

10 PALLETIZING FUNCTION

This chapter explains the palletizing function.

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10.1 PALLETIZING FUNCTION

Palletizing function

Palletizing is a function for the orderly stacking of workpieces by only teaching several representative points.

- A stacking pattern can be created easily by teaching representative stack points.
- A path pattern can be created by teaching path points (approach points and retraction points).
- Multiple path patterns can be set to perform palletizing in a wide variety of patterns.

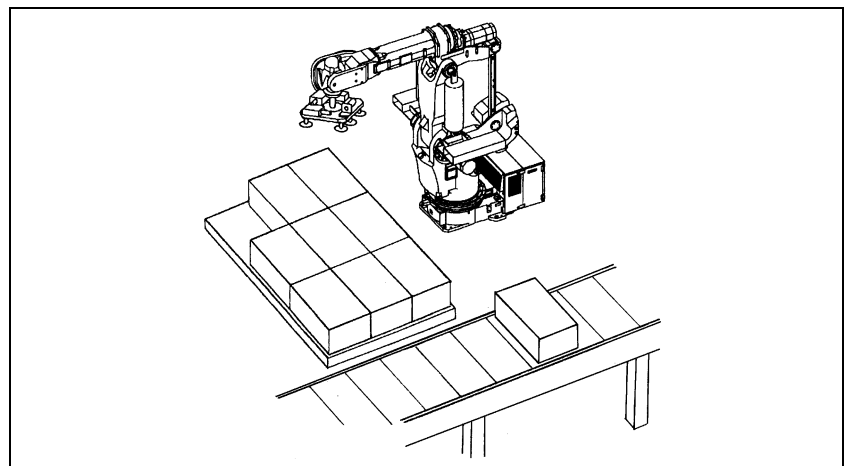


Fig. 10.1 (a) Palletizing

Structure of the palletizing function

The palletizing function consists of the following two patterns:

- Stacking pattern : Determines the method of stacking workpieces.
- Path pattern : Determines the path along which the robot hand moves to stack workpieces.

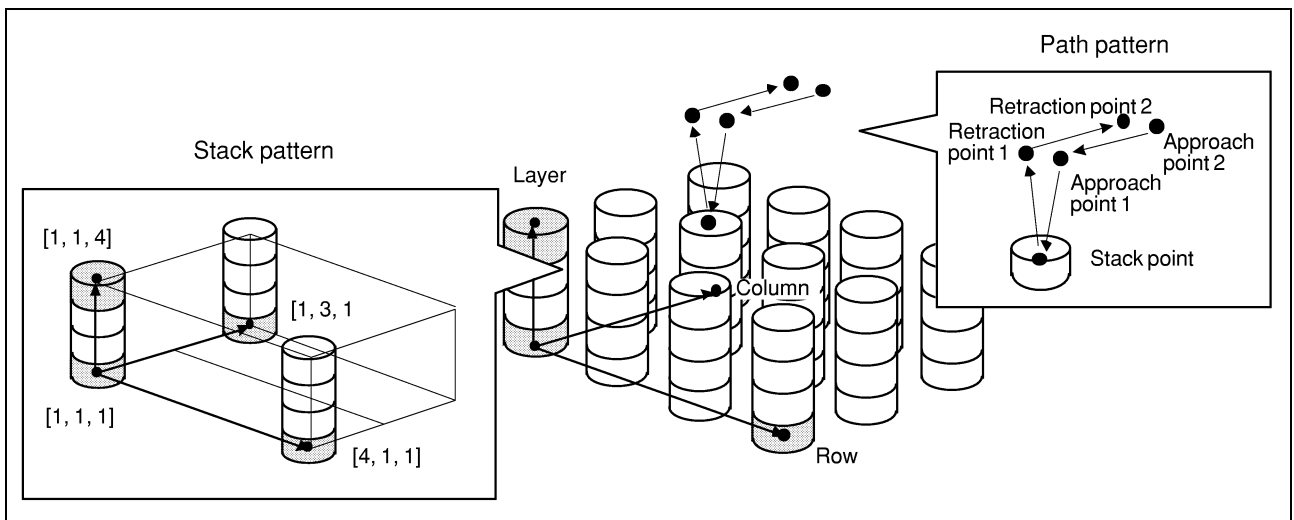


Fig. 10.1 (b) Palletizing Pattern

Types of palletizing

There are the following four types of palletizing according to the methods for setting stack and path patterns (See Section 10.3).

- Palletizing B and palletizing BX
- Palletizing E and palletizing EX

- Palletizing B

Palletizing B only the palletizing-B function can be taught. Palletizing B can achieve a comparatively easy stacking pattern by one kind of path pattern.

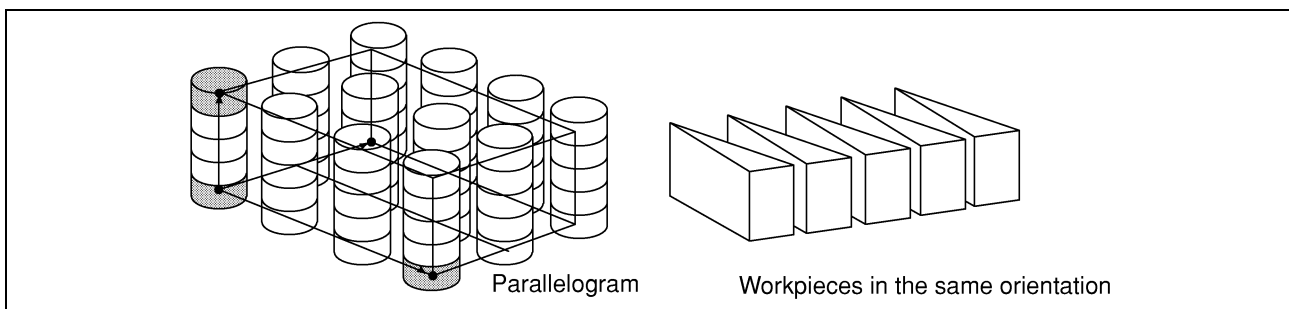


Fig. 10.1 (c) Palletizing-B Function

- Palletizing E

Palletizing E can be used for more complex stack patterns (such as when the attitudes of workpieces are to be changed or when the shape made by the stacked workpieces, as viewed from below, is not a parallelogram).

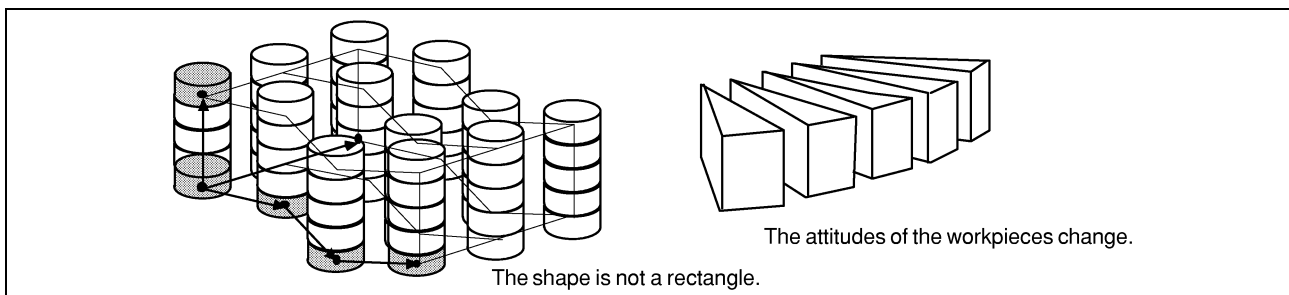


Fig. 10.1 (d) Palletizing E

- Palletizing BX and EX

For palletizing BX and EX, multiple path patterns can be set. For palletizing B and E, only one path pattern can be set.

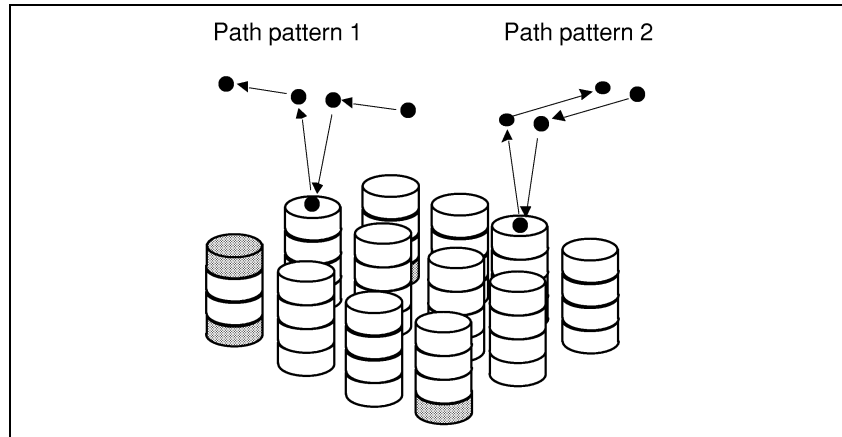


Fig. 10.1 (e) Palletizing BX and EX

10.2 PALLETIZING INSTRUCTIONS

The following palletizing instructions are available:

Table 10.2 Palletizing instructions

Instruction	Function
Palletizing instruction	Calculates the current path based on a stacking pattern, path pattern, and the value held in the palletizing register, and rewrites the position data of a palletizing motion instruction.
Palletizing motion instruction	A motion instruction dedicated to palletizing. It has position data of an approach point, stack point, or retraction point.
Palletizing end instruction	Increments (or decrements) the value of a palletizing register.

Palletizing instruction

Based on the value held in the palletizing register, the palletizing instruction calculates the position of the current stack point from a stack pattern, and also calculates the current path from a path pattern. It then rewrites the position data of a palletizing motion instruction.

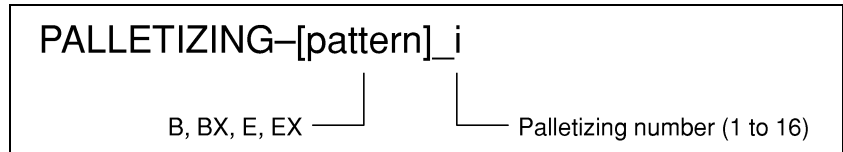


Fig. 10.2 (a) Format of the Palletizing Instruction

Palletizing motion instruction

The palletizing motion instruction is a motion instruction that uses three path points — an approach point, stack point, and retraction point — as position data. This instruction is dedicated to palletizing. Each palletizing instruction rewrites such position data.

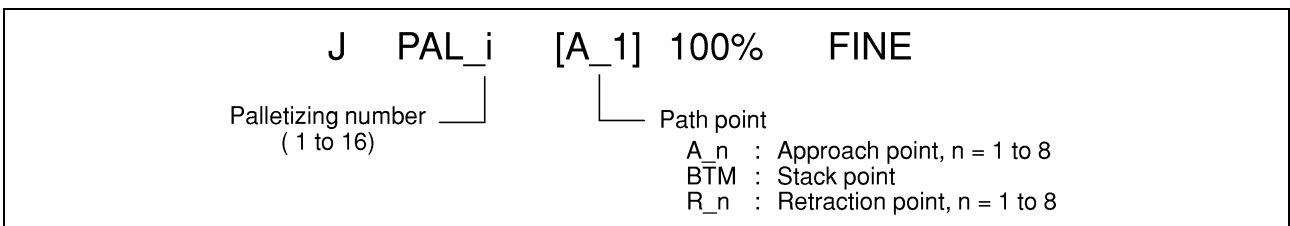


Fig. 10.2 (b) Format of the Palletizing Motion Instruction

Palletizing end instruction

The palletizing end instruction calculates the next stack point and increments (or decrements) the palletizing register value.

