input format]

RT

[Functions]

(a) This command returns to the main program from the subroutine called by the GS command.
(b) When there is a command error or no corresponding GS command, error mode II occurs.

REPEAT CYCLE SET

[Input format]

RC a

(a) $1 \leqq a \leqq 99$

[Functions]

(a) This command is used with the NX command and repeats the program steps between the RC and NX commands the number of times specified by parameter a. (It is equivalent to FOR – NEXT of BASIC.)

[Example 1]

```
10      LPRINT "30 RC 99"
20      LPRINT "40 TI 99"
30      LPRINT "50 NX"
```

– TI 99 command is executed 99 times.
(Stopping time is 9.9 x 99 = 980.1 sec.)

[Example 2]

```
10      LPRINT "1 MO 1"
20      LPRINT "3 RC 50"
30      LPRINT "4 IP"
40      LPRINT "7 TI 1"
50      LPRINT "8 NX"
```

IP executed 50 times

– Position No. 1 is the starting position and there is sequential operation of the recorded position one position at a time until position 51.
– There is a stopping time of 0.1 sec. for reaching the next position.

(b) In the following case, error mode II occurs.
Command or parameter error
When there is no position recorded previously by the IP command in the execution of a program as in example 2, error mode II occurs from that point even if the initial operations are correct.

(c) The REPEAT command cannot be used in a repeat cycle.

NEXT CYCLE EXECUTE

[Input format]

NX

[Functions]

(a) This command is used with the RC command.
(b) When there is a command error or no corresponding RC command, error mode II occurs.

GOTO

[Input format]

GT a

(a) $1 \leq a \leq 2048$

[Functions]

(a) This command jumps unconditionally to step a.
(b) When there is not step specified by a, operation stops at the 2048th step. (No error occurs.)
(c) Command and parameter errors are in error mode II.

[Example]

```
          ROM converted step
10        LPRINT "5 MO 1"
20        LPRINT "10 MO 2"
30        LPRINT "20 MO 3"
40        LPRINT "30 SP 9"
50        LPRINT "40 MO 4"
60        LPRINT "50 GT 5" ..... Jump to ROM converted step 5
100       LPRINT "PS 1, -1000, 200, 0, 0, 0, 0"
110       LPRINT "PS 2, -500, 300, 400, 0, 0, 0"
120       LPRINT "PS 3, 1000, -300, -200, 0, 0, 0"
130       LPRINT "PS 4, -500, 300, 0, 0, 0, 0"
```

END

[Input format]

ED

[Functions]

(a) This command indicates the end of the program.
(b) Ending of the program is necessary except for operation in the personal computer mode.
(c) This command can be omitted when the program is ended by a GT command.
(d) Command errors are in error mode II.

NEW

[Input format]

NW

[Functions]

(a) This command clears all programs prepared by the user and previously recorded positions in the RAM area of the drive unit.
(b) Command errors are in error mode II.

DELETE

[Input format]

DL a_1 (, a_2)

(a) $a_1 \leqq a_2$, $1 \leqq (a_1, a_2) \leqq 2048$
(b) Parameter in brackets can be omitted but if omitted, all program steps from those set by a_1 are deleted.

[Functions]

(a) This command delites program steps $a_1 - a_2$.
a_1 : leading step,
a_2 : final step
(b) Command and parameter errors are in error mode II.

RUN

[Input format]

RN (a)

(a) $1 \leqq a \leqq 2048$
(b) Parameter in brackets can be omitted but if omitted, the program is executed from the first step.

[Functions]

(a) This command executes the program from step a.
(b) When the parameter is omitted, the program is executed from the start.
(c) Command and parameter errors are in error mode II.

WRITE

[Input format]

WR a

(a) $0 \leqq a \leqq 5$

[Functions]

(a) This command converts the RAM area specified by a to ROM inserted socket in front of the D/U. The relation between a and the programs prepared by the users are as follows.

Parameter a	Contents
0	Program from step 1 to 512
1	Program from step 513 to 1024
2	Program from step 1025 to 1536
3	Program from step 1537 to 2048
4	Positions from No. 0 to 314
5	Positions from No. 315 to 629

(b) After confirming that the red ROM lamp of the ROM writer is extinguished, execute this command.
The lamp lights when this command is executed. It is extinguished when the write-in is completed.

(c) Command and parameter areas and defective ROM are in error mode II.

TRANSFER

[Input format]

TR a

(a) $0 \leqq a \leqq 5$

[Functions]

(a) This command transfers the ROM contents insert the ROM socket in front of D.V. to the RAM area specified by a.

(b) The relation between a and the program contents is the same as in (a) for the WR command.

(c) Command and parameter errors and defective ROM are in error mode II.

RESET

[Input format]

RS

[Functions]

(a) This command resets error mode II (error lamp continuously lit).
(b) Command errors are in error mode II.

ERROR FLAG

[Input format]

```
EF a
```

(a) a = 1 or a = 0

[Functions]

(a) When an error mode corresponding to error mode I or error mode II occurs during execution of the program, this command is used to give out a signal from bit 7 of the external I/O terminals.

(b) When parameter a is specified as 1, the highest bit of the external I/O terminals gives out a signal when an error occurs. In this case, bit 7 can not be used for output of other signals.

(c) When parameter a is specified as 0, no signal is given out when an error occurs. In this case, bit 7 can be used for signal output in the same way as the other bits.

(d) When the power supply is closed, the condition is the same as parameter a = 0.

(e) This command remains valid until it is modified. Note, however, that if an EF output is required after the occurrence of an error, it is necessary to redefine the command.

(f) This command can be released by the RS command only in error mode II.

[Example]

```
10      PRINT "SP 9"
20      LPRINT "EF 1"
30      LPRINT "MO 1"
40      LPRINT "MO 2"
50      LPRINT "PS 1, -1000, -500, 200, 300, 300, 0"
60      LPRINT "PS 2, 1000, 500, -200, -300, -300, 0"
```

6 PROCEDURES

6.1 PREPARATIONS BEFORE OPERATION

After completion of installation of the robot unit according to section 3, check the following points.

(1) The robot and drive units (D/U) are connected by two connection cables, one for the motor power supply and one for signals. Screw in the connector screws tightly.

Note: When screwing in the connector screws of the motor power supply cable, tighten the screws alternately a little at a time.

(2) The controller (personal computer MX-6000, etc.) is connected.

(3) The teaching box (T/B) is connected.

(4) The power supply cord is inserted in the socket.

Note: The teaching box slide switch must always be as follows:
– During teaching box operation ON
– Other times OFF

6.2 NEST COMMAND AFTER SWITCHING ON

For operation of the robot, "NEST COMMAND" is necessary after switching on the power supply. This procedure is intended to match the points of origin of the mechanical and control systems. The procedure is performed as follows after the personal computer and D/U power supply switches are turned ON. The following procedures are for the case when an MX-6000 is connected to the centro interface of connector 3 (refer to section 10.2 for the procedures when connecting the RS-232C).

(1) When the origin output is performed by the MX-6000.
  (a) Start the MX-6000 in accordance with the MX-6000 operating manual. (Do not forget to change the distribution of the output port by the STAT command.)
  (b) LPRINT "NT" ↵ (Pay attention to the wrist and hand positions described in the section under 'NT Command.')

(2) When origin output is performed by the teaching box.

[NST] [ENT]

Match the origin (NEST) of the mechanical system and the origin (hone position) of the control system (calculated) by procedures (1) or (2). The control origin is the site where the limit switch is closed.

Note: If the robot is operated from the teaching box or personal computer immediately when the power is turned on before execution of NEXT, the robot operation is limited .

6.3 HOME POSITION SETTING

This procedure is performed when the origin of the control system is moved. Therefore, the following procedure is necessary only when such a movement is required.

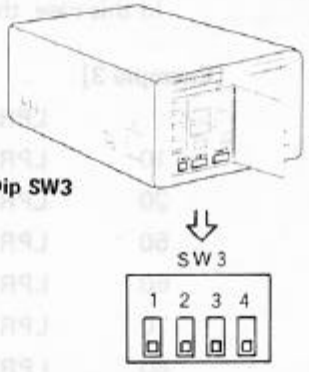
Use this procedure with care since all of the positions set by the PS, HE and other commands will be moved relatively when the home position is changed by this procedure. (Refer to 5.4.3.)

(1) When setting the home position by the MX-6000.
  (a) Move the robot to the desired position by the PS, MO, M1 or other commands.
  (b) LPRINT "HO" ↵
(2) When setting the home position by the teaching box.
  (a) Move the robot to the desired position by the manipulator.
  (b) Input [PS] [0] [ENT] from the teaching box.

6.4 PREPARATION OF PROGRAMS

Programs must be prepared to operate the robot. Operation of the robot can be roughly divided into the that in the personal computer and ROM modes. The modes are changed by dip SW3 on the drive unit. (Operation is possible when the cover on the right side of the D/U is opened.)

