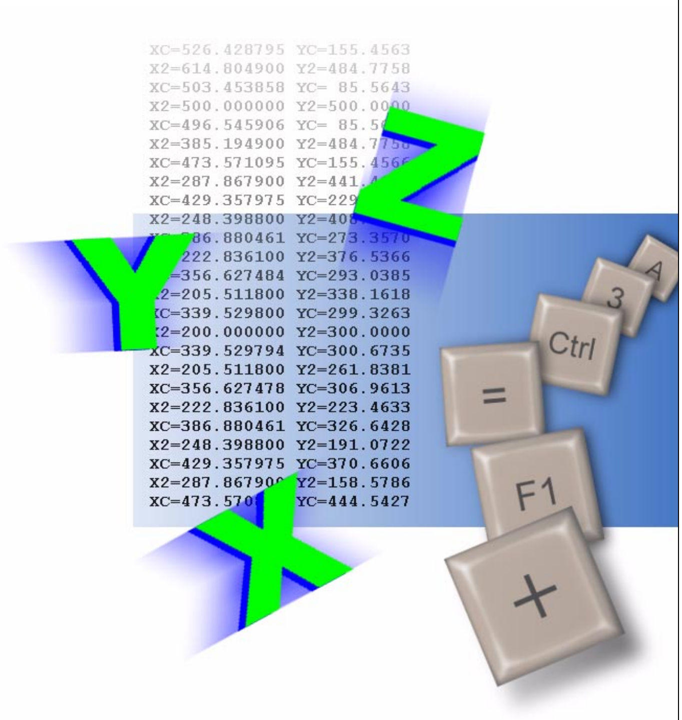
SOFTWARE USER'S MANUAL

Software

XNC 1.2



5804A0030 ENGLISH
Issue.Revision: 1.4

Matricola

RINA CISQ
QUACER ISO 9001
481/96

BIESSE™
BIESSE GROUP woodworking machinery

Informations on this publication

Code:	Issue:	Revision:	Approval number:
5804A0030	1	4 (06, 2000)	99/0064M

List of changes			
Revision:	Additions:	Deletions:	Changes:
3	■ Biesse Applications.		■ Part lists. ■ Appendices. ■ Use (page 153-154)
4	■ Biesse Applications: paragraphs 1.6 and 1.8		

The manual must only be used by personnel who have been adequately trained to operate the machine. BIESSE cannot be considered responsible or liable for damage resulting from incorrect or improper use of the documentation provided. In order to avoid incorrect manoeuvres that might result in danger to the operator or to third parties, it is essential to read and fully understand all the documentation supplied with the machine.

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02480600374
R.S.T. Bologna n. 41287 - CCIAA R.D. N. 294814 - M 138519

MACHINE VERSION *1.2.x.x*

MANUAL REVISION *1.2.0.2*

MANUAL ISSUE *3/1998*

ARCHIVE NUMBER *X2532*

1.2.0.1 ⟹ 1.2.0.2

1. Part *Appendices* - Appendix C: *Update of Part 5 - USE*

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Contents

1 General Description

This part of the manual is dedicated to the description of how the machine operates. This introductive chapter will give a simple panorama of the machine interface devices; the successive chapters will give a detailed description of the software.

1.1 Introduction

Two are the most significant changes made to the Numerical Control produced by CNI:

- The Multitask, Real-Time, Multiuser Operating System,
- The XWindows graphic interface.

Without entering into details, we wanted to specify that the terms Multitask and Real-Time indicate, generally speaking, that the Operating System is capable to manage the simultaneous execution in real time of more than one application. The term Multiuser indicates that more than one user can access the resources of the System.

These important characteristics are made all the more relevant by the graphic interface (GUI) that allows simultaneous display and edit of data relative to more than one application, through the use of freely sizeable windows acting each as a virtual terminal.

For this reason, the acronym XNC was created, which stands for X (Windows System) Numerical Control.

1.2 Description of the Numerical Control

The XNC consists basically of a Personal Computer, whose hardware and software have been specially designed for the programming and control of machine tools. The specific hardware components and the software loaded on the XNC depend on the characteristics of the machine which it is connected to. Common characteristics will be described below. Specific customised features will instead be described in a separated chapter in this manual.

1.3 Operator Interface

The term Operator Interface refers to those hardware and software components dedicated to allow the entry, the display, and the memorisation of data. The software part of the Operator Interface is described in the chapters dealing with the Application Programs. The hardware includes:

- MONITOR: SVGA 14", colour, 0.28 dot pitch.
- KEYBOARDS: 3 types of keyboards are available.
  - Waterproof operative keyboard, with built-in mouse for fast access to NC functions.
  - Programmable keyboard with 12 or 24 lighted keys, used with the PLC.
  - Standard PC pull-out keyboard, for intensive on-line NC programming.
- FLOPPY DISK DRIVE: 3.5 inches, high density (1.44 Mb) for data storage.
- HARD DISK DRIVE: high capacity.

Following is a brief description of the functions of the keys on the operative keyboard. For technical information regarding the operative keyboard or other components of the hardware interfaces, refer to the section entitled *Composition and Connections*.

1.3.1 Operative Keyboard

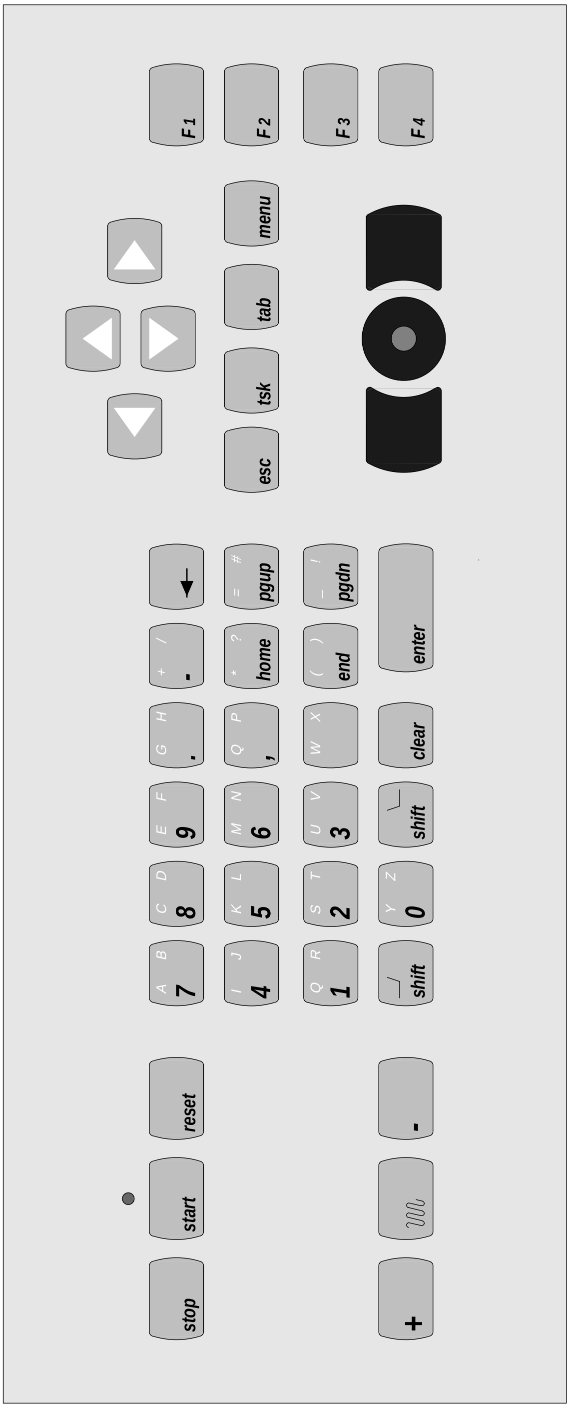


Figure 1.1: XNC Keyboard

Referring to Figure 1.1, the keys on the Operative Keyboard can be classified according to the function they perform:

1. Multi-function keys,
2. Navigation keys,
3. STOP, START and RESET,
4. Jog keys,
5. Function keys,
6. Mouse.

Multi-function keys

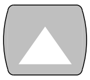
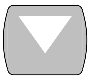
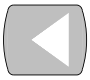
They contain letters and numbers, or letters and punctuation marks. The lower left corner shows a number from 0 to 9, a point ".", or a comma ",". The upper left and right corners show the letters of the English alphabet. Press the key by itself to write the symbol or the number shown at the bottom left corner. To write a letter, press instead first one of the two SHIFT keys and then the key containing the required letter.

Example To write the letter Q, press the left SHIFT key *shift* and then the key with the letter Q *Q P ,* :
The multifunction keys permit both the writing of symbols + - * ? ( ) as well as performing some editor functions, such as scrolling one page down, deleting a character, moving the cursor to the end of the line, etc.
They are called special keys, following is a brief description of them.

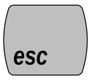
- *shift* (SHIFT SX): used to write the character at the top left corner of the Multi-function keys.
- *shift* (SHIFT DX): used to write the character at the top right corner of the Multi-function keys.
- ← (BACKSPACE): moves the cursor to the previous character and deletes it.
- *clear* (CLEAR): Used to clear the error codes displayed on the monitor following incorrect user operations. In some instances it allows the user to cancel sending a command to the NC.
- *enter* (ENTER): Used to send commands to the NC or to confirm a selection when expressly required.
- *= # pgup* (PAGE UP): Scrolls up the text displayed. The cursor remains at its current position.
- *_ ! pgdn* (PAGE DOWN): Scrolls down the text displayed. The cursor remains at its current position.
- ** ? home* (HOME): Moves the cursor to the beginning of the current line of text.
- *( ) end* (END): Moves the cursor to the end of the current line of text.

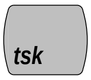
Cursor Movement Keys:

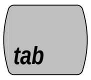
used to move the cursor along the lines of text being displayed.

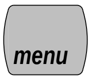
-  Moves the cursor up.
-  Moves the cursor down.
-  Moves the cursor left.
-  Moves the cursor right.

Other Keys

- 

In some instances, it allows the user to cancel sending a command to the NC. It is also used to exit from the selected window.
- 

Used to select the various windows present in the video area. Alternatively, the ALT+TAB key combination can be used.
- 

It is used to select the various buttons or boxes within the windows.
- 

Selects the Menu bar of the active window.

STOP, START and RESET Keys

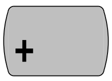
- 

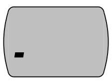
Starts the cycle of a program. During an Automatic Start, the led remains ON.
- 

Stops immediately the execution of a program.
- 

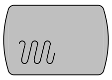
Resets the NC so that, at the next START, the selected program will start at the beginning.

Jog Keys

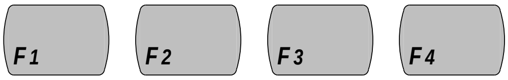
- 

Moves the selected axis in the positive values direction. The speed at which the axis moves is that defined in the `Slow Jog Speed` machine data in the Axes Data table (Sec. 12.3.1).
- 

Moves the selected axis in the negative values direction. The speed at which the axis moves is that defined in the `Slow Jog Speed` machine data in the Axes Data table (Sec. 12.3.1)

-  Used to change the jog speed of the axis from slow to fast. It must be pressed together with one of the two keys described above. The speed at which the axis moves is the speed defined in the `Fast Jog Speed` Machine data in the Axes Data table (Sec. 12.3.1).

Function Keys



The operation of the Function Keys is directly controlled by the application programs of the XNC.

1.3.2 Mouse

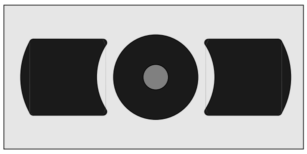


Figure 1.2: Mouse

Consists of 1 pointer button and two side buttons:

- Centre pointer button: if kept pressed and turned as necessary, it moves the mouse pointer on screen.
- Left side button: Selects the area where the mouse pointer is currently located.
- Right side button: not used for XNC applications.

1.4 Graphic Interface

The graphic interface of the XNC is based on a system called X Windows (or simply X), which allows working on more applications at the same time, each of which is displayed in a well-defined portion of the screen, called *window* (Fig. 1.3).
Many different types of operations can be carried out from within each window, according to the program currently active in it. For instance, some can accept input from the user to control mechanical axes, create work programs, edit databases, etc, others simply display information, such as date and time, or images. The windows in Fig. 1.3belong to the first type, while the windows which are opened by choosing `X terminal` from the `Root Menu` belong to the second type.
The small, lower windows inserted into the horizontal strip of Fig. 1.3, are called icons and represent active windows in which direct display has been temporarily suspended.
The structure and the management of the windows is demanded to a program, called *Window Manager*, which defines the graphic style and controls all operations that the user can perform on the windows, such as select them, resize them, move them on the screen, reduce them to icon, etc. The Window Manager used by the XNC is called `mwm (Motif Window Manager)` and is relative to the OSF/Motif graphic style.

1.4.1 Selecting a Window

When a window is selected, it becomes interactive, that is, the user can perform actions on them (for instance move it or resize it), or in them, such as entering data or commands in the application currently being displayed.
Windows can be selected in various ways:

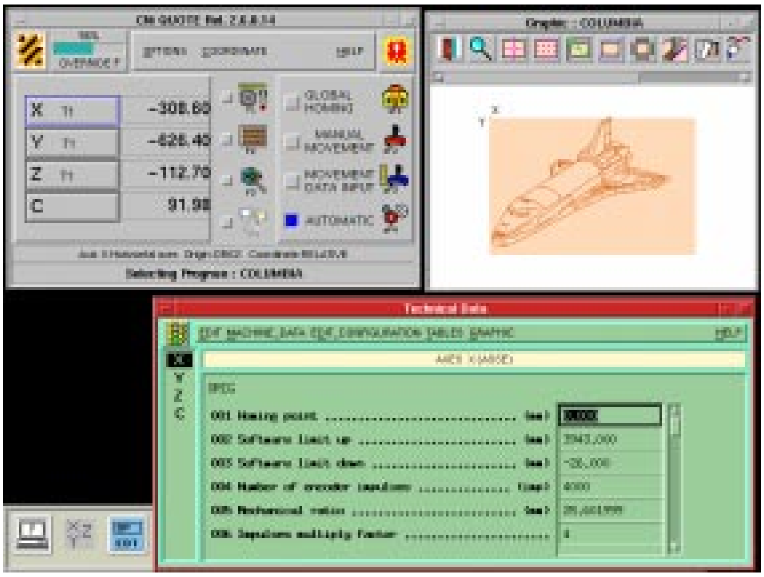


Figure 1.3: Video page

- Moving the mouse pointer inside the required window and clicking the left mouse button.
- Pressing the Alt+Tab keys at the same time to select the windows present on screen recursively one after the other.

When a window is selected, its border changes colour. One window only at the time can be selected.

1.4.2 Structure of Windows

Windows are delimited by a border that may in turn contain the following elements:

- title bar (Fig. 1.4-A-B-C-D)
- scroll bars (Fig. 1.4-E)
- insertion and display area (Fig. 1.4-F)
- resizing corners (Fig. 1.4-G)

The window shown here was opened by choosing `X terminal` from the `Root Menu`.
Some windows do not have a title bar. Generally, these windows are used only to display data or images.

Title Bar

The Title Bar is found at the top of the border. It is larger than the other borders and contains:

- Menu button (Fig. 1.4-A),
- Title area (Fig. 1.4-B),
- Minimise button (Fig. 1.4-D),
- Magnification button (Fig. 1.4-C).

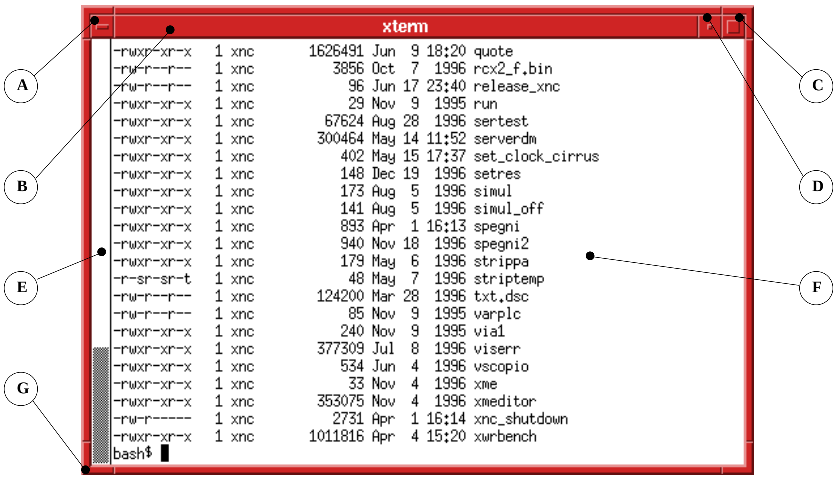


Figure 1.4: X Terminal window

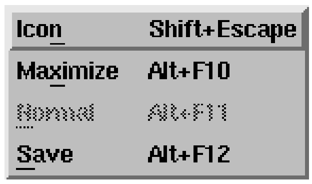


Figure 1.5: Menu option window

◇ **Menu Button** shown in Fig. 1.4-A. Click with the mouse to display a box containing some items relative to the window, such as in Figure 1.5

To make a function item active, press the key combination indicated next to it, or click on it with the mouse.

1. `Icon Shift+Escape`: Used to minimise, or reduce to icon, a window. The reduced icon is placed at the bottom of the screen.

2. `Maximize Alt+F10`: Used to enlarge the window to full-screen size. To restore the window to its previous size, activate this function again.

3. `Normal Alt+F11`: Converts the icon to a window.

4. `Save Alt+F12`: Saves the position, the dimensions and the status of the window. The next time the window is open, it will appear exactly as it had been saved. This function is useful if a specific arrangement of the windows is required when the NC is first turned on.

◇ **Title Area** The central part of the title bar (Fig. 1.4-B) contains a text string describing the window. Generally this is the name of the application, but a different title can be specified.

◇ **Magnify button** Located near the top right corner of the window (Fig. 1.4-C). Click it to enlarge the window to full-screen size. Click it again to restore the window to its normal size. It performs the same functions of the Maximize and Normal items.

◇ **Minimise Button** It is located next to the top left corner of the window (Fig. 1.4-D). Click it to reduce the window to an icon. Acts the same as the Icon menu item.

1.4.3 Resizing a Window

To resize a window, you must select it first, then position the pointer of the mouse on one of the four corners of the border, so that the mouse pointer changes shape and becomes like one of those shown in Figure 1.6.

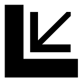


Figure 1.6: Cursor on a corner of the window

Now keep the left mouse button pressed while moving the mouse to enlarge or shrink the window as required.

1.4.4 Moving a Window

To move a window on the screen, place the mouse pointer on any part of its border except for the corners or the Title Bar. When the mouse pointer is in the correct position, its shape changes to that shown in Figure 1.7.

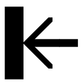


Figure 1.7: Cursor on the border of the window

Now keep the left mouse button pressed while moving the mouse pointer to place the window in the required location on the screen.

1.5 Application Programs

1.5.1 General Considerations

The `Application Programs`, are all the interactive programs (those with an interface allowing the interchange of information and data with the user) used to process, organise and transmit to the NC all the data which the NC requires to control the machine to which it is connected. From this point on in the manual the abbreviation A.P. will be used to indicate an Application Program.
For instance: with the Quote Application you can display the coordinates of the axes of the machine, perform homings, execute programs. The Technical data Application can be used to modify the data relative to the tool magazine, to the spindles, to the heads, etc. outfitted on the machine. The Editor application can be used to build work programs, etc.

Before describing the functions of the Application Programs supplied with the XNC, we'll illustrate some common characteristics relative to the type of Graphic User Interface used to built them. To do so, let us look at a generic Application, i.e. `A.P. QUOTE` as shown in Fig. 1.8.
First of all, let's note that all A.P. is displayed inside a window and can therefore be enlarged, reduced to icon, moved to a different position on the screen, etc. as described in Chapter 1.4. The title area of the window shows, generally, the name of the Application Program, which in this case is QUOTE.
As you can see from Figure 1.8 the appearance of the `P.A. QUOTE` consists of a background on which 3D rectangles and squares of various colours and sizes. These 3D boxes contain:

- Areas for displaying information,
- Areas for entering information,

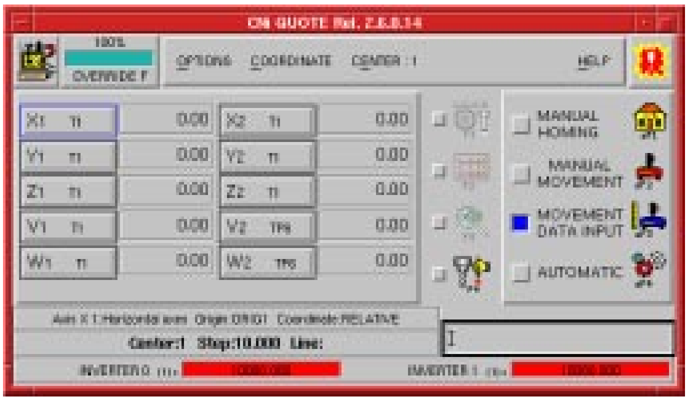


Figure 1.8: Sample Application Program

- Areas of access to functions of the A.P.,
- Software buttons.

The rectangle located immediately below the Title Area, in the upper central area of the window is the `Menu Box`. When you click with the mouse on one of the words present in the Menu Box you can access a menu which lists the particular functions of the A.P. These functions may be performed immediately, or they may give access to other windows or submenus. One letter of each item in the Menu box is underlined. This letter represents the item's "mnemonic selection code". If you press at the same time the `ALT` key together with the `underlined letter`, you can select the corresponding menu item.

Menu items are generally listed together with a sequence of two characters: a caret ˆ and a letter of the alphabet. This sequence is called "fast key" and is obtained by pressing at the same time the Ctrl key and the "letter".
The "fast keys" have this name because they are used to activate the associated function without having to select the list that contains it from the the menu bar.

1.5.2 Software Buttons

Generally speaking, *software buttons* are 3D squares on the background. They can be defined as structures that, when activated, cause some action to be performed, such as the display of information, the access to a specific function of the AP, or the transmission of a command to the machine. There are three types of "software buttons":

- push buttons
- toggle buttons
- arrow buttons

The push buttons are used to activate functions, such as accessing an application, creating a window, transmitting a command to the NC, etc.

Toggle buttons are mainly used to select various operation settings. The colour is used to show whether the button is "toggled", or "untoggled".

The arrow buttons are similar to the push buttons. The difference is that the icon that defines them has the shape of an arrow.
Toggle buttons can be found in two types of dialogue boxes:

- check boxes

- radio boxes

In radio boxes, the buttons are diamond-shaped and are mutually exclusive, in other words, when you select one, the others are de-selected. In the check boxes the buttons are square-shaped and they can be selected independently of the others.

There is also another special type of buttons, called "option buttons". They have the same characteristics of the "radio boxes". Only the selected option is displayed, next to a box containing a descriptive explanation. The other options are generally hidden and are shown only if the button is clicked.

2 Root Menu'

By clicking on the left mouse button in a free area of the XNC screen, or by pressing the F12 key on the PC keyboard, or else by pressing in sequence the "shift" and "menu" keys of the operative keyboard of the XNC, a box called the `Root Menu` will appear which allows access to the following functions:

- `X Terminal`
- `Manual`
- `Disk Manager`
- `HardCopy`
- `Maintenance` ▶
  - `Debug PLC`
  - `XScope`
  - `Kill XNC`
  - `Restart XNC`
  - `Install XNC`
  - `Select Printer`
- `Reboot`

These items activate NC functions or give access to application programs.