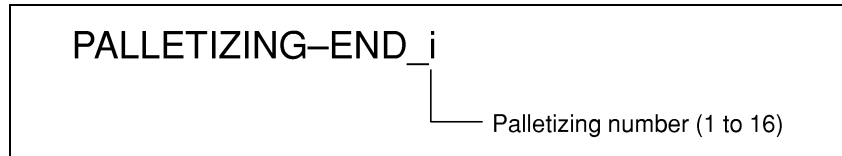


Fig. 10.2 (c) Format of the Palletizing End Instruction

```

Example
1:   PALLETIZING-B_3
2: J PAL_3[ A_2 ] 50% CNT50
3: L PAL_3[ A_1 ] 100mm/sec CNT10
4: L PAL_3[ BTM ] 50mm/sec FINE
5:   handl open
6: L PAL_3[ R_1 ] 100mm/sec CNT10
7: J PAL_3[ R_2 ] 50% CNT50
8:   PALLETIZING-END_3
    
```

- Palletizing number

Upon completion of the teaching of palletizing data, palletizing numbers are written automatically together with the instructions (palletizing instruction, palletizing motion instructions, and palletizing end instruction).

When a new palletizing operation is taught, a palletizing number is assigned automatically.

Palletizing register instruction

The palletizing register instruction is used to control palletizing. It performs stack point specification, comparison, and branch. (See Subsection 10.4.1)

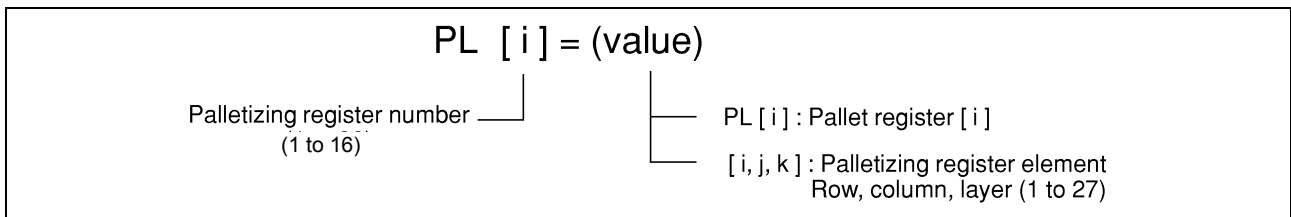


Fig. 10.2 (d) Palletizing Register

10.3 TEACHING THE PALLETIZING FUNCTION

The palletizing function is taught using the following procedure:

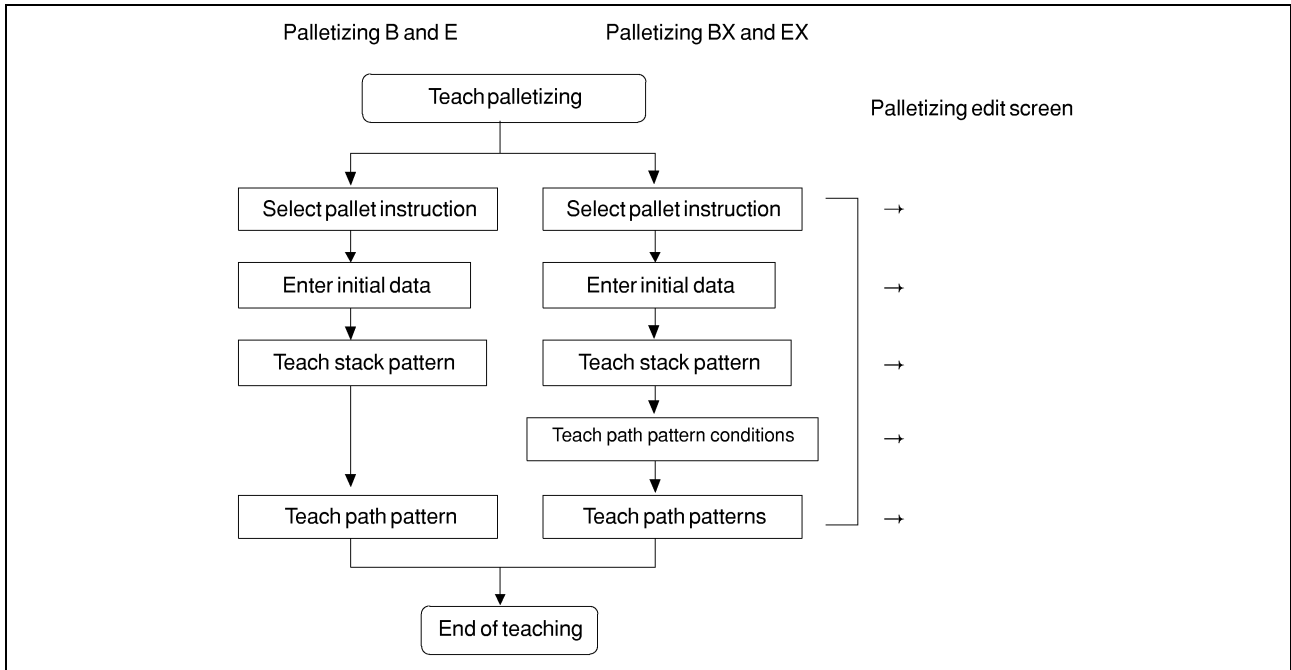


Fig. 10.3 Procedure for Teaching the Palletizing Function

The palletizing function is taught on the palletizing edit screens. One of the palletizing edit screens appears automatically when a palletizing instruction is selected.

When the palletizing function is taught, necessary palletizing instructions such as a palletizing instruction, palletizing motion instruction, and palletizing end instruction are inserted automatically.

The following sections explain the teaching of palletizing EX. For palletizing B, BX, or E, assume that some functions of palletizing EX are restricted.

NOTE

To improve the motion accuracy of palletizing, TCP should be accurately set. (See Subsection 3.9.1, "Setting a Tool Coordinate System")

10.3.1 Selecting a Palletizing Instruction

To select a pallet instruction, select the type of palletizing to be taught (palletizing B, BX, E, or EX).

Procedure 10-1 Selecting a palletizing instruction

Condition

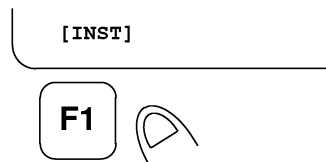
- Make sure that the teach pendant is enabled.
- Make sure that the palletizing instruction is selected on the program edit screen.

```

PROGRAM1                                JOINT 30%
                                         6/6
5: J P[2] 300mm/sec CNT50
[End]
POINT                                  TOUCHUP >
    
```

Step

- 1 Press NEXT ">" to display the next page. Press F1 "[INST]" to display a submenu.



```

Instruction                               JOINT 30 %
1 Registers                               5 JMP/LBL
2 I/O                                     6 CALL
3 IF/SELECT                               7 Palletizing
4 WAIT                                     8 ---next page---
PROGRAM1                                6/6
5: J P[2] 300mm/sec CNT50
    
```

- 2 Select "Palletizing."

```

                                         JOINT 30%
5 JMP/LBL
6 CALL
7 Palletizing
8 --next page--
ENTER
    
```

```

PALLETIZING system
1 PALLETIZING-B 5
2 PALLETIZING-END 6
3                7
4                8
PROGRAM1
5: J P[2] 300mm/sec CNT50
                                         6/6
    
```


- 3 Select "PALLETIZING-EX." The screen then changes to the initial data input screen automatically, one of the palletizing edit screen.

```

PALLETIZING system
1 PALLETIZING-B 5
2 PALLETIZING-END 6
3 7
4 8
PROGRAM1
                
```

ENTER

```

PROGRAM1                JOINT 30 %
PALLETIZING Configuration
  PALLETIZING_1 [          ]
  TYPE = [PALLET ] INCR = [ 1 ]
  PAL REG = [ 1 ] ORDER = [RCL ]
  ROWS = [ 1 FIX ]
  COLUMNS = [ 1 FIX ]
  LAYERS = [ 1 FIX ]
  AUXILIARY POS = [ NO ]
  APPR = [ 1 ] RTRT = [ 1 ]
Press ENTER

PROG                                DONE
                
```

10.3.2 Inputting Initial Data

On the initial data input screen, specify how palletizing is performed. The data set on the initial data input screen is used for subsequent teach screens. The initial data screen contains the following items:

For palletizing B

```

PRG1                JOINT 30%
PALLETIZING Configuration

  PALLETIZING_1 [          ]
  TYPE = [PALLET ] INCR = [ 1 ]
  PAL REG = [ 1 ] ORDER = [RCL ]
  ROWS = [ 5 ]
  COLUMNS = [ 4 ]
  LAYERS = [ 3 ]
  AUXILIARY POS = [ NO ]
  APPR = [ 2 ] RTRT = [ 2 ]
Press ENTER

PROG                                DONE
                
```

For palletizing BX

```

PRG1                JOINT 30%
PALLETIZING Configuration

  PALLETIZING_1 [          ]
  TYPE = [PALLET ] INCR = [ 1 ]
  PAL REG = [ 1 ] ORDER = [RCL ]
  ROWS = [ 5 ]
  COLUMNS = [ 4 ]
  LAYERS = [ 3 ]
  AUXILIARY POS = [ NO ]
  APPR = [ 2 ] RTRT = [ 2 ] PATTERN = [ 2 ]
Press ENTER

PROG                                DONE
                
```

For palletizing E

```

PRG1                JOINT 30%
PALLETIZING Configuration

  PALLETIZING_1 [          ]
  TYPE = [PALLET ] INCR = [ 1 ]
  PAL REG = [ 1 ] ORDER = [RCL ]
  ROWS = [ 5 2 LINE FIX ]
  COLUMNS = [ 4 2 LINE FIX ]
  LAYERS = [ 3 2 LINE FIX 1 ]
  AUXILIARY POS = [ NO ]
  APPR = [ 2 ] RTRT = [ 2 ]
Press ENTER

PROG                                DONE
                
```

For palletizing EX

```

PRG1                JOINT 30%
PALLETIZING Configuration

  PALLETIZING_1 [          ]
  TYPE = [PALLET ] INCR = [ 1 ]
  PAL REG = [ 1 ] ORDER = [RCL ]
  ROWS = [ 5 2 LINE FIX ]
  COLUMNS = [ 4 2 LINE FIX ]
  LAYERS = [ 3 2 LINE FIX 1 ]
  AUXILIARY POS = [ NO ]
  APPR = [ 2 ] RTRT = [ 2 ] PATTERN = [ 2 ]
Press ENTER

PROG                                DONE
                
```

Table 10.3.2 (a) Types of Palletizing

	Arrangement mode	Layer pattern	Attitude control	Path pattern count
B	2-point teaching only	Not set	Always fixed	1
BX	2-point teaching only	Not set	Always fixed	1 to 16

	Arrangement mode	Layer pattern	Attitude control	Path pattern count
E	2-point teaching, all-point teaching, or interval specification	Set	Fixed or split	1
EX	2-point teaching, all-point teaching, or interval specification	Set	Fixed or split	1 to 16

When a pallet instruction is selected, the initial data input screen corresponding to the selected type of palletizing appears. For palletizing EX, all palletizing functions can be specified. For palletizing B, BX, and E, restrictions are imposed on the specification of the functions.

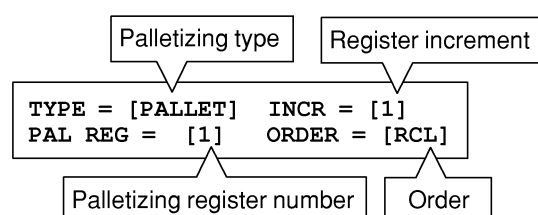
This section explains how to enter initial data for palletizing EX. For palletizing B, BX, or E, assume that some functions of palletizing EX are restricted.

Table 10.3.2 (b) Initial Palletizing Data

Palletizing number	A number is assigned automatically when a palletizing statement is taught. PALLETIZING N: 1 to 16
Palletizing type	Specify whether the palletizing register is to be incremented or decremented by the palletizing end instruction. (See Subsection 10.4.1.) Select stacking (PALLET) or unstacking (DEPALLET).
Register increment	Specify the value by which the value held in the palletizing register is to be incremented or decremented by the palletizing end instruction. (See Subsection 10.4.1.)
Palletizing register	Specify the palletizing register to be used by the palletizing instruction and palletizing end instruction.
Order	Specify the stacking (unstacking) order of row, column, and layer. R: Row, C: Column, L: Layer
Numbers of rows, columns, and layers Arrangement mode Attitude control Layer pattern count	Numbers of rows, columns, and layers for a stacking pattern. (See Subsection 10.3.3.) 1 to 127 How rows, columns, and layers are arranged for a stack pattern. The 2-point or all-point teaching, or interval specification can be specified (only for palletizing E or EX). Control the attitude at rows, columns, and layers for a stacking pattern. Select E or EX. How workpieces are stacked can be specified for each layer (only for palletizing E or EX). 1 to 16
Number of approach points Number of retraction points Path pattern count	Number of approach points in a path pattern. (See Subsection 10.3.5.) 0 to 7 Number of retraction points in a path pattern. (See Subsection 10.3.5.) 0 to 7 Number of path patterns (Subsection 10.3.4) (only for palletizing BX or EX). 1 to 16

Initial data related to the stacking method

In the palletizing function, the stack point is controlled using a palletizing register. (See Subsection 10.4.1, "Palletizing Register.") How the palletizing register is controlled can be specified as initial data. According to this data, the way of stacking is determined.