Two of dip switch 3	ON side	:	ROM mode
Two of dip switch 3	OFF side	:	personal computer and edit modes



When the right side of the drive unit is opened, the dip can be confirmed.

Note: All the switches of dip SW3 are set to OFF during factory shipment.
- In personal computer mode edit mode or ROM mode, when either position data or program data or both are transferred from a ROM on the CPU board (mode number 2,3,4 in 6.4.1 or 6.5.1) to be modified, corrected, or confirmed during or after the operation, be sure to set SW3 mode 1 to ON (SW3-3 4 to OFF) (in 6.4.1 or 6.5.1) and press the START/STOP switch.
  If the START/STOP switch is pressed without switching the mode, the data is retransmitted from the ROM on the CPU board in the mode specified by SW3, causing the modified or corrected data to become invalid.
- In personal computer mode/edit mode, the same mode switching as described above is required when the RS command is executed.

6.4.1 PERSONAL COMPUTER MODE

This mode operates the robot by a personal computer. At this time, dip SW3-2 is on the OFF side. (Dip SW3-3 and SW3-4 are disregarded.)

Table 6.1

Mode No	SW3			機　　能
	2	3	4	
1	OFF	OFF	OFF	No transfer in ROM and RAM of user area
2	OFF	OFF	ON	Transfer of position data only to RAM from ROM of user area
3	OFF	ON	OFF	Transfer of program only to RAM from ROM of user area
4	OFF	ON	ON	Transfer of both program and position data to RAM from ROM of user area

For operation in the personal computer mode, intelligence commands are given out by printer output commands, etc.

[Example 1]

```
LPRINT "MO 3" ↵
```

In this case, the robot starts operating immediately in position No. 3. However, it is necessary to teach the position beforehand (BASIC direct mode).

[Example 2]

```
10    LPRINT "MO 3" ↵
      RUN ↵
```

In this case, the robot operates after RUN (BASIC program mode).

[Example 3]

```
      LPRINT "NT"
10    LPRINT "PS 1, -2000, 0, 0, 0, 0, 0"
20    LPRINT "PS 2, -8000, 0, 0, 0, 0, 0"
50    LPRINT "SP 5"
60    LPRINT "MO 1"
70    LPRINT "TI 5"
80    LPRINT "MO 2"
90    LPRINT "TI 5"
100   LPRINT "OG"
110   END
      RUN ↵
```

Robot operation can be confirmed. When the teaching box is used, program steps 10 – 20 are not necessary when positions No. 1 and No. 2 are recorded in the teaching box.

Note: The contents of the quotation marks after LPRINT have no relation to the program no master if there is a space or not a space after the intelligence command.

6.4.2 EDIT MODE

When the program is converted to ROM, the programs are prepared by this mode. At this time, dip SW3-2 is on the OFF side as in 6.4.2. (Dip SW3-3 and 3-4 are disregarded.) For operation in the edit mode, the steps must always be arranged before the intelligence commands. Therefore, all programs for ROM conversion except for intelligence commands transferring position data must have steps.

[Example 1]

(When LPRINT is used.)

```
10    LPRINT "PS 1, 100, 100, -100, 0, 0, 0"
20    LPRINT "PS 2, -100, 100, 100, 0, 0, 0"
30    LPRINT "PS 3, 0, 0, 0, 100, 100, 0"
40    LPRINT " 5     MO     1 "
50    LPRINT " 6     TI     10 "
60    LPRINT " 8     MO     2 "
80    LPRINT " 10    MO     3 "
90    LPRINT " 11    OG     "
```

BASIC step ROM step Intelligence command

(i) BASIC steps 10 – 30 are operated by the personal computer mode. However, position data can be transferred to RAM and converted to ROM thereafter.

(ii) When programs are sent from the personal computer to the drive unit, the programs are controlled by the BASIC step. In the drive unit, all control is by the steps in the quotation marks. The BASIC steps are signs for sequential transfer of the prepared programs into the drive unit, and the steps in the quotation marks are signs for deciding the robot operation sequence.
When LPRINT "RN" ↵ is fed in after completion of the program transfer, the robot starts operation under the control of the CPU in the drive unit.

[Example 2]

(When LLIST is used.)

Example 1 can be written as follows.

```
5    MO   1
6    TI   10
8    MO   2
10   MO   3
11   OG
```

```
3000   LPRINT "PS 1, 100, 100, -100, 0, 0, 0"
3010   LPRINT "PS 2, -100, 100, 100, 0, 0, 0"
3020   LPRINT "PS 3, 0, 0, 0, 100, 100, 0"
```

(i) After input of the above program into the personal computer, perform the following input:

LLIST 5 – 11 ↵

By this procedure, the program from steps 5 to 11 are transferred to the drive unit. In this case, the BASIC steps are used concomitantly for robot control.

(ii) Next, when RUN 3000 ↵ is fed in, the program after step 3000 is transferred. For robot operation,
LPRINT "RN" ↵ is used as input as in the case of example 1.
When the parameters of OT and OD commands are given out in hexadecimal from by LLIST commands, always close the REM.

```
5   REM   OT & FF
```

[Example 3]

(When REM is used.)

When the input is an in steps 5 – 11 in example 2 by the personal computer, there are cases where an error occurs in the program and input is impossible. In such cases, perform input as indicated below. Even in cases of personal computers with no errors, the following input will present no problem.

```
5     REM   MO   1
6     REM   TI   10
8     REM   MO   2
10    REM   MO   3
11    REM   OG
```

Note: The REM simple signal can not be used.

For details, contact the manufacturer of your personal computer. The program performing the same operations as in example 3 of 6.4.1 is prepared as follows using this mode. In this case, the method of writing the program must be changed slightly.

[Example 4]

```
10    NT
20    SP   5
30    MO   1
40    TI   5
50    MO   2
60    TI   5
70    OG
80    ED
```

```
3000    LPRINT "PS 1, -2000, 0, 0, 0, 0, 0"
3010    LPRINT "PS 2, -8000, 0, 0, 0, 0, 0"
3020    END
```

```
LLIST        10 – 80 ↵
RUN          3000    ↵
LPRINT "RN"          ↵
```

It is possible to confirm that the same operation can be performed. Position data input programs have values greater than step 2049 whenever possible. (However, since the maximum number of program steps is 2048, do not exceed this limit.)

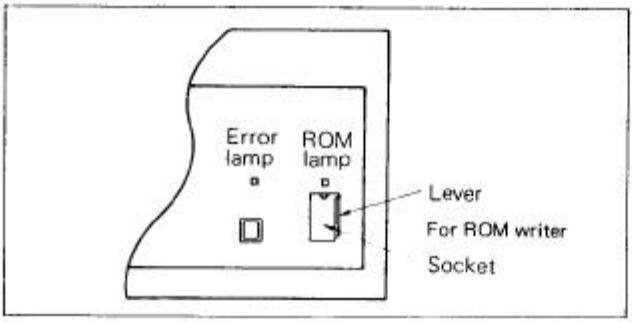
The position can also be taught from the teaching box. To stop the robot during operation, push the START/STOP switch of the drive unit. When an error occurs, the power supply is turned OFF by error mode I (error lamp extinguished). In error mode II (error lamp continuously lit), resetting is performed by the RS (reset) command.

6.4.3 ROM CONVERSION OF PROGRAMS

(1) ROM conversion from the personal computer
Programs prepared as in section 6.4.2 (edit mode) are converted to ROM in the following sequence.

(a) A suitable cleared ROM is applied.

(b) Pull up the lever of the ROM writer socket on the front of the drive unit by pulling it forwards.



Note:
Check that the power supply is turned on when inserting the ROM into the ROM writer socket.

(c) Confirm that the ROM lamp is extinguished and insert the ROM into the socket. (Pin 1 of the IC comes to side 1 of the socket.)

(d) Attach the ROM tightly and perform ROM conversion.

(e) ROM conversion of example 4 in section 6.4.2 is performed as follows:

(i) LPRINT "WR 0" ↵

(ii) When the ROM lamp is extinguished, ROM conversion of program data of steps 10 – 80 in example 4 is completed.

(iii) ROM conversion of position data is performed in the same way.

LPRINT "WR 4" ↵

(f) Arrange the program and position data efficiently with reference to the following table.

(g) The user area is divided in 6 as shown in the following table.

Table 6.1

Parameter a	User area
0	Program from steps 1 to 512
1	Program from steps 513 to 1024
2	Program from steps 1025 to 1536
3	Program from steps 1537 to 2048
4	Positions from No. 0 to 314
5	Position from No. 315 to 629

As far as possible, pack the programs and position data in ROMs sequentially from the smallest numbered ROM.

Note: When using the user standard ROM mounted on the CPU board, be sure to check that the power is off before pulling out the ROM from the IC socket. (For the procedure, see Fig. 6.3 in subsection 6.5.2.)