2.1 X Terminal

Opens a terminal window by means of which commands may be sent to the operating system that manages the NC software. This window is opened in the `/home/xnc/bin` directory, and its "owner" is the `xnc` user. The terminal window is not opened if the user password does not belong to a high enough level, namely level 15. The concept of password level is explained with more detail in Section 7.11, Section 12.2 or else, Section 10.3.

2.2 Manual

Recalls the on-line XNC manual to the screen. The Html (or electronic manual) is accessed through Mosaic and is available at every password level. The electronic manual opens from the Home Page of the language selected at the moment the NC is turned on. Fig. 2.1 shows the Home Page of the manual for the version 1.1.0.0. It is possible to choose one of the other available languages with the command `Select Language`, found on the Home Page itself. The languages available are: *Italian, English, French, German, Spanish, Portuguese, Dutch, Danish, Swedish, Norwegian, Finnish*. Usually the original language and English are the default languages installed in the system. The electronic manual is the same as that provided in book form, except that the sections regarding general technical information have been eliminated. The electronic manual can be consulted by clicking with the mouse on the desired item. There are 4 principal parts: the `User's manual`, the `Programming manual`, the `Error list`, and the `Appendices`. By selecting one of these parts, the index of the relative chapters can be consulted. The other means of consulting the manual is through the on-line help. In fact, some of the applications have a HELP menu. By clicking on it, the on-line manual opens to the requested section. If a language different from the original language has been selected, the on-line manual accessed by clicking on HELP will always be in the language selected for the NC.

2.3 Disk Manager

Calls up `Disk Manager A.P.` to screen (see Sec. 3).

Figure 2.1: Home Page of on-line manual

2.4 HardCopy

`HardCopy` is a function of the `Root Menu` which prints an image captured from the screen. This function is also accessible from level 1 passwords. The captured image may be printed to a file or to the selected printer by using the `Select Printer`function from the `Maintenance Menu`. For a description of the `Select Printer` function, read the section entitled 2.5.6. By selecting `Hardcopy` a the window shown in Fig. 2.2 appears. Once the print option has been chosen (file or printer), click on OK with the mouse; the window is closed and the mouse cursor becomes a circle with a dot at the center.
Now, position the cursor (circle with a dot at the center) on the window to be captured and click with the left mouse button. If the operations have been performed correctly and the proper printer has been chosen, the captured image will be printed.
If the option to print to a file has been chosen, the window shown in Fig. 2.2 appears without the list of options. In this case, by clicking on OK, the mouse cursor becomes a $+$. once the image has been captured, the window shown in the Fig. 2.3 appears. Using this window the output device and the name of the file can be chosen. Once the desired choices have been made, click on OK; a message will appear advising that the image is being printed to a file. The file is saved in PCX format.

2.5 Maintenance Menu

2.5.1 Debug PLC

Recalls the `A.P. Debug Plc` to the screen to debug the global variables and the exchange signals between PLC-NC and NC-PLC. (see Sez. 4). The `A.P. Debug Plc` is activated at password level 3 and higher. For a complete description of the exchange signals between PLC-NC and NC-PLC, consult the *Exchange Signal Manual*, currently

Figure 2.2: Copy video window

Figure 2.3: Select file window

in *version* $\beta 1$. This manual has been prepared by the CNI documentation office.

2.5.2 XScope

The `A.P. XScope` permits:

- the display of physical size and parameters relative to the axes of the machine in function of time, for example, speed, tracking errors, etc.,
- the triggering of the machine axes with suitable signals in order to automatically calculate the parameters of

the XNC controller and to adjust the load-motor-operation system,

- the display of signals external to the XNC system, in function of time, like a normal oscilloscope.

For a complete description of this application, please consult the *Service Manual*, currently available in the *version* β, prepared by the CNI documentation office. The `A.P. XScope` is activated at password level 3 and higher.

2.5.3 Kill XNC

Causes the termination of application programs which form the XNC. The processes can be terminated all at the same time, or they may be terminated one (or more) at a time, as explained below. Fig. 2.4 shows the window which opens when this function is selected.

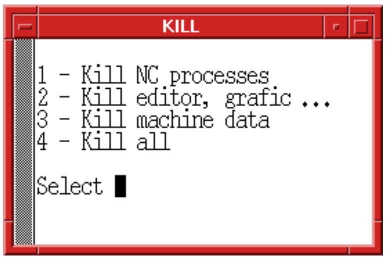


Figure 2.4: KILL Window

The available options are:

Kill NC processes: kills (or makes disappear) all the A.P. dedicated to the movement of the machine.

Kill editor, graphics, ...: kills all the A.P. relative to the editor and the graphics, except for the `Technical Data A.P.`

Kill machine data: kills the `Technical Data A.P.`

Kill all: kills all the A.P. of the XNC.

To activate one of the functions described above, enter the number of the required function at the `Select` prompt. Any other key will exit from the `A.P. Kill` application. The `Kill XNC` application is available at all password levels.

2.5.4 Restart XNC

Reloads all inactive XNC application programs. It is generally used after it has been necessary to kill some or all of the XNC processes. The `Restart XNC` procedure is available at all password levels.

2.5.5 Install XNC

Opens the `A.P. Install` for the installation of XNC software updates. The Install XNC application is available at password level 3 and higher. (See Section 5).

2.5.6 Select Printer

This option permits the user to choose the output device when printing by XNC. When the option Select Printer is chosen, available at password level 3 and higher, the window shown in Fig. 2.5 appears.
The first choice to be made in this window is that of either local printer or network printer; in the latter case either Unix network or Windows network can be chosen, as shown in Fig. 2.5-A in which a printer in Unix network has been chosen. At the center of the window there is a list of printers, the user can use the scrolling bar at the right

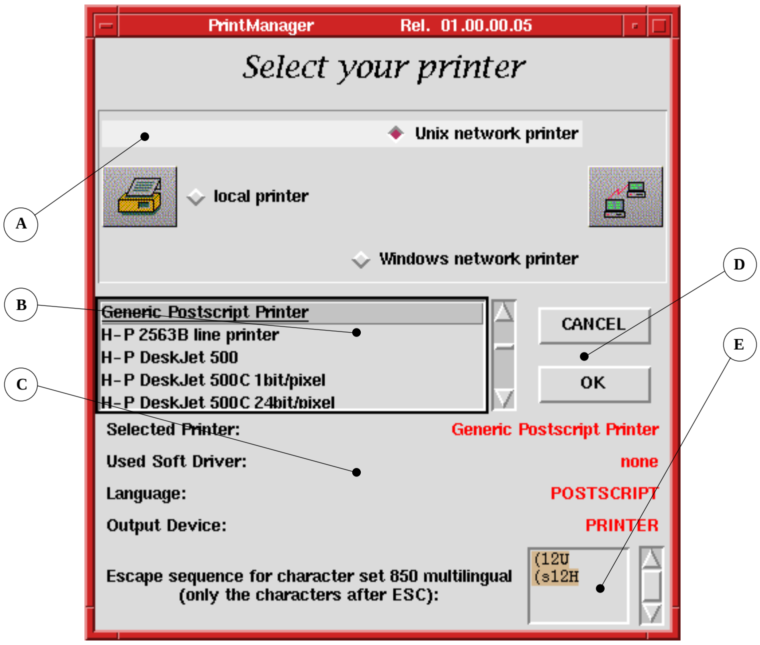


Figure 2.5: Printer set-up window

(Fig. 2.5-B) to scroll through the list of printers. To select a printer, double-click on it with the mouse. A summary of the information relative to the device selected appears under the list. For example, if the `Generic PostScript Printer` is chosen, the information summary shown in Fig. 2.5-C will appear.
In the event it becomes necessary to print the *ASCII extended* character set, for example, the accented letters in Italian, or certain special characters in some foreign languages, or if the user wants to change the printer font, the user can insert the desired ESC sequences from the Printer Set-up window. These ESC sequences, which are inserted as shown in Fig. 2.5-E, depend on the type of printer selected and can be found in the specific printer User's Manual. There are numerous and varied operations which can be performed with the ESC sequences. Therefore, it is suggested that the user be well-informed on the possibilities offered by the particular printer in use. Several ESC sequences can be inserted at the same time, in the event that the user wants to perform several operations on a given file. These sequences must be inserted line by line; each line is automatically associated with an $< ESC >$, and each line is placed at the beginning of a file before it is sent to the printer. For example, in Fig. 2.5-E, the user can see how the sequences *(12U* and *(s12H* have been inserted; respectively, they are for choosing to print the *ASCII extended* character set and to change the font for the printer in question.
To activate the set-up procedure, press OK, otherwise press CANCEL Fig. 2.5-D) to nullify the selected changes. All of the print operations initiated from the XNC after the printer set-up, will maintain the selected characteristics, including the ESC sequences. In order to eliminate the latter, the set-up procedure must be repeated.

2.6 Reboot

It deactivates the XNC operating system, starting control procedures and saving of data managed by the operative system. For a more detailed description, see the 6 section.

3 A.P. Disk manager

The `Disk Manager` application program has the dual purpose of providing a backup of the data contained in the machine and entering data in the machine itself. The `Disk Manager`application program is accessible from all password levels. The application supports diskettes formatted UNIX as well as DOS. The files that may be copied regard programs, routines, and lists directories that may be directly accessed and modified by the user, as well as technical data, icons, and figures.

3.1 Access to the application

Considering the purpose of the `Disk Manager`, it is not available when the machine is turned on, but rather from the `Root Menu‘`, which is called up by clicking with the left button of the mouse on the display screen without any windows. Keeping the mouse key pressed, after having called up the menu, select `Disk Manager`.
After copying the files you want to export from or import to the machine, the procedure may be closed by selecting Exit (ˆX) on the SERVICES Menu and opened again when needed in the same manner described above.

3.2 Description of first page

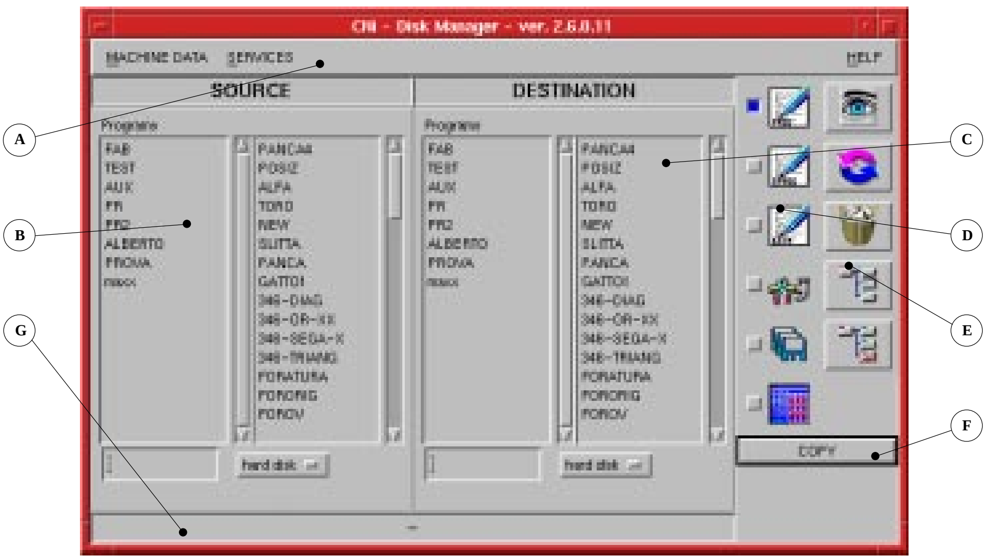


Figure 3.1: Disk ManagerWindow

When opened, the procedure appears as arranged in Fig. 3.1 and is composed of:

- A Menu Bar (Fig. 3.1-A).
- Two identical display sections, one for the SOURCE files (Fig. 3.1-B and one for DESTINATION file (Fig. 3.1-C).
- A column with six *toggle* type software buttons. (Fig. 3.1-D).
- A column with six *push* type software buttons. (Fig. 3.1-E).
- A *push* button to activate copy. (Fig. 3.1-F).
- A label field at the bottom of the page. (Fig. 3.1-G).

Following is a detailed description of the items above.

3.3 Menu Bar

From the Menu Bar (Fig. 3.1-A) you can access two submenus:

- MACHINE_DATA
- SERVICES

3.3.1 Machine_data

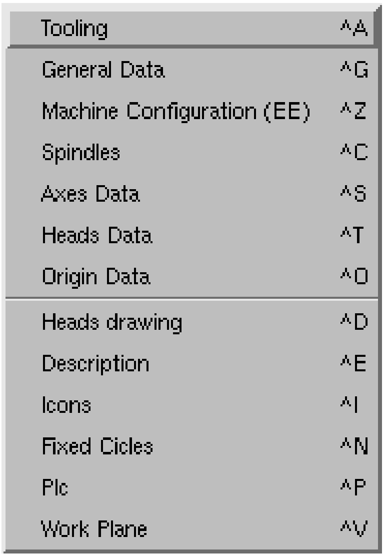


Figure 3.2: MACHINE_DATARiquadro

Under the MACHINE_DATA item (Fig. 3.2) are 13 *toggle* buttons that summarise thirteen categories into which the MACHINE_DATA have been subdivided. Toggling each button selects automatically the files or the subdirectories relative to the selected category. These categories are:

1. TOOLING (ˆA)
2. General Data (ˆG)
3. Machine Configuration (EE) (ˆZ)
4. Spindles (ˆC)
5. Axes Data (ˆS)
6. Heads Data (ˆT)
7. ORIGINS (ˆO)
8. Heads drawing (ˆD)
9. Description (ˆE)
10. Icons (ˆI)
11. Fixed Cicles (ˆN)
12. Plc (ˆP)

13. Work Plane (ˆV)

If you want to perform a copy to or from a diskette, multiple selection is allowed.
If more than one *toggle* buttons have been selected, the four *Scrolled List* fields will contain all the files of the selected items. When both the selected source and the selected destination are the Hard Disk, or in the case of remote connection, multiple selections are not permitted. This subject will be explained further in paragraph 3.6.

3.3.2 Services

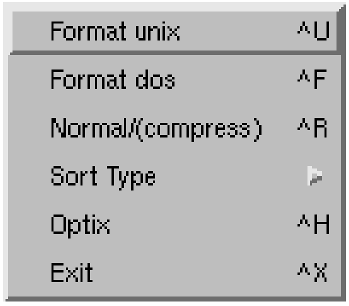


Figure 3.3: Services window

Some utilities complementing the functionalities of the application have been included under SERVICES item (Fig. 3.3) Some of these utilities are:

- Format unix (ˆU): formats a UNIX diskette. After this selection, a window will appear asking to confirm the operation (Fig. 3.4).
- Format dos (ˆF): formats a DOS diskette. After this selection, a window will appear asking to confirm the operation (Fig. 3.4).

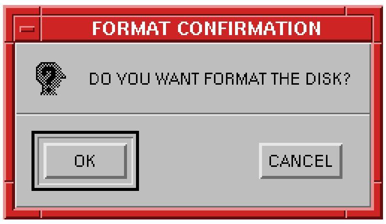


Figure 3.4: FORMAT CONFIRMATION window

- Normal/(compress) (ˆR): (or Compress/(normal)) activates or deactivates file compression when copying with a UNIX diskette.
- Sort Type: it allows to sort files in three different ways:
  - Unsorted (ˆJ): leaves the files in the input order.
  - Sort by name (ˆL): orders the files in the source *Scrolled list* by letter.
  - Sort by date (ˆM): orders the files in the source *Scrolled list* by date.
- Optix (ˆH): All of the machine configuration data is copied to two DOS formatted diskettes without user intervention, When Optix is selected, a Confirmation window appears as shown in Fig. 3.5. If the application operates under Windows, the user will be asked if the application is to be installed from diskettes or from the

Figure 3.5: Optixwindow

network. In the first case, the system asks for the same two diskettes obtained with the NC; in the second case, the files are copied to the PC from the NC through the network.

- Exit (ˆX): exits the application.

3.4 File Display Section

Fig. 3.1-B and Fig. 3.1-C illustrate the two file display sections in which the procedure is divided. Only one of the sections is examined since the two sections are identical and interchangeable. This section presents, before the scrolled list, two label fields that supply information on the operations being performed. In particular, the first field specifies if the section is the source or the target of the copy to be made; in addition, if the section refers to the diskette, the type of diskette inserted (DOS or UNIX) will appear before copying. The second field, immediately under the first, reproduces the file category selected by means of a toggle button on the MACHINE_DATA menu. In the event of multiple selection, the last selection will appear.
The following two "Scrolled lists" list the sub-directories on the left, and the files in the selected category on the right. It is possible to do a rapid search for the file needed in the files list in both the source and target. To obtain this function, position the cursor on the list and type the first letter of the file; if there is more than one file whose name begins with that letter, the cursor will move to the first of these.
Another, more direct, way to quickly search for a file involves the use of the text field at the bottom left of the section. Write the entire file name and press ENTER: if the file exists, it will be displayed. If you type the character * in this field, followed by ENTER, you will select all of the files in the current directory; typing one or more letters followed by * will select all of the files that begin with the sequence of characters typed.
At the bottom left is an Option Menu with which you can select the hard disk or the floppy as source or target of the copy. The selection floppy-floppy is not allowed. Finally, there is the last label field, which displays the name of the last file selected, its size, and the file change date.

3.5 Software buttons

3.5.1 “Toggle” type software buttons

Next to each software button (Fig. 3.1-D) is an icon that identifies its function. For a brief explanation of the action associated with each button, you can make a short string appear on the yellow background by placing the mouse arrow on the button for a few seconds. Fig. 3.1-D shows the following buttons, from top to bottom:

PROGRAM SELECTION Selects the user programs directory.

SUBPROGRAMS SELECTION Selects the user routines directory.

WORKLIST SELECTION Selects the list directory.

MACHINE DATA SELECTION Selects all files contained in the Machine Data directory.

TOTAL BACKUP Turn on or off the total backup of all files and directories for machine configuration created by the user.

SELECT/DESELECT FILES Selects or unselects files on the *Scrolled list* in the source section.

3.5.2 “Push” type software buttons

The philosophy that regulates the five *push* buttons (Fig. 3.1-E) is similar to that described in the preceding section for the *toggle* buttons, therefore we will proceed directly with an analysis of their functions.

DISK DISPLAY Displays the contents of the diskette inserted, starting with the directory of the category selected.

SOURCE/DESTINATION SWITCHING Switches the source section to target and vice versa.

REMOVE FILE Deletes files: this operation is permitted only in program, routine, and list directories.
To delete a file, simply select it with the mouse and confirm using the Message Box that appears. This operation is allowed on both Hard Disk and on DOS diskette.

MAKE DIRECTORY Creates a new subdirectory. In this case as well, the operation is permitted for programs, routines, and lists.
The name of the new directory to be created must be typed in the text field of the Message Box that appears (Fig. 3.6).

Figure 3.6: MAKE DIRECTORY

REMOVE DIRECTORY Cancels entire subdirectories using the same methods as REMOVE FILE.

To delete a directory, simply select it with the mouse and confirm Message in the following Box.

3.5.3 Copy Button

The file copy function is activated by pushing this button (Fig. 3.1-F). The next section gives a detailed description of all of the copying functions offered by the application.

3.6 Copying modes

Copying operations can be performed with multiple selections; to proceed, simply choose the file, or files to be copied by clicking with the left mouse button on the files. To deselect a file, click on it a second time with the left mouse button. To select all the files in a directory, or deselect all the files selected from the source section, the SELECT/DESELECT FILES may be used. A selected file is highlighted with a black background.

3.6.1 Hard disk - Hard disk

When copying to the Hard Disk, Multiple Selections are not possible, to the contrary it is possible to copy one or more files or entire directories from one sub-directory to another.
The user may access the subdirectory containing the file to be copied or which copied file must be added to by clicking twice on the name of the subdirectory in the Scrolled list to the left of the source or target section, respectively.
Select the file to be copied by clicking once on the name that appears in the Scrolled list on the right side of the source section.
After subdirectories and files selection, start copying with the COPY "push" button.
By selecting only one file in the source field and writing a new name in the target text field, you may give the copy a new name.

3.6.2 Hard Disk - Disk A

Generally speaking, saving files on diskettes follows the following procedure.
The selection of files or directories is done with a single click of the mouse. To display the content of a directory, a double click is required. It is possible to select multiple files in the same directory, multiple files in different directories, and also of entire directories, at the same time.
To cancel a wrong selection, press the SELECT/DESELECT FILES toggle button which will cancel all current selections. To start the copy, use the COPY software button. In case the destination is a UNIX diskette, a window will be displayed warning that the copy operation will delete all the pre-existing files.

If the space on the diskette is not sufficient to contain all the files that you want to copy, in case of a UNIX diskette you can replace the diskette and continue the copy operation after a Message Box is displayed. In case of a DOS diskette, multivolume copy is not allowed and an Error Message will be displayed.
File compression is possible only in UNIX mode and is enabled by selecting on the Menu Bar the SERVICES Submenu, and then the Normal/(compress)) item.
The same considerations apply for the opposite operation, that is for the copy from Disk A to the Hard Disk. When copying a file with the same name from a DOS or diskette to the Hard Disk, or from the Hard Disk to a DOS the warning message in Fig. 3.7 appears.

Figure 3.7: File overwrite window

3.6.3 Hard Disk - Remote Connection

A remote connection is signalled by the name of the remote machine displayed in the menu described in par. 3.2. Multiple file copy from the Hard Disk to the Remote Connection is only possible if all the selected files are contained in the same directory. The copy of entire directories or subdirectories is not permitted. In general, the modalities for the copy from Hard Disk to Hard Disk apply here also. The same considerations apply for the opposite operation, that is for the copy from Remote Connection to the Hard Disk. If the copy procedure is to be aborted, simply press the `ESC` key while the copy is under way.

3.7 Label Field

This field, located at the bottom of the page, Fig. 3.1-G, is reserved for various types of messages concerning the application. Detailed messages inform the user about the file being copied, about the compression or decompression phase, and of the fact that a multiple selection is being performed.

4 A.P. Plc Debug

4.1 Introduction

The Plc Debug application program has been designed to allow the user to debug the exchange signals between PLC and NC of the global variables defined in the PLC program. If the variables are Booleans, they can also be traced.
Plc Debug is not immediately available upon machine start up, but it can be accessed through the Root Menu. To access this menu, click the background of the video with the left mouse button. For a detailed description of the Root Menu, see Section 2. After accessing the menu, keep the mouse button pressed and select the Maintenance Menu item. The item Debug PLC can be chosen from the successive sub-menu. The A.P. Debug Plc application is available at password level 3 and higher.
At the end of debugging, you can close the procedure by selecting Exit from the FILE Menu, and re-open it as necessary as indicated above.
Once launched, the process presents the user with the screen shown in Fig. 4.1, containing the following elements.