- For the pallet type (TYPE), specify either PALLET or DEPALLET (standard setting: PALLET). (See Subsection 10.4.1, “Palletizing Register.”)
- For the register increment (INCR), specify by which amount the stack (unstack) position advances or retracts. That is, specify a value by which the palletizing register is incremented or decremented by the palletizing end instruction. The standard setting is 1. (See Subsection 10.4.1, “Palletizing Register.”)
- As the palletizing register, specify the register number of a palletizing register used for stack control.

CAUTION
 Make sure that the specified palletizing register number is not used by another palletizing function.

- For the order (ORDER), specify the stacking/unstacking order of row, column, and layer.

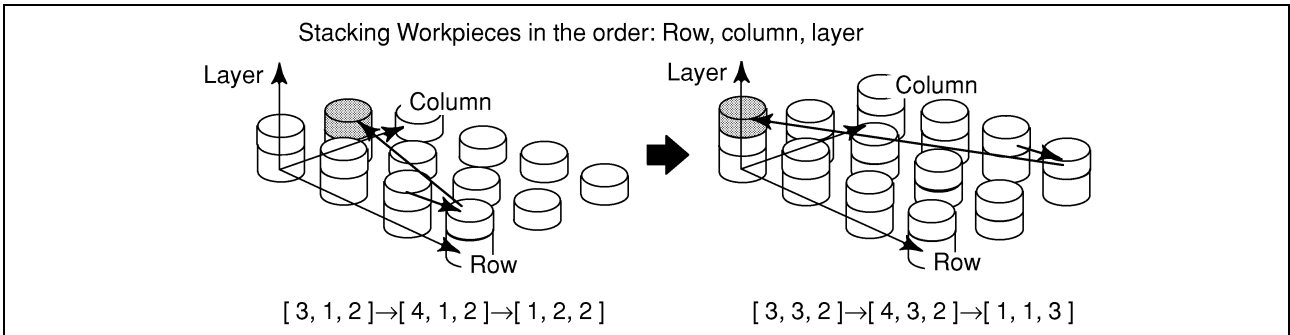
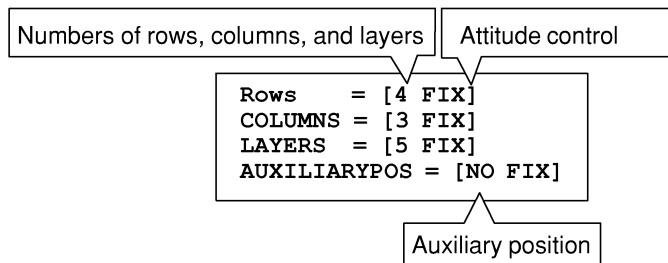


Fig. 10.3.2 Palletizing Order

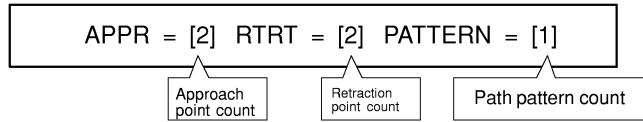
Initial data related to a stacking pattern

As the stacking pattern data, specify the numbers of rows, columns, and layers, attitude control type and also specify whether to provide an auxiliary position. (See Subsection 10.3.3, “Teaching a Stacking Pattern.”)



Initial data related to a path pattern

As the initial path pattern data, specify the number of approach points and the number of retraction points. (See Subsection 10.3.5, “Teaching a Path Pattern.”)



Procedure 10-2 Inputting initial palletizing data

Step

- 1 As the palletizing instruction, select palletizing-EX. The initial data input screen then appears. (See Subsection 10.3.1, “Selecting a Palletizing Instruction.”)

```

PALLETIZING system
1 PALLETIZING-B 5
2 PALLETIZING-END 6
3 7
4
    
```

ENTER

```

PROGRAM1 JOINT 30 %
PALLETIZING Configuration
PALLETIZING 1 [ ]
TYPE = [PALLET ] INCR = [ 1 ]
PAL REG = [ 1 ] ORDER = [RCL ]
ROWS = [ 1 FIX ]
COLUMNS = [ 1 FIX ]
LAYERS = [ 1 FIX ]
AUXILIARY POS = [ NO ]
APPR =[ 1 ] RTRT =[ 1 ]

Press ENTER

PROG DONE
    
```

NOTE
 PALLETIZING displayed on the initial data input screen indicates the fourth palletizing instruction in the program.

- 2 To enter a comment, follow the procedure below.
 - a Place the cursor on the comment line, then press the ENTER key. The character input submenu appears.

```

JOINT 30%
[ ]
] INCR=[ 1 ]
    
```

ENTER

```

JOINT 30%
1 Upper Case
2 Lower Case
3 Punctuation
4 Options ---Insert---
PROGRAM1
    
```

- b Select the type of character input to be used — upper case, lower case, punctuation or options — with the ↑ and ↓ keys.
 - c Press an appropriate function key, then enter characters.

- d After a comment has been completely entered, press the ENTER key.

```

PROGRAM1                                JOINT 30%
PALLETIZING Configuration
    PALLETIZING_1  [WORK4                ]
PROG                                     DONE
    
```

- 3 To select a palletizing type, move the cursor to the TYPE field, then select a function key.

PROG PALLET DEPALL

F2

```

PROGRAM1                                JOINT 30%
PALLETIZING Configuration
    TYPE = [PALLET]    INCR = [1]
PROG    PALLET    DEPALL    DONE
    
```

- 4 To enter a numeric value, press a numeric key, then press the ENTER key.

1

ENTER

```

PROGRAM1                                JOINT 30%
PALLETIZING Configuration
    TYPE = [PALLET]    INCR = [1 ]
PROG                                     DONE
    
```

- 5 Specify a palletizing order by selecting the function keys in the target order.

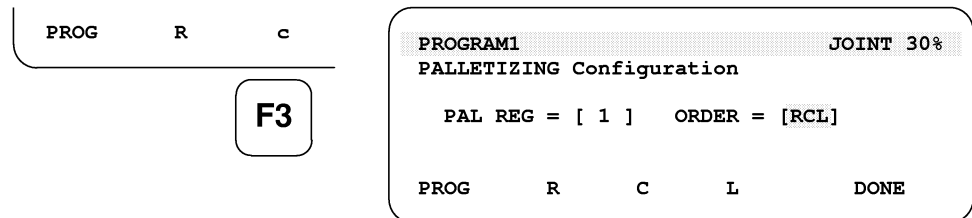
PROG R c

F2

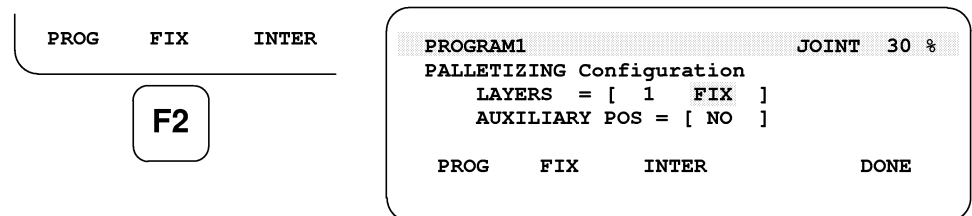
```

PROGRAM1                                JOINT 30%
PALLETIZING Configuration
    PAL REG = [ 1 ]    ORDER = [R__]
PROG    R    C    L    DONE
    
```

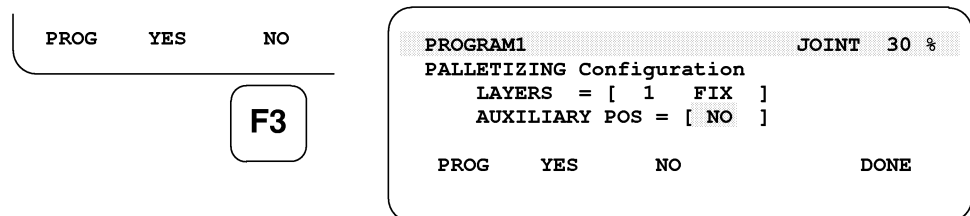
After the second item has been selected, the third item is determined automatically.



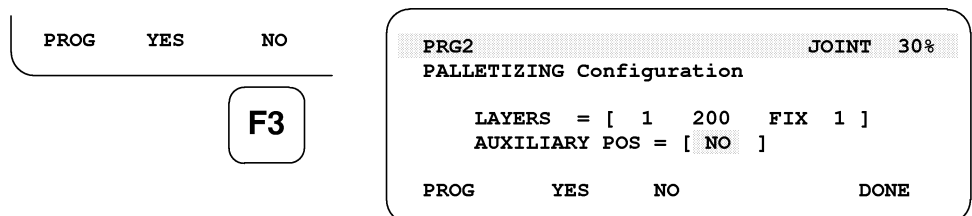
- 6 To specify the type of attitude control, move the cursor to the setting field and select the function key.



- 7 To select whether there is an auxiliary position or not, move the cursor to the setting field and select function key menu.



- 8 To specify whether to set auxiliary points, position the cursor at the auxiliary point field and select the desired function key menu.



NOTE

When specifying the setting of auxiliary points, also select either of FIX/INTER.

- 9 Enter the approach point count and retraction point count.
 10 To stop the initial data setting, press F1 "PROG."

⚠ CAUTION
 When the initial data setting is stopped before it is completed, the values set up to that time are invalidated.

```

PROGRAM1                                JOINT 30 %
PALLETIZING Configuration
PALETIZING 1 [WORK PALLET ]
TYPE = [PALLET ] INCR = [ 1 ]
PAL REG = [ 1] ORDER = [RCL ]
ROWS = [ 5 FIX ]
COLUMNS = [ 4 FIX ]
LAYERS = [ 3 FIX ]
AUXILIARY POS = [ NO ]
APPR =[ 2] RTRT =[ 2]
Press ENTER

PROG                                     DONE
    
```

- When all data items have been entered, press F5 “DONE.” The initial data input screen then disappears and the palletizing stacking pattern teach screen appears.

F5

DONE

```

PROGRAM1                                JOINT 30%
PALLETIZING Bottom Points
1: *P [ 1, 1, 1 ]
2: *P [ 5, 1, 1 ]
3: *P [ 1, 4, 1 ]
4: *P [ 1, 1, 3 ]

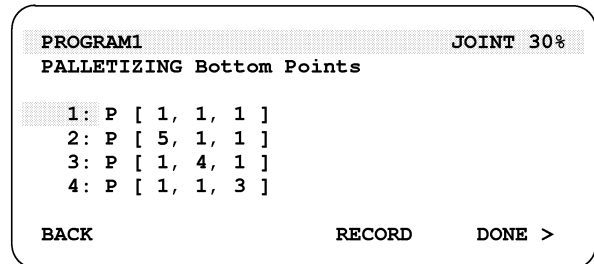
BACK                                     RECORD     DONE >
    
```

When the palletizing stacking pattern teach screen is displayed after the setting or changing of initial palletizing data is completed with F5 “DONE,” the palletizing register is initialized automatically. (See Subsection 10.4.1, “Palletizing Register.”)

10.3.3 Teaching a Stacking Pattern

On the palletizing stacking pattern teach screen, teach representative stack points of a stacking pattern. From these representative points, a target stack point is calculated automatically at the time of palletizing.

Stacking Pattern Teach Screen



With or without an auxiliary position

A list of the positions to be taught is displayed based on the initial palletizing data. Following this list, teach the positions of the representative stack points.