If the program shown in Example 4 in subsection 5.4.2 is divided into ROM No. 0 and ROM No. 3 and if ROM No. 1 and ROM No. 2 are not mounted, the program should be as shown below.

[Example]

```
10  NT
20  SP   5
30  MO   1      ROM No. 0 (Parameter a is 0.)
40  TI   5
50  GT   1537   Be sure to insert program line 50.

          JUMP instruction

1537  MO   2
1540  TI   5    ROM No. 3 (Parameter a is 3.)
1550  OG
1560  ED
```

(2) To store programs in ROM from the teaching box, see section 7.9.

(3) If the drive unit error lamp flickers for some reason (error mode I), it can be reset by turning off the power. (For ROMs whose operation has not been confirmed, check their operation in edit mode before using them.)

6.5 ROM MODE OPERATION

6.5.1 ROM MODE SELECTION

The following 4 modes can be selected by setting SW3 on the right side of the drive unit.

Table 6.3 SW3 mode switching

Mode No.	SW3			Functions
	2	3	4	
1	ON	OFF	OFF	No transfer in ROM and RAM of user area
2	ON	OFF	ON	Transfer of position data only to RAM from ROM of user area
3	ON	ON	OFF	Transfer of program only to RAM from ROM of user area
4	ON	ON	ON	Transfer of both program and position data to RAM from ROM of user area

(1) When all programs and position data are operated by ROM on the CPU board, select mode No. 4.

(2) When the program and position data are both operated on the ROM writer, select mode No. 1.
When the program is fixed and to be used for a long period, (1) should be followed and when the program is to be changed daily, follow (2).

Note: In transfers from ROM to RAM, the ROM lamp lights and is extinguished when the transfer is completed.

6.5.2 ATTACHMENT OF ROM TO THE CPU BOARD (REFER TO FIG. 6.1)

(1) Attach the ROM as follows.

(a) Open the cover on the right side of the drive unit (Fig. 6).

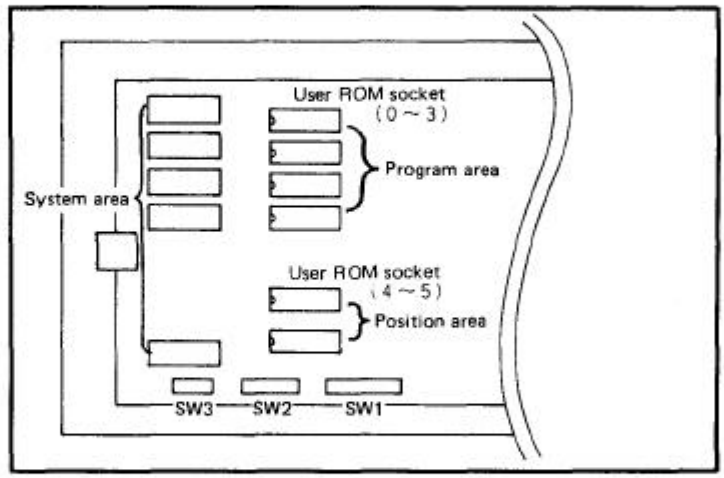


Fig. 6.1

(b) Confirm the ROM No. and direction and attach by pushing in from the front as in Fig. 6.1.

Note: Be sure to turn off the power when inserting ROM into the IC socket on the CPU board.

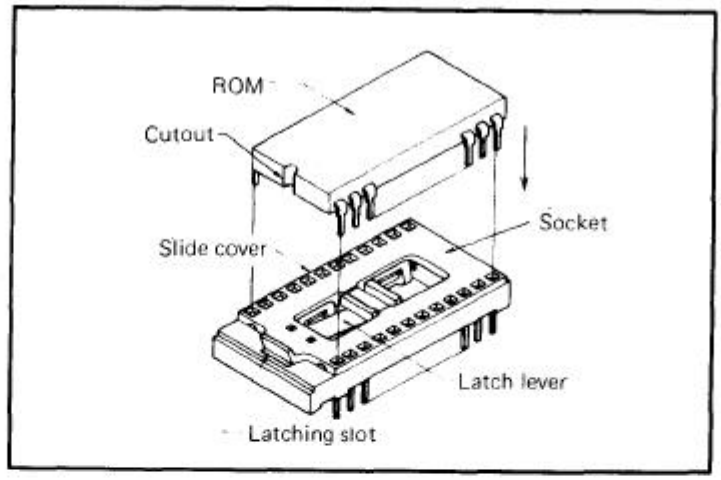


Fig. 6.2

Note: Be careful that screwdrivers, etc. are not inserted in the latching slot during ROM insertion.

(2) Remove the ROM as follows (refer to Fig. 6.2).

(a) Slide the cover with a screwdriver.

- Insert the tip of a small commercially available screwdriver in the latching slot and gently push down the latch lever.
- Move the screwdriver in the direction shown in the figure and slide the cover. Remove the ROM from the socket.

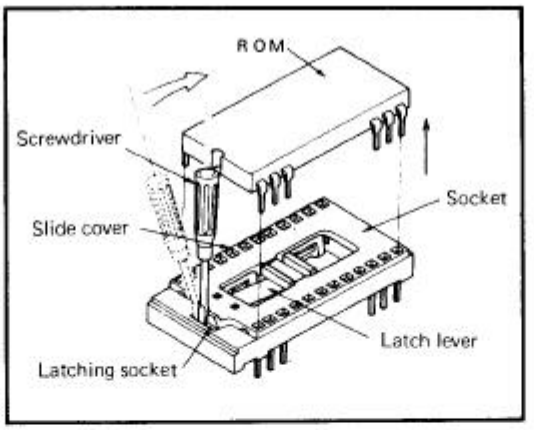
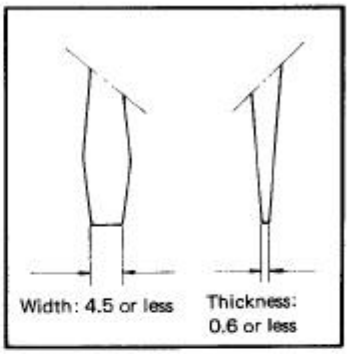


Fig. 6.3



Dimensions of tip of screwdriver used (mm)

(b) Remove the ROM.
The slide cover automatically returns to the original position by means of the built-in spring.

6.5.3 ROM MODE OPERATION

(1) In cases of operation by ROM on the CPU board in the drive unit.
  (a) Use ROM mode No. 4 (refer to section 6.5.1 and Table 6.2).
  (b) If the START/STOP switch of the drive unit is pushed, operation starts automatically from the beginning of the program.
  (c) To interrupt operation, push the START/STOP switch again. At this time, operation is stopped after completion of the command being executed.
  (d) For restarting of operation, repeat the operation in (b).
  (e) When the error lamp of the drive unit is extinguished for some reason (error mode I), turn off the power supply and reset. (Attach ROM of unconfirmed operation after confirming that it operates well using the edit mode.)

(2) In case of operation by the ROM writer on the front of the drive unit.
  (a) Use ROM mode No. 1 or No. 3 (refer to section 6.5.1 and Table 6.2).
  (b) Read in by the ROM writer using the personal computer or teaching box (T/B). (Refer to section 6.4.3 (1) concerning the method of inserting the ROM into the ROM writer socket.)
  (b-1) For example, the procedure is as follows when reading in ROM No. 5 (position data) with the T/B.

TRN 5 ENT

  is displayed in display column 4 by TRN. When transfer is completed, is displayed.
  In the case of an error, is displayed.
  (b-2) When ROM No. 5 (position data) is read in by the personal computer, the procedure is as follows.

LPRINT "TR 5" ↵

  (c) Operation and stopping are the same as in (1) (b) – (e).

6.5.4 ROM COPYING

When a program is converted to ROM and the ROM is copied in another ROM, the procedure is as follows.

(1) When executed from the ROM writer socket of the drive unit.
  (a) Insert the ROM with the program to be copied in the IC socket.
  *Always confirm that the power supply is ON.
  (b) When input is performed as follows from the teaching after completion of insertion, the program is transferred to the RAM on the CPU board in the drive unit.

  [TRN] [a] [ENT]

  (c) After completion of transfer to the RAM, replace the ROM with the copied ROM and perform the following input from the teaching box.

  [WRT] [a] [ENT]

  After completion, the ROM lamp in the drive unit is extinguished. ROM copying is then completed. In case of six copies, repeat the above procedure six times.

(2) When executed from the IC socket on the CPU of the drive unit.
  (a) Turn the power supply OFF.
  (b) Insert the ROM with the program to be copied in the IC socket on the CPU.
  (c) After insertion is completed, change dip switch No. 3 on the CPU board to the No. 4 mode. (Refer to 6.5.1.)
  (d) Turn the power supply ON.
  (e) Perform the following input from the personal computer for transfer to the RAM.
  (f) Insert the ROM for copying into the ROM writer socket.
  (g) After completion of insertion, perform the following input from the personal computer.