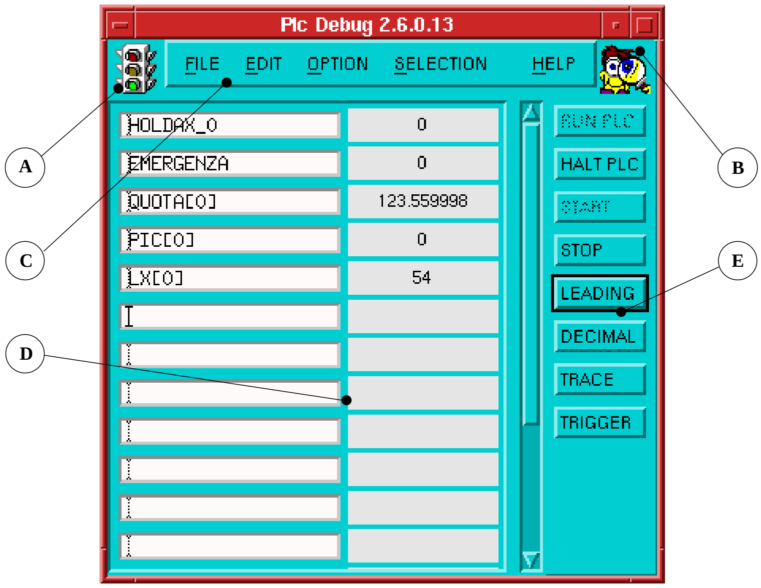


Figure 4.1: PLC Debug Main Window

- Menu Bar (Fig. 4.1-C).
- Two icons at the side of the menu bar. (Fig. 4.1-A-B).
- List formed by two columns of 17 items each, consisting of one editable field and one label field, that can be scrolled with a vertical scroll bar (Fig. 4.1-D).
- Software Buttons (Fig. 4.1-E).

The PLC-NC and NC-PLC exchange are mentioned frequently in this chapter, but no explanatory information is given regarding them. For those who do not know these signals and would like more information on them, consult the *Exchange Signal Manual*, currently available in the $\beta 1$ *version*, prepared by the CNI documentation office.

4.2 Menu Bar

The Menu Bar includes the following five items:

1. FILE
2. EDIT
3. OPTION
4. SELECTION
5. HELP

4.2.1 File

The FILE menu can be used to save or recall files of specific type. Below is a description of the functions of each menu item.

Open (ˆO) When you select Open a file selection box is opened, accessing directly a directory of text files. (Fig. 4.8). These files contain lists of variables. If you select a file from this Selection Window (similar to the one described for the Editor), the PLC Debug enters each variable name contained in the file into the editing fields of the list. If the file contains names which are neither exchange variables nor global variables of the current PLC program, an error message is generated. For a more detailed description of the File Selection Window, see Section 4.8.

Save (ˆS) When you select Save another File Selection window is opened. In this case, however, you save the names of the variables contained in the editable fields into the file indicated in the window. For more information, see Section 4.8.

Load PLC (ˆL) If you select the Load PLC option, the file selection window is again displayed, showing this time the directory containing previously compiled PLC programs. This option may be selected only when the PLC is in HALT state. The state of the PLC is shown by the traffic light displayed on the left of the menu bar. The colours have the following meaning: Green, the PLC is running; Yellow or Red, the PLC is in HALT, either requested or because of faults. The state of the PLC is also shown by means of the first two upper buttons, (RUN PLC and HALT PLC), shown in Fig.4.1-E. These buttons are reciprocally exclusive and reflect the operations that can be performed on the PLC. After loading the required program, you can use the same button to re-start the PLC.

Restore PLC (ˆR) Select the “Restore PLC” option to reload automatically the original PLC program.

Exit (ˆX) Select “Exit” to leave PLC Debug.

4.2.2 Edit

With the EDIT menu, you act directly on the scrollable list. The only option available is Delete resetting both the editable fields and the label fields of the list.

4.2.3 Option

The OPTION menu allows you to access auxiliary debug functions.

Statistic (ˆZ) Press the “Statistic” button to open a window displaying the maximum, current, and minimum execution time of the PLC program, as represented in Fig. 4.2.

The times are supplied both as a 50-sample diagram, and in punctual format in the label field near the name. The unit of measurement of the data displayed is the microsecond. To leave the submenu, use the “Cancel” button.

Save I/O (ˆV) Press the “Save I/O” to memorise in the non-volatile RAM the current configuration of the input/output modules. By input/output module configuration we mean how many and which modules are present and available to the machine. This operation must be done when the machine is ON and all the modules are visible and connected. If it is carried out when the machine is OFF and only the NC is ON, an incomplete configuration may be saved.

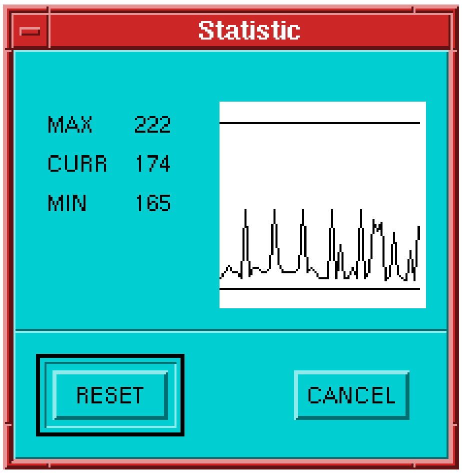


Figure 4.2: Statistic Window

Restore Trace (ˆT) By choosing this option, the last image saved by the Trace is reloaded.

4.2.4 Selection

You can use the SELECTION menu to access the second page of the application, as shown in Fig. 4.6. This page is used for the debug of the input/output modules and the tracing of Boolean variables. It is described in detail at paragraphs 4.6 and 4.7.
Each of the items of this submenu correspond to a IOS card installed. There will be as many items as the connected cards.

4.2.5 Help

The HELP item allows access to the XNC on-line electronic manual described in Section 2.2. The on-line manual opens to the section relative to the selections on the `Debug Plc`.

4.3 Icons

The icon on the left (Fig. 4.1-A) shows a traffic light and has the purpose, as mentioned before, to indicate the status of the PLC. If the PLC is running without problems of any sort, the traffic light is green. If, for any reason, the PLC has problems, or it has been stopped on purpose to load a new program, the traffic light is red. Only if the machine has never been initialised, i.e. the PLC has never been run, the traffic light is yellow. The icon on the right (Fig. 4.1-B) discriminates instead the punctual debug of variables from the trace of the variables. In other words, when the icon shows a Man with a Magnifying Glass (Sherlock Holmes), only the punctual debug of the variables in the scrollable list is visible. When the icon shows instead a Reel (Fig.4.3), in addition to the punctual debug, the application is collecting and memorising information relative to the Boolean variables in the list.

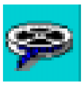


Figure 4.3: Reel Icon

At the end of the collection stage, another window will be opened, described in detail in paragraph 4.6.

4.4 List

The list is that indicated in Fig. 4.1-D. The list contains two columns of 17 items each. One column contains editable fields, and the other label fields. A scroll bar may or may not be present next to the columns. The arrow keys are used to select the boxes, the backspace key is used to delete characters. The user can enter the name of the variable to debug directly into the editable field. If the variable is an exchange signal, the application already has all the necessary information; if the variable is a global variable of the current PLC program, a window will be displayed (Fig. 4.4) to allow the selection of the variable type. The permitted types are: LONG, FLOAT, CHAR, BOOLEAN, CHAR [ ], STRING.

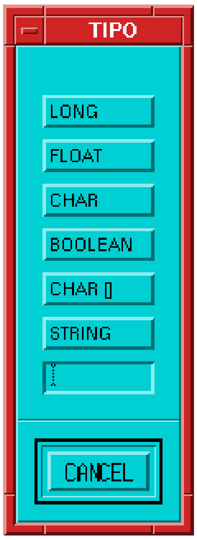


Figure 4.4: Selection window of the variable type

LONG indicates the whole numbers, FLOAT indicates the real numbers. CHAR and BOOLEAN are two different ways of indicating variables that can only have values of 0 e 1. CHAR indicates the arrays of characters, while STRING indicates the character pointers. If the variable is either CHAR [ ] or STRING, the numbers of characters in the variable must also be specified by means of the editable field at the end of the list. To start the debug procedure, press the START button. From this moment on, the current value of the specified variable will be displayed in the label field of the list as it changes. Variables can be added, deleted or replaced in the list at any time. The last item on the list is the "Trigger". The Trigger can be used for the trace described at paragraph 4.6. In this case also, enter the name of the variable in the editable field, which is now at the left. Only Boolean-type exchange variables are permitted here.
In addition to the scale type variables, vector and matrix type variables can also be debugged; to do so, just indicate the desired item by placing it between square brackets. In the case of a matrix the column index must be specified in the editable field.

4.5 Buttons

Six buttons are located on the right section of the window. Their functions are: Fig. 4.1-E illustrates some software buttons, the functions of which are described below.

RUN PLC This button puts the PLC in `Run`.

HALT PLC Thos button puts the PLC in `Halt`. Before the PLC can be Halted, the machine must be stopped.

START Use this button to start the punctual debug of the variables in the scrollable list.

STOP Stops the debug of the variables in the scrollable list.

If the trace option is selected, the memorisation of the boolean signal values can be stopped and those gathered up until that moment can be displayed by means of the proper pages.

LEADING/FALLING Use this button to select whether the trigger is activated by the leading transition or the falling transition of the signal indicated in the last field of the scrollable list.

DECIMAL/HEXADECIMAL Use this button to toggle the display of integer variables as decimal or hexadecimal values.

TRACE Press this button to start the memorisation of the values of the Boolean signals present in the list, to be later displayed in the appropriate window. The icon on the right becomes a reel. The data collection process can be stopped with the STOP button.

TRIGGER/PRE TRIGGER If the trigger mode has been selected, the tracing does not start until a leading or falling transition of the signal entered in the last field of the list occurs. The leading or falling transition depends on that which is specified with the (LEADING/FALLING) key. The search for the leading transition is always started with the TRACE key.

If the PRE TRIGGER mode has been selected, sampling begins right after the Trace button is activated and continues until 1600 samples have been collected, or until the STOP is pressed. If during this period a leading or falling transition of the signal entered in the last field of the list is detected, a yellow line is displayed to mark the event.

4.6 Exchange signal trace

To monitor Boolean-type exchange signals, the relevant signals must be entered in the editable fields of the scrollable list. In addition, ensure that the PLC is running by checking the traffic light. Once the signal names have been entered, enable tracing with the Trace software button. Data collection can be stopped at any time with the STOP software button. During data collection, the icon shown in Fig. 4.1-B becomes a reel, as illustrated in Fig. 4.3. If the Trigger field, the last item of the scrollable list, is empty, the application will start collecting data immediately. To the contrary, data collecting will be carried out as described in Section 4.5, where the software buttons LEADING/FALLING and TRIGGER/PRE TRIGGER are discussed. When the data recording is completed, the page shown in Fig. 4.5 will be displayed. Data recording will stop after 1600 samplings, or when the STOP is pressed.

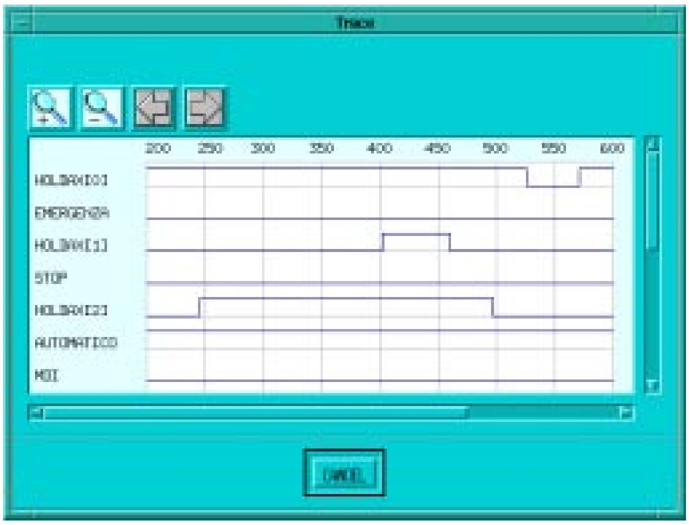


Figure 4.5: Trace page

This window shows a central rectangle in which the names of the variables are shown at the left, and the tracing of the corresponding variables is shown at the right. There are two scroll bars at the sides of this rectangle; and over the window there are four software buttons. The right arrow and left arrow icons are used to scroll the sampling display window +50 and -50 respectively. The magnifying glasses are used to zoom in and zoom out around the cycle highlighted by the yellow line. The zooming ratios available for the samplings are: 10, 20, 25, 50.

By clicking with the mouse on the central rectangle, a vertical dividing line appears, and in the upper left area the cycle number which corresponds to the selection made with the mouse; the value of the relative PLC cycle is next to each signal. From the keyboard, using the right-arrow and left-arrow keys, you can move the line forward and backward, one cycle at the time. The cycle number and the value of the variables are updated automatically.

Press Cancel to exit Trace.

4.7 Display of I/O modules

As described in the Menu Bar SELECTION item section, a submenu is displayed showing as many items as the IOS cards connected. After selecting the IOS to debug, the page shown in Fig. 4.6 is displayed.

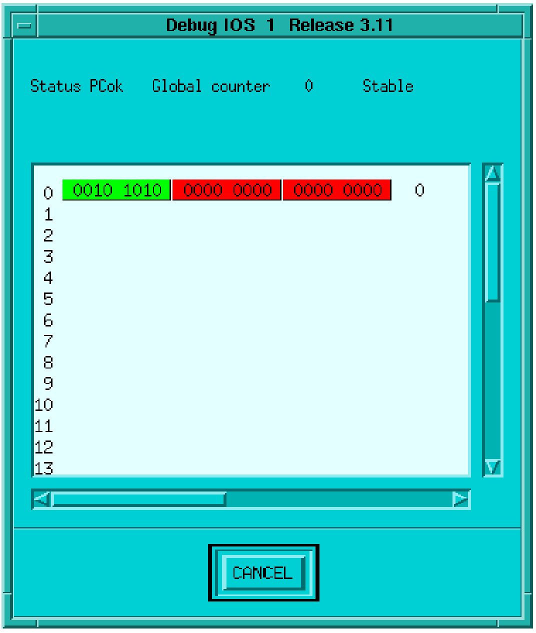


Figure 4.6: IOS Debug page

The first line contains some general information, such as the status of the PC, the total number of communication errors, and the stability or instability of the line. The connections of the modules are displayed on a table whose rows correspond to the 32 possible modules that can be connected, and whose columns correspond to the input or output bytes of each module. On the extreme right of the window, for each module, the number of communication errors is displayed. Output bytes are displayed as red rectangles, and input bytes as green rectangles. To display the actual value of the individual bytes, click on the rectangle corresponding to the required module. Click again to clear the display. If a communication error occurs in the module, the relative module number on the left flashes, and only the outline of the byte squares is displayed. If the module enters fault state, its number is displayed in reverse, and again, only the outline of the byte squares is displayed. If the PLC is placed into HALT state, it is possible to "force" the outputs. Just click on the byte you want to change to display a window (Fig. 4.7). If the buttons in the window are clicked, the corresponding byte is set to 0 or to 1 accordingly. Press Cancel to leave IOS Debug.

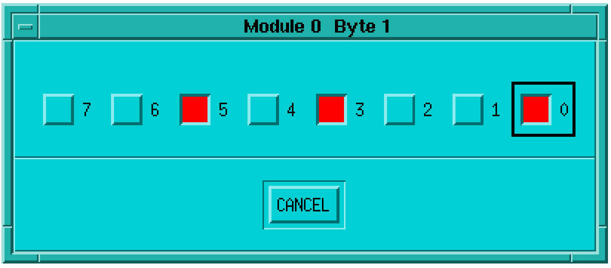


Figure 4.7: Output Forcing Window

4.8 Selecting Files

This application is used to select the files that contain the lists of exchange signals or the global variables of the current PLC program. The File selection window (Fig. 4.8) is divided into the following parts:

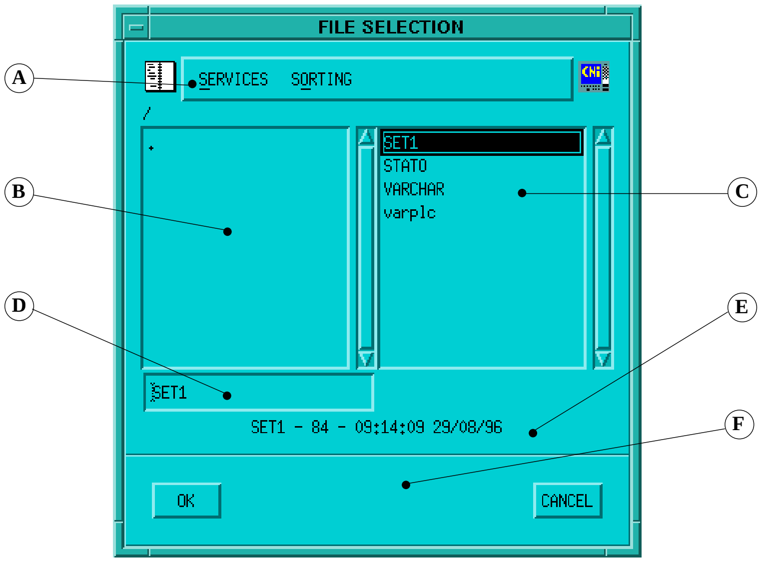


Figure 4.8: File SelectionWindow

Menu Bar , placed under the Window Title Bar, as seen in Fig 4.8-A, and it includes the options for selecting, handling and sorting the Files. These options are:

SERVICES For handling Files and Directories.

SORTING For sorting files.

Current Directory field from the select file menu, found under the menu bar.

Sub-directory field , on the left side of the window (Fig. 4.8-B), and contains the list of the sub-directories relative to the selectable files. It has a scroll bar to the right, which can be used when the list exceeds the window dimensions.

Files Field , on the right side of the window (Fig. 4.8-C), and contains the list of files relative to the selected sub-directory. It has a scroll bar to the right, which can be used when the list exceeds the window dimensions. The user can move through the list by typing the initials of the names, the selection bar automatically moves to the programs with the typed initials.

Selected File Box , under the list of currently selected sub-directories (Fig. 4.8-D), and contains the name of the currently selected file. To load a file, select the box with the mouse and type in the name of the file to be loaded. If the name of an invalid file is typed, an error message appears.

Characteristics of Selected File, which appear on the line under the body of the window (Fig. 4.8-E), as follows:

<Filename> <No. bytes> <Time> <Date>

Ok and Cancel Buttons Ok confirms the program selected to be run and closes the application, while Cancel blocks the operation (Fig. 4.8-F).

4.8.1 Services

When the mouse is used to select the option SERVICES from the menu bar of the File Selection window, the following list of options is accessed.

REMOVE FILE This option opens the REMOVE FILE window which allows the elemination of the files in a directory. Type the name of the file to be eliminated and confirm the cancellation with the Ok button or abort the command with the Cancel button.

MAKE DIRECTORY This option opens the MAKE DIRECTORY window for creating new directories. Type the name of the directory in the window and confirm the choice with Ok or abort with Cancel.

REMOVE DIRECTORY This window works the same way as the previous one, except that this command is used to eliminate a directory.

EDIT PASSWORD This option requires the file access level password. If the correct password is entered, the user gains access to the corresponding level, and control of lower levels, as well. The maximum level password gives access to level 15. The introduction of a level two password or higher gives access to the following command CHANGE PASSWORD.

CHANGE PASSWORD This option allows the user to change the passwords at lower levels than the one identified in the previous paragraph. The user is asked to type the new password twice.

4.8.2 Sorting

When the mouse is used to select the option SORTING from the menu bar of the File Selection window, a list containing the following items appears on the screen:

UNSORTED No sort is performed.

SORT BY NAME Sorting the files in alphabetical order.

SORT BY DATE Sorting the files in chronological order.

5 Install

The application `Install` is used to update the XNC software automatically. To update the software, files are loaded containing new Application Programs or new versions of existing applications.

5.1 Accessing Install

To access `Install`:

- access the `Root Menu` with key F12 on the PC keyboard, or by clicking the left mouse button on a free area of the XNC screen. (see Section 2).
- Select the `Install XNC` item in the `Root Menu` and press *Enter*.

The window containing `Install XNC` shown in Fig. 5.1 will be displayed

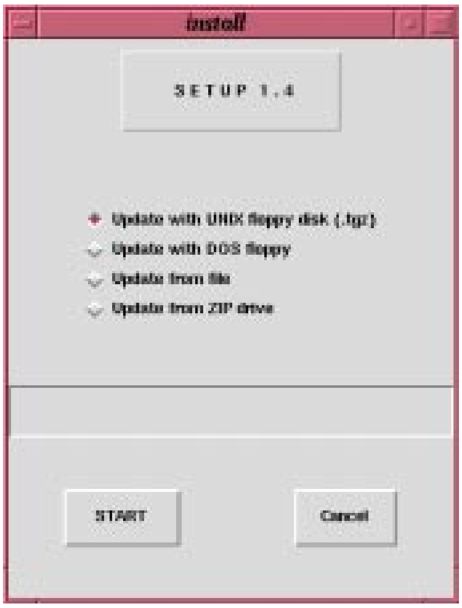


Figure 5.1: Install XNC P.A.

The box at the top of the window shown in Fig 5.1 displays the label SETUP, followed by a decimal number. These number indicates the version of the application `Install XNC`. Version 1.4 was the valid version when this manual went to print. The buttons START and Cancel are used to start and stop the installation procedure. The four radio boxes present at the center of the window are used to select the method for the installation of the updates, i.e.:

- **Update with UNIX floppy disk (.tgz)**

  The files are loaded from a UNIX-formatted diskette.

- **Update with DOS floppy**

  The files are loaded from a DOS-formatted diskette.

- **Update from file**

  The files are loaded from directories in the XNC system. This function is used in the case of updating via modem. This function is used in case of updating via modem.

- **Update from ZIP drive**

  The files are loaded from an external ZIP drive that can be connected to the parallel port of the XNC.

5.2 Update installation procedures

Software updates can only be installed after all the XNC applications have been stopped. To do so, use the `Kill XNC` function from the `Root Menu` (see Sec. 2.4).
If password level 15 is active, updates can be made without stopping the execution of the application programs. In this case, it is the XNC itself that stops the execution of the applications automatically before proceeding with the update operation. (On XNC versions prior to 1.1.x.x, this action is not automatic).

5.2.1 Installation from UNIX disk

1. Open the ROOT MENU window (F12 key).
2. Access the `Install XNC` function from the Maintenance Menu.
3. Insert the floppy disk containing the update files into the drive of the XNC.
4. Select the option `Update with UNIX floppy disk (.tgz)`.
5. Click on the START button.
6. Wait until the SETUP COMPLETE message is displayed, signalling the end of the installation and click on the "Cancel" button.
7. Open the ROOT MENU window (F12 key).
8. Select the REBOOT function.
9. Turn the XNC OFF and then ON again.

5.2.2 Installation from DOS disk

1. Open the ROOT MENU window (F12 key).
2. Select the `Install XNC` function from the Maintenance Menu.
3. Insert the floppy disk containing the update files into the drive of the XNC.
4. Select the option `Update with DOS floppy disk`.
5. Click on the START button.
6. Wait until the SETUP COMPLETE message is displayed, signalling the end of the installation and click on the "Cancel" button.
7. Open the ROOT MENU window (F12 key).
8. Select the REBOOT function.
9. Turn the XNC OFF and then ON again.

5.2.3 Installation from file

1. Open the ROOT MENU window (F12 key).
2. Select the `Install XNC function from the Maintenance Menu`.
3. Select the option `Update from file`.
4. Click on the START button.