For the stacking pattern without an auxiliary position, individually teach four tops of the quadrangle of the stacking pattern.

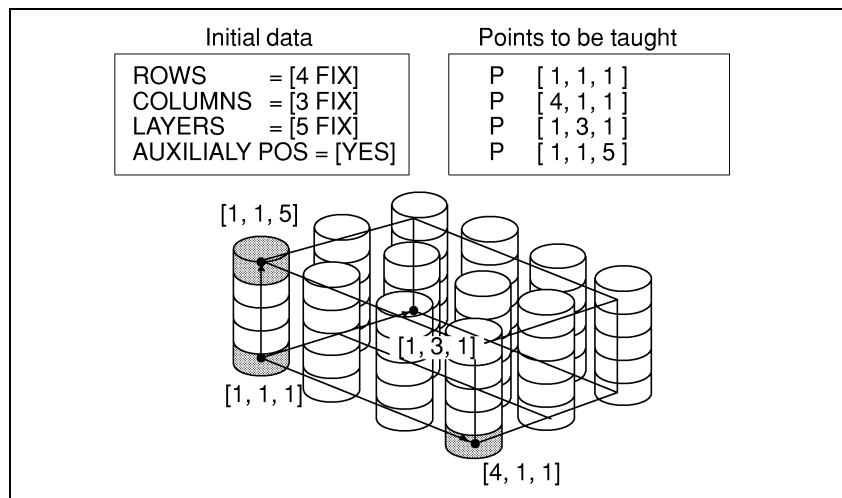


Fig. 10.3.3 (a) Stacking Pattern with No Auxiliary Position

For a stacking pattern with an auxiliary position, when the shape of the first layer is a trapezoid, also teach the fifth position using the function provided.

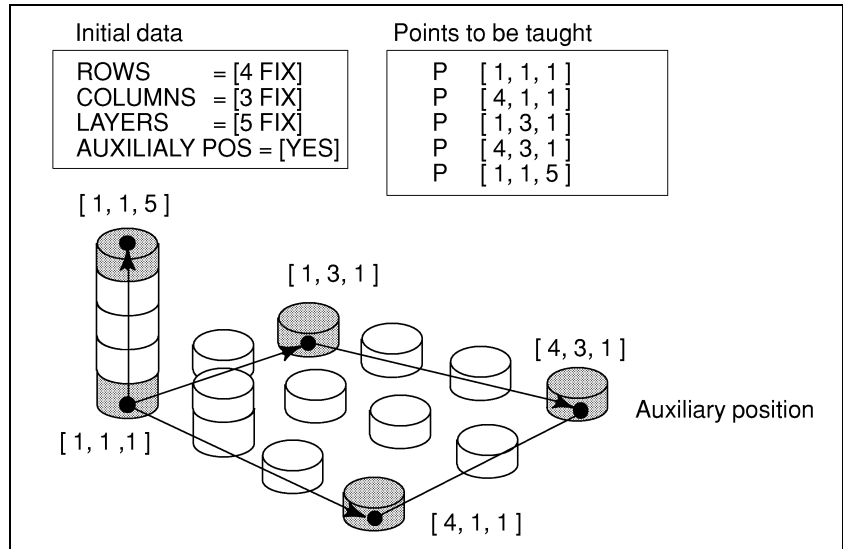


Fig. 10.3.3 (b) Stacking Pattern with an Auxiliary Position

Types of arrangement modes/2-point teaching

When 2-point teaching is selected, teach the representative two points at both ends to set all the points in the row, column, and layer directions (standard).

NOTE
The following explanation is not relevant to palletizing B and BX. See Subsection 10.3.4.

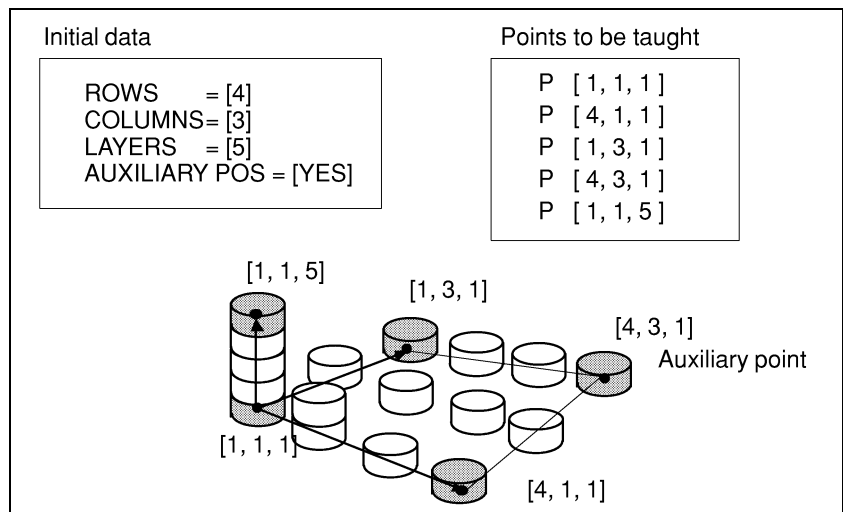


Fig. 10.3.3 (c) Teaching Method by 2-Point Teaching

All-point teaching

When selecting all-point teaching, directly teach all the points in the row, column, and layer directions.

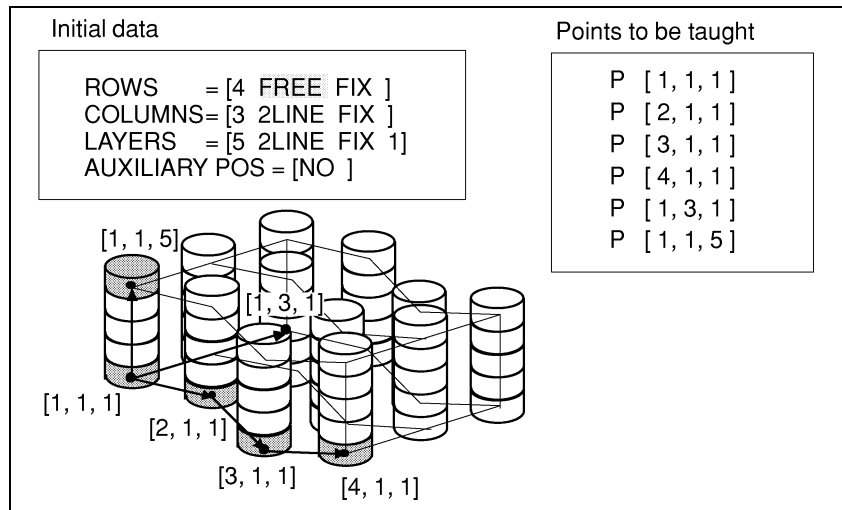


Fig. 10.3.3 (d) Teaching Method by All-Point Teaching

Interval specification

When selecting the interval specification, specify the two points at both ends in each of the row, column, and layer directions, as well as the distance between workpieces, to set all points.

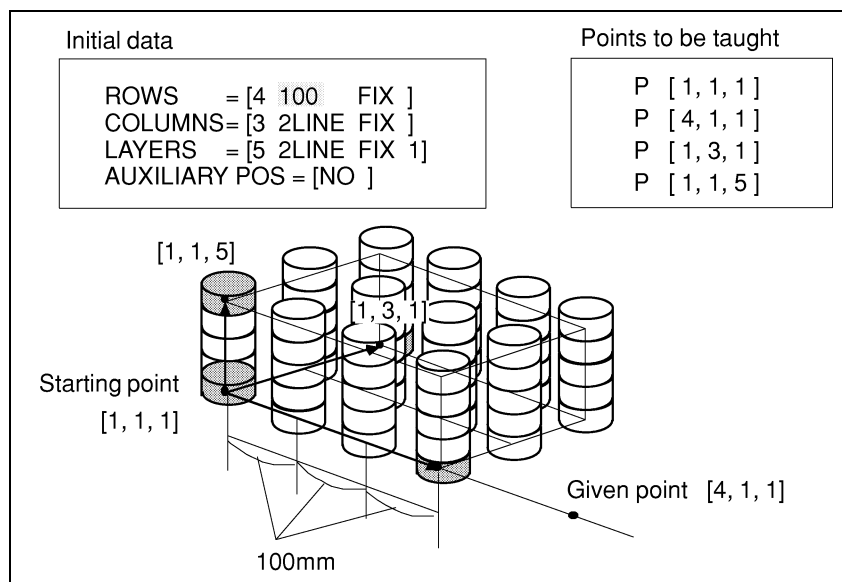


Fig. 10.3.3 (e) Teaching Method by Interval Specification

Types of attitude control

When the fixed attitude is specified, workpieces at all the stack points always take the attitude taught at point [1,1,1] (standard).

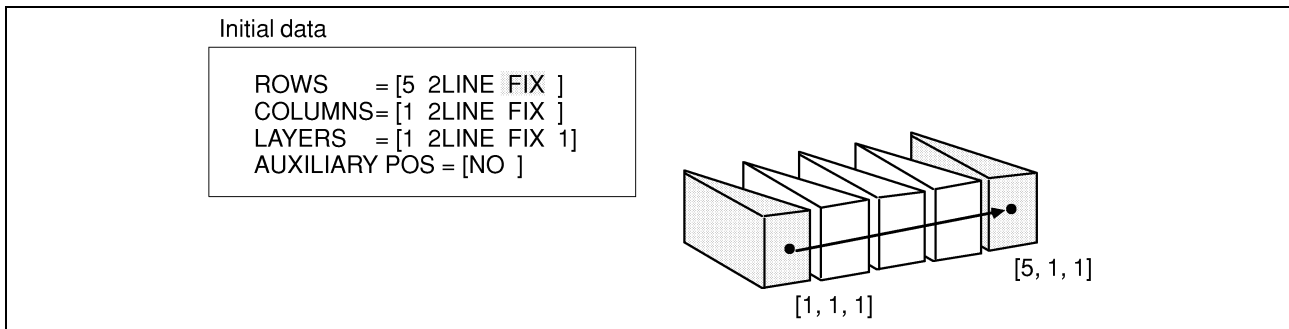


Fig. 10.3.3 (f) Attitudes of Workpieces at Stack Points when the Fixed Attitude Is Specified

For the split attitude, when 2-point teaching is specified, workpieces take the attitudes obtained by splitting the attitudes taught at the two end points. When all-point teaching is specified, workpieces take the attitudes at the taught points.

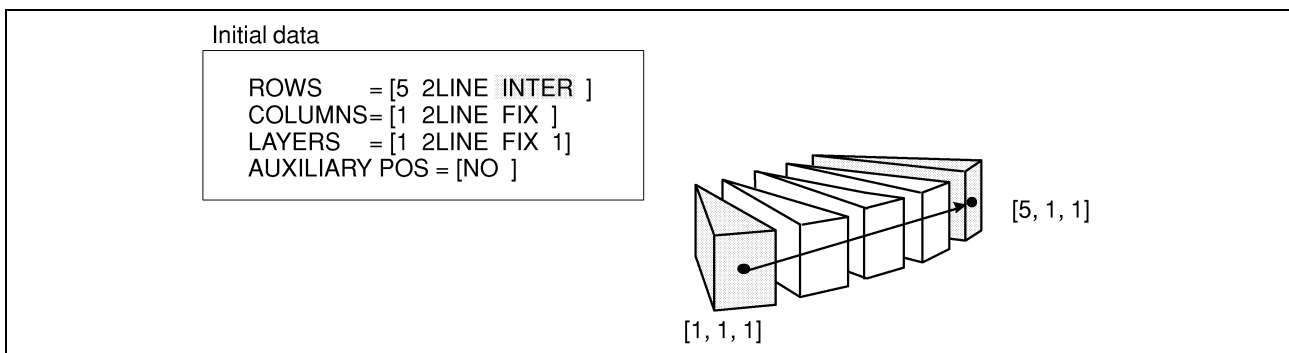


Fig. 10.3.3 (g) Attitudes of Workpieces at Stack Points when the Split Attitude Is Specified

Layer pattern count

To change the stack pattern every few layers, enter the number of layer patterns.

The layer pattern count is valid only when 2-point teaching is specified for the layer arrangement (for other cases, the layer pattern count is always 1).