  [WRT] [a] [ENT]

  After completion, the ROM lamp is extinguished and ROM copying is then completed. In case of six copies, repeat the above procedure six times.

Note: 1. Be sure to use ROMs specified by Mitsubishi.
2. It takes approximately three to four minutes to copy a single ROM.

7 TEACHING BOX (T/B) (OPTION)

With the T/B, it is possible to confirm actual robot operation for each step of the teaching program and operate the robot arm by key operation. Robot origin output, position correction, addition, deletion, etc. are also possible. Write-in to the ROM and read-out by a special ROM writer are also possible. When not in use, it can be disconnected.

7.1 PREPARATIONS FOR OPERATION

Fig. 7.1 shows the outer appearance seen from the front panel.

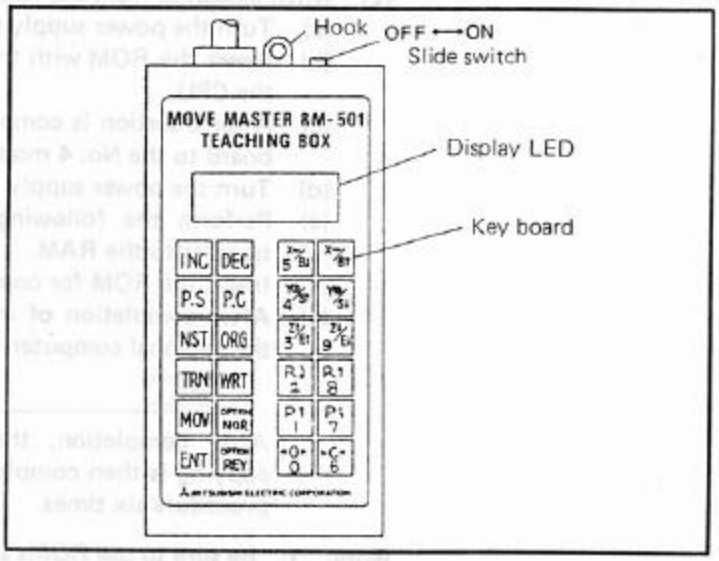


Fig. 7.1 Outer appearance of the teaching box

(1) Explanation of each switch

(a) Slide switch

When the slide switch is moved to the right, it is ON and teaching is possible.

When moved to the left, it is OFF and input from the personal computer is possible.

(b) Input keys

Input key	Function
B 5	When pushed, the body moves in the clockwise direction.
B	When pushed, the body moves in the counterclockwise direction.
S 4	When pushed, the shoulder moves upwards.
S	When pushed, the shoulder moves downwards.
E 3	When pushed, the elbow moves upwards.
E 9	When pushed, the elbow moved downwards.
R 2	When pushed, the wrist is turned in the clockwise direction.
R 8	When pushed, the wrist is turned in the counterclockwise direction.
P 1	When pushed, the wrist moves upwards.
P 7	When pushed, the wrist moves downwards.
0 0	When pushed, the hand opens.
C 6	When pushed, the hand is closed.
INC	Used to continuously confirm the No. of recorded position after the position No. input into the teaching box.
DEC	Used to continuously confirm the No. of the recorded position before the position No. input into the teaching box.
P.S	Used when the position is decided by teaching and the position is recorded as a No.
P.C	Used when the recording of a portion already recorded is erased.
NST	Used for origin output of the mechanical system.
ORG	Used to return to the origin by control system operation.
TRN	Used for transfer of a ROM converted program to the RAM in the drive unit.
WRT	Used for read-in of the prepared program into the ROM (ROM conversion)
MOV	Used for movement to a recorded position.
ENT	Execution key
OPTION REV	Not used.
OPTION NOR	

(2) Attach the T/B to the drive unit (D/U) as follows.
   (a) Turn the D/U power supply OFF.
   (b) Confirm that the T/B slide switch is OFF and attach to the D/U.
   (c) Do not just insert but also fix firmly with the connector screws.
   (d) Turn the D/U power supply ON.
   (e) Confirm that all display (LED) is 8, and turn the slide switch ON.

   This completes the preparations.

7.2 ROBOT NEST OUTPUT

When the hand has already been attached, check the following two points to determine of the relation between the wires to the hand and the hand attachment part are as shown in Fig. 7.2.

(1) Is the limit switch knob (refer to Fig. 7.2) visible on the right side as seen from the front?
(2) Is the hand wiring twisted or stretched and is it attached to the top?

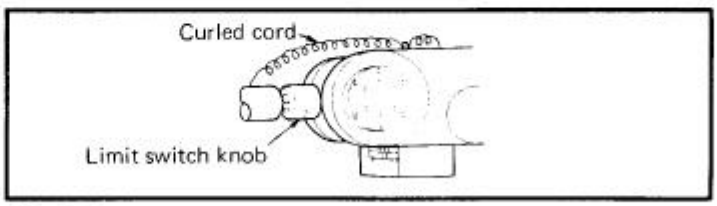


Fig. 7.2

If the condition is not as shown in Fig. 7.2, adjust to this condition by pushing the [R] (rotation) or [P] (bending) keys of the T/B.
After completion of the above, origin output is possible by the following precedure.

[NST] [ENT]

The above indicates pushing of the [NST] key and then the [ENT] key. The same applies in the following explanation.

7.3 MANIPULATOR OPERATION

When the 12 keys on the right side of the front panel are pushed, the joint corresponding to the key name is operated. The letters in parentheses hereafter indicate the name of the key.
– When keys continue to be pushed, joint operation is as follows.

	Waist, shoulder, elbow	Wrist rotation and bending
First 0.5 sec.	0.025°/0.5 sec.	0.075°/sec.
Next 1 sec.	2.5°/sec.	7.5°/sec.
Thereafter	10°/sec.	30°/sec.

– When the key is released, operation stops and when it is pushed again, the initial minimum speed operation occurs.
– When the key is pushed and released within 0.5 sec., operation occurs at the minimum speed.
  For example, when [B] is pushed and released four times in 1 sec., the waist rotation 0.1°.
– The grip is opened or closed by pushing [◂O▸] or [▸C◂], respectively. The same key is disregarded from the 2nd time.

Try to move the joints as indicated above.

Operation of the keys on the left side of the front panel can be explained as follows. The keys on the left are for display and operation.

(1) Numbers can be input in the bottom three columns in the display unit. The final three columns fed in become effective.
If there is a mistake, continue and insert the correct numbers.

(2) The 4th column in the display unit displays to reception of operation and processing results. The relation between the display and conditions is as follows.

(a) Extinguished : Condition where the key for execution has been received.

(b)  : Condition of no operation after power supply closing or cases where the slide switch is OFF or being turned from OFF to ON.

(c)  : Command is being executed or completed.

(d)  : Command concerning position can not be executed.

(e)  : Key reception condition after ROM write-in (WRT) operation

(f)  : Key reception condition after ROM read-out (TRN) operation

(g)  : Error in ROM write-in or read-out

7.4 HOME POSITION SETTING

Move to the desired position by manipulator operation as follows:

PS 0 ENT

(1) PS : Display unit 4th column extinguished
(2) 0 : Display of 000 in the bottom 3 columns
(3) ENT :  displayed in 4th column
Confirm that  is always displayed in step (3).

Note: Considerable caution is necessary when changing the home position since all of the stored positions are moved relative to the change.

7.5 HOME POSITION RETURN

After completion of home position setting as in 7.4, move each of the joints by means of the manipulator. Return to the home position by the following operation.

ORG ENT

7.6 POSITION SETTING

After setting the home position as in 7.4, set the positions in the No. 1 – 629 range. Also set the grip opening and closing conditions accordingly.

[Example] Setting position 123

PS 1 2 3 ENT

7.7 CONFIRMATION OF POSITIONS

The following methods are used to confirm the positions set as in 7.6.

7.7.1 CONFIRMATION BY SPECIFYING POSITION NO.

For example, to confirm position 123, use the following procedure:

MOV 1 2 3 ENT

If position 123 is recorded already,  is displayed and there is movement to this position, but if it is unrecorded,  is displayed and there is no movement.

7.7.2 CONTINUOUS CONFIRMATION OF POSITION

Use the following procedure to confirm the recorded positions after position 123 in 7.7.1.

(1) Confirm that 1 2 3 are displayed.

(2) INC ENT

(3) Confirm that  is displayed in the 4th column and the display in the bottom 3 columns has changed. If position 124 is recorded, 124 is displayed.

(4) INC ENT

Continue to confirm each recorded position.

(5) If  is displayed in the 4th display column, this indicates that there are no recorded positions thereafter. The robot does not operate.
In cases of confirmation of recorded position before position 123, change from INC to DEC and confirm by the same procedure.

7.8 DELETION OF RECORDING OF RECORDED POSITIONS

Use the following procedure to delete recorded position 30.