5. In the dialog box that appears on the screen, enter the name of the directory containing the file with the update that you want to install.
6. Press the ENTER key.
7. Wait until the SETUP COMPLETE message is displayed, signalling the end of the installation and click on the "Cancel" button.
8. Open the ROOT MENU window (F12 key).
9. Select the REBOOT function.
10. Turn the XNC OFF and then ON again.

5.2.4 Installation from a ZIP drive

The following type of installation is possible only if a ZIP drive is connected to the XNC parallel port. The machine does not have to be turned off to connect a ZIP drive; simply turn on the drive after it has been connected.

1. Open the ROOT MENU window (key F12).
2. Select the `Install XNC` function from the Maintenance Menu.
3. Select the option `Update from ZIP drive`.
4. Click on the START button.
5. In the window that appears on the screen, choose the file containing the updates to be installed.
6. Press the ENTER key.
7. Wait until the "SETUP COMPLETE" message is displayed, signalling the end of the installation and click on the "Cancel" button.
8. Open the ROOT MENU window (function key F12).
9. Select the "REBOOT" function.
10. Turn the XNC OFF and then ON again.

6 Turning the XNC on and off

6.1 Turning the XNC on

There is no particular procedure for turning on the XNC; generally, being connected to the electric cabinet, it is activated when the machine is turned on.
To the contrary, the shut-down procedure for the XNC is very important, and must be followed before turning the machine off (as explained in Section 6.2).
If the XNC has been turned off without having followed the shut-down procedure, the next time it is turned on the operating system controls the integrity of the various system files in its memory.
During this control operation a flashing message, similar to the following, appears on the screen:

```
                         W A R N I N G   !!!

                 The system was down not correctly
PLEASE WAIT .... checking file system
```

After the system verification, if nothing is found to be wrong, the XNC accesses the various application programs which handle and control the machine.
If the operating system verifies that one or more system files have been ruined, it tries to restore them.
If the restore is successful, the system asks the user to turn the NC off and then on again, and the following flashing message appears:

```
S w i t c h   o f f   f i l e   s y s t e m
```

If the file restore is not successful, the XNC Hard Disk must be replaced.

6.2 Turning the XNC off

The XNC operating system requires a special shut-down procedure for turning off the NC, thus protecting several very important system files which it uses to manage the various application programs.
The shut-down procedure is as follows:

- Select the `Reboot` function from the `Root Menu`. This function can be accessed at any password level. The message in Fig. 6.1 appears.

Figure 6.1: XNC shut-down window

- Press the OK button to confirm the shut-down procedure or the CANCEL button to abort.

  If the OK button is pressed, a window representing an hour-glass appears on the XNC screen; this window is replaced by that shown in Fig. 6.2 when the entire shut-down and system file saving procedure has been completed.

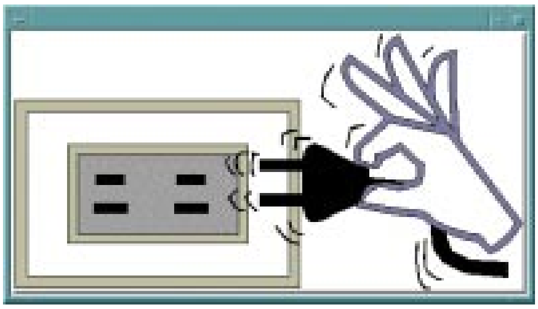


Figure 6.2: XNC shut-down complete window

- When the window shown in Fig. 6.2 appears on the XNC screen, the NC can be turned off, as well as the machine.

7 A.P. Quote

7.1 Introduction

The A.P. QUOTE is used to display the co-ordinates of the axes, and other information, for example, the active configuration, the origin of the piece, the type and number of the selected spindle, the override percentage, etc. It also permits the user to send commands to the machine, for example, homing or moving the axes, the execution of a program or a work list, powering up the spindles, and other applications which will be described below.
When the XNC is turned on, the `A.P. QUOTE` window is generally like the one shown in Fig. 7.1. However, other situations are possible since the initial configuration depends on the machine data. The option CENTER on the menu bar is only displayed if multicenter is implemented, and several other boxes may not be displayed, as well. As is the case with all of the application programs, QUOTE can be minimised to an icon. The QUOTE icon is shown in Fig. 7.2.

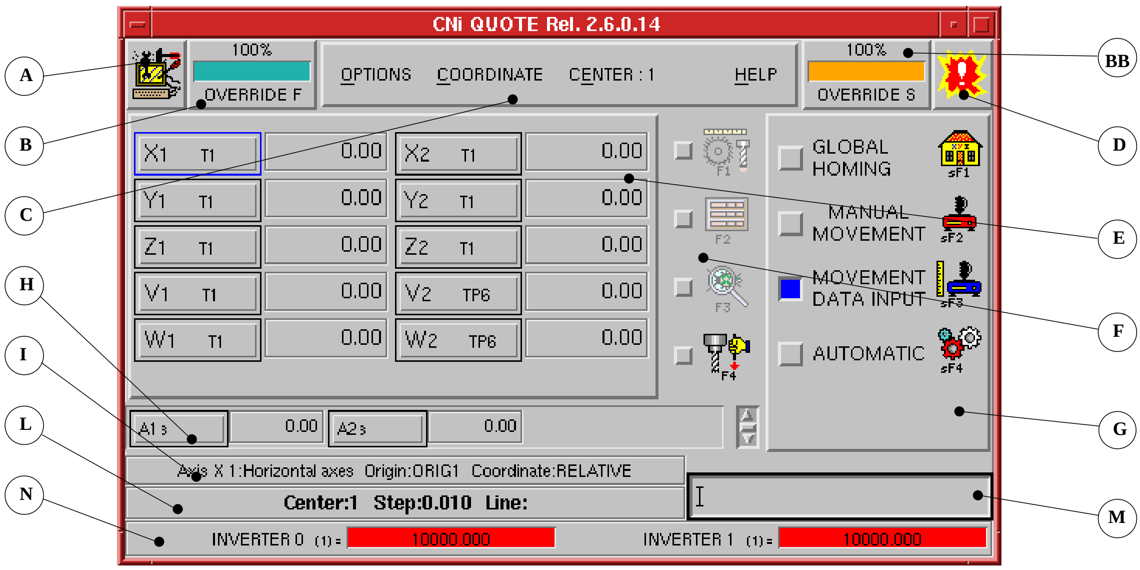


Figure 7.1: A.P. QUOTE Window

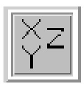


Figure 7.2: A.P. QUOTE Icon

Several dialogue boxes are highlighted and identified by different letters. A list of these dialogue boxes follows:

- The machine function indicator (Fig. 7.1-A)
- From one to four boxes OVERRIDE (Fig. 7.1-B and Fig. 7.1-BB)
- The Menu Bar with menu items OPTIONS, COORDINATE, CENTER and HELP (Fig. 7.1-C)
- The error icon (Fig. 7.1-D)
- The Axis Co-ordinate display box (Fig. 7.1-E)
- The software buttons (Fig. 7.1-F):

- PROGRAM (F1)
- WORKLIST (F2)
- DEBUG (F3)
- SET SPINDLES (F4)

The buttons present in the actual window may not necessarily be those described here. In fact, the buttons actually displayed depend on the machine configuration. The list, itself, may not be displayed.

- The Machine Command Mode Window, containing the software buttons (Fig. 7.1-G):
  - HOMING (Shift+F1)
    (Homing can be GLOBAL, CENTER, SINGLE, MANUAL)
  - MANUAL MOVEMENT (Shift+F2)
  - MOVEMENT DATA INPUT (Shift+F3)
  - AUTOMATIC (Shift+F4)
- The Auxiliary Axes Window (Fig. 7.1-H). This window may not be displayed.
- The Information Box (Fig. 7.1-I,L)
- The co-ordinate movement box (Fig. 7.1-M). This box appears when the relative software button is selected as seen in Fig. 7.1-G.
- The Inverter box (Fig. 7.1-N). Up to four inverters may be present; at times, the inverter may be absent.

Mention must be made of the fact that the following applications may be launched from the QUOTE A.P., if they are present: WORKLIST, DEBUG and SET SPINDLES, in addition to ERRORS, which is activated whenever an error occurs.

7.2 Machine Function Indicator

It is located on the top left of the main window of the `A.P. QUOTE` (Fig. 7.1-A); it displays different icons depending on the movement of the machine. If no movement command is issued, it displays the machine manufacturer's logo.

7.3 Override

There are two types of override, Axis Override and Spindle Override. Both may or may not be present depending on the machine configuration.

7.3.1 Axis Override

It is located between the Machine Function Indicator and the Menu Bar (Fig. 7.1-B). It displays a speed percentage value. Axis Override is useful when performing routing or boring tests, to ensure that the machining is performed correctly. Using Axis Override, it is possible to vary the displacement speed of the axes of the machine, setting it as a percentage of the value set in the machine data or in the program. To enable this function, use the Axis OVERRIDE controls located on the PLC keyboard of the NC. One or two Axis Override boxes may be present in the `A.P. QUOTE` window. These boxes are located to the left of the Menu Bar, after the Machine Function Indicator icon.

7.3.2 Spindle Override

Located between the Error icon and the Menu Bar (Fig. 7.1-BB), it displays a speed percentage value. To change the speed, enter suitable instructions in the work programs, or or use the Spindle Override controls on the PLC keyboard. One or two Spindle Override boxes may be present in the `A.P. QUOTE` window. These boxes are located to the right of the Menu Bar, before the Error icon.

7.4 Error Signal Box

It is located at the top right of the window containing the `A.P. QUOTE` (Fig. 7.1-D) Its function is to signal the occurrence of a generic error.
Generally, it displays the CNi Logo. If an error occurs, the CNi logo disappears and is replaced by an exclamation mark (Fig. 7.4).

Figure 7.3: Error Signal inactive

Figure 7.4: Error Signal active

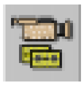


Figure 7.5: Simulation

If the machine is in the Simulation mode, an option on the OPTIONS menu, the icon becomes a video camera, which indicates the Simulation status (Fig. 7.5).

7.5 Menu Bar

The Menu Bar of the QUOTE Application (Fig. 7.1-C) contains the following items:

- OPTIONS: accesses the various functions and allows other application programs to be launched.
- COORDINATE: allows you to select the type of coordinate displayed, the origin which the coordinates refer to, and the reference spindle.
- CENTER: opens a box for the selection of a center of the machine. This item is only displayed on multicenter machines.
- HELP: provides access to help information. The information accessed depends on the selected machine command mode.

7.5.1 Options

Select OPTIONS to display a pull-down menu, similar to the one shown in Fig. 7.6.
The items present in this menu are:

- PROGRAM (F1): This option is available only if the AUTOMATIC machine command mode is active and the `A.P. WORKLIST` is closed. Select this item to display the PROGRAM SELECTION window, (Fig. 7.18), used to select the program to execute. The Program Selection window is explained in detail in par. 7.11.

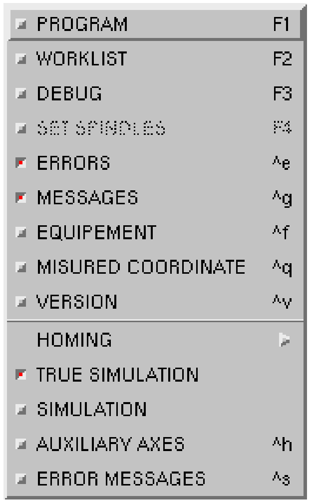


Figure 7.6: OPTIONS Menu

- WORK LIST (F2): This option is available only if the Automatic machine command mode is active. If the WORKLIST mode is not activated in the machine configuration, the WORKLIST option is never displayed.

  Opens the WORKLIST application; this application is described in Chapter 8.

- DEBUG (F3): This option is available only if the Automatic machine command mode is active. Opens the DEBUG application which is described in Section 8.5.7. It allows the program to be debugged in START.

- SET SPINDLES (F4): This option is available only if Manual Movement command mode is active. If the machine is not equipped with spindles, the SET SPINDLES option is never displayed. Select this option to open the window containing the SET SPINDLES application, described in chapter 9.

- ERRORS (ˆe): Opens the Errors window (Fig. 9.3) to display current errors. For a complete description of this application, see Chapter 9.5.

- MESSAGES (ˆg): Opens the messages window (Fig. 7.7). This window displays the control messages contained in the work programs being executed and in the PLC program, and which the programmer, with suitable instructions, wants to display.

Figure 7.7: Options: MESSAGES Window

- EQUIPEMENT (ˆf): Opens the EQUIPEMENT window, (Fig. 7.8), displaying the Active equipment . To change the current configuration, type the number of the new configuration in the data entry box and press the Enter key or the Ok button.

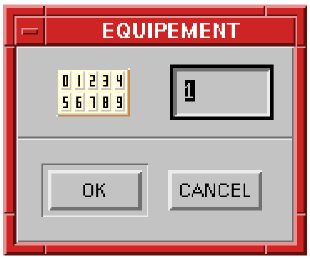


Figure 7.8: EQUIPEMENT Window

- MEASURED COORDINATE (ˆq): Used to calibrate the Homing point data (see par. 12.3.1). This operation is only possible at high password levels. It can be used only when in the pull-down menu associated to the Coordinate, Origin Setting is selected. The window displayed requires in fact the measured coordinate of the selected axis. Next to the selected axis, is displayed a value corresponding to Current Machine Origin - (Absolute Coordinate - Measured Coordinate).
- VERSION (ˆv): Opens the Version window, shown in Fig. 7.9. This window displays the version numbers of the application programs forming the XNC.

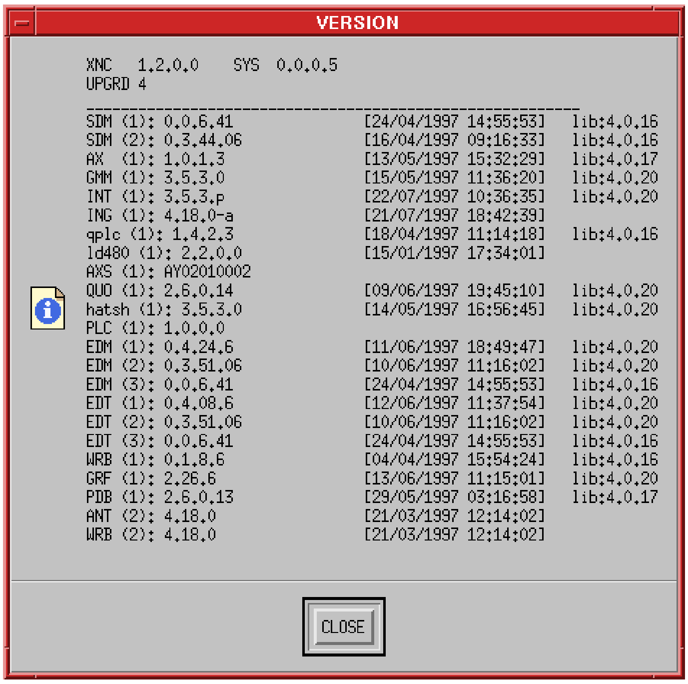


Figure 7.9: VERSION Window

- HOMING ▶: Selects the type of machine homing. The types of homing implemented are:
  - GLOBAL,
  - CENTER
  - SINGLE,
  - MANUAL.

  The type of homing selected is displayed in the Machine Command Mode box (Fig. 7.1-G).

- TRUE SIMULATION: allows a program or work list to be tested without actually using the machine. The real name is is due to the fact that at the end of the simulation, the tool change parameters of the NC are actually those obtained with the simulated program.

  This operation is only possible at a high password level.

- SIMULATION: allows a program or work list to be simulated without altering the NC parameters at the end of the simulation. This means that the tool change values remain those prior to the beginning of the simulation.

- AUXILIARY AXES (ˆh): allows the auxiliary axes to be displayed. The auxiliary axes are those which do not need to be constantly displayed because they are rarely used. These axes appear in the box shown in Fig. 7.1-H. If there is more than one auxiliary axis, the user can scroll through the list using the small bar at the right of the box. If at a given password level, the auxiliary axes have not been classified, the relative menu option is not active. To remove the display of these axes, reselect the menu option.

- ERROR MESSAGES (ˆs): Opens a window, (Fig. 7.10), which memorizes the messages presented by the operating system to the user whenever the anomalous operation of some of its components is detected.

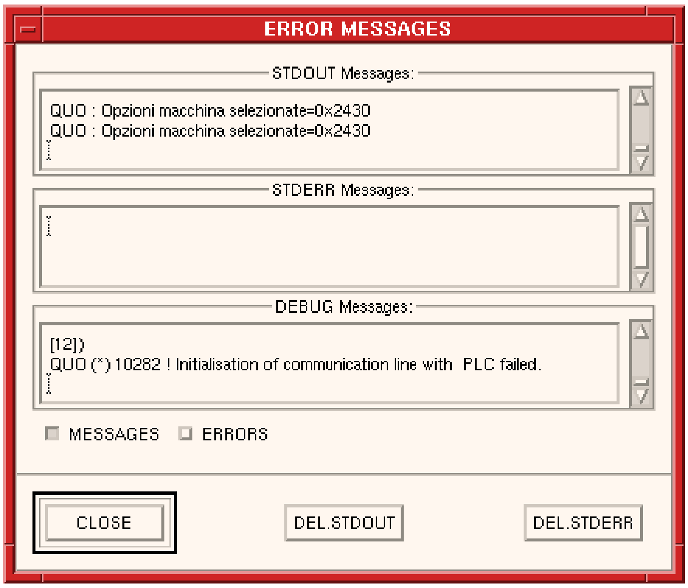


Figure 7.10: ERROR MESSAGESWindow

The messages are active at high password levels.

7.5.2 Coordinate

Select COORDINATE to display a pull-down menu similar to the one shown in Fig. 7.11. Select one of the items to change the coordinates of the axes as described below:

- RELATIVE (ˆr): The coordinate displayed is relative to the origin and the selected spindle.
- ABSOLUTE (ˆa): The distance that the spindle declared with displacement 0, typically T1, has to the machine zero.
- RESIDUAL (ˆu): The difference between the target coordinate and the absolute coordinate when the axis is actuated.
- THEORETICAL: The ideal absolute coordinate where the axis would be if it responded instantaneously to the speed profiles supplied by the NC.

Figure 7.11: COORDINATE Menu

- R.THEORETICAL: The ideal coordinate, relative to the considered reference point where the axis would be if it responded instantaneously to the speed profiles supplied by the NC.
- TARGET: The final absolute coordinate of the line being executed.
- R.TARGET: The final coordinate, relative to the considered reference point, of the line being executed.
- MICRO/MARKER: The distance from the release of the homing microswitch to the first transition of the marker signal of the encoder. This value is measured during the automatic homing operation of the axis. When the machine is in start, this option is replaced by SAMPLER, relative to the absolute coordinate of the Sampler device.
- ORIGIN SETTING: the origin setting coordinate is the coordinate to set as machine origin so that the coordinate displayed after homing corresponds to the measured coordinate (to be set through the Options Menu). This coordinate helps with homing the axis. When the machine is in start, this option is replaced by R.SAMPLER relative to the coordinate of the Sampler device relative to the considered reference point.
- ERROR: The difference between the theoretical and the absolute coordinate of the axis.
- TRUE SPEED: The speed of movement of the axis.
- RATED SPEED: The speed at which the axis would move if it responded instantaneously to the speed profiles supplied by the NC.
- AXES DISPL. Correction value relative to the reference spindle active on the axis.
- ORIGIN DISPL. Correction value relative to the active origin.
- Millimeter (Inces) ▶: opens a small window for selecting the unit of measure for the axes: either Millimeter (ˆl), or Inces (ˆi).
- ORIGIN ▶: Opens a box in which you can select the reference origin for the coordinates displayed in the context of the selected center.
- SPINDLE (ˆt): Opens a box in which you can change the reference spindle in the context of the selected center.

The following options are only available at high password levels. THEORETICAL, R.THEORETICAL, TARGET, R.TARGET, MICRO/MARKER, ORIGIN SETTING, ERROR, TRUE SPEED, RATED SPEED, AXES DISPL., ORIGIN DISPL.. Further explanations on the meaning of the various values may be found in the manual, at paragraph 12.3.1.

7.5.3 Center

Select Center to display a drop-down menu similar to the one shown in Fig. 7.12.

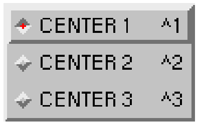


Figure 7.12: CENTER Menu

This menu item is present only on multicenter machines. The menu is used to select the required center.

7.5.4 Help

The option HELP accesses the on-line manual of the XNC. The on-line manual opens to the section which corresponds to the selection on QUOTE. Once accessed, the user can browse through the manual and use it in the desired language.

7.6 Axis coordinate display box

It is located on the left of the main window and contains areas with the names of the axes (Upper case letters, as shown in the example in Fig. 7.1-E). The co-ordinates are displayed next to the name of the corresponding axis; these are defined as the principal axes. The number next to the axis name represents the number corresponding to the work center which the axis is linked to.
Next to the name of the axis and the number of the center, the window also displays the reference spindle.

7.7 Software buttons

The function icons are software buttons, located at the center of the window(Fig. 7.1-F) which access the following functions:

- PROGRAM (F1): Opens the PROGRAM SELECTION window, described in par. 7.11.
- WORKLIST (F2): opens the window containing the WORKLIST application. This application is described in chapter 8.
- DEBUG (F3): Opens the window containing the DEBUG application. This application is described in chapteri 8.5.7.
- SET SPINDLES (F4): opens the window containing the application SET SPINDLES, described in the Section 9, if this option is available.

7.8 Machine Commands Mode Window

The Machine Commands Mode Window is located on the right of the Main Window (Fig. 7.1-G) and is the main window of the entire application program. The displayed software buttons activate the functions described below. Please note that all the operations described for the principal axes are also valid for all auxiliary axes. The following functions can also be activated with the software buttons; in particular, Homing with Shift+F1, Manual Movement with Shift+F2, Data Input Movement with Shift+F3 and Automatic with Shift+F4.

7.8.1 Homing

The type of homing is displayed next to the button, as selected from the HOMING SubMenu in the OPTIONS Menu, that is GLOBAL, CENTER, SINGLE, MANUAL. When you press the Start button, the selected homing is performed. GLOBAL performs an automatic homing of all axes. CENTER homes all the axes of the selected center. SINGLE homes automatically only the selected axis.
If MANUAL HOMING is active, when you select an axis (e.g. axis X) and you press Enter (or double click), the homing coordinate entry window is displayed (Fig. 7.13). Enter the required coordinate and press START, the display of the axis coordinate turns to the required value. In this case the axis makes no movement as this operation is performed only to define manually the actual position of the axis. The selected co-ordinates for manual homing of the axes are displayed in the information box shown in Fig. 7.1-L.

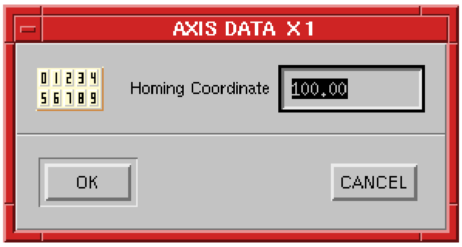


Figure 7.13: X AXIS DATA Window

7.8.2 Manual movement

Activates the jog function of the axis (manual movement). To move the selected axis, use keys + and - of the keyboard on the machine, using if necessary also the fast jog key (see par. 1.3.1). The + key causes the movement of the axis in the direction set as positive. The - key causes the movement of the axis in the direction set as negative. When you select the required axis (e.g. axis X) and press Enter (or double click), the Jog Speed Set-up Window is displayed. In this window, Low Speed indicates the speed of movements commanded by the - and + keys, and High Speed indicates the speed of movements commanded with the High Jog key (Fig. 7.14). The two above mentioned speeds, by default are assigned values which correspond to the machine data and are displayed in the information box shown in Fig. 7.1-L.
Changing these values does not alter the `machine data`.