For the first layer, the workpieces are always stacked at the stack points in layer pattern 1.

When the layer pattern count is N, the numbers of layers and layer patterns are the same until layer N. For layer (N+1) and beyond, layer patterns starting from layer pattern 1 are repeated.

Specify the height of a layer only for layer pattern 1. For the height of each layer pattern, the deviation from the position in pattern 1 is corrected.

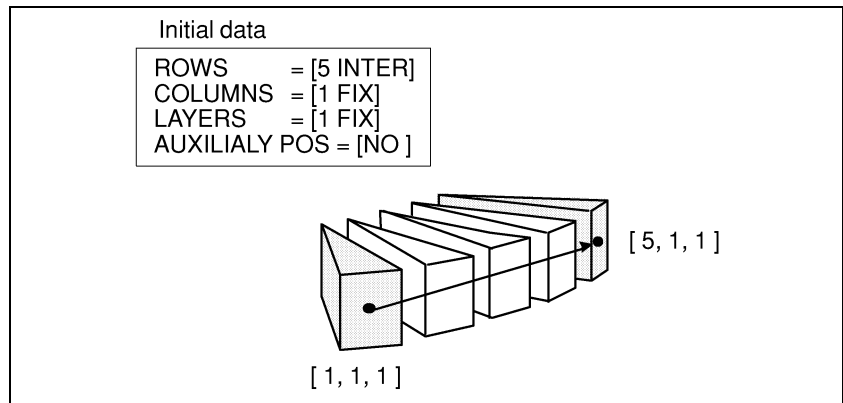


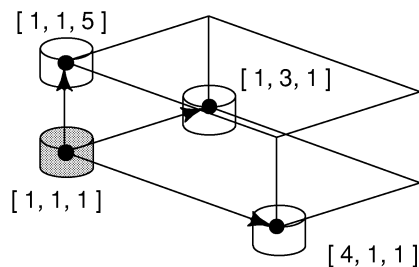
Fig. 10.3.3 (h) Attitude at the stacking point in division attitude

When the total number of layers is less than 16, a number not greater than the total number can be set for the layer pattern count. If a number less than the layer pattern count is subsequently specified for the number of layers, the layer pattern count is automatically changed to the number of layers.

Procedure 10-3 Teaching a palletizing stacking pattern

Step

- 1 Based on the initial data setting, a list of stack points to be taught is displayed.



```

PROGRAM1                                JOINT 30%
PALLETIZING Bottom Points

1: *P [ 1, 1, 1 ]
2: *P [ 4, 1, 1 ]
3: *P [ 1, 3, 1 ]
4: *P [ 1, 1, 5 ]

BACK                                RECORD    DONE >
    
```

NOTE

The number of representative stack points to be recorded depends on the numbers of rows, columns, and of layers set on the initial data input screen. In the above sample screen, four rows, three columns, and five layers are set. For each point, row, column, and then layer numbers are specified.

- 2 Move the robot by jog feed to a position which is to be taught as a representative stack point.

- Place the cursor on the appropriate line, and press F4 “RECORD” while holding down the SHIFT key. The current robot position is then recorded.

```
PROGRAM1
PALLETIZING Bottom Points
1:*P[ 1, 1, 1 ]
RECORD  DONE >
```

```
PROGRAM1 JOINT 30%
PALLETIZING Bottom Points
1: *P [ 1, 1, 1 ]
2: *P [ 4, 1, 1 ]
3: *P [ 1, 3, 1 ]
4: *P [ 1, 1, 5 ]
BACK RECORD  DONE >
```

The positions not yet taught are marked with an asterisk. The positions already taught are marked with ”-”.

- To display detailed position data for a taught representative stack point, move the cursor to the target stack point number, then press F5 “POSITION.” The detailed position data is then indicated.

```
PROGRAM1
PALLETIZING Bottom Points
1:-P[ 1, 1, 1 ]
POSITION>
```

```
Position Detail JOINT 30%
PAL_1[BTM] UF:0 UT:1 CONF: NT 0
X 516.129 mm W 180.000 deg
Y 111.347 mm P 0.000 deg
Z 1010.224 mm R 0.000 deg
PROGRAM1
PALLETIZING Bottom Points
1: *P [ 1, 1, 1 ]
2: *P [ 4, 1, 1 ]
3: *P [ 1, 3, 1 ]
4: *P [ 1, 1, 5 ]
CONFIG DONE
```

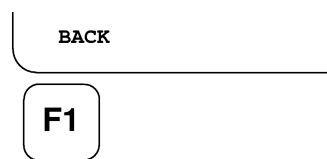
Numeric values can also be entered directly to specify position data. To return to the previous stacking pattern teach screen, press F4 “DONE.”

```
PROGRAM1 JOINT 30%
PALLETIZING Bottom Points
1: *P [ 1, 1, 1 ]
2: *P [ 4, 1, 1 ]
3: *P [ 1, 3, 1 ]
4: *P [ 1, 1, 5 ]
BACK RECORD  DONE >
```

- Pressing the FWD key while holding down the SHIFT key causes the robot to move to the representative stack point indicated by the cursor. This operation can be performed to confirm the taught point.

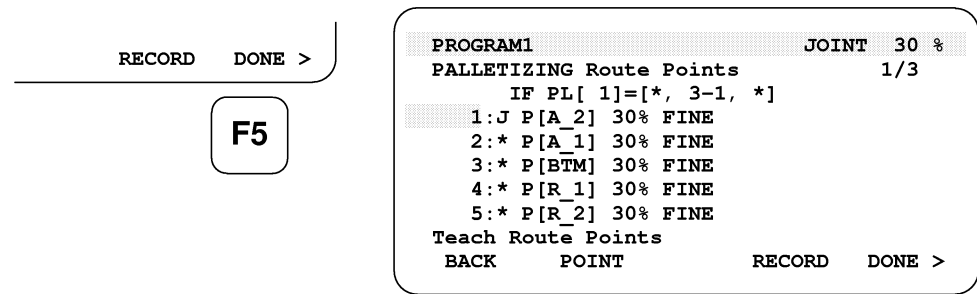


- To return to the previous initial data teach screen, press F1 "BACK."



- Press F5 DONE to display the path pattern condition setting screen (BX or EX) or path pattern teaching screen (B or E) (Subsection 10.3.4 or 10.3.5).

NOTE
 When layer patterns are used (E or EX) and F5 DONE is pressed, the screen for specifying the stack pattern for the next layer appears.



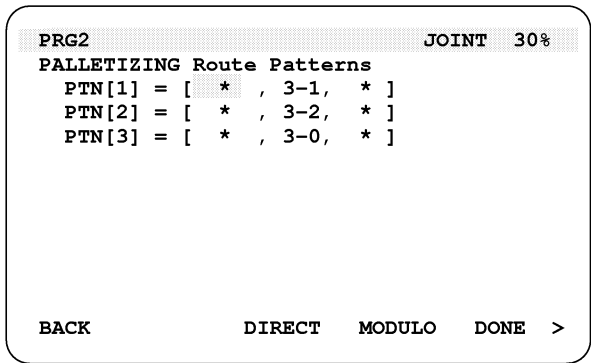
10.3.4 Setting Path Pattern Conditions

The screen explained in this section is not displayed for palletizing B or E. See Subsection 10.3.5.

The palletizing path pattern condition setting screen is used to set conditions indicating which path pattern is to be used for each stack point in advance when multiple path patterns are to be set on the path pattern teaching screen (See Subsection 10.3.5).

For palletizing BX and EX, multiple path patterns can be set independently for stack points. For palletizing B and E, this screen is not displayed because only one path pattern can be set.

Path pattern condition setting screen



To specify a path for each stack point, as many path patterns as required must be specified when initial data is set. For each path pattern, set a path pattern condition.

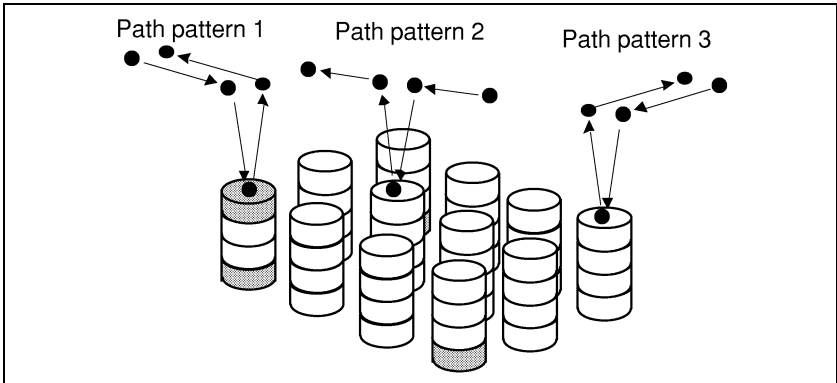


Fig. 10.3.4 (a) Palletizing Using Three Path Patterns

How to use path pattern conditions

- The execution of palletizing uses the path pattern with the condition number for which the row, column, and layer numbers at the stack point match the row, column, and layer (element) values of a path pattern condition.
- In direct specification mode, specify numbers between 1 to 127 for a stack point. An asterisk indicates an arbitrary stack point.

- In the remainder specification mode, specify path pattern condition element "m-n" using a remainder system for a stack point.
Layer element "3-1" indicates a layer corresponding to a stack point value for which a remainder of 1 is obtained by dividing the value by 3.
- If the current stack point corresponds to no path pattern condition, an alarm occurs. If the current stack point corresponds to two or more path pattern conditions, a path pattern condition is used according to the following conditions:
 - a. A path pattern condition specified in direct specification mode is used.
 - b. When two or more path pattern conditions are specified in direct specification mode, a path pattern condition specified in the remainder specification mode is used. When two or more path pattern conditions are specified in remainder specification mode, a path pattern condition in which the greatest value is specified for m is used.
 - c. When two or more path pattern conditions satisfy conditions a and b above, the path pattern condition having the smallest path pattern condition number is used.

The following shows the priority among the sample path pattern conditions:

Example PTN [1] = [* , 1 , 2]
 PTN [2] = [* , * , 2]
 PTN [3] = [* , 3-2 , 4-1]
 PTN [4] = [* , * , 4-1]
 PTN [5] = [* , * , 2-1]
 PTN [6] = [* , * , *]

For the example shown on the previous page, pattern 1 is used for the stack points in column 1, pattern 2 is used for the stack points on column 2, and pattern 3 is used for the stack points in column 3.

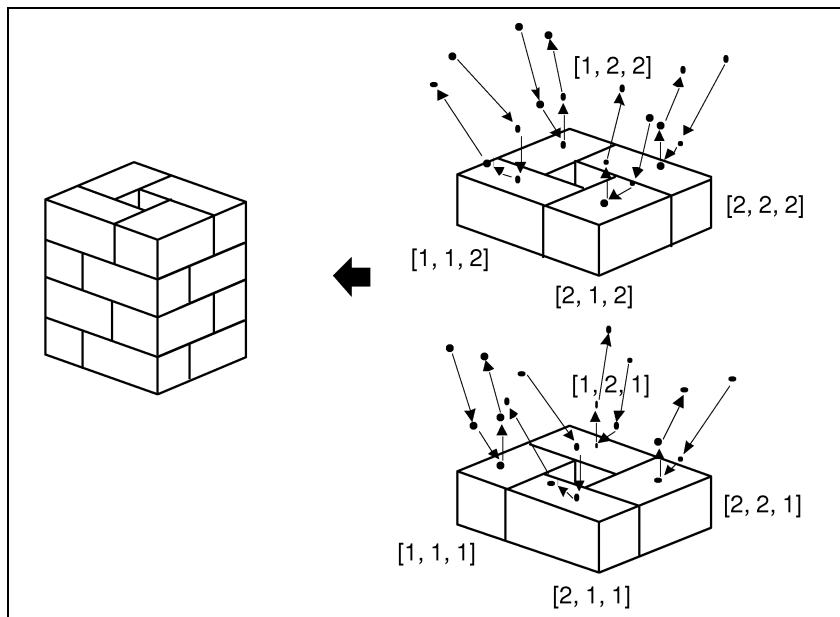


Fig. 10.3.4 (b) Box Palletizing Using Eight Path Patterns

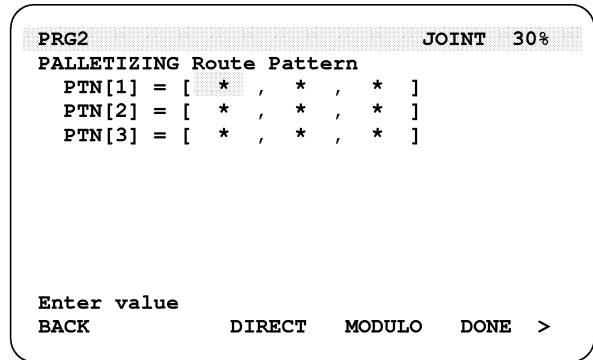
Example PTN [1] = [1 , 1 , 2-1]
 PTN [2] = [2 , 1 , 2-1]
 PTN [3] = [1 , 2 , 2-1]
 PTN [4] = [2 , 2 , 2-1]
 PTN [5] = [1 , 1 , 2-0]
 PTN [6] = [2 , 1 , 2-0]
 PTN [7] = [1 , 2 , 2-0]
 PTN [8] = [2 , 2 , 2-0]

In the above example, eight path patterns are defined and repeated for every two layers because different paths must be set according to the box position.