PC 3 0 ENT

7.9 WRITE-IN TO ROM

When writing prepared programs and recorded positions into ROM, confirm the area for the write-in and operate ROM No. a as follows:

WRT a ENT

$0 \leq a \leq 5$ (a is the ROM No.) Refer to 6.1.

When the WRT key is operated,  is displayed in the 4th display column. When 0 0 a ENT is entered,  is displayed during and at the completion of the write-in, and the ROM lamp on the D/U front surface is lit during write-in and extinguished when it is completed. If an error such as defective ROM occurs,  is displayed.

7.10 TRANSFER FROM ROM INSERTED SOCKET IN FRNT OF D/U TO THE DRIVE UNIT RAM

To transfer the ROM contents inserted the ROM socket into the RAM, this operation is used. Specify the following when transferring ROM No. a.

TRN	a	ENT

8 is displayed in the 4th display column by TRN
When the transfer is completed, 4 is displayed. When there is an error, 8 is displayed.

8 CONNECTION TO EXTERNAL I/O

8.1 INPUT/OUTPUT TERMINAL SPECIFICATIONS

Table 8.1 Input terminals

Terminal No.	Name	Specifications	Remarks
1 2	DC 12/24V	DC 12V or DC24V Constant voltage power supply (DC 10.8~ 26.4 V)	
3 4 5 6 7 8 9 10	0 bit 1 bit 2 bits 3 bits 4 bits 5 bits 6 bits 7 bits	Input current: ON voltage DC 3V (max.) OFF voltage DC 10V (min.) Input current: 10 mA (TYP) Insulation type: photocoupler	Input
11	STB	Same as terminals 3 – 10.	Input
12	BUSY	Rated load voltage : DC 24V Maximum absolute voltage: DC 50V Load current : 0.1 A (max.) Insulation type : photocoupler	Output

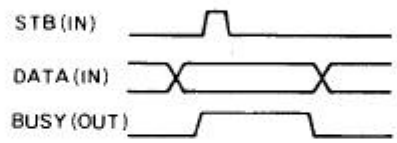
Table 8.2 Output terminals

Terminal No.	Name	Specifications	Remarks
1 2	DC 12/24 V	DC 12V or DC 24V Constant voltage power supply (DC 10.8 – 26.4 V)	
3 4 5 6 7 8 9 10	0 bit 1 bit 2 bits 3 bits 4 bits 5 bits 6 bits 7 bits	Rated load voltage: DC 24V Maximum absolute voltage: DC 50V Load current: 0.1A (max.)/ terminals Insulation type: photocoupler	Output
11	ACK	Input voltage: ON voltage DC 3V (max.) OFF voltage DC 10V (min.) Input current: 10 mA (TYP) Insulation type: photocoupler	Input
12	RDY	Same as terminals 3 – 10.	Output

- Input into both the input and output terminals is LOW level.
- Output surge currents must be limited to within the ratings. (Care is especially necessary when operating electric light bulbs since surge current about 10 times the ratings flow.)
- The specifications on page 67 - 72 are for the U.S.A. For European specifications, see the attached sheet.

[Input signal timing]

(a) IN indicates the input to the drive unit and OUT the output signals from the drive unit.



(b) On the drive unit side, data stand-by from an external control occurs when BUSY is in the L period.

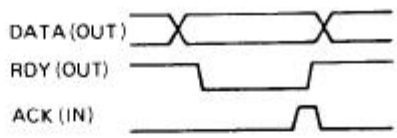
(c) When the S.T.B. signal is input, there is output on the external controller side when the BUSY signal is in H.
Data can not be changed in the external controller during the BUSY H period.

(d) When data input to the drive unit is completed, the BUSY signal becomes L and input of the next data is possible.

(e) BUSY has the same timing as the IBF (Input Buffer Full) signal of the drive unit PPI (Programmable Peripherals Interface) (8255).

[Output signal timing]

(a) IN indicates the input to the drive unit and OUT the output signals to the external controller.



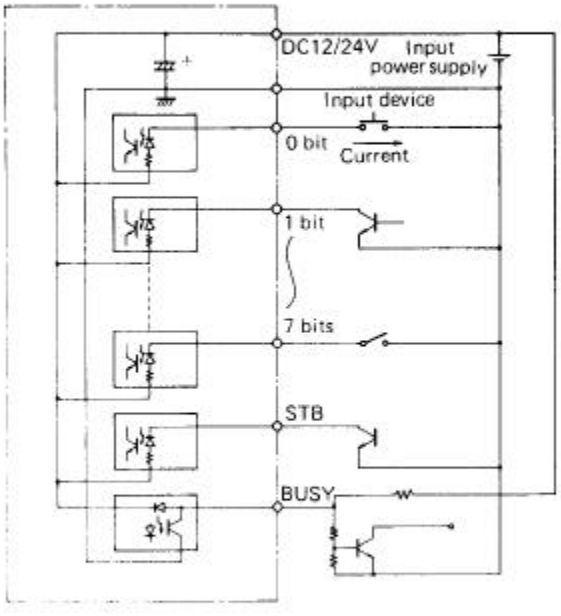
(b) From the drive unit, the DATA is locked until the ACK signal of the external controller changes from L to H.

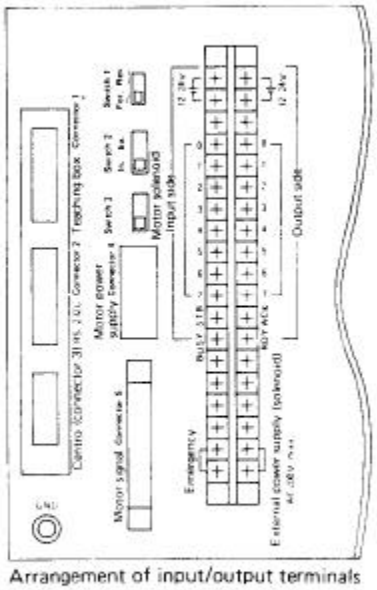
(c) After ACK signal input in the drive unit, the next data are given out.

(d) RDY has the same timing as OBF (Output Buffer Full) of the drive unit PPI (Programmable Peripherals Interface) (8255).