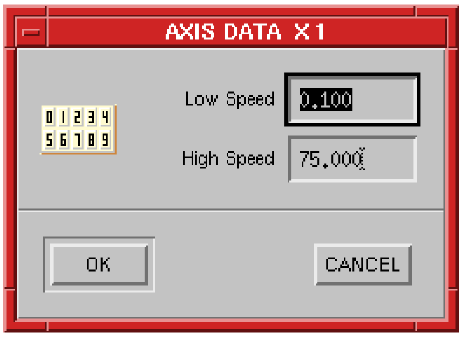


Figure 7.14: Speed Set-up Window.

7.8.3 Movement data input

Activates the Single Step and Data Input Movement function (Fig. 7.1-M). There are three different ways to execute Data Input Movement; they they are described below:

1. Single Step
2. Data Input Movement
3. step

By Single Step we describe the possibility of editing one program line and execute it immediately afterwards. To take advantage of this function, write the program line in the corresponding data entry box located on the right of the information box. To execute the line entered, press the START key on the machine keyboard.
By Data Input Movement we describe the movement of the selected axis. The movement is determined by the assignment of the following parameters:

- Target coordinate, or displacement from the current position of the axis,
- Positioning speed.

The target coordinate of the selected axis can only be determined when the program line box (single step) is not displayed. To close it, select the box and press the ESC key. The target co-ordinate is displayed in the information box shown in Fig. 7.1-L and can be changed by opening the corresponding data entry window (Fig. 7.15). To open the window, press Enter (or double click) after selecting the required axis.

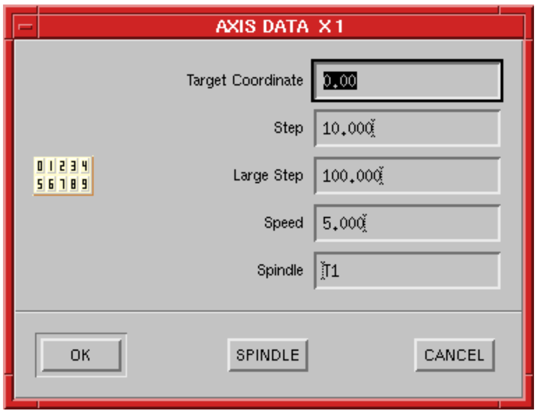


Figure 7.15: MDI Window

In this window, you can determine the target coordinate and the reference spindle for the coordinates and the positioning speed. Press the SPINDLE button to access a table to assist with the selection of the spindle (Fig. 7.16), selected among those linked to the axis. Press the Start key on the machine keyboard to position the axis.
Lastly, a consideration for the `step` mode. It is not necessary to press the ESC key to exit from the single step mode. When the single step mode is active, the movement of the selected axis is always possible by pressing either the + or - key of the machine keyboard. The + key moves the axis towards greater coordinate values. The - key moves the axis towards smaller coordinate values. The High Jog key can also be used if necessary (see par. 1.3.1). When you select the required axis and press Enter (or double click), the Step, Large Step and Speed data entry window is displayed (Fig. 7.17). Step and Speed default to the corresponding machine data values, while Large Step is given by the Step value multiplied by 10. Some of this information is also displayed in the Information Box.

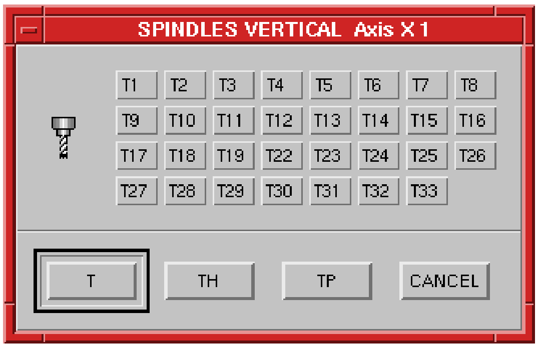


Figure 7.16: MDI Window: Spindles

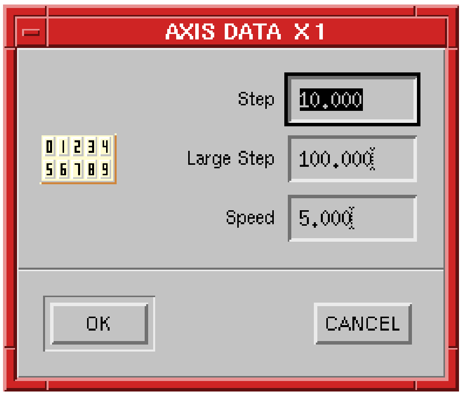


Figure 7.17: MDI Window: Single Step

7.8.4 Automatic

When this option is selected, a program can be chosen, run and controlled. If the `A.P. WORKLIST` is active, a work list can be chosen and executed. To perform these operations, several applications are made available, such as PROGRAM, WORKLIST, DEBUG. To execute a program without a work list, close the `A.P. WORKLIST`, select the required program, and press the START key on the machine keyboard. The name of the program selected is displayed in the Information Box. To execute a work list, open the `A.P. WORKLIST`, load the required work list file, and press the START key on the machine keyboard. The name of the selected work list is displayed in the Information Box. Programs or work lists memorized in a remote machine can also be executed if the remote connection has been activated. Further information on remote connection and DNC mechanisms are found in paragraph 7.12.

7.9 Information Box

The box shown in Fig. 7.1-I contains the following information in the following order:

- Name of axis selected
- Center to which the selected axis is linked
- A description (if any) relative to the axis
- Origin active for the center which the axis is linked to

- Type of coordinate or value displayed

The box shown in Fig. 7.1-L contains information that may vary depending on the active machine command mode. In the HOMING mode, the centering selection made from the menu bar is displayed along with a message which corresponds to the type of homing. In the MANUAL MOVEMENT mode the low speed and high speed values, described in the 7.8.2 Section, are displayed. In the Data Input Movement mode, the movement of the selected axis is displayed, in addition to the single step data box described in Section 7.8.3. In the AUTOMATIC mode, information regarding the selected program is displayed.

7.10 Inverter Box

There may be from zero to four inverters present. If the set-up provides for them, they are found under the information box (Fig. 7.1-N). The rotation speed of the spindles piloted by the inverter is displayed in the inverter window.

7.11 Program

This application is used to select the programs to be executed. The Program selection window (Fig. 7.18) is divided in the following parts:

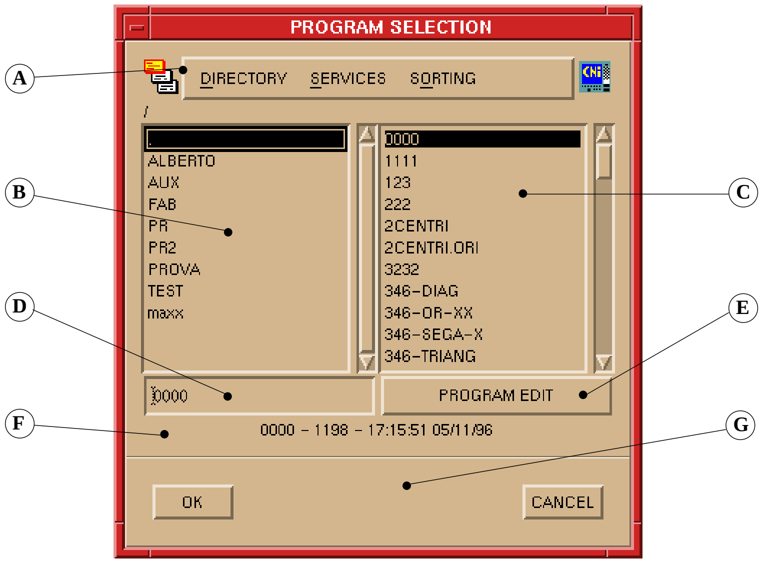


Figure 7.18: PROGRAM SELECTION Window

Menu Bar located under the window Title Bar, as seen in Fig 7.18-A and contains the options for the selection, handling and sorting of files. The available options are:

DIRECTORY With this option it is possible to select the local or remote directory from which the files are loaded.

SERVICES This option is used to manage Files and Directories.

SORTING This option is used to sort the files

Current directory of the file selection menu, and located under the menu bar

Sub-directory field which contains the list of the subdirectories relative to the files to be selected, and is found in the left part of the Window (Fig. 7.18-B). On the right of the Subdirectory Field is located a scroll bar, active when the list exceeds the size of the window.

Files Field which contains the list of files relative to the selected subdirectory and is found in the right part of the Window (Fig. 7.18-C). There is a scroll bar to its right, which is activated when the list is too long to be contained in the window. The user can move through the list by typing the initials of the filenames; the selection bar automatically moves to the programs which begin with the initials typed in.

File Selection box which contains the name of the file currently selected and is found under the list of subdirectories (Fig. 7.18-D). If the box is highlighted by a click of the mouse, a file can be loaded by typing its name in the box itself. If the name of a non-existing file is typed in, an error message appears at the time of the START.

Edit Program Button shown in Fig. 7.18-E, which loads the selected program to the `A.P. Editor` for display and changes (See Section 10).

Attributes of Selected Files which are shown on a line under the the main body of the window (Fig. 7.18-F), as follows:

<FileName> <No. bytes> <time> <Date>

Ok Cancel Buttons With Ok the program selected for execution is confirmed and the application is closed, while with Cancel the operation is blocked (Fig. 7.18-G).

7.11.1 Directory

When you select the DIRECTORY option with the mouse, you can access files located on a remote machine. Fig. 7.19 shows the menu displayed by the DIRECTORY option.
CN indicates that those directories are located on the machine itself. PC indicates the presence of a connection with a remote machine called PC. When you select PC, the directories shown in the various windows are those located on the remote machine. Remote connections are in any case possible only if enabled.

Figure 7.19: Menu‘ DIRECTORY

7.11.2 Services

When you select with the mouse the option SERVICES on the menu bar, from the File Selection window, the following list of options is displayed.

REMOVE FILE When you select this option, the DELETE FILE window is opened. From this window you can delete a file from the directory. To do so, write the filename in the window and confirm the deletion with OK, or abort with Cancel.

MAKE DIRECTORY When you select this option, the MAKE DIRECTORY window is opened. From this window you can enter a new directory name to create. Use OK to confirm the creation, or Cancel to abort.

REMOVE DIRECTORY Operates similarly to the previous command, except that in this case the directory is deleted.

RELOAD REMOTE DIRECTORY This option is active by default. When disabled, it speeds up the connection with remote directories since their structure is not reloaded every time. Nevertheless it must be enabled when deleting or creating remote files and directories, otherwise the changes will not be shown.

EDIT PASSWORD This option can be selected with the files access level password. Enter the password to obtain access to the corresponding level and control on the lower levels. The top-level password provides access to level 15. All passwords above the second level enable the CHANGE PASSWORD command.

CHANGE PASSWORD This option allows changing the passwords of a level lower than the one of the password entered in the previous option. The new password must be entered twice.

7.11.3 Sorting

Select with the mouse the SORTING option on the menu bar of the File Selection Window to display a submenu containing the following items:

UNSORTED No sorting is performed on the file list.

SORT BY NAME Sort the files alphabetically by name.

SORT BY DATE Sort the files chronologically by date.

7.12 Remote Connection (DNC)

The DNC performs those operations necessary to execute programs located on a remote machine. The procedures to enable remote connection are found in the Technical Data application. When the connection is enabled, the name of the remote machine is displayed in the DIRECTORY menus of File Selection in Editor, of PROGRAM SELECTION in QUOTE, and of WORKLIST SELECTION or PROGRAM SELECTION in WORKLIST. In addition, when remote directories are accessed to select a remote file, the icon located at the right of the Menu Bar displays the image of two PC connected instead of the CNi logo.

When a program from the remote PC is selected, its name will be preceded by the name of the remote machine followed by a colon ":". This makes it possible to use programs with the same name but residing on two different machines, such as for instance Prog and PC:Prog. It is then possible to issue a Start using a program residing on a remote machine. Please note however that, when a remote program is Started, it will be requested and loaded in the memory of the local machine. If it contains subroutines, these will not always be loaded from the remote machine but the subroutines with the same name present in the local machine will be used instead.

This mode of operation applies also to worklists. As with individual programs, files residing on a remote machine can be selected. If the connection has been enabled, it is possible to execute a worklist on a remote machine. A worklist, whether it be local or remote, may contain programs of both machines. Remote worklists are also identified by the name of the machine and the ":" colon sign prefixed to their name. If a remote worlist is opened, all the programs contained in it will retain the indication of the machine they belong to. This means that if you save on the local machine a remote worklist, each program name will contain the reference to the remote machine, and viceversa.

When a remote or local worklist is started, the mechanism for requesting and loading a remote program in the memory of the local machine is also activated to prepare for the possibility that the worklist should contain remote programs also. The requests are carried out in sequence as the worklist is executed, but in advance of the Start line so as not to delay the execution of the programs. If a program already loaded from the remote machine is to be executed again, it will not be re-loaded. The copy present in the memory of the local machine will be executed instead. This means that all changes implemented on the remote machine will take effect only with a new machine Start cycle.

8 P.A. Worklist

8.1 Introduction

The WorkList is a file containing a list of program names, labels, numbers and instructions arranged in a precise order. By using WorkList files, the NC is able to execute the programs automatically, following the order defined in the file.
The Worklist application program allows you to build worklist files containing all data necessary to organise the work of the machine for an extended period of time. You can organise for example the sequence and the number of programs to be executed on the machine during one or more days of work. The execution of the sequence can be interrupted or modified at any time as required.
To display on the NC screen the window containing the Worklist application, select first the `A.P. QUOTE`, verify that the AUTOMATIC machine command mode is active, and click on the Worklist button (alternatively, press the Function Key F2).
Fig. 8.1 shows the `A.P. Worklist`. The window consists of the following parts:

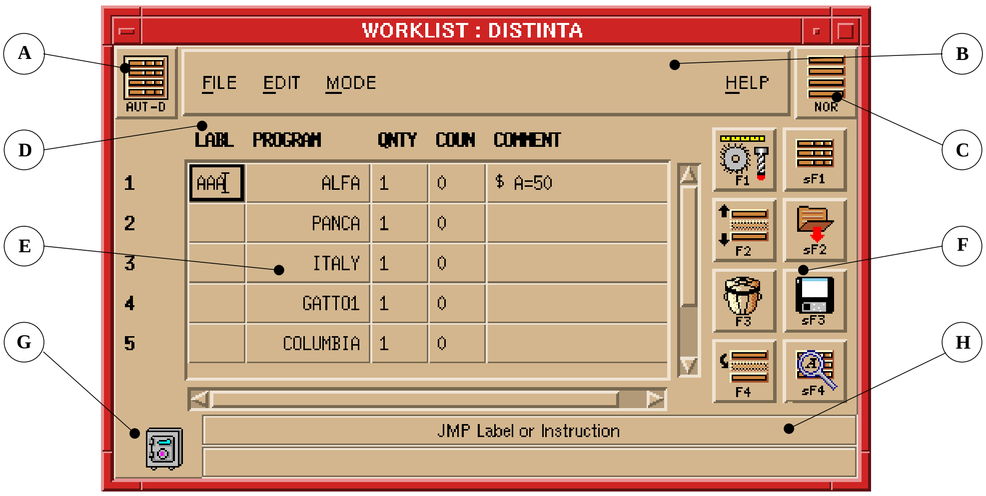


Figure 8.1: Worklist Window

Machine Function Icon It is the icon on the top left of the screen (Fig. 8.1-A).

Menu Bar Contains the options FILE, EDIT, MODE and HELP (Fig. 8.1-B).

WorkList function mode icon Currently, it operates only in the following states: NORMAL and SELFEXITINGUISH. It is the icon on the top right of the screen. (Fig. 8.1-C).

Legend for the fields in the data insertion box (Fig. 8.1-D).

Data insertion box The box is in the central part of the window (Fig. 8.1-E).

Rapid access icons They give rapid access to various application functions, they are arranged in a column to the right of the worklist table (Fig. 8.1-F).

The WorkList Function mode icon It appears as a closed safe if the file has been saved or an open one, if not. (Fig. 8.1-G).

Information box Provides information regarding the currently selected field (Fig. 8.1-H).

This application can be minimised to an icon, as shown in Fig. 8.2.

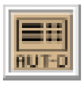


Figure 8.2: Worklist Icon

8.2 Menu Bar

The Menu Bar can be used to recall the following menus:

- FILE provides access to the functions for loading and saving WorkList files. These functions are described at par. 8.2.1.
- EDIT provides access to the functions for editing the WorkList files as described in par. 8.2.2.
- MODE Used to select the execution mode of the WorkList files. At present only NORMAL and SELFEXITINGUISHmode is active.
- HELP provides access to help information.

8.2.1 File

Select FILE on the Menu Bar to open a box allowing you to load and save worklist files and work programs (Fig. 8.3).

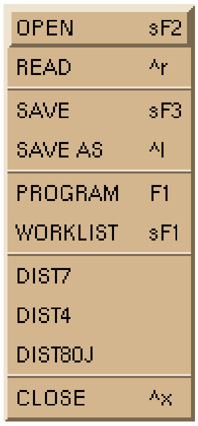


Figure 8.3: FILE Menu

Open (Shift + F2)

Opens the WORKLIST SELECTION window. From this window you can load a worklist file and check it, modify it, or execute it. The WORKLIST SELECTION window operates identically to the PROGRAM SELECTION window. Par. 7.11 contains a description of the individual items.
As with individual programs, it is possible to select files located on remote machines when working with worklists also.

Read (ˆr)

Opens the WORKLIST SELECTION window. The local or remote worklist is inserted beginning with the line following the one on which the cursor is located.

Save (Shift + F3)

Saves the worklist file being displayed with the same name, and in the same local or remote directory in which it was located originally.

Save as (ˆl)

Opens the WORKLIST SELECTION window to save the worklist file being displayed under a different name, either on the local or on the remote machine.

Program (F1)

This option is used to compose a worklist. It opens the PROGRAM SELECTION window, from which the user can choose the program to be placed in a line of the worklist. For a description of the window, see Section 7.11, keeping in mind, however, that with this option two additional buttons are displayed: INSERT and REPLACE. INSERT places a program at the end of the worklist, while REPLACE modifies the line of the worklist selected, with the selected program.

Worklist (SHIFT + F1)

Opens the WORKLIST SELECTION window from which the user can insert the names of other worklists into the lines of the current worklist. These worklists will be exploded during program execution. This is another function of building a worklist.
In this case the WORKLIST SELECTION window, represented by the option OPEN of this menu, is displayed with the following software buttons INSERT, REPLACE, CLOSE, instead of software buttons OK and CANCEL. Use the INSERT option to add a line beginning with the READ instruction to the end of a worklist. Use the REPLACE option to modify the line selected with the cursor, by inserting the name of the worklist beginning with the READ instruction in the place of the preceding line. For details on the READ command, see Section 8.5.
Use the CLOSE option to exit from the WORKLIST SELECTION window.

Last selected WorkLists

The last three worklists remain in the menu to allow rapid selection, should the user need to re-open them.

Close (ˆx)

Closes the Worklist Window.

8.2.2 Edit

Select EDIT on the Menu Bar to display a pull-down menu containing the following items: (Fig. 8.4).

- PROGRAM EDIT (ˆb): allows the program selected in the worklist to be edited with the `A.P. Editor` (Section 10).
- SUCTION CUP (ˆv): launches the Tooling System relative to the program selected in the worklist by means of the `A.P. Editor` (Section 11).
- INSERT (F2): Inserts a blank line in the worklist immediately below the line on which the cursor is located.
- DELETE (F3): Deletes the worklist line on which the cursor is located.
- COPY (F4): Copies the worklist line on which the cursor is located to a new line immediately below it.
- MARK (ˆm): Allows one or more lines of a worklist to be selected. The first and last lines of the selection must be marked.

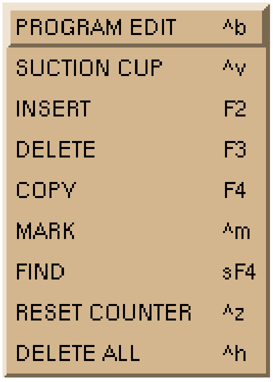


Figure 8.4: EDIT Menu

When only the first line is marked, it is highlighted in black; when the final line is also marked, all of the selected lines are highlighted in red. Once a selection is highlighted, the elimination or copy functions may be used.

- FIND (Shift F4): Opens the find and replace string function (Fig. 8.5), active only in the worklist column on which the cursor is located. After finding and replacing the required string, the cursor will move automatically to the next occurrence, if found.

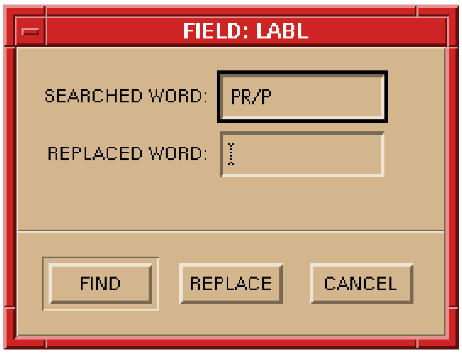


Figure 8.5: FIND REPLACE Window

- RESET COUNTER (ˆz): Resets the value of the piece counters for all the worklist lines, that is all the elements in the Count column.
- DELETE ALL (ˆh): eliminates all the lines of the worklist. A window is opened which asks for confirmation of the operation.

8.2.3 Mode

Currently, the following are the active modes:

NORMAL (ˆn) In this mode the execution occurs line by line until the END command is reached; the same line may be executed repeatedly until the COUN value is equal to that set in QNTY.

SELFEXITINGUISH (ˆu) In this mode, a line is cancelled after it has been executed; this makes it possible to insert other worklist lines during the execution phase.

8.2.4 Help

This function accesses the on-line manual. The manual is opened to the beginning of the chapter relative to the worklist.

8.3 Data Entry Box

Consists of several lines, called worklist lines, each subdivided into five fields (Fig. 8.1-E). The fields of the worklist are called LABL, PROGRAM, QNTY, COUN, COMMENT (Fig. 8.1-D).
To move across worklist lines and fields, use the cursor movement keys, Home, End, PgUp, PgDn, or the mouse.
To move inside the selected field, use the right and left arrow keys together with the Alt key.
Below is a brief description of the worklist line fields:

- Labl (label). Contains a numeric or alphanumeric character string.
- Program. Contains the names of the programs, or some of the programming instructions of the worklist (see par. 8.5).
- Qnty (quantity). Contains a positive integer, indicating the number of times that the line must be executed.
- Coun (piece counter). Contains a number which is increased every time that the worklist line is executed.
- Comment . Used to enter an alphanumeric string to comment the worklist line. It also allows parameter passing to the program being executed.