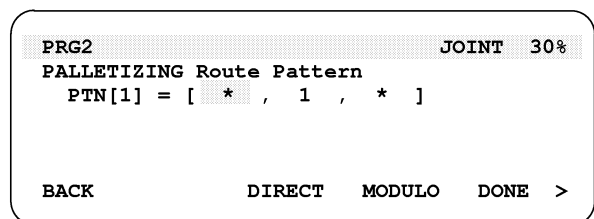
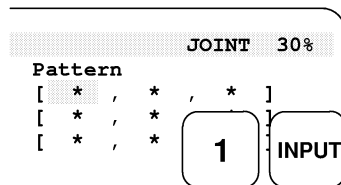
Procedure 10-4 Setting palletizing path pattern conditions

Step

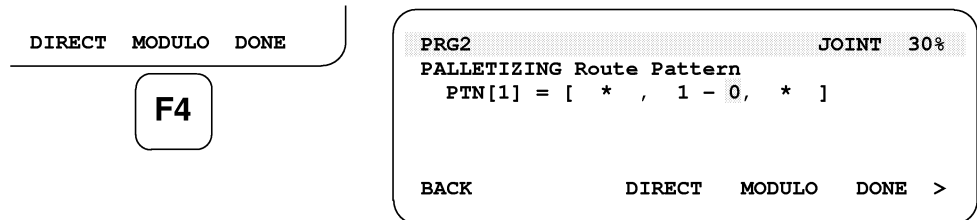
- 1 Condition items to be entered are displayed according to the value set for the pattern count as initial data.



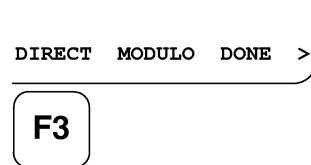
- 2 In direct specification mode, position the cursor to the point to be changed and enter a numeric value. To specify an asterisk (*), enter zero.



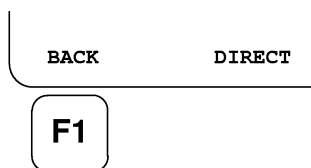
- In remainder specification mode, press F4 MODULO. The target item is divided into two sub-items. Enter a value for each sub-item.



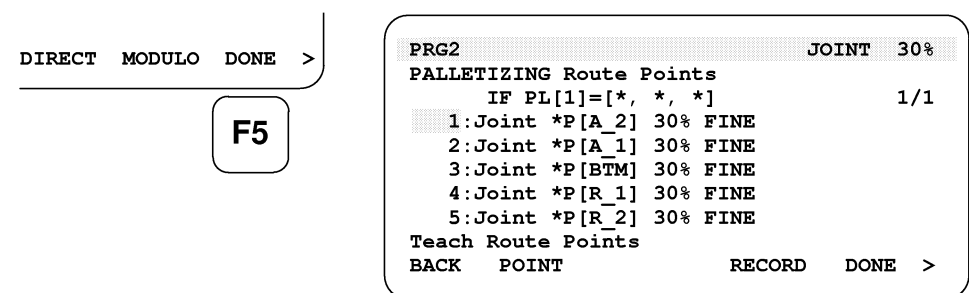
- To specify values in direct specification mode, press F3 DIRECT.



- Press F1 BACK to display the previous stack point teaching screen again.



- Press F5 DONE to display the next path pattern teaching screen.



10.3.5 Teaching a Path Pattern

On the palletizing path pattern teach screen, set several path points which are passed before and after a workpiece is stacked (or unstacked) at a stack point. The path points change depending on the position of the stack point.

Path Pattern Teach Screen

```

PROGRAM1                                JOINT 30 %
PALLETIZING Route Points                 1/3
    IF PL[ 1]=[*, 3-1, *]
1:J P[A_2] 30% FINE
2:* P[A_1] 30% FINE
3:* P[BTM] 30% FINE
4:* P[R_1] 30% FINE
5:* P[R_2] 30% FINE
Teach Route Points
BACK      POINT      RECORD  DONE >
    
```

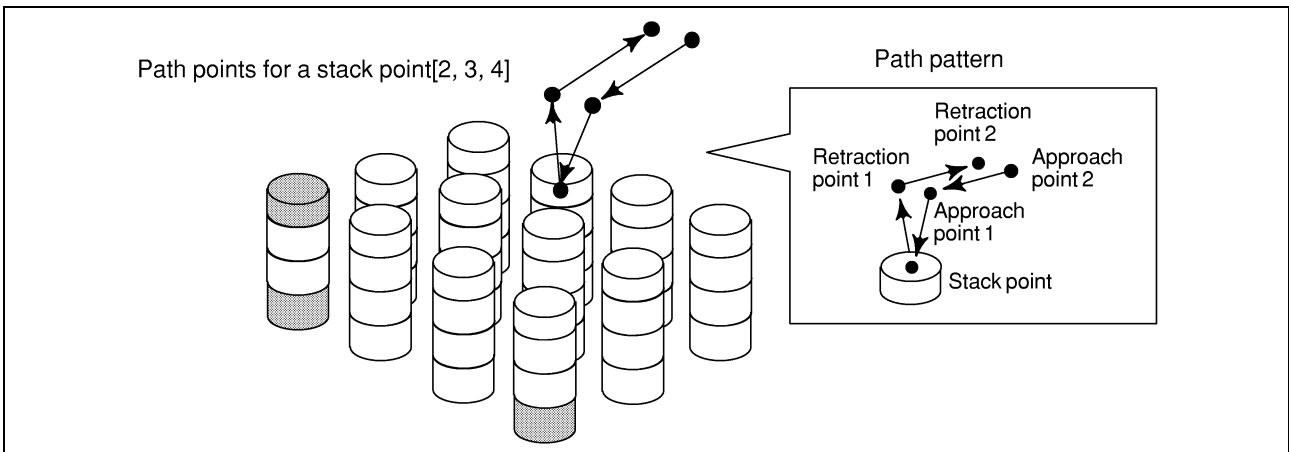


Fig. 10.3.5 Palletizing Path

Procedure 10-5 Teaching a palletizing path pattern

Step

- 1 Based on the initial data setting, a list of the path points to be taught is displayed.

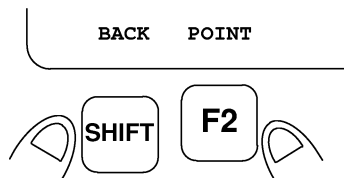
```

PROGRAM1                                JOINT 30 %
PALLETIZING Route Points                 1/3
    IF PL[ 1]=[*, *, *]
1:* P[A_2] 30% FINE
2:* P[A_1] 30% FINE
3:* P[BTM] 30% FINE
4:* P[R_1] 30% FINE
5:* P[R_2] 30% FINE
Teach Route Points
BACK      POINT      RECORD  DONE >
    
```

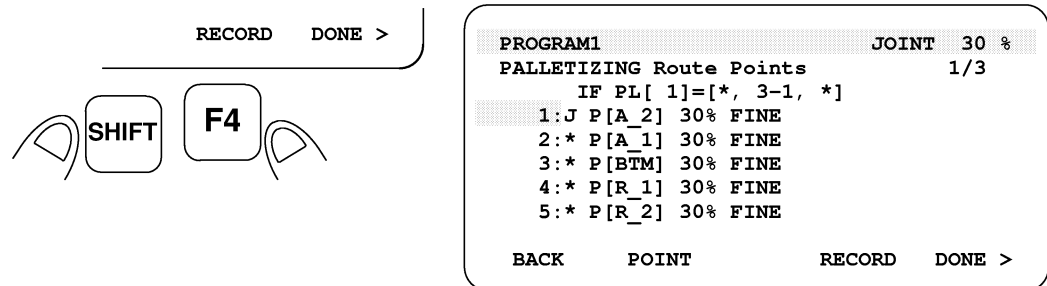
NOTE

The number of path points to be recorded depends on the number of approach points set on the initial data input screen and the number of input points. In the above sample screen, the number of approach points is 2 and the number of retraction points is 2.

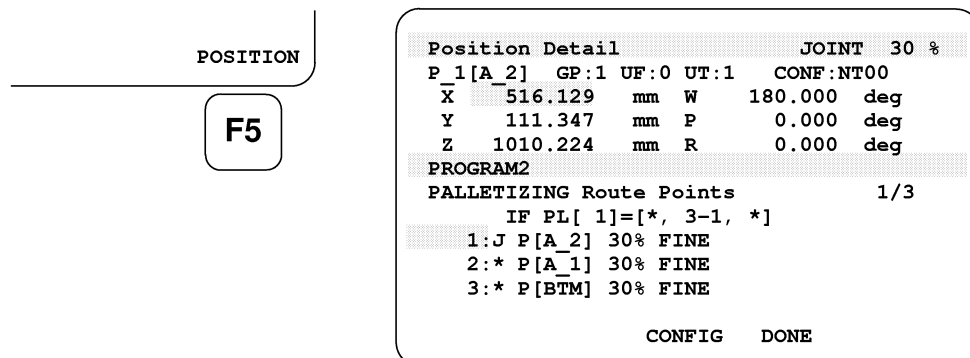
- 2 Move the robot by jog feed to a position which is to be taught as a path point.
- 3 Move the cursor to the setting field to be taught and teach the position using one of the following operation.
 - a Press F2 "POINT" while holding down the SHIFT key. When pressing F2 "POINT", without pressing and holding the SHIFT key, default logical motion menu is displayed and then you can set the motion type or feedrate, etc. (This key is displayed only at teaching route pattern points.)



- b Press and hold the SHIFT key and press F4 "RECORD".



- 4 To display detailed position data for a taught path point, move the cursor to the target path point number, and press F5 "POSITION." The detailed position data is then indicated.

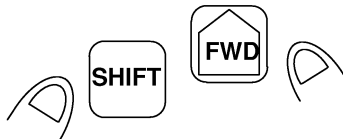


Numeric values can also be entered directly to specify position data. To return to the previous path pattern teach screen, press F4 “DONE.”

```

PROGRAM1                                JOINT 30%
PALLETIZING Route Points                 1/3
IF PL[1]=[*,*,*]
1: Joint P[A_2] 100% FINE
2: Joint P[A_1] 100% FINE
3: Joint P[BTM] 100% FINE
4: Joint P[R_1] 100% FINE
5: Joint P[R_2] 100% FINE
BACK   POINT           RECORD   DONE >
    
```

- Pressing the FWD key while holding down the SHIFT key causes the robot to move to the path point indicated by the cursor. This operation can be performed to confirm the taught point.



- To return to the stacking pattern teach screen, press F1 “BACK.”