8.2 CONNECTIONS TO INPUT/OUTPUT TERMINALS

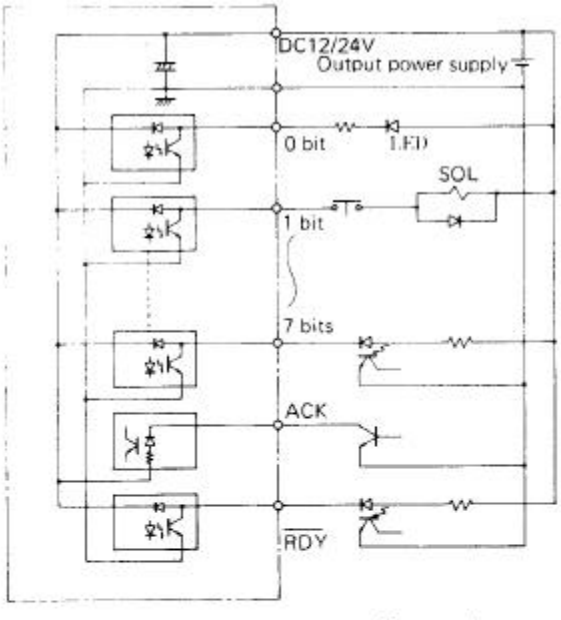
8.2.1 EXAMPLE OF CONNECTION TO AN INPUT TERMINAL





Arrangement of input/output terminals

8.2.2 EXAMPLE OF CONNECTION TO AN OUTPUT TERMINAL



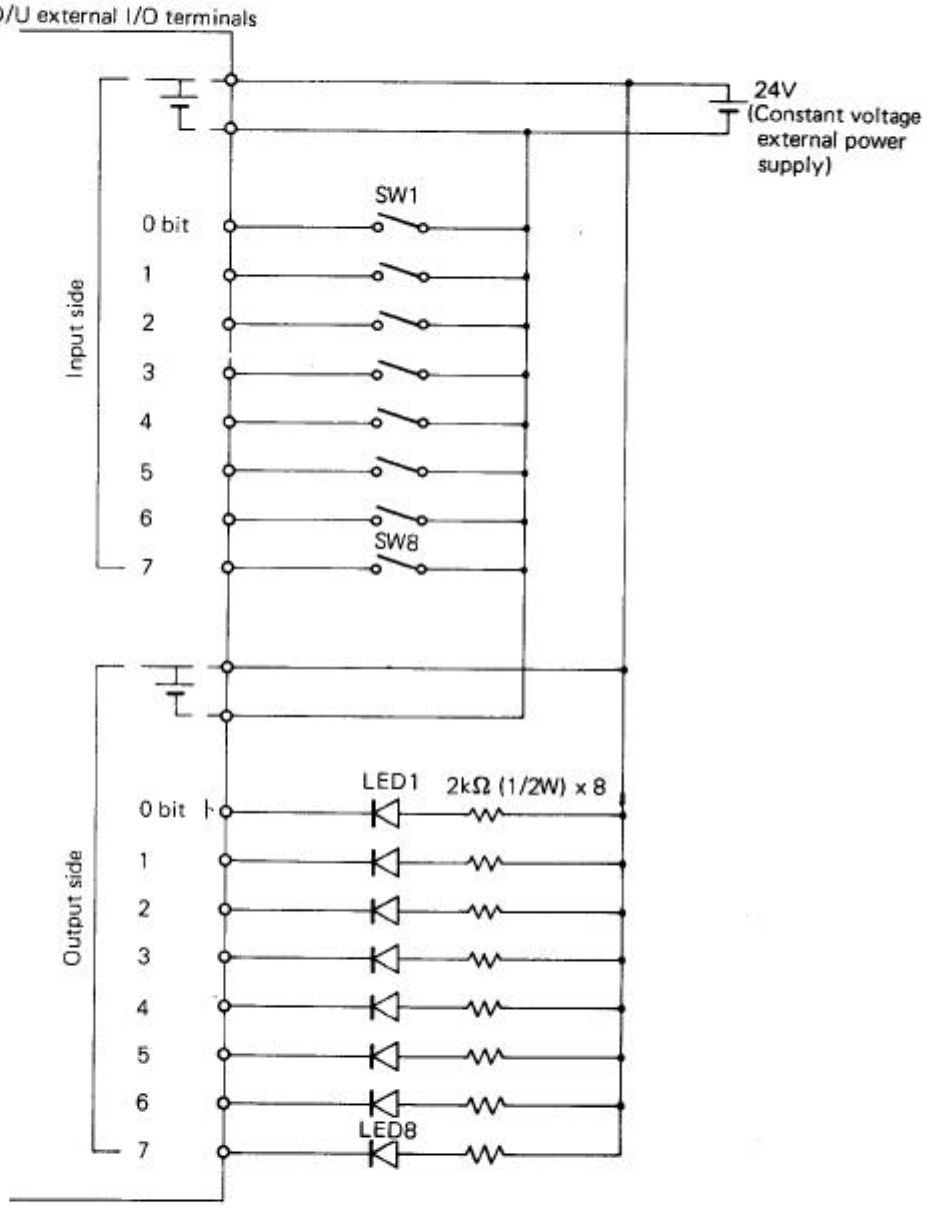
- The input/output power supplies can be common.
- When ID and OD commands are used, STB, BUSY, ACK and RDY conditions are disregarded.

8.3 EXAMPLE OF A PROGRAM USING EXTERNAL I/O

Try to perform the following example.
Example conditions

(1) Eight toggle SW are connected to the input board and 8 types of tasks are selected. (In actual cases, switch selection is performed by a sequencer, etc.)
(2) The task currently being executed is displayed in 8 LED.

[Connection diagram]



[Main program]

```
1          NT ..............  NEST
2    REM   OD & FF .........  All LED extinguished
4          SP 5 ............  Speed setting
6          ID ..............  Input
7          TB  -0,100 ......  Jump to step 100 when SW1 ON
8          TB  -1,200
9          TB  -2,300
10         TB  -3,400
11         TB  -4,500
12         TB  -5,600
23         TB  -6,700
24         TB  -7,800 ......  Jump to step 800 when SW8 ON
25         GT 6 ............  Jump to step
```

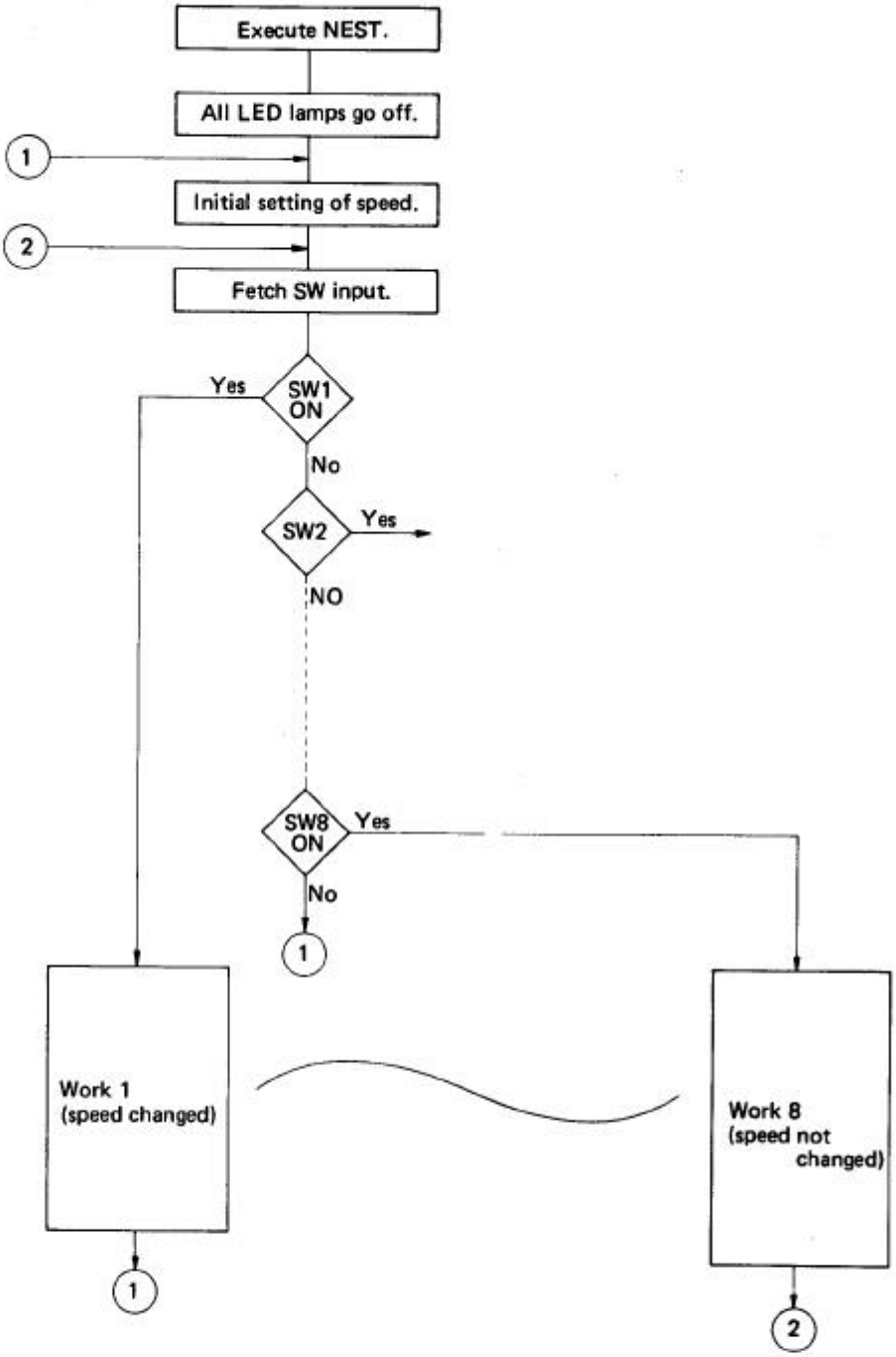
[Task 1 program]

```
100    REM   OD & FE  ..... LED1 extinguished
110          SP 3
               |
               |
199          GT 4
```

[Task 2 program]

```
800    REM   OD & 7F  ..... LED8 extinguished
801          SP 5
               |
               |
900          GT 6
```

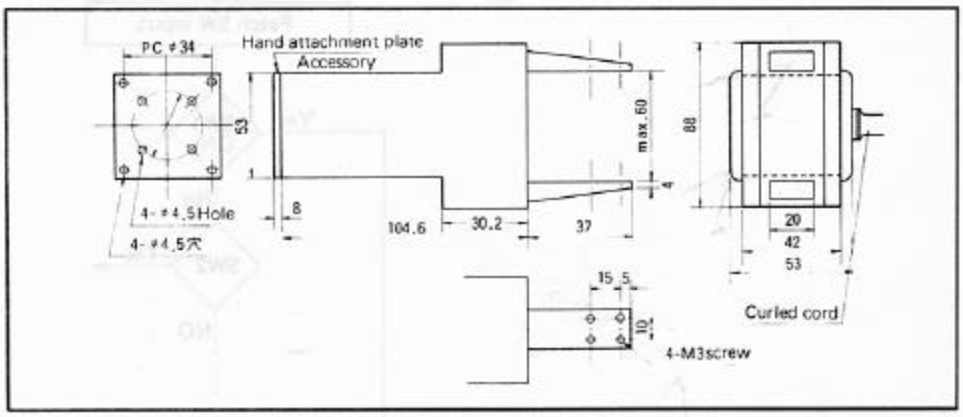
[Flowchart]


Execute NEST.
All LED lamps go off.
1
Initial setting of speed.
2
Fetch SW input.
Yes
SW1 ON
No
SW2
Yes
NO
SW8 ON
Yes
No
1
Work 1 (speed changed)
1
Work 8 (speed not changed)
2

9 STANDARD HAND (OPTION)

9.1 EXTERNAL APPEARANCE

There is a special hand for the MOVE MASTER II RM-501. Attach the accessories to the wrist tool surface of the robot.