8.4 Function Icons

The eight icons in Fig. 8.1-F provide shortcuts to the following functions:

- Icon F1: selects the option FILE with the item PROGRAM.
- Icon F2: selects the option EDIT with the item INSERT.
- Icon F3: selects the option EDIT with the item DELETE.
- Icon F4: selects the option EDIT with the item COPY.
- Icon Shift F1: selects the option FILE with the item WORKLIST.
- Icon Shift F2: selects the option FILE with the item OPEN.
- Icon Shift F3: selects the option FILE with the item SAVE.
- Icon Shift F4: selects the option EDIT with the item FIND.

8.5 Programming the Work List

The programming instruction set of the work list currently includes the following instructions:

1. ;
2. STOP
3. JMP
4. READ
5. WRIT
6. _NOR
7. _SXG

8.5.1 ;

This instruction must be entered in the LABL field. It indicates that the current line is a comment.

8.5.2 Stop

This instruction must be entered in the LABL field. It causes the interruption of the execution of the worklist. If the Program column contains the name of a program, as in the example in Fig. 8.6, a subsequent Start WorkList command will cause the start of the execution beginning with the line containing that instruction. If no program names are specified in the line containing the Stop instruction, the subsequent Start command will cause the execution to resume with the next line.

	LABL	PROGRAM	QNTY	COUN	COMMENT
1	STOP	PIPPO			
2					
3					
4					
5					
6					

Figure 8.6: Example: Stop

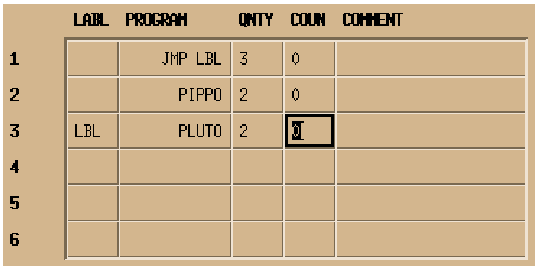
8.5.3 Jmp

This instruction must be entered in the Program field. It causes the execution of the Program to jump to a specified line, identified by a label. It is possible to jump forward to a line after, or backwards, to a previous line. Jumps in work lists can intersecate and there is no nesting limit. In the example in Fig. 8.7 the worklist flow jumps back to a line before the Jmp instruction. In this case the program "Pluto" is executed twice, and then the program "Pippo" is executed twice. When the NC executes the Jmp instruction, the value of COUN is increased by 1. If the counter has not reached the value indicated in the field QNTY, the execution is transferred to the line containing the label Lbl in the LABL field, and all the counters in the jumped lines are reset. When the counter of the line with the Jmp instruction reaches the value contained in the QNTY field, the execution continues with the following line. The

	LABL	PROGRAM	QNTY	COUN	COMMENT
1	LBL	PLUTO	2	0	
2		PIPPO	2	0	
3		JMP LBL	3	0	
4					
5					
6					

Figure 8.7: Example of Jmp to previous line

example in Fig. 8.8 shows a jump to a line after the Jmp instruction. This jump is executed without checking the values contained in the QNTY and COUN fields.



	LABL	PROGRAM	QNTY	COUN	COMMENT
1		JMP LBL	3	0	
2		PIPPO	2	0	
3	LBL	PLUTO	2	0	
4					
5					
6					

Figure 8.8: Example of Jmp to subsequent line

8.5.4 Read

The READ instruction must be inserted in the LABL field, while the name of a worklist file must appear in the PROGRAM field, During execution READ reads the specified worklist file. In the case of NORMAL mode execution, the READ instruction replaces the worklist displayed with that specified and the execution restarts from the first line. Therefore only one READ instruction can be inserted. In the case of SELFEXITINGUISH mode, each time the NC encounters the READ instruction, it reads the specified worklist, executes it, and then continues with the execution of the original worklist.

8.5.5 Writ

The WRIT instruction must be inserted in the LABL field, while the name of a worklist file must appear in the PROGRAM field. With the WRIT instruction the user can write the displayed worklist in a file. The name of the file is that indicated in the PROGRAM field.

8.5.6 _NOR

The _NOR instruction activates the selection of the NORMAL mode.

8.5.7 _SXG

The _SXG instruction activates the selection of the SELFEXITINGUISH mode.

CHP.A. Debug

8.6 Introduction

If AUTOMATIC mode is selected, you can select DEBUG from the OPTIONS Menu to recall the DEBUG application, which provides all the tools necessary to Debug the program in start.

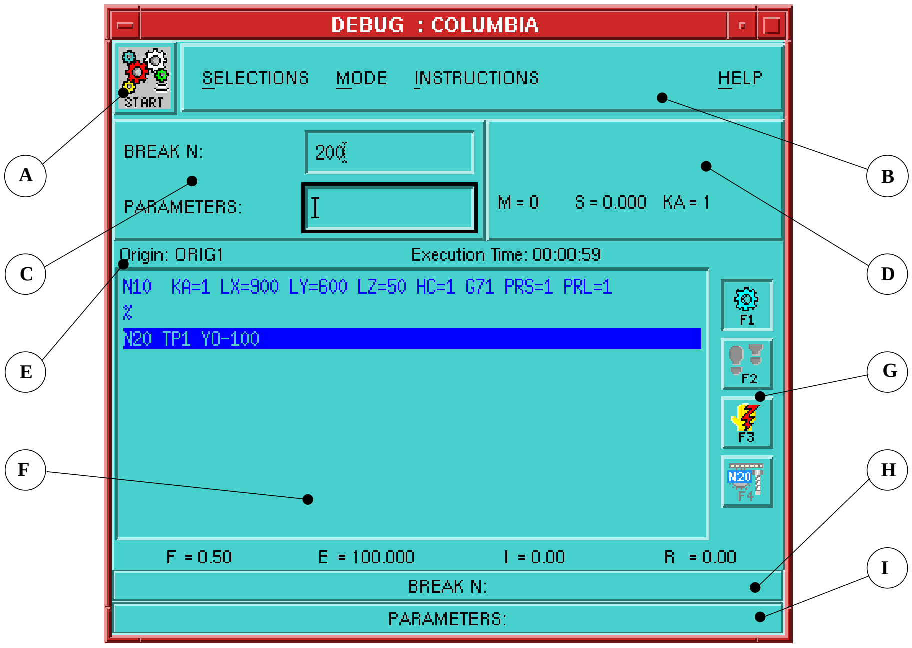


Figure 8.9: DEBUG A.P.

The Debug application allows you to monitor the development of the programs being executed. The DEBUG window (Fig. 8.9) contains the following elements:

- Machine status description icon (Fig. 8.9-A).
- Menu Bar (Fig. 8.9-B).
- Break and Parameters Box (Fig. 8.9-C).
- Instructions Box (Fig. 8.9-D).
- Information line (Fig. 8.9-E).
- Program line display area (Fig. 8.9-F).
- Accessory icons (Fig. 8.9-G).
- Instruction lines (Fig. 8.9-H).
- Active Breaks display area and Parameters display area (Fig. 8.9-I).

This application can be minimised. Its icon is shown in Fig. 8.10.

8.7 Description Icon

This icon (Fig. 8.9-A) describes the status of the machine. With the machine down, the application program logo is displayed; with the machine in START or in STOP, the `A.P. QUOTE` icons are displayed. When a break is encountered, the icon displayed is a yellow hand.

Figure 8.10: Debug Icon

8.8 Menu Bar

The Menu Bar contains the following options:

- SELECTIONS
- MODE
- CENTER
- INSTRUCTIONS
- HELP

8.8.1 Selections

The SELECTIONS item in the Menu Bar contains the following options:

LINE (F4) Select LINE to open a window for entering the program line number from which you want to launch the program in the selected routing or boring section.

RESET BREAK (F3) Cancels the break activated in the appropriate box.

ROUTINES (ˆr) Turn OFF this software button (ON by default) to prevent the display of the lines of the subroutines called by the program.

COMMENTS (ˆc) Turn OFF this software button (ON by default) to prevent the display of the lines of the subroutines called by the program.

CLOSE (ˆx) Closes Debug. All breaks still set when Debug is exited will still have effect, and the program being executed will stop when it meets them.

8.8.2 Mode

The MODE item in the Menu Bar contains the following options:

AUTOMATIC (F1) A software button (ON by default) that allows automatic debug. In other words, the program will pause only when breaks are encountered.

SEMIAUTOMATIC (F2) This software button can be selected as an alternative to AUTOMATIC; it activates the semi-automatic execution of the indicated program, that is one line of the program is executed each time the START key is pressed.

8.8.3 Center

Select this option to display a menu in which you can select the required reference center. The option is active only on multicenter machines.

8.8.4 Instructions

Select this item to display a menu containing the following options:

- SPEED ▶
- ACCELERATION ▶
- ADVANCE ▶
- CIRCLE/ELLIPSE ▶

By means of the menu options, some less common instructions can be be displayed in the instruction line shown in Fig. 8.9-H.
The option SPEED corresponds to a sub-menu containing the `F` instruction, speed along the path (interpolation) and the instructions `FX`, `FY`, `FZ`, `FC` for the independent movements along each axis.
The option ACCELERATION corresponds to a sub-menu containing the `E` instruction, acceleration along the path and the instructions `EX`, `EY`, `EZ`, `EC` for the independent movements along each axis.
The option ADVANCE corresponds to a sub-menu containing `II`in addition to the instructions `IX`, `IY`, `IZ`, `IC` for the independent movements along each axis.
The option CIRCLE/ELLIPSE corresponds to a sub-menu containing the instructions `R`, `RI`, `RJ`, `I J K` , respectively, circle radius, semi-axis of the ellipse and center co-ordinates. By selecting an instruction, the others in the relative sub-menu are excluded. The selected instruction is displayed in the instruction display line, with the last value given in a program step (Fig. 8.9-H).

8.8.5 Help

HELP accesses the On-Line Manual of the XNC.

8.9 Break and Parameters Box

It is the box shown in Fig. 8.9-C. Here you can set a debug break line by entering its number in the box next to the Break label, and confirming it with the Enter key. When the execution of the program reaches that line, it will be paused.
If the program contains several lines with the same number, the program will stop at the first line it finds.
You can activate a break also in a subroutine recalled by the program, by entering the line number and the name of the routine. The parameter box is used instead to request information on one or more parameters when a break is active. The break and the status of the parameters are displayed below the program line display area. The program line highlighted in break status has already been executed.

8.10 Instruction Box

The status of several real time instructions is displayed in this area Fig. 8.9-D. The instructions displayed are T, setting the spindles; G, mode instruction; S rotation speed of the spindles; M and KA, PLC interface instructions. A comprehensive analysis of the instructions can be found in the *Programming Manual*, at section `VI` of this manual.

8.11 Information Line

The Information Line is displayed at the bottom of the window and shows the active origin and the time of execution of the program (Fig 8.9-E).

8.12 Program Line Display Area

This area shows the lines of the program being executed (Fig. 8.9-F). If you wish, you can choose not to display comment lines and subroutine lines. The currently active line is highlighted to distinguish it from the others.

8.13 Accessory Icons

In Fig. 8.9-G, four icons are displayed that facilitate the rapid selection of a function. These icons are: AUTOMATIC, SEMIAUTOMATIC, RESET BREAK and LINE. The functions of these icons are described in Section 8.8.

8.14 Instructions Line

The Instructions line is shown in Fig. 8.9-H. This line, containing instructions relative to the axes, displays the instructions selected with option INSTRUCTIONS from the Menu Bar. Only four of the numerous possibilities are shown. This because the instructions that can be selected for this line are those less commonly used.

8.15 Display lines

The display lines are shown in Fig. 8.9-I.
The Active Break display area shows the number of the line where the program is paused.
The Parameters area displays the status of the parameters, selected in the Parameters Box, when the execution of the program was paused.

9 A.P. Set spindles

9.1 Introduction

The SET SPINDLES option (F4) is available only if the MANUAL MOVEMENT machine command mode is active. This application is available only if the machine is configured to have spindles. Select this option to open the window containing the SET SPINDLES application, (Fig. 9.1) used to set the spindles of the machine. This application can be minimised to the icon shown in Fig. 9.2.

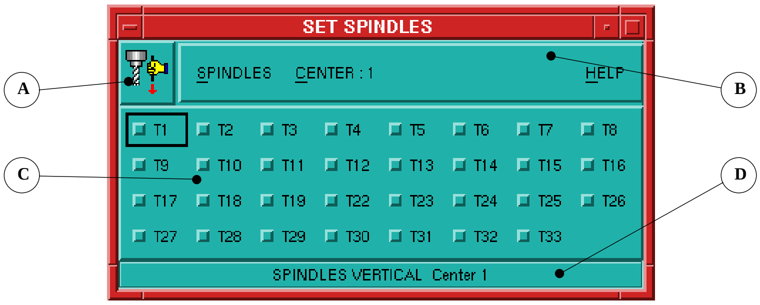


Figure 9.1: SET SPINDLES Window

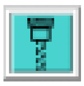


Figure 9.2: SET SPINDLES Icon

The window includes the following elements:

- SPINDLES Icon (Fig. 9.1-A)
- Menu Bar (Fig. 9.1-B)
- SET SPINDLES Area (Fig. 9.1-C)
- Information Line (Fig. 9.1-D)

9.2 Menu Bar

In the Menu Bar (Fig. 9.1-B) the following options are displayed:

- SPINDLES
- CENTER : 1
- HELP

9.2.1 Spindles

The SPINDLES menu, accessible from the Menu Bar, contains the options VERTICAL (ˆt), HORIZONTAL (ˆh), PANTOGRAPH (ˆp) and CLOSE (ˆx). The first three items select the type of spindle. Accordingly, the selection changes the SET SPINDLES Area, as the spindles have different codes. Obviously, the information line displaying the type of spindle selected is also modified. CLOSE exits from the application.

9.2.2 Center : 1

This item is present only on multicenter machines. It is used to select the center of the spindles to set. The Spindles Set area will show only the spindles belonging to the selected center.

9.2.3 Help

The option HELP allows access to the on-line XNC manual. The manual opens to the beginning of the chapter relative to spindle activation.

9.3 Set spindles Area

Comprises the central part of the window shown in (Fig. 9.1-C) and is displayed as a series of software buttons, each with the symbol of the spindle it represents next to it. SPINDLES VERTICAL are identified by the code T, HORIZONTAL by the code TH, PANTOGRAPH by the code TP.
For instance, if you want to set spindle TP1, select SPINDLES on the Menu Bar, choose PANTOGRAPH (to display the list of the ROUTER SPINDLE available), and press the button corresponding to spindle TP1.
The "spindle set" status is shown by the depressed button. More than one spindle can be set at the same time. Close the window or press Reset to reset the spindles.

9.4 Information Line

This line is located at the bottom of the window shown in (Fig. 9.1-D) and provides information on the current selections, i.e. the type of spindles and which centers are enabled.

9.5 Introduction

The `A.P. ERRORS` displays the various errors that may occur during the operation of the XNC. (Fig. 9.3).

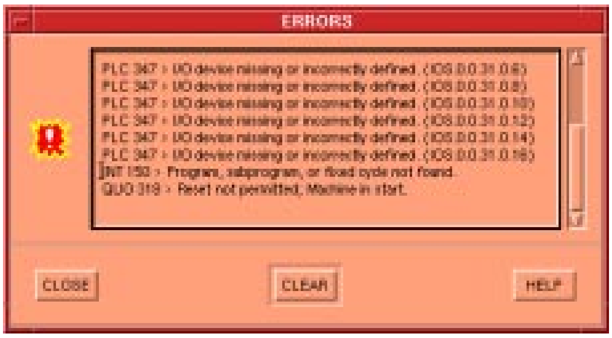


Figure 9.3: ERRORS Window

The central area of the application displays the error codes and messages. Next to this box there is a scroll bar that also makes it possible to view previous errors. To cancel these errors, press software button CLEAR. If an error that has been found previously is found again, and is therefore already in the list, no error string is added, because the existing one is used. When this occurs, it is highlighted by the fact that the cursor appears over the desired string.

9.6 Error Messages

Following is an example of how errors are structured and how it is possible to display a help message. Fig. 9.3 shows the following error:

```
INT 150 > Program, sub-program or fixed cycle not found.
```

which appears after having selected and executed a worklist that contains a program which the XNC cannot find. In the example we can see the following parts:

INT a CNi internal code.

150 the error number.

> a separation character.

non-existing program, sub-program, fixed cycle which is the error message.

All error messages are signalled using the same format outlined above. Every error has a unique code and an internal number, related to the application software that produces it.
Errors having a number in the range 0 to 9999 are caused by operator errors. These errors are defined *User Errors* and can be found in the section of this manual dedicated to the `Error List`. In the XNC electronic manual (see Section 2.2) this error list is given with suggestions for correcting each error. However, not all errors are accompanied by a help message. Each help message may be displayed by means of the `on-line help` by selecting the HELP software button located on the bottom right of the `A.P. ERRORS`.
Errors with a number above 10000 are operating system errors. These errors, defined as *Technical Errors*, do no have help messages and are not available in this manual. The meaning of these errors can be displayed by means of the ERROR MESSAGE window, discussed in Section 7.5.1.
Should a more detailed explanation of the error codes be desired, or if a list of the *Technical Errors* is desired, consult the *Service Manual*, currently available in the *version* β, prepared by the CNI documentation office.

9.7 Software Buttons

The software buttons in this window perform the following functions:

1. CLOSE: closes the `A.P. ERRORS` Window.
2. CLEAR: clears the errors being displayed.
3. HELP: calls up the help messages for the elimination of the errors as previously described. If the help message is not available, another error message is displayed, explaining that no on-line help is available.

10 A.P. Editor

10.1 Introduction

The `Editor A.P.` is used to create, change, and manage various types of files, such as work programs, subprograms, Fixed Cycles, and ASCII files. The files are grouped into homogeneous directories, so that each directory can contain files of a single type.
Let us now look at the sequence of operations necessary to access the `Editor` environment from the screen displayed when the NC is first turned on. To access the `Editor` environment, it is sufficient to double click with the left mouse button on the EDT Icon (Fig. 10.1).

Figure 10.1: EDT Icon

The window displayed is that shown in Fig. 10.2. When the `Editor A.P.` is activated for the first time, the only possible operation is that of selecting the option OPEN from the FILE menu, making it possible to load a file.

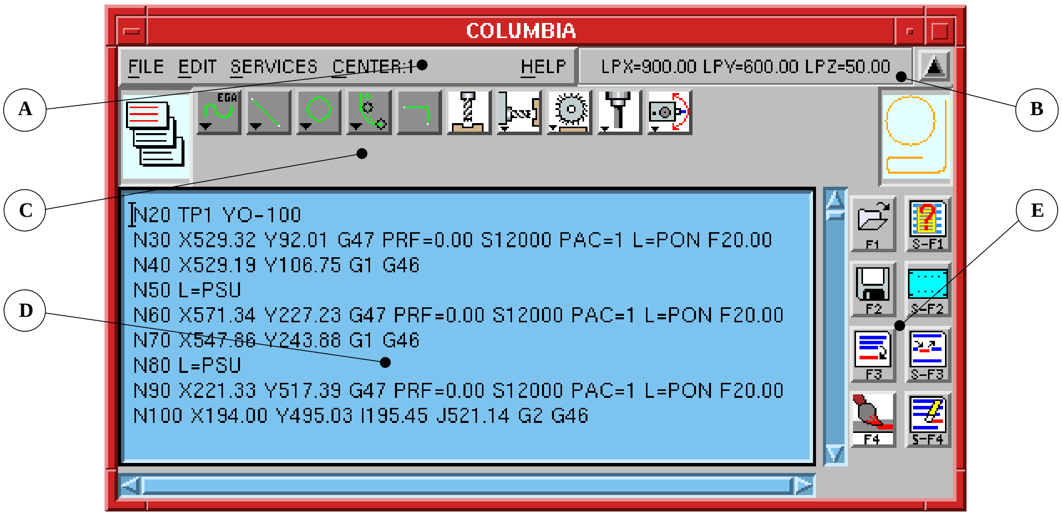


Figure 10.2: Editor Window

When a file is loaded, the Assisted Graphic Editor (EGA) window opens, available if the mouse pointer is positioned on the icon shown in Fig. 10.2-C. This window is used to display the drawings of the panel or to illustrate the icons present under the Menu Bar of the `Editor Environment`. The drawing associated with the icon indicated with the mouse appears in the EGA window and the title bar contains a description of the operation underway. Images, unlike previous versions of the software, are made active only by positioning the mouse on the icons of the EGA. When the mouse is moved away from the icon, the window is closed. A more detailed description of the EGA window is given in Section Sez. 10.8.
In the Editor window are displayed:

The Menu Bar where you can choose the following options: the options FILE, EDIT, SERVICES, CENTER:1 e HELP (Fig. 10.2-A).

The comment line located to the right of the Menu Bar (Fig. 10.2-B). Comments and data regarding the dimensions of the panel being examined are displayed on this line. These comments are displayed alternatively with the black arrow.

The Icon Area for the Assisted Graphic Editor (EGA) is located immediately below the Menu Bar (Fig. 10.2-C). The two larger icons at the outer edges cannot be selected; they provide information on the status of the application. Specifically, the large icon to the right changes shape when the displayed section is changed (profiling, boring, optimised boring). The icons for the Standard Assisted Editor are placed between these two icons and the Configurable Assisted Editor which will be described in detail in Section 10.8.

The Program Area is the main body of the window. It has scroll bars in the event that the programs or lines are longer than the available area. (Fig. 10.2-D). The lines of the loaded program file can be edited in the program area.

The accessory icons area is located on the right of the program area and contains eight icons replicating the most used commands from the menu bar (Fig. 10.2-E).

10.2 Menu Bar

The following options are available on the `A.P. Editor` Menu Bar (Fig. 10.2-A):

- FILE: gives access to the various functions relative to loading, saving and handling files.
- EDIT: opens a menu containing the options for the edit operations to be performed on the files.
- SERVICES: allows access to more editing functions and allows other application programs to be launched.
- CENTER: opens a list for the selection of a machine center. The option is available only on machines with multiple centers.
- HELP: allows access to help information. The information accessed depends on the machine command mode selected.

10.2.1 File

File management is possible using the FILE menu commands. The most commonly used items in this menu are the ones that allow loading a file from the hard disk in RAM, or saving on the hard disk the file currently loaded in RAM after having modified it. Click on FILE to display the pull-down menu shown in Figure 10.3.

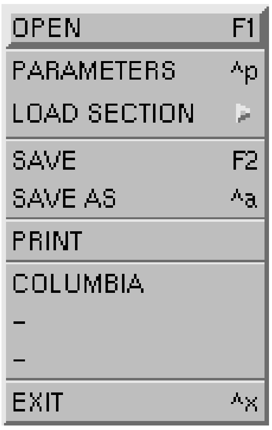


Figure 10.3: FILE Menu

OPEN (F1) This is the only function enabled at the beginning of an editing session. All other functions can be executed only if an edited file is present. The last three files opened from Editor may also be shown. OPEN opens the File Selection Window (Fig. 10.12) allowing you to select the type and the name of the file to edit. This window is described in Section 10.3.

PARAMETERS (ˆp) This item is active in the FILE menu only if a file has already been loaded in memory (with the OPEN option). When you click on PARAMETERS, the PARAMETERS window opens (Fig. 10.4), used to edit the parameters of the panel associated to the work program.