- Press F5 “DONE” to terminate the palletizing edit screen and return to the program screen. The palletizing instructions are automatically written in the program.

```

RECORD   DONE>
F5
PROGRAM1                                JOINT 30%
                                           13/13
5: L P[2] 300mm/sec CNT50
6:   PALLETIZING-B_1
7: J PAL_1[A_2] 100% FINE
8: J PAL_1[A_1] 100% FINE
9: J PAL_1[BTM] 100% FINE
10: J PAL_1[R_1] 100% FINE
11: J PAL_1[R_2] 100% FINE
12:   PALLETIZING-END_1
[End]
POINT                                     TOUCHUP >
    
```

- Press F1 BACK to specify the previous path pattern. Press F5 DONE to specify the next path pattern.

- 9 After teaching of all the path patterns is complete, press F5 DONE to exit from the palletizing edit screen and display the program screen again. The palletizing instruction is automatically written in the program.

```

PRG1                                JOINT 30%
                                      13/13
5: L P[2] 300mm/sec CNT50
6:   PALLETIZING-EX_4
7: L PAL_4[A_2] 30% FINE
8: L PAL_4[A_1] 30% FINE
9: L PAL_4[BTM] 30% FINE
10: L PAL_4[R_1] 30% FINE
11: L PAL_4[R_2] 30% FINE
12:   PALLETIZING-END_4
[END]
POINT                                TOUCHUP >

```

- 10 Editing, such as modifying a hand instruction executed at a stack position or the motion format at a path point can be performed on this program screen, in the same way as for normal programs.

```

PALLET1                              JOINT 30%
                                      14/14
5: L P[2] 300mm/sec CNT50
6:   PALLETIZING-B_1
7: L PAL_1[A_2] 1000cm/min CNT30
8: L PAL_1[A_1] 300mm/sec CNT30
9: L PAL_1[BTM] 50mm/sec FINE
10:   hand open
11: L PAL_1[R_1] 300mm/sec CNT30
12: L PAL_1[R_2] 1000cm/min CNT30
13:   PALLETIZING-END_1
[End]
POINT                                TOUCHUP >

```

For details of palletizing programs, see Section 10.4, “Executing the Palletizing Function.”

10.3.6 Notes on Teaching the Palletizing Function

- The palletizing function is enabled only when a program contains these three instructions: A palletizing instruction, palletizing motion instruction, and palletizing end instruction. When just one of the three instructions is taught into a subprogram by another operation such as copying, normal operation cannot be performed.
- When all palletizing data has been taught, palletizing numbers are automatically written together with the instructions (a palletizing instruction, palletizing motion instruction, and palletizing end instruction). The user need not be concerned about the duplication of these numbers in other programs. (Each program has its own data for palletizing numbers.)
- In the palletizing motion instruction, C (circular motion) cannot be specified as the motion format.
- When palletizing, with a system with extended axes, there are some special conditions. For a system with extended axes, refer to Section 10.6 "Palletizing Function with extended axes"

10.4 EXECUTING THE PALLETIZING FUNCTION

The execution of the palletizing function is shown below.

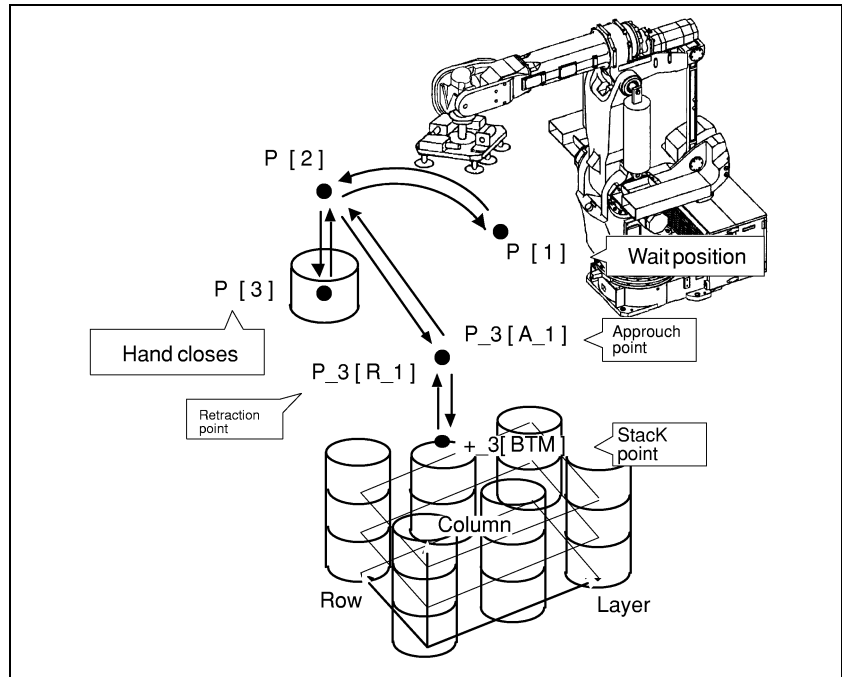


Fig. 10.4 (a) Example of Palletizing

Example

```

5: J P[1] 100% FINE
6: J P[2] 70% CNT50
7: L P[3] 50mm/sec FINE
8: hand close
9: L P[2] 100mm/sec CNT50
10: PALLETIZING-B_3
11: L PAL_3[ A_1 ] 100mm/sec CNT10
12: L PAL_3[ BTM ] 50mm/sec FINE
13: hand open
14: L PAL_3[ R_1 ] 100mm/sec CNT10
15: PALLETIZING-END_3
16: J P[2] 70% CNT50
17: J P[1] 100% FINE
    
```

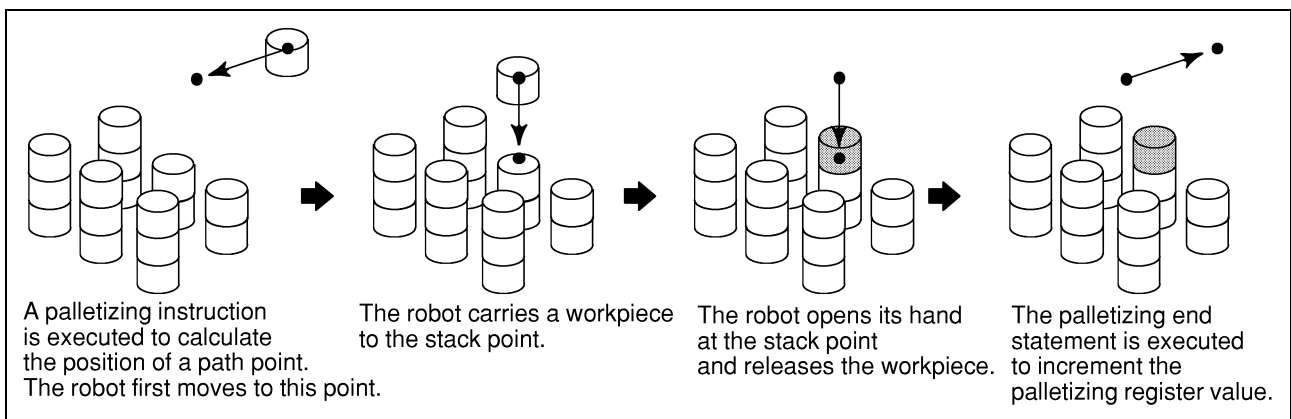


Fig. 10.4 (b) Workpiece Stacking Process

10.4.1 Palletizing Register

The palletizing register manages the position of the current stack point. When a palletizing instruction is executed, the value held in the palletizing register is referenced, and the actual stack point and path points are calculated. (See Section 7.5, "PALLETIZING REGISTER.")

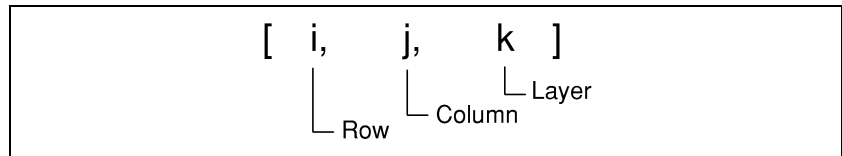


Fig. 10.4.1 (a) Palletizing Register

The palletizing register indicates the row, column, and layer which are used for calculating the position of the stack point when the palletizing instruction is executed.

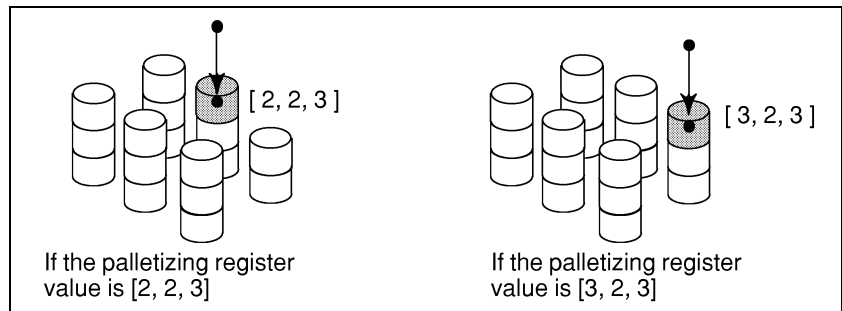


Fig. 10.4.1 (b) Relationship between the Palletizing Register and Stack Point

Updating the Palletizing Register

The palletizing register is incremented (or decremented) by executing the palletizing end instruction. The increment (decrement) method is determined depending on the initial data setting.

For 2-row, 2-column, and 2-layer palletizing with ORDER = [RCL] specified, executing the palletizing end instruction changes the palletizing register as follows:

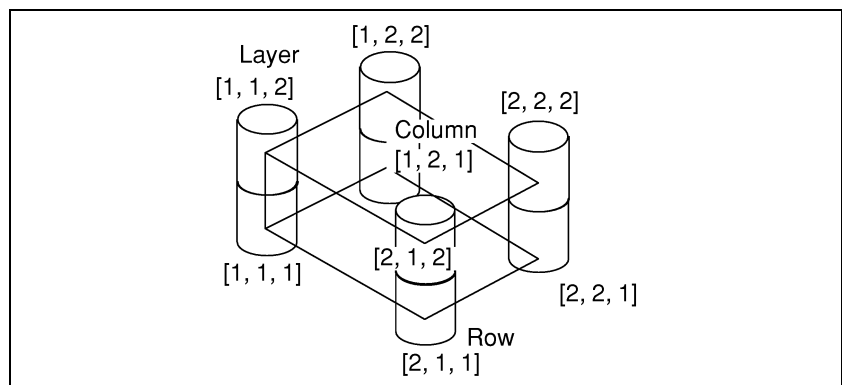


Fig. 10.4.1 (c) Example of 2-Row, 2-Column, and 2-Layer Palletizing

Table 10.4.1 (a) Incrementing (Decrementing) Order of the Palletizing Register

	TYPE = [PALLET]		TYPE = [DEPALLET]	
	INCR = [1]	INCR = [-1]	INCR = [1]	INCR = [-1]
Initial value	[1, 1, 1]	[2, 2, 1]	[2, 2, 2]	[1, 1, 2]
↓	[2, 1, 1]	[1, 2, 1]	[1, 2, 2]	[2, 1, 2]
↓	[1, 2, 1]	[2, 1, 1]	[2, 1, 2]	[1, 2, 2]
↓	[2, 2, 1]	[1, 1, 1]	[1, 1, 2]	[2, 2, 2]
↓	[1, 1, 2]	[2, 2, 2]	[2, 2, 1]	[1, 1, 1]
↓	[2, 1, 2]	[1, 2, 2]	[1, 2, 1]	[2, 1, 1]
↓	[1, 2, 2]	[2, 1, 2]	[2, 1, 1]	[1, 2, 1]
↓	[2, 2, 2]	[1, 1, 2]	[1, 1, 1]	[2, 2, 1]
↓	[1, 1, 1]	[2, 2, 1]	[2, 2, 2]	[1, 1, 2]

Initializing the palletizing register

When F5 “DONE” is pressed upon completion of the setting or changing of initial palletizing data, the palletizing stacking pattern teach mode is set. At this time, the palletizing register is initialized automatically. (See Subsection 10.3.2, “Inputting Initial Data.”)