9.2 SPECIFICATIONS

(1)	Motor used	DC servomotor
(2)	Rated voltage	DC 24V
(3)	Rated output	15W
(4)	Weight	700 g
(5)	Grip force	max. 4 kg

9.3 ACCESSORIES

(1)	Hand attachment plate	1
(2)	Cord attachment plate	1
(3)	P countersunk screws M4 x 10	4
(4)	P pan-head screws M4 x 10	4
(5)	P pan-head screws M3 x 6	2
(6)	Spring washers M4	4

9.4 ATTACHMENT METHOD

(1) The robot hand attachment part is as shown in Fig. 9.1.
(2) First, attach the accessory hand attachment plate with four accessory P pan-head screws M4 x 10 and four spring washers M4.
(3) Next, attach the standard hand to the hand attachment plate using four accessory P countersunk screws M4 x 10.
(4) Attach the cord attached plate fitted to the middle part of the curled cord with two accessory P pan-head screws M3 x 6 to the based plate of the robot unit.
(5) Insert the connector at the tip of the curled cord into the hand connector of the robot.

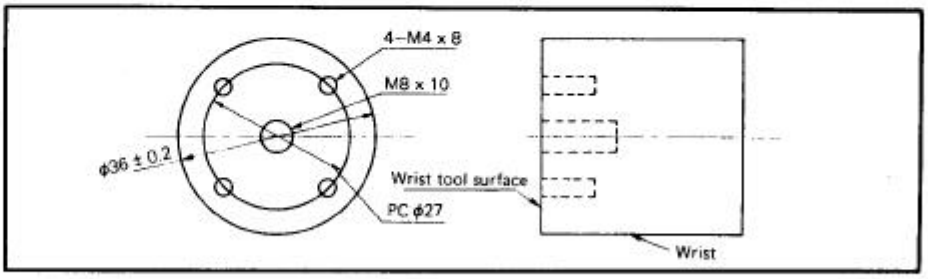


Fig. 9.1 Robot hand attachment part

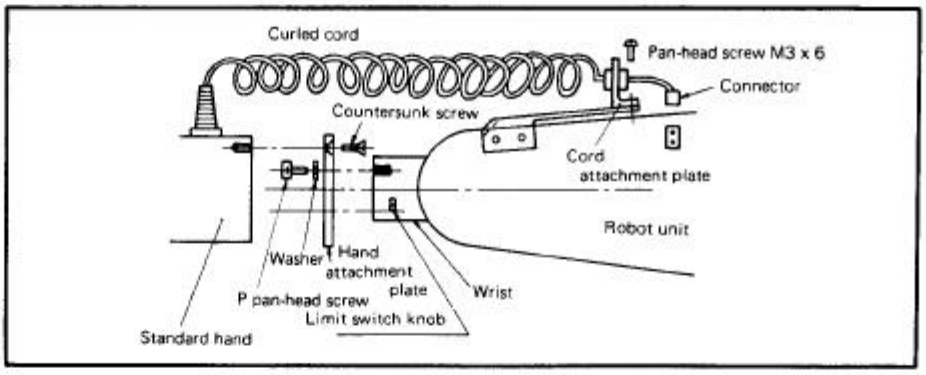


Fig. 9.2 Instructions for standard had attachment

Note: Attach the standard hand so that the positional relation between the curled cord and the limit switch knob of the wrist is as shown in Fig. 9.2.

10 INTERFACES WITH THE PERSONAL CO

10.1 CENTRO INTERFACE (CONNECTOR 3)

The main personal computers and connection terminal relations are as follows. Since special cables are used for the connections, please purchase these separately.

Table 13.1 Various personal computers and connections

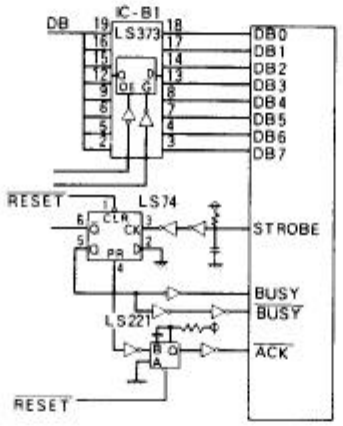
MOVE MASTER		Mitsubishi Electric	Mitsubishi Electric	NEC
Signal	Terminal No.	MX-6000	MULTI-16	PC-8001
DB0	A8	2	32	3
DB1	A7	3	30	5
DB2	A6	4	28	7
DB3	A5	5	26	9
DB4	A4	6	24	11
DB5	A3	7	22	13
DB6	A2	8	20	15
DB7	B2	9	18	17
STB	A1	—	34	—
STB		1	—	1
Busy	B8	11	14	21
Busy	B3	—	—	—
ACK	B7	10	16	19
GND	B4, B5	19~29	2,4,11,13,15,17,19,21,23,25,27,29,31,33	2,4,6,8,10,12,14,16,18,20,22,31
NC	B1	—	—	—

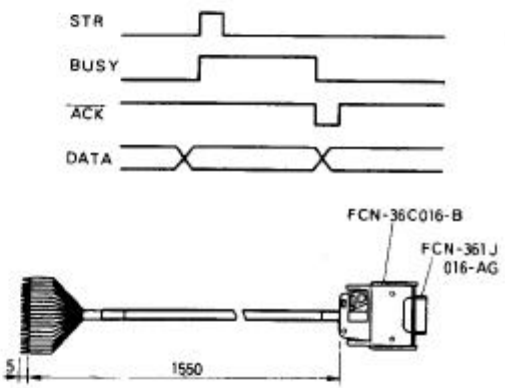
- The MULTI-16 GND must always be connected to 12 sites.
- Connections of personal computers other than the above such as the Sharp MZ-80B, NEC PC8801, Hitachi Level II, Toshiba PASOPIA, Fujitsu FM-8, Oki IF-800 and Sodo M100 are made by connector-free connection cables (sold separately).
  The MOVE MASTER has a built-in interface with specifications based on the printer manufactured by the Centronics Co. for interface with personal computers. Discuss connection with the computer manufacturer since there are cases where special interfaces are necessary depending on the personal computer.

Connector free terminal numbers

Signal	Wire color	Signal	Wire color	Signal	Wire color	Signal	Wire color
STB, $\overline{STB}$	Brown	DB3	Green	NC	Red, white	GND	Black, white
DB6	Red	DB2	Blue	DB7	Orange, white	NC	Green, white
DB5	Orange	DB1	Gray	$\overline{Busy}$	Yellow, white	$\overline{ACK}$	Purple (blue,white)
DB4	Yellow	DB0	Brown, white	GND	Black	Busy	White (gray,white)

(1) Connect specified wire colors to the connectors, matching the names of the personal computer signals and the above signals.
(2) Purchase the connectors for the computer side separately from the computer manufacturers.





10.2 RS-232C INTERFACE

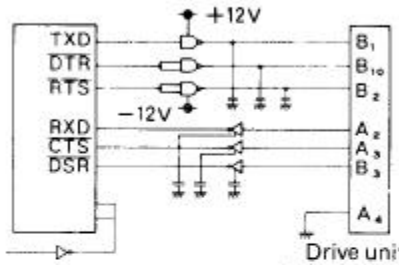
(1) Setting of baudrate (CPU board dip SW1)

SW1	Borate
1	9600
2	4800
3	2400
4	1200
5	600
6	300
7	150
8	75

– Set the baudrate with the switch ON.
– Always operate with the power supply OFF.
– Never have more than one switch ON simultaneously.