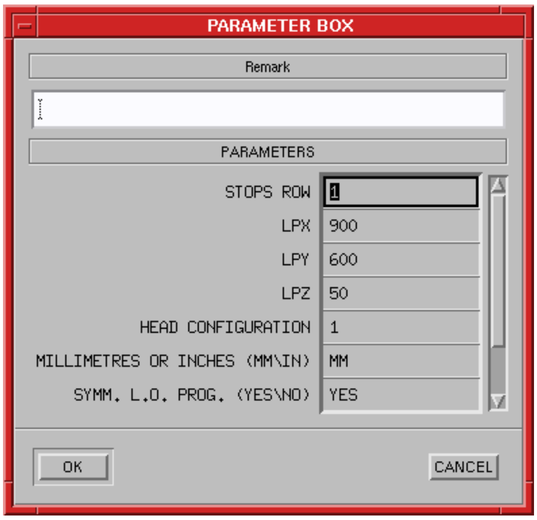


Figure 10.4: PARAMETERS Window.

The PARAMETERS window automatically opens with the creation of a new file. The parameters in the BOX are those that appear on the comment line shown in Fig. 10.2-B. For a more detailed discussion of the Parameters Box, see the *Appendix* part of this manual.

LOAD SECTION ▶ This item is enabled only if a file has already been loaded in RAM. It opens the pull-down menu shown in Fig. 10.5.

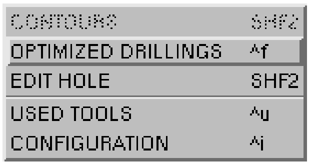


Figure 10.5: LOAD SECTION Option

- CONTOURS (SHF2)
  The CONTOURS option (SHF2) is not highlighted because it is relative to the default environment. This section allows editing of the program code relative to the contours.
- OPTIMIZED DRILLINGS (ˆf)
  When this option is selected, the program code created by the boring optimiser in the EDIT HOLE section is displayed. Although not advisable, it is possible to edit this section.
- EDIT HOLE (SHF2)
  Choose the option EDIT HOLE (SHF2), to enter into the boring environment, discussed in more detail in Section 10.7. In this environment it is possible to select CONTOURS, which has been activated in the meantime, and return to the Countour environment.
- USED TOOLS (ˆu)
  In this section the names of the tools in the tool magazine can be displayed and edited. A return must follow each name. If incorrect or non-existent tools have been edited, at the program START an error message appears.

- CONFIGURATION (ˆt)
  This section is used to create the Parameters Box for the selected fixed cycle. The syntax necessary for this operation is denominated *A.E.P.L. language* and is described in complete detail in the *Service Manual*, currently in the *version* β, prepared by the CNI documentation office.

SAVE (F2) Saves the program with its original name and in the same local or remote directory. While the program is saved, the system displays the message "Wait". It is enabled only if a file has been loaded.

SAVE AS (ˆa) Saves the program under a different name and/or in another directory or on another machine. If this option is selected, the File Selection window is opened; it is used to choose a directory and a name for the loaded file. It is enabled only if a file has been loaded.

PRINT If this option is selected, a specific section or sections of the program currently in memory can be printed. The file can be printed only if it has not been modified. The window that appears when PRINT is selected, is shown in Fig. 10.6.

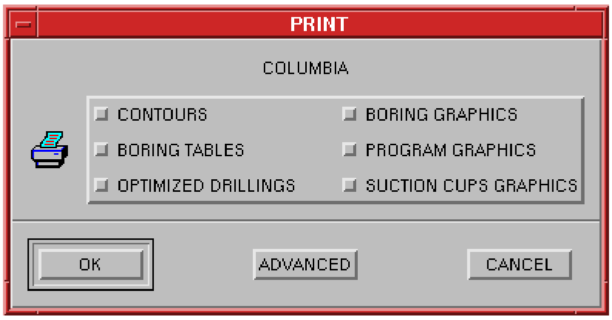


Figure 10.6: PRINT Window

One or more of the displayed print options can be selected. The choices in the first column allow the print-out of the program codes relative to the indicated sections. The choices labeled "graphic" print the drawing or the graphic that would appear in the applications specified by the options. With CANCEL the print command is blocked, with OK the print command is executed. Wtih ADVANCED the window in Fig. 10.7 is displayed; it allows the sheet dimensions to be selected.

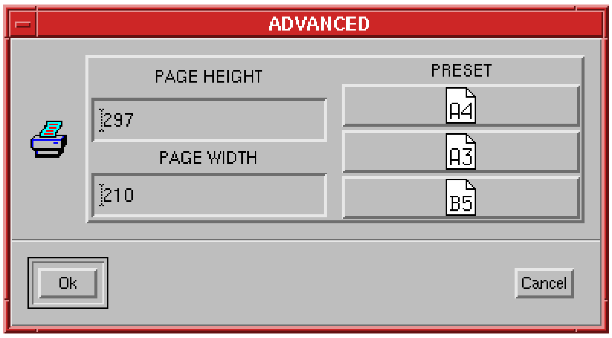


Figure 10.7: PRINT-windowAdvanced

Refer to Section 2.5.6, for information on how to choose a printer.

Last Three Selected Files The three items in the pull-down menu highlighted between PRINT and EXIT, are either empty, or contain the names of the last three files opened. To open the selected file, it is sufficient to click on its name.

EXIT (ˆx) Closes the window and reduces it to an icon. If any files are open, they are closed; if they have been modified, it is requested that the user either confirms or cancels the changes.

10.2.2 Edit

A program can be written when a file, new or existing, has been opened. The lines of the program can be written directly using the alpha-numeric keys, following the standard CNI-ISO syntax. The programming language is described in the *Programming Reference* part of this manual.
The cursor movement keys can be used to move the cursor in the text. The Backspace key can be used to delete the character to the left of the cursor.
The Enter key is used to enter a LF code (Line Feed) in the ASCII file of the program. A LF entered in the middle of a line, splits it in two, moving down the section to the right. A LF entered at the end of a line creates an empty line below the current line. Several utilities are supported by the program editor to assist with writing and debugging the programs. To access these utilities, select the EDIT option in the Editor window. The menu in Figure 10.8 is displayed.

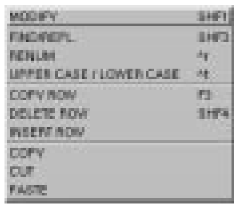


Figure 10.8: EDIT Menu

The options present in the EDIT menu box are:

MODIFY (SHF1) Select this option to open a window in which you can change the parameters of the program line where the cursor is positioned. If the line is a comment line, or no program is resident in memory, the command has no effect.

FIND/REPL. (SHF3) Opens in the upper part of the window the dialogue box shown in Fig. 10.9.

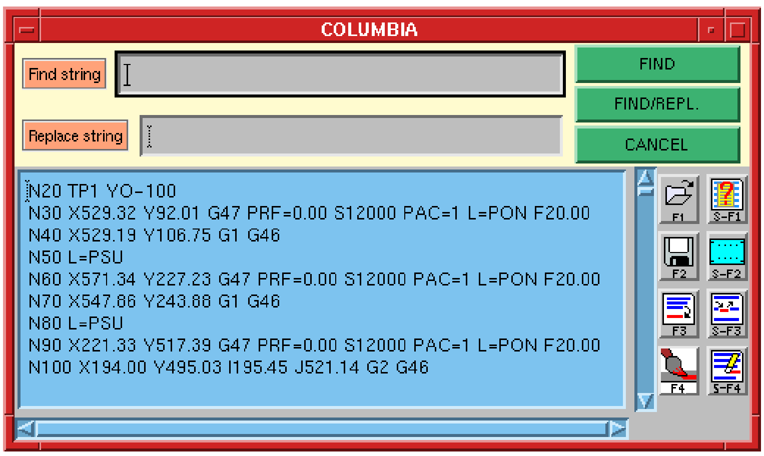


Figure 10.9: FIND/REPL. Dialogue Box

This dialogue box contains two fields in which you enter respectively the Search String and the Replace With String. Three new buttons are also displayed:

- FIND: Searches for the string in the program, starting with the line where the cursor is located. If the string is found, the cursor will move the corresponding line, otherwise a window with the String not found message is displayed.
- FIND/REPL.: Searches for the next occurrence of the selected string in the program and replaces it with the Replace With String.
- CANCEL: Cancels the operation and closes the FIND/REPL. dialogue box.

RENUM (ˆr) Renumbers the text lines of the program. The first line is numbered 10. The following lines are numbered at increments of 10.

UPPER CASE / LOWER CASE (ˆt) Changes the character after the cursor from lower case to upper case or vice versa.

COPY ROW (F3) Copies the row under the cursor and places it below.

DELETE ROW (SHF4) Deletes the row under the cursor.

INSERT ROW Inserts a new row immediately above the line where the cursor is located.

COPY Memorises text selected with the mouse. To select text with the mouse, click on the beginning of the section and drag the mouse pointer to the end of the section to be selected.

CUT Cuts and memorises text selected with the mouse.

PASTE Pastes the text memorised with the commands COPY and CUT at the place indicated by the mouse cursor.

10.2.3 Services

Click on the option SERVICES to display the following pull-down menu (Fig. 10.10):

Figure 10.10: SERVICES Menu.

SELECT PROGRAM This option makes available the open program `A.P. QUOTE`. from the `A.P. Editor`. If a work list is open, the option puts the program in queue after it.

OPTIMIZE (SHF3) This option is disabled in the CONTOURS environment; it becomes active in the EDIT HOLE environment. It permits the optimisation of the boring procedure on the panel being machined. For more information, see Section 10.7.

DIAGNOSTIC (F4) This option is not active in the CONTOURS environment; instead, it becomes active in the EDIT HOLE environment. After having executed the boring optimisation, the option DIAGNOSTIC allows the user to close the diagnostics window that displays problems encountered during the operation. For more information see Section 10.7.

DRAW (F4) Opens the window GRAPHIC relative to the file currently in the editor; for a description, see Section 10.6.

SUCTION CUP Launches the `A.P. ROVER Tooling System` which is a software package designed to simplify and guide the operations relative to tooling-up the machine and the work plan of point to point boring. It allows the configuration of the placement of various objects on the work table so as to suitably position the piece to be worked, and avoid that it enters into conflict with parts of the tool assembly. There is a complete description of the package in Section 11.

10.2.4 Help

The HELP option gives access to the on-line XNC electronic manual The Electronic Manual opens to the beginning of the section relative to `A.P. Editor`. Once accessed, the manual can be used and consulted as desired, in the language desired. For more information on how the manual works, refer to Section 2.2.

10.2.5 Center

When this option is selected a pull down menu appears like that shown in Fig. 10.11. This option is available only

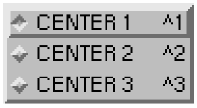


Figure 10.11: CENTER menu

on machines with multiple centers. The desired center is selected from the menu.

10.3 File selection

When the option "FILE' is chosen from the Menu Bar, the appropriate menu is opened; now select the option "OPEN" to display the File Selection window (see Fig. 10.12).

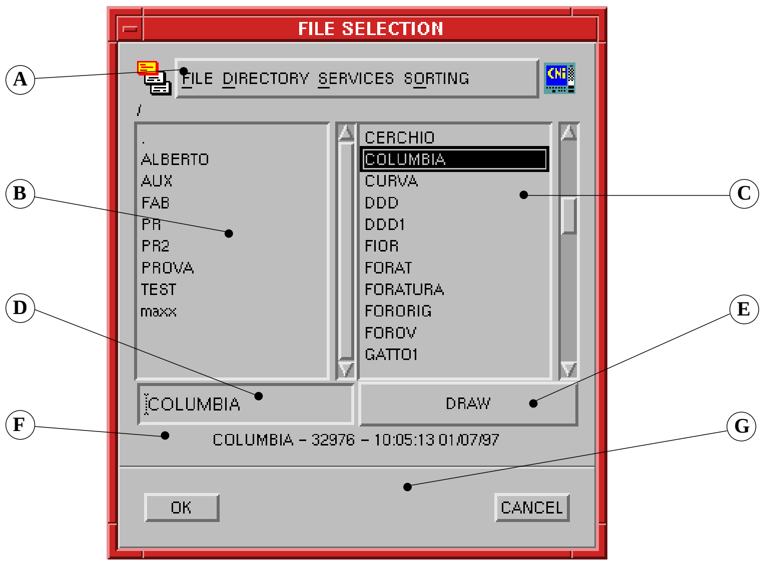


Figure 10.12: Finestra File Selection.

The File Selection window is divided into the following parts:

Menu Bar located under the Title Bar of the window; it contains options for the selection, handling and sorting of the files (Fig. 10.12-A). These options are:

- FILE: This option is used to select the type of file, and therefore, the relative directories.
- DIRECTORY: This option is used to select the local or remote directory from which the files are loaded.
- SERVICES: This option is used to handle Files and Directories.

- SORTING: This option is used for sorting the files.

Current Directory in the File Selection Menu, located under the Menu Bar.

Sub-directory Field containing the list of the sub-directories relative to the files which can be selected; it is located in the left part of the window body (Fig. 10.12-B). It has a scroll bar on its right side, which is activated when the list is longer than the space provided in the window.

File Field containing the list of files belonging to the selected sub-directory; it is located in the right part of the window body. (Fig. 10.12-C). It has a scroll bar on its right side, which is activated when the list is longer than the space provided in the window. The user can scroll through the list by typing the initials of the names; the selection bar automatically moves to the programs with the typed initials.

Selected File Box containing the name of the currently selected file; it is located under the list of sub-directories. (Fig. 10.12-D). Click on the box with the mouse to choose it, and type the name of the file to be loaded into the box. To open a new file, follow the same procedure; the data to be inserted into the Parameters Box will be requested, then it will have to be saved. For further information on the Parameters Box, refer to the *Appendix* part of this manual.

DRAW Box which calls up the GRAPHIC window, described in Section 10.6 (Fig. 10.12-E).

Characteristics of the Selected File are shown in a line under the body of the window (Fig. 10.12-F), as follows:

<Filename> <No. of bytes> <Time> <Date>

Ok Cancel buttons Use Ok to perform the operation and close the box; use Cancel to block the operation and close the box (Fig. 10.12-G).

10.3.1 File

Now, the File Selection will be considered; select the option FILE with the mouse. The following options are displayed in the FILE menu.

PROGRAM Selects the sub-directories that contain the Program files.

SUB-PROGRAM Selects the sub-directories that contain Sub-program files

FIXED CYCLE Selects the sub-directories containing the Fixed Cycle files.

ASCII Selects the sub-directories containing the Ascii files.

Each directory contains only one type of files. Therefore, by selecting a type of file, the directory that contains that type of file is automatically selected.

10.3.2 Directory

Now, select the DIRECTORY option with the mouse. The following selections are possible: NC, RT480 and, if desired, the name of a remote host. NC represents the directory of the machine itself. RT480 represents directories loaded from diskette, relative to RT480 control. A third possibility exists, that of connecting by network to a remote host. The later possibility is optional and is a pay service. For further information, refer to Section 7.12 which discusses access to this service, or contact CNI. Once the remote connection is activated, remote files can be edited.

10.3.3 Services

Now use the mouse to select the SERVICES option from the File Selection window menu bar; a list of options for file and directory handling is displayed. The following options are displayed in the SERVICES Box:

REMOVE FILE This option opens the REMOVE FILE window, used for cancelling a file from a directory. Write the name of the file to be eliminated in the window, either confirm the cancellation with Ok, or use Cancel to abort.

MAKE DIRECTORY This option opens the MAKE DIRECTORY window, used to create a new directory. Write the name of the directory to be created in the window, either confirm with Ok, or use Cancel to abort.

REMOVE DIRECTORY It functions in the same way as the previous command, except that with this command the indicated directory is eliminated.

RESCAN REMOTE DIR This option is activated and deactivated with the mouse. It is active by default; when deactivated, it does not re-read the structure each time and so connection operations to remote directories are faster. However, in the case of the elimination and creation of remote files and directories, it must be activated, otherwise these operations are not recognised.

EDIT PASSWORD This option can be accessed only at password levels sufficient for file access. By inserting the proper password, access to the corresponding level is obtained. The maximum password level accessible to the user is level 15. By entering a password for a level higher than the latter, the CHANGE PASSWORD option in enabled.

CHANGE PASSWORD This option allows the passwords of levels lower than the the one mentioned in the previous paragraph, to be changed. The user is asked to type the new password two times.

PRINT This option is used to print a specific section or sections of the selected program. For further information on Print, refer to the Section 10.2.1.

10.3.4 Sorting

When the SORTING option is selected with the mouse from the File Selection window menu bar, a list containing the following options is displayed:

UNSORTED No sort operation is performed.

SORT BY NAME The files are sorted in alphabetic order.

SORT BY DATE The files are sorted in chronological order.

10.4 Accessory Icons

The Accessory Icons field contains eight icons located in the dialogue box on the right of the Editor window, on the side of the tool bar (Fig. 10.2-E). This icons provide shortcuts to the selection of the most used commands in the FILE and EDIT menu. We will give now a brief description of the meaning of each icon.

Open file (F1) This icon, located on the first row to the left, when selected, has the same purpose of the OPEN option in the Menu Bar FILE item and opens the File Selection Window.

Modify row (SHIFT F1) If you select this icon, located on the first row to the right, a window is opened where it is possible to modify the parameters of the program line where the cursor is located. If the cursor is located on a comment line, or there is no file loaded in memory, the command has not effect.

Save file (F2) This icon, on the second row to the left, when selected, has the same purpose of the SAVE option in the Menu Bar FILE item and saves the file to the hard disk.

Edit hole (SHIFT F2) This icon, on the second row to the right, when selected, produces the same result obtained selecting FILE from the Menu Bar and then LOAD SECTION and EDIT HOLE in the corresponding pull-down menu. With this command you can access the environment in which it is possible to perform optimised borings.

Copy row (F3) Copies the line on which the cursor is located and places the copy immediately below it. It is the icon on the left of the third row from the top.

Find/replace (SHIFT F3) Has the same function of the FIND/REPL. command in the EDIT pull-down menu from the Menu Bar. Refer to the relevant section for more information on the command. It is the icon on the right of the third row from the top.

Draw (F4) This icon, on the left of the bottom line, acts like the Graphic or DRAW command. More information in paragraph 10.6.

Delete row (SHIFT F4) Deletes the line on which is located the cursor. This icon is the one on the right of the bottom row.

10.5 Creating and displaying a program

The operations to perform to create a program are:

1. Activate the Editor Window, selecting with the mouse the EDT icon in the window that appears in the lower part of the monitor when the NC is first turned on.
2. Select with the mouse the FILE option from the Menu Bar and open the corresponding list of options.
3. From this list, open the File Selection Window, selecting the OPEN option.
4. In this window, select FILE, then select the PROGRAM type for the list that appears.
5. Now, using if necessary the scroll bar, with the mouse select the required subdirectory from the corresponding box.
6. Using the mouse in the window at the side, select the required file if it exists, using the scroll bar if necessary to display the entire list. The name of the selected file is displayed in the Selected File Box.
7. If the required file does not exist, it can be created clicking with the mouse on the Selected File box and typing the required file name in it.
8. Press Ok or Enter to perform the operation, that is, to load the selected file from the Hard Disk or to open the new file. At the end of this operation you are taken back to the Editor window where:
   - The file name is written on the Title Bar.
   - If you opened an existing file, its contents are displayed in the program area window.
   - If you created a new file, the parameters box is opened automatically.
   - Once confirmed the data in the parameters box, you can proceed with writing and/or modifying the text of the program. More details on this may be found in the section 10.2.2.
9. Cancel stops the operation and closes the window.

10.6 Graphic

The option DRAW from the EDIT menu, the option DRAW from File Selection, the accessory icon indicated by Graphic, and the function key F4 on the keyboard, all open the `A.P. Graphic` application which represents the work operation carried out by the program loaded in editor, as shown in the example in Fig. 10.13.
The Graphic window contains, as usual, the title bar showing the name of the application and the name of the program represented in the main body of the window. All the commands of this application are represented as icons. We will give below a concise description of the icons and their functions.

Exit The first icons on the left contains a door. Click it to leave the graphic application.

Zoom The icon with the magnifying glass allows you to zoom into the picture. The zoom is centred at the position indicated by the pointer. Each time the pointer is moved the zoom is refreshed. Click the Zoom icon to open a window containing the zoommed area. A $+$ and a $-$ on the title bar of this window are used to vary the zoom factor. The current zoom factor is also shown on the title bar (Fig. 10.14). Zoom allows the desired

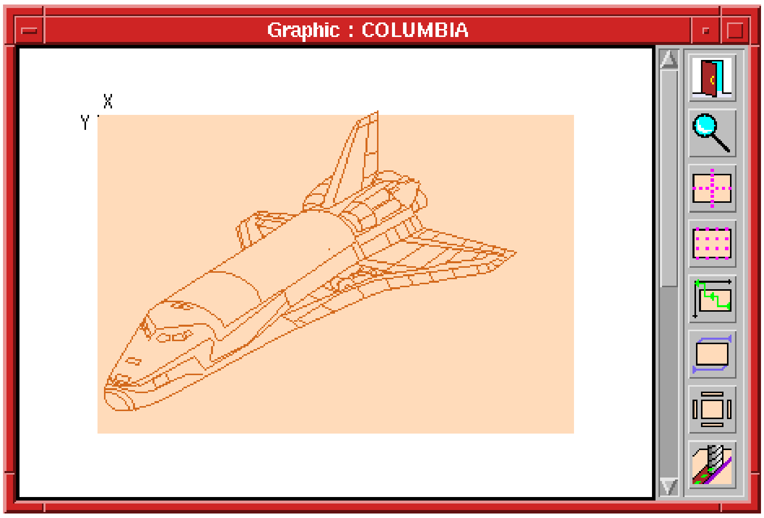


Figure 10.13: Graphic Window

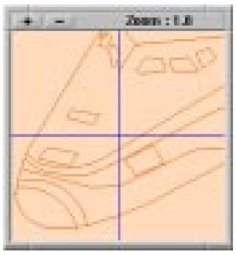


Figure 10.14: Zoom Window

area of the panel, including the axis path to be enlarged by a maxim zoom factor of 20. To exit Zoom mode, click a second time on the icon.

If Graphic is closed with the zoom on, the zoom remains active the next time the application is launched, either with the same program or a different one, set at the same position it was before the application was closed.

Pointer The third icon from the left (or from the top) is the Pointer icon. This icon is used to show the pointer axes, which can then be moved to the required position using the right mouse button. The position of each axis in relation to the origin is displayed next to the axis itself. The Zoom area is centred around the point of intersection of the axes. To hide the axes click a second time on the icon.

Grid Shows or hides a grid of reference points in the drawing window. The pre-defined grid distance value is 50mm. The icon has a rectangle with a grid of points.

G_Zero This option shows, in green, all the positionings of the program, including those that do not concern actual tool work. It is an indication of the non interpolated movements performed by the axes: it is, however, only a theoretic indication, since the real axes movement cannot be known in advance.

Out of panel This option is used when the tool, although it has a coordinate Z which interferes with the panel, still remains outside the panel itself.

Sides Shows any workings on the sides of the panel. Click on the icon to toggle ON or OFF.

Select path A multistatus button that can assume four possible values. The first shows the nominal path of the tool. Instead, the second shows the correct path; i.e. it takes into consideration the tool diameter. The third shows both paths, while the fourth doesn't show any path. In the fourth case, it can be used in combination with the Actual work key.

Actual work Shows how the panel will look after machining.

Trace Turn the Trace Icon on (with the closed hand and the index finger raised) to scroll each line of the program shown in editor and see highlighted the section of drawing relative to the program line on which the cursor is located. A scroll bar located at the bottom of the window contains the parameters relative to the specific program line. To exit Trace, click the icon again.

Infos Click on this icon to display information on the panel in a scroll bar located at the bottom of the window. In particular, information is shown on the piece dimensions, the grid, and the current tool with its relative diameter or thickness.

Redraw Click this icon to reprocess the drawing. This function does not take into account any changes you have made to the program, even if they have been saved. To reflect the changes select the DRAW option in one of the various ways provided.

Stop/Go The icon shows a traffic light. When the traffic light is green, each time a DRAW command is launched from the Editor, the graphic window displays the corresponding drawing. If the traffic light is red, the drawing remains unchanged, regardless of the commands issued from Editor. Click on the Traffic Light Icon to toggle between green and red.

Axis trace This option can be turned on during the execution of a program and shows the subsequent stages of work of the panel. The Icon contains feet and the letters "xyz".

Machining times This option displays a window that gives an estimate of the time necessary to execute the program. This window is shown in Fig. 10.15.

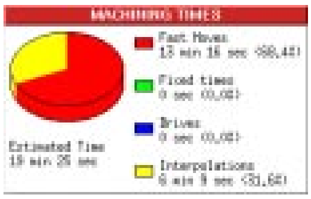


Figure 10.15: Machining times Window.

10.7 Edit hole

The FILE menu has a sub-menu called LOAD SECTION which has the option, EDIT HOLE. This option, also available in the icons shown in Fig. 10.2-E, as well as the keys SHIFT F2, gives access to the `A.P. Editor` boring application. This application is available only if a file is loaded. Its purpose is to provide a help for the boring procedures and seek the optimization of such operations. It specifically helps to define holes on the entire panel and to create an optimised program code for executing these holes. Having an optimised program means having a program that chooses the most appropriate path and bits for executing the work in the shortest time possible. Once launched, the application appears as shown in Fig. 10.16.
The Menu Bar is the same as that of the Contour program; however, some of the menu options are not available because they correspond to operations which are not enabled in the boring environment. Instead, the options CONTOURS and DIAGNOSTIC are enabled; these options are not active in the default environment.
Also the auxiliary icons are changed to reflect the commands used in this environment. The CONTOURS icon replaces the EDIT HOLE icon to return to the main environment. Instead of the FIND/REPL. icon there is the OPTIMIZE icon, and instead of the DRAW icon there is the DIAGNOSTIC icon.

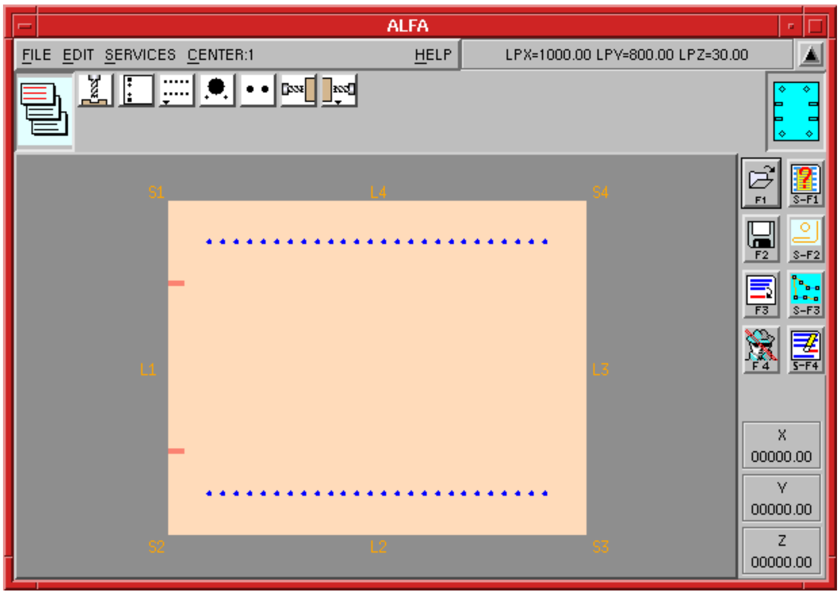


Figure 10.16: EDIT HOLE Window

As for the Editor icons, only the Configurable Assisted Editor icons are present. These icons can be used to select the boring operations to be carried out on the panel shown in the main body of the window. Therefore, by clicking on one of these icons, an Assisted Editor box is displayed, in which all the parameters necessary for executing the group of holes represented by the icon are defined. In the *Appendix* part of this manual all the possible holes available with the assisted editor are listed.

When one or more groups of holes are drilled, it can be observed that the holes may be identified by different colours on the panel. These colours are associated to particular groups of holes and can be configured by means of the `Tables` on the `A.P. Technical Data`.

One colour defines the holes with a depth greater than or equal to the thickness of the panel. The default colour for these holes is white.

Instead, black is the default colour for the holes which do not pass through the panel, that is holes with a depth less than the thickness of the panel. There is also a colour, yellow by default, to indicate when a group of holes has been selected.

To select a group of holes, simply click with the left mouse button on one of the holes in the group; using the four arrows, the selected groups can be alternated. A single selected hole is red by default. To move quickly among the various holes in a group, press the *space* on the keyboard. The selected holes are called holes in the edit phase.

The MODIFY can be used to change, at the user's discretion, some of the parameters. This can also be accomplished by means of the right mouse button. By using one of these two methods, an assisted editor box is opened in which all of the desired changes can be made.

If a group of holes is to be eliminated, simply use the DELETE ROW command; instead, to copy a line, use the COPY ROW command. With the latter operation, an assisted editor box is displayed where the characteristics of the copied group of holes must be defined.

When the process of configuring the boring of the panel is completed, it is advisable to perform an optimisation using the OPTIMIZE command, available either from the accessory icons Fig. 10.2-E, or as an option from the SERVICES menu.

If the optimisation is successful, a program code is created and displayed in the OPTIMIZED DRILLINGS section of the LOAD SECTION sub-menu of he FILE menu, which allows the drilling to be executed in the shortest time possible.

If the optimisation is not successful, a diagnostic window is displayed (Fig. 10.17), the `A.P. Technical Data` is opened, although without access to the *machine data* and the `A.P. Editor` in the boring environment is minimised and cannot be modified.

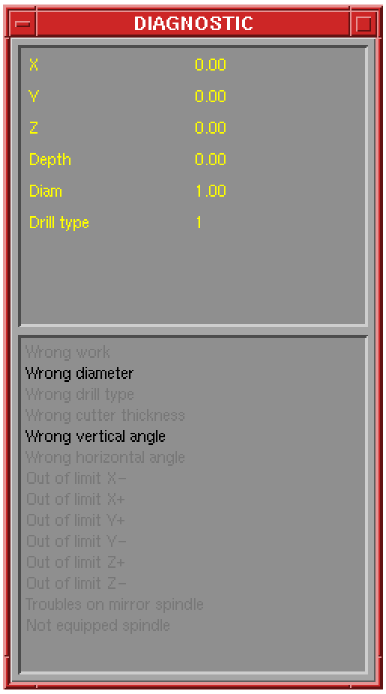


Figure 10.17: DIAGNOSTIC Window

The diagnostic window corresponds to the group of holes that has caused an error in the optimisation phase; by clicking on holes, or groups of holes, the errors displayed by the diagnostic window change. The `A.P. Technical data`, instead, opens to verify that the errors are not due to an incorrect tooling up. Access to the *machine data* is once again available when the diagnostics is closed, either through the icon in the group shown in Fig. 10.2-E, or with the DIAGNOSTIC option on the SERVICES menu. Once the errors or the tooling up has been corrected, the optimisation procedure must be repeated.

10.8 Assisted Editor

The assisted editor is that part of the Program Editor that aims to assist the user when writing work programs. The assisted Editor can be divided in two parts:

1. Standard Assisted Editor
2. Configurable Assisted Editor

The Standard Assisted Editor consists of a series of programs (examined in detail further on in the 10.9 section), supplied by CNI together with the NC software, and which may not be modified by the user. The Configurable Assisted Editor consists in a series of programming helps that can be generated by the user himself. These helps are similar to those provided by the Standard Assisted Editor, but are specific for the machine considered.
The Icon Area of the Assisted Editor is located under the Menu Bar and consists of a line of Icons defined as Base Level Icons (Fig. 10.2-C). The first five icons from the left are the icons of the standard Assisted Editor *(EGA, Line Segments, Arcs, Tool Correction, Positioning)* the other icons are of the Configurable Assisted Editor. If you move the mouse pointer in the area of the Assisted Editor icons, you can see that Assisted Graphic Editor (Ega) takes the title and the contents of the icon on which the pointer (Fig. 10.18) is located. This allows fast selection of the required icon freeing the operator from having to decipher the symbols in the icons. As soon as the mouse arrow leaves the icon area, the window disappears automatically.
On some icons of the Standard Assisted Editor and Configurable Assisted Editor there is a small triangle pointing downwards; these are called base level icons. Each base level icon has an associated level 1 icon line; click the

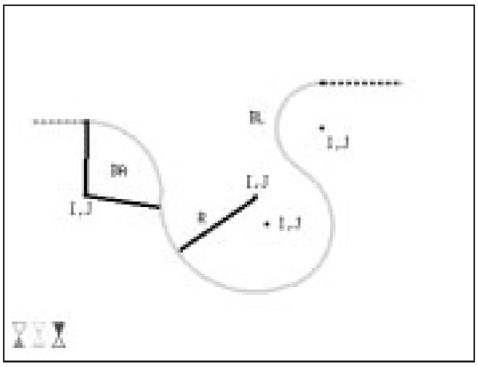


Figure 10.18: Ega Window

mouse on the desired base level icon to display it. The selected base level icon is highlighted as a pressed button. (Fig. 10.19) An example of a level 1 icon is shown in Fig. 10.19.

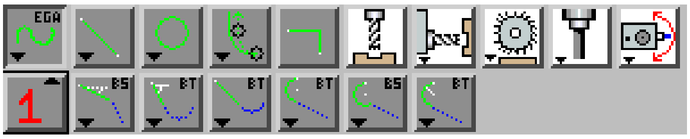


Figure 10.19: Example of Level 1 Icons.

The first in the Level 1 Icon Menu is the Close button 1, used to close the Level 1 Icon Menu and release the Basic Level button. Scrolling with the mouse on the Level 1 Icons displays in the Ega window the drawings illustrating the programming relative to the selected option. When a Level 1 Icon is selected, the Data Programming Window relative to the associated option opens. Level 1 Icons with a triangle pointing down indicate the presence of a Level 2, operating in the same way, and so forth to other levels, if present.
If the data inserted in the Box are correct, the drawing shown in the EGA window adapts to those values.

10.9 Standard Assisted Editor

Following are listed the various possibilities that the Standard Assisted Editor offers.

10.9.1 Icon Ega

Tab. 10.1 shows the parameters found in the various Boxes of the Standard Assisted Editor which correspond to this icon, and a brief description of their meaning.

Table 10.1: Assisted Graphic Editor Parameters

Parameter	Meaning
BA $(+/-)$	The meaning of the parameter is different depending on whether it refers to arcs or segments. 1. Segments: angle in sexagesimal degrees formed by the segment with the X axis. 2. Arcs: angle in sexagesimal degrees subtended by the arc. May be preceded by a $+$ sign or by a $-$ sign, depending on what is indicated in the associated figure.
BS $(+/-)$	Step secant to the next figure with sign to discriminate the solution.
BT $(+/-)$	Step tangent to the next.
BL	The meaning of the parameter is different based on whether it refers to arcs or segments. 1. Segment: Length of the segment. If a sign is present, it acts as discriminator between two solutions. With the $+$ sign, the larger is taken into consideration, with the $-$ sigh, the smaller. 2. Arc: Length of the arc. May be preceded by a $+$ sign or by a $-$ sign, depending on what is indicated in the associated figure.
I	X co-ordinate of the center of the circumference.
J	Y co-ordinate of the center of the circumference.
K	Z co-ordinate of the center of the circumference.
R	Radius of the arc. May be preceded by the $+$ sign or by the $-$ sign, depending on what is indicated in the associated figure.
RI	Length of semi-axis X of the elipse.
RJ	Length of semi-axis Y of the elipse.
X	X co-ordinate of the end point, if known.
Y	Y co-ordinate of the end point, if known.
Z	Z co-ordinate of the end point, if known.
C	Additional axis, if any.
ROTATION $(+/-)$	The $+$ sign indicates a counter clockwise rotation, The $-$ sign indicates a clockwise .
CONNECTING ARC	Connecting Radius.
CONNECTING SEGMENT	Length of the rounding; more precisely, how much of each of the two segments is to be shortened starting from the contact point.
EDITABLE LINE	Empty line in which various information and instructions can be inserted, for example, positioning speed, rotation repetitions, etc.

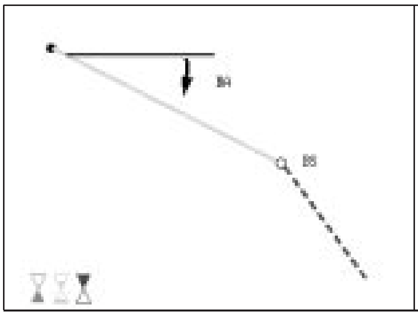
For a more complete treatment of the parameters and corresponding CNI-ISO instructions, consult the*P.G.A.* chapter of the *Programming Reference* part of this manual.
The EGA Icon is used to access that part of the Assisted Editor demanded to the programming of movements that can be described with geometrical entities. Select the EGA Icon to display a line of Level 1 Icons. The EGA Icon is displayed as a depressed button. When you position the mouse pointer on a Level 1 icon, the EGA win-

dow displays the drawing of the associated operation, and the corresponding description is displayed on the Title Bar. When a Level 1 Icon is clicked on, the Data Programming Window is opened for the parameter editor of the selected icon.

The icons of the EGA option are:

1. Button 1 Icon: Close Menu
2. Segment with known angle & intersecting n.f.
3. Segment with known angle e tangential n.f.
4. Segment tangential to next figure
5. Arc with known center, tangential to next fig.
6. Arc with known center & intersecting n.f.
7. Arc with known radius & tangential to n.f.

The figures displayed for each level 1 icon with a list of corresponding parameters will be shown. For the successive levels, only the names of the geometric operations they allow will be listed. Once the user has entered the upper levels, to exit correctly, the geometric programming must be completed. Remember that correctly inserted parameters allow the display of the results in the EGA window.



Segment with known angle & intersecting n.f.:

1. BS
2. BA
3. CONNECTING ARC
4. CONNECTING SEGMENT

If the operations in the data programming windows have been carried out correctly, other nine Level 2 Icons are associated to this icon. The Level 2 Icons relative to the “Segment with known angle & intersecting n.f.” option are:

1. Button 2 Icon: Close Menu and return to Level 1
2. Segment with known end point & angle
3. Segment with known angle e tangential n.f.
4. Arc with known center, rad. tangential to n.f.
5. Arc with known center, rad. & intersecting n.f.
6. Arc with known center, radius & angle
7. Arc with known center, radius & length
8. Arc with known center & end point
9. Arc with known center, tangential to next fig.

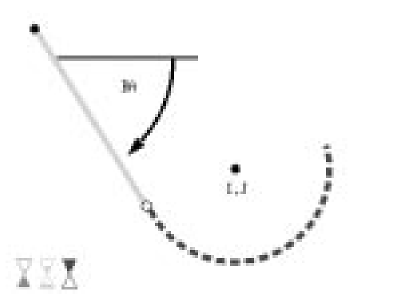
Each of these icons, except for the first one that is used to return to the previous level, opens a data programming window. Icons number 3 and number 9, moreover, open a third level. The parameters associated to the data programming windows have been defined already and there is no need for each icon to be explained in detail here as it was done for level 1. Icon 3 (Segment with known angle e tangential n.f.), when selected and used correctly, allows access to Level 3, which includes the following list of icons:

1. Button 3 Icon: Close Menu and return to Level 2
2. Arc with known center, rad. tangential to n.f.
3. Arc with known center, rad. & intersecting n.f.
4. Arc with known center, radius & angle
5. Arc with known center, radius & length
6. Arc with known center & end point

Icon 9 (Arc with known center, tangential to next fig.), when selected and used correctly, allows access to Level 3, which includes the following list of icons:

1. Button 3 Icon: Close Menu and return to Level 2
2. Segment with known end point & angle
3. Arc with known center, rad. tangential to n.f.
4. Arc with known center, rad. & intersecting n.f.
5. Arc with known center, radius & angle
6. Arc with known center, radius & length
7. Arc with known center & end point

All these icons will not be described in detail here as they correspond to programming windows similar to the ones that will be covered in the following paragraphs for level 1, and that contain parameters which will be illustrated further along in the manual.



Segment with known angle e tangential n.f.:

1. BT
2. BA

If the operations in the data programming windows have been carried out correctly, other seven Level 2 Icons are associated to this icon. The Level 2 Icons relative to the Option “Segment with known angle e tangential n.f.” are:

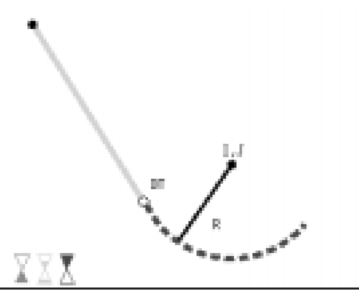
1. Button 2 Icon: Close Menu and return to level 1
2. Arc with known center, tangential to next fig.
3. Arc with known center & intersecting n.f.

4. Arc with known center & angle
5. Arc with known center & length
6. Arc with known end point & radius
7. Arc with known radius & tangential to n.f.

Each of these icons, except for the first one that is used to return to the previous level, opens a data programming window. Icon number 7, moreover, opens a third level. The parameters associated to the data programming windows have been defined already and there is no need for each icon to be explained in detail here as it was done for level 1. Icon 7 (Arc with known radius & tangential to n.f.) when selected and used correctly, allows access to a Level 3, which includes the following list of icons:

1. Button 3 Icon: Close Menu and return to Level 2
2. Segment with known end point & angle
3. Arc with known center, rad. tangential to n.f.
4. Arc with known center, rad. & intersecting n.f.
5. Arc with known center, radius & angle
6. Arc with known center, radius & length
7. Arc with known center & end point

These icons open programming windows similar to those seen before, containing parameters which are already known, and will not be illustrated in detail here.

	**Segment tangential to next figure:** 1. BT

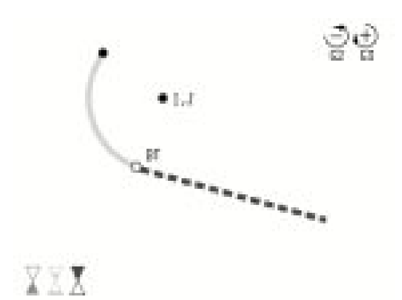
If the operations in the data programming window have been carried out correctly, other seven Level 2 Icons are associated to this icon. The Level 2 Icons relative to the Option “Segment tangential to next figure” are:

1. Button 2 Icon: Close Menu and return to level 1
2. Arc with known center, rad. tangential to n.f.
3. Arc with known center, rad. & intersecting n.f.
4. Arc with known center, radius & angle
5. Arc with known center, radius & length
6. Arc with known center & end point
7. Arc with known center, tangential to next fig.

Each of these icons, except for the first one that is used to return to the previous level, opens a data programming window. Icon number 7, moreover, opens a third level. The parameters associated to the data programming windows have been defined already and there is no need for each icon to be explained in detail here as it was done for level 1. Icon 7 (Arc with known center, tangential to next fig.) when selected and used correctly, allows access to a Level 3, which includes the following list of icons:

1. Button 3 Icon: Close Menu and return to Level 2
2. Segment with known end point & angle
3. Arc with known center, rad. tangential to n.f.
4. Arc with known center, rad. & intersecting n.f.
5. Arc with known center, radius & angle
6. Arc with known center, radius & length
7. Arc with known center & end point

These icons open programming windows similar to those seen before, containing parameters which are already known, and will not be illustrated in detail here.



Arc with known center, tangential to next fig.:

1. BT
2. I
3. J
4. ROTATION

If the operations in the data programming window have been carried out correctly, other fourteen Level 2 Icons are associated to this icon. The Level 2 Icons relative to the Option “Arc with known center, tangential to next fig.” are:

1. Button 2 Icon: Close Menu and return to Level 1
2. Segment with known angle e tangential n.f.
3. Segment with known angle & intersecting n.f.
4. Segment with known length & angle
5. Segment with known angle & x coordinate
6. Segment with known angle & y coordinate
7. Segment with known end point
8. Segment tangential to next figure
9. Arc with known center, tangential to next fig.
10. Arc with known center & intersecting n.f.
11. Arc with known center & angle
12. Arc with known center & length
13. Arc with known end point & radius
14. Arc with known radius & tangential to n.f.

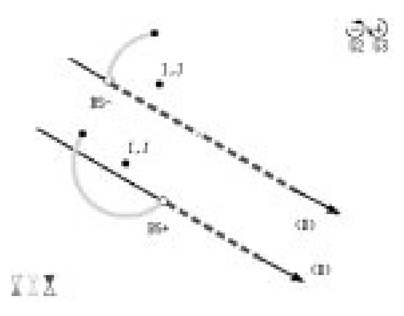
Each of these icons, except for the first one that is used to return to the previous level, opens a data programming window. Icons number 8 and number 14, moreover, open a third level. The parameters associated to the data programming windows have been defined already and there is no need for each icon to be explained in detail here as it was done for level 1. Icon 8 (Segment tangential to next figure) when selected and used correctly, allows access to Level 3, which includes the following list of icons:

1. Button 3 icon: Close menu and return to Level 2
2. Arc with known center, rad. tangential to n.f.
3. Arc with known center, rad. & intersecting n.f.
4. Arc with known center, radius & angle
5. Arc with known center, radius & length
6. Arc with known center & end point

Icon 14 (Arc with known radius & tangential to n.f.), when selected and used correctly, allows access to a Level 3, which includes the following list of icons:

1. Button 3 icon: Close menu and return to Level 2
2. Segment with known end point & angle
3. Arc with known center, rad. tangential to n.f.
4. Arc with known center, rad. & intersecting n.f.
5. Arc with known center, radius & angle
6. Arc with known center, radius & length
7. Arc with known center & end point

These icons open programming windows similar to those seen before, containing parameters which are already known, and will not be illustrated in detail here.



Arc with known center & intersecting n.f.:

1. BS
2. I
3. J
4. ROTATION
5. CONNECTING ARC
6. CONNECTING SEGMENT

If the operations in the data programming window have been carried out correctly, other nine Level 2 Icons are associated to this icon. The Level 2 Icons relative to the Option “Arc with known center & intersecting n.f.” are:

1. Button 2 icon 2: Close menu and return to Level 1
2. Segment with known end point & angle
3. Segment with known angle e tangential n.f.
4. Arc with known center, rad. tangential to n.f.
5. Arc with known center, rad. & intersecting n.f.
6. Arc with known center, radius & angle
7. Arc with known center, radius & length
8. Arc with known center & end point
9. Arc with known center, rad. tangential to n.f.

Each of these icons, except for the first one that is used to return to the previous level, opens a data programming window. Icons number 3 and number 9, moreover, open a third level. The parameters associated to the data programming windows have been defined already, and there is no need for each icon to be explained in detail here