Table 10.4.1 (b) Initial Value of the Palletizing Register

Initial data		Initial value		
TYPE	INCR	ROWS	COLUMNS	LAYERS
PALLET	Positive value	1	1	1
	Negative value	Total number of rows	Total number of columns	1
DEPALLET	Positive value	Total number of rows	Total number of columns	Total number of layers
	Negative value	1	1	Total number of layers

10.4.2 Controlling the Palletizing Function by a Palletizing Register

In 5-row, 1-column, and 5-layer palletizing, suppress stack operation for the fifth workpiece in each even-numbered layer. (Stack five workpieces in odd-numbered layers, and stack four workpieces in even-numbered layers.)

```

PROGRAM2                                JOINT 30%
                                         1/17
1:   PL[1] = [1,1,1]
2:   LBL[1]
3:   IF PL[1] = [2-0,*,5],JMP LBL[2]
4: L P[1] 100mm/sec FINE
5:   hand close
6:   PALLETIZING-B_1
7: L PAL_1[A_1] 100mm/sec CNT30
8: L PAL_1[BTM] 50mm/sec FINE
9:   hand open
10: L PAL_1[R_1] 300mm/sec CNT30
11:  LBL[2]
12:  IF PL[1] = [5 1,5],JMP LBL[3]
13:  PALLETIZING-END_1
14:  JMP LBL[1]
15:  LBL[3]
16:  END
[End]

POINT                                TOUCHUP >
    
```

Palletizing register [1] is loaded with [1,1,1].

If the row is 5 and the layer is an even number, a jump to label [2] is performed.

If the row, column, and layer values are [5,1,5], a jump to label [3] is performed.

Set the values of the row, column and layer for the next stack operation in the palletizing register [1].

Procedure 10-6 Displaying the palletizing status

```

PROGRAM1                                JOINT 30%
                                         6/82
5: L P[2] 300mm/sec CNT50
6:   PALLETIZING-B_1
7: L PAL_1 [ A_2 ] 1000cm/min CNT30

[MODIFY]                                LIST >
    
```

Step

- 1 To display the palletizing status, place the cursor on the palletizing instruction, then press F5 “[LIST].” The current stack point and the value of the palletizing register are displayed.



```

Pallet List                                JOINT 30%
PALLETIZING-B_1
CURRENT BOTTOM POINT [ 3, 1, 1 ]
PALLET REGISTER [ 1 ] = [ 4, 1, 1 ]
ROUTE PATTERN [ 1 ] = [ *, *, * ]
PROGRAM1
                                         6/82
    
```

10.5 MODIFYING THE PALLETIZING FUNCTION

Modifying the palletizing function

The palletizing data and palletizing instructions which were taught can be modified later.

Procedure 10-7 Modifying palletizing data

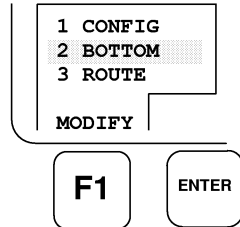
```

PROGRAM1                                JOINT 30%
                                           6/82
5: L P[2] 300mm/sec CNT50
6:   PALLETIZING-B_1
7: L PAL_1[A_2] 1000cm/min CNT30

Select item
[MODIFY]                                LIST >
    
```

Step

- 1 Place the cursor on the palletizing instruction which is to be modified, then press F1 “[MODIFY]” to display the modification menu.
- 2 Select a target palletizing edit screen in the modification menu.



```

PROGRAM1                                JOINT 30%
PALLETIZING Bottom Points
1: --P [ 1, 1, 1 ] --
2: --P [ 4, 1, 1 ] --
3: --P [ 1, 3, 1 ] --
4: --P [ 1, 1, 5 ] --
[End]
BACK                                RECORD    DONE >
    
```

To return to the previous palletizing edit screen, press F1 “BACK.”

To proceed to the next palletizing edit screen, press F5 “DONE.”

NOTE

After palletizing data has been modified, the normal edit screen can be called from any palletizing screen. In this case, the new data after modification is kept valid.

- 3 When the modification is completed, press NEXT “>” to display the next page. Then press F1 “PROG.”



Procedure 10-8 Changing the palletizing number

```

PROGRAM1                                JOINT 30%
                                           6/52
6:    PALLETIZING-B_1
7: L  PAL_1[A_1] 300mm/sec CNT30
8: L  PAL_1[BTM] 50mm/sec FINE
9:    hand open
10: L  PAL_1[R_1] 300mm/sec CNT30
11:    PALLETIZING-END_1

```

Step

- 1 Place the cursor on the palletizing instruction having the palletizing number which is to be changed, then enter a new number.

```

PROGRAM1                                JOINT 30%
                                           6/52
6:    PALLETIZING-B_1
7: L  PAL_1[A_1] 300mm/sec CNT30
8: L  PAL_1[BTM] 50mm/sec FINE
9:    hand open
10: L  PAL_1[R_1] 300mm/sec CNT30
11:    PALLETIZING-END_1

```

2 ENTER

```

PROGRAM1                                JOINT 30%
                                           6/52
6:    PALLETIZING-B_2
7: L  PAL_2[A_1] 300mm/sec CNT30
8: L  PAL_2[BTM] 50mm/sec FINE
9:    hand open
10: L  PAL_2[R_1] 300mm/sec CNT30
11:    PALLETIZING-END_2

```

At the same time the palletizing number of the palletizing instruction is changed, the palletizing numbers of the palletizing motion and palletizing end instructions are also changed.



CAUTION

When changing palletizing numbers, make sure that the new numbers are not used by other palletizing instructions.

10.6 PALLETIZING FUNCTION WITH EXTENDED AXES

This section explains the special items when using palletizing on a system with extended axes.

When teaching the bottom point or route points for palletizing, which are different from the usual teaching of motion instruction, the position which is removed the position of extended axes is recorded.

Execution

When palletizing is executed, palletizing will be done at the position of the extended axes at that time. (The robot does not automatically return to the position of the extended axes at teaching bottom points or route points.) For example, on a system with a linear extended axis, when the palletizing instruction is executed at a point 1000 mm away from the position at teaching palletizing, the robot will perform the same motion as taught at the position which is 1000 mm away from the teaching position.

Position teaching/modifying

When teaching the bottom/route points for palletizing on a system with extended axes or modifying the position, the following attention is necessary.

- When teaching bottom/route points for palletizing, it must be done at the fixed point.
 - When the position of extended axes shifts while teaching the bottom/route points for the same palletizing, the robot will follow a different path than the taught path when the program is executed.
- When modifying the position, move the robot to the position of the extended axes at teaching bottom/route points before modifying.

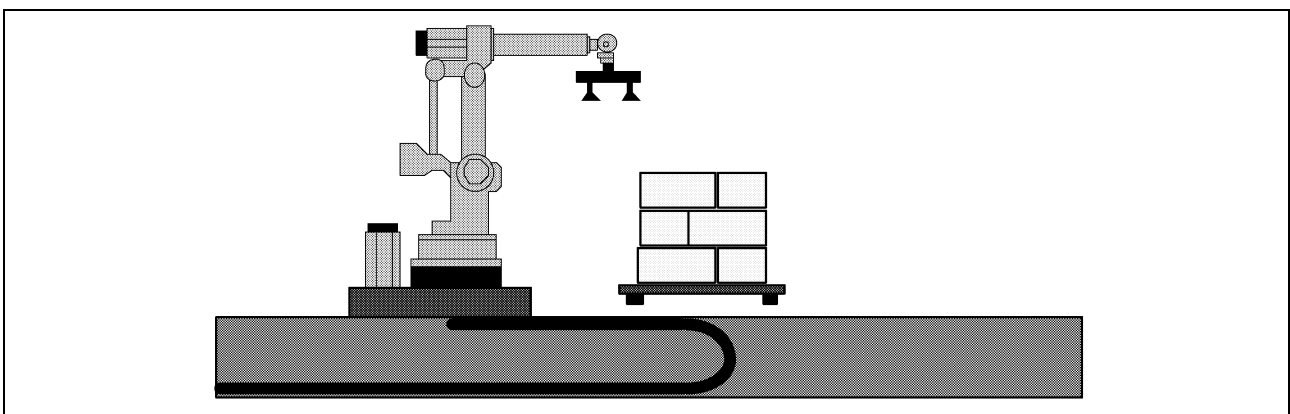


Fig. 10.6 Palletizing function with extended axes

10.7 PALLETIZING ALL-POINT TEACHING

Palletizing all-point teaching allows the stacking (or unloading) of workpieces without changing the taught form by changing a system variable.

Operation

Set the following values to stack (or unload) workpieces without changing the taught attitude and form:

- 1 On the system variable screen, set system variable \$PALCFG.\$FREE_CFG_EN to TRUE (the initial value is TRUE).
- 2 On the palletizing initial data screen, set INTER for attitude control in the row, column, or layer direction for which FREE is specified as the arrangement mode.

For each taught workpiece in the specified direction, all workpieces corresponding to the taught workpiece are stacked (or unloaded) with the same attitude and form as that for the taught workpiece.

The following shows an example of palletizing for an irregular arrangement of four rows, two columns, and five layers.

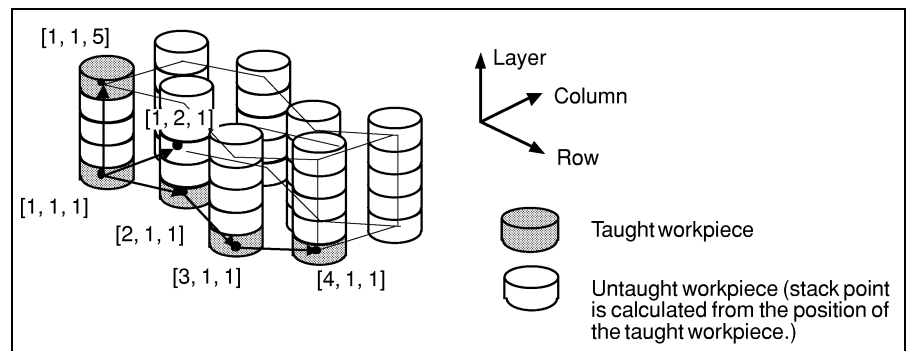


Fig. 10.7 Palletizing All-Point Teaching

The following palletizing initial data is set:

```
ROWS      = [4  FREE  INTER]
COLUMNS  = [2  LINE  FIX ]
LAYERS    = [5  LINE  FIX 1]
```

In this example, FREE and INTER are set in the row direction. When system variable \$PALCFG.\$FREE_CFG_EN is set to TRUE under this condition, the following forms are used:

- Form for stacking (unloading) workpieces on row 1: Form in P[1,1,1]
- Form for stacking (unloading) workpieces on row 2: Form in P[2,1,1]
- Form for stacking (unloading) workpieces on row 3: Form in P[3,1,1]
- Form for stacking (unloading) workpieces on row 4: Form in P[4,1,1]

Notes

Note the following points when using this function:

- 1 FREE and INTER can be set at the same time in only one of the row, column, and layer directions (when this function is not to be used, set system variable \$PALCFG.\$FREE_CFG_EN to FALSE).

This is because if FREE and INTER are set at the same time in two or more of the row, column, and layer directions, two or more forms to be taken at the position of an untaught workpiece (workpiece for which the stack point is calculated from the position of a taught workpiece) are made.

If such a setting is made in a program, the program causes the error indicated by PALT-024 Calculation error occurred and cannot be executed.

- 2 Carefully teach a program so that the program is not stopped due to a form mismatch alarm.

If the form in the current position differs from the form data for the destination position, the robot cannot move in Linear operation mode (a form mismatch alarm occurs and execution of the program is stopped).

The form at a stack point is used for the form at an approach or retraction point during palletizing. Therefore, if the pallet operation instruction to be executed first is in Linear operation mode, a form mismatch may occur depending on the form of the robot when an attempt is made to execute the line.

To avoid such a problem, specify Joint for the operation mode of the first pallet operation instruction.

For example, to avoid a form mismatch alarm, the following programming can be used for palletizing with three approach points and two retraction points.

```

:
10: PLETIZING-EX_1
11: J PAL_1[A_3] 100% FINE
12: L PAL_1[A_2] 500mm/sec CNT50
13: L PAL_1[A_1] 300mm/sec CNT10
14: L PAL_1[BTM] 100mm/sec FINE
15: Open hand 1
16: L PAL_1[R_1] 300mm/sec CNT10
17: L PAL_1[R_2] 500mm/sec CNT50
18: PALLETIZING-END_1
:

```