(2) Connection to the RS-232C

① RS-232 circuit



Drive unit sidel
connector terminal,
made by Fujitsu FCN-365P024-AU

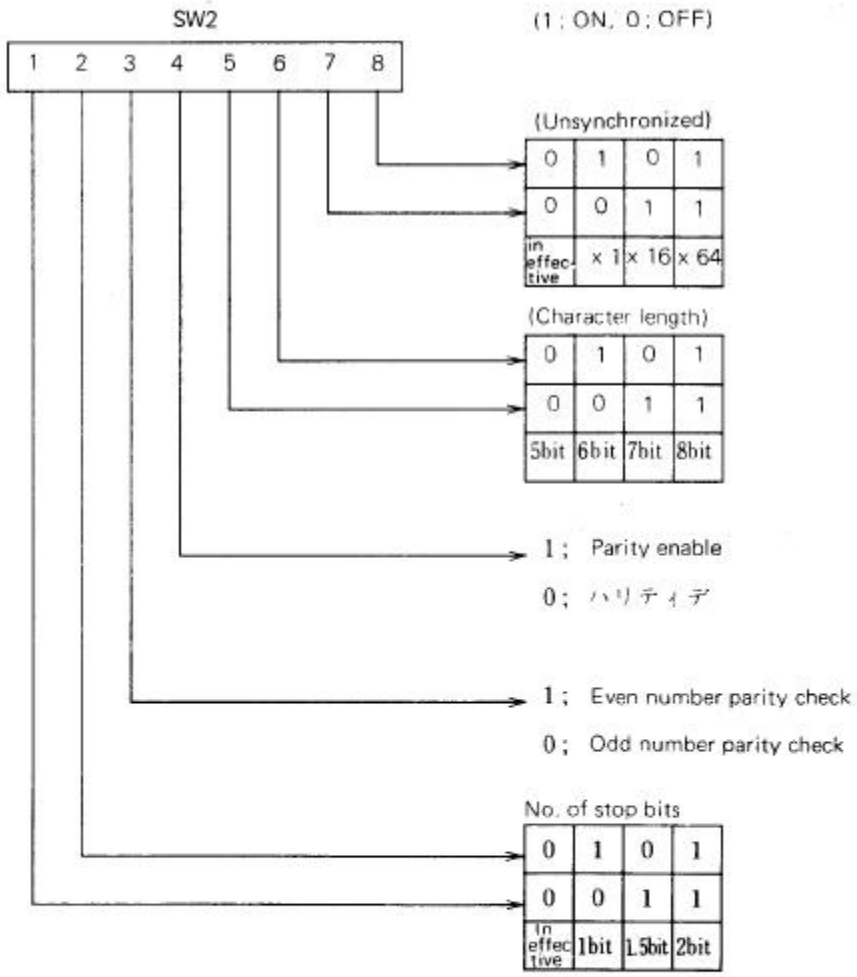
② Connectors

2.1 Prepare the following connectors for connection to the robot.

Made by Fujitsu	Jack	FCN-361J024-A
	Cover	FCN-360C024

2.2 Connect the connectors on the control side (personal computer, etc.) after checking with the manufacturer concerned.

(3) PCI (8251) mode setting (CPU board dip SW2)



10.3 EXAMPLES OF THE USE OF THE CENTRO AND RS-232C WITH MX-6000

Examples of programs are shown when robot No. 1 (RB1) is connected to centro 1, robot No. 2 (RB2) to centro 2 and robot No. 3 (RB3) to RS-232C as interfaces for the MX 6000. First, the following subroutine is fed in.

```
32000 REM <<< PORT SET >>>
32010 POKE 56136!,12
32020 IF PT$<>"PR" THEN 32040
32030 PT=0:GOTO 32100
32040 IF PT$<>"C1" THEN 32060
32050 PT=128:GOTO 32100
32060 IF PT$<>"C2" THEN 32080
32070 PT=192:GOTO 32100
32080 IF PT$<>"RS" THEN RETURN
32090 PT=64
32100 PT2=PEEK(3)
32110 PT2=PT2 AND 63
32120 PT=PT OR PT2
32130 POKE 3,PT
32140 RETURN
```

[Program example 1]

```
 1   PT$ = "C 1" : GOSUB 32000 ....  Selection of centro 1 (RB1)
20   LPRINT "PS 1, -1000,0,0,0,0,0" ... RB1 position No. 1 set
30   LPRINT "MO 1" ..................  Move to RB1 position No. 1
40   PT$ = "C 2" : GOSUB 32000 ......  Selection of centro 2 (RB2)
50   LPRINT "PS 1, -5000,0,0,0,0,0" ... RB2 position No. 1 set
60   LPRINT "MO 4" ..................  Move to RB2 position No. 1
70   PT$ = "RS" : GOSUB 32000 .......  Selection of RS-232C (RB3)
80   LPRINT "PS 5,0, -500,0,0,0,0" .... RB3 position No. 5 set
90   LPRINT "MO 5" ..................  Move to RB3 position No. 5
100  PT$ = "PR" : GOSUB 32000 .......  Printer selection
     LLIST ..........................  Total list output
```

In this example, robots 1, 2 and 3 operate in sequence and not simultaneously.

[Program example 2]

The three robots in example 1 are operated simultaneously.

```
10   PT$ = "C 1" : GOSUB 32000
20   LPRINT "PS 1, -1000, 0,0,0,0,0"
30   PT$ = "C 2" : GOSUB 32000          Position sent to
40   LPRINT "PS 1, -5000, 0,0,0,0,0"    each robot.
50   PT$ = "RS" : GOSUB 32000
60   LPRINT "PS 5, 0, -500,0,0,0"
```

```
 70      FOR C=1 TO 2
 80      PT$ = "C" + STR$(C) : GOSUB 32000
 90      LPRINT "10 MO 1"                          Program sent to
100      NEXT C                                    each robot.
110      PT$ = "RS" : GOSUB 32000
120      LPRINT "3 MO 5"

130      FOR C=1 TO 3
140      PT$ = "C" + STR$(C) : GOSUB 32000
150      LPRINT "RN"
160      NEXT C                                    Each robot started.
170      PT$ = "RS" : GOSUB 32000
180      LPRINT "RN"
190      END
```

Note: There can be differences in the starting of the three robots just by differences in the execution times of steps 130 – 180.

11 INSPECTIONS AND MAINTENANCE

11.1 DAILY INSPECTIONS

(1) Confirm that there are no loose screws or connection cables.
(2) Operate the robot by the test mode or your own check program (refer to 5.3.1).
(3) Confirm that no dust, foreign matter or shavings have accumulated.
(4) Confirm the connection condition to the base and if there is any looseness, tighten it.

11.2 PERIODIC INSPECTIONS

(1) Confirm that the ambient temperature and the temperature inside the housing panel is in the 5 ~ 40°C range. If the temperature is over 40°C, cool with a fan, etc.
(2) Replace the brushes, motor (wrist), curled cord and timing belts after every 2,000 hours of operation in principle.
(3) Confirm the safety measures such as the emergency stop switch.

11.3 TROUBLES AND COUNTER MEASURES

A simple troubleshooting method is explained in this instruction manual.

Trouble	Items to confirm	Countermeasures
Power supply not ON.	1 Is power supply cord in power supply plug?	Repair.
	2 Is the fuse blown?	Replace the fuse.
	3 Check the power supply voltage.	When over voltage supplied by mistake, contact the dealer.
Robot does not move.	1 Is error lamp lit or extinguished?	○ Check if there are any mistaken commands, etc. and correct.
		○ Is the cable connection proper? → connect properly.
Input/output of program from personal computer impossible.	1 Is the teaching box changeover switch ON?	○ Turn it to OFF.
	2 Is the error lamp lit?	○ Check the commands and input formats and correct.
	3 Is it in the ROM mode?	○ Turn all SW3 in the drive unit to OFF.

Trouble	Items to confirm	Countermeasures
Stoppage during operation	1 Is the error lamp extinguished?	○ Is the connection cable disconnected or broken? → replace or connect properly.
	2 Is there a power interruption?	○ Start again from NEST.
	3 Has the emergency stopping switch been pushed by mistake?	○ Start again.
Repeated positional inaccuracies.	1 Has some unexpected noise occurred?	○ Correct positional discrepancies using the NEST command every 30 minutes.
	2 Is the robot firmly fixed in position?	○ Fix the robot firmly in position.
Abnormal noise.	Are there any loose attachment (unit) screws?	○ Tighten the screws firmly.
Hand does not open and close.	1 Select the DC motor and solenoid changeover switch.	○ Select the changeover switch in accordance with the motor used.
	2 Is the parameter current time of the GP command short?	○ Make the parameter larger.
	3 Is there a mistake in the selection of the solenoid forward/reverse changeover switch?	

11.4 SPARE PARTS

Since the RM-501 uses DC servomotors with brushes, it is necessary to replace the brushes at least enery 2000 hours of operation. There are five of these DC servomotors used, but replace the servomotors (2) for wrist drive for structural reasons. Contact the Mitsubishi concerning replacement of servomotor brushes and servomotors, curled cord replacement and timing belt replacement.

	Name
1	Fuses
2	Wrist DC motor
3	Brushes (base, elbow, shoulder)
4	Curled cord (2 types)
5	Timing belts
6	Limit switches

11.5 GUARANTEE PERIOD

When breakdowns occur during normal use, please contact with your Mitsubishi Electric sales office. However, this does not apply in cases of re-construction of disassembly, motor and motor brush replacement due to motor and brush wear and replacement of signal curled cord dur to wear. Terminal belts will also not be replaced free of charge. Refer to section 11.4 concerning replacement of brushes and curled cord.

11.6 OPTIONS

The following are options for this robot. Contact your sales outlet to order these options.

Options
Teaching box
Standard hand
EP-ROM for expansion
Serial cable (for MX-6000) (3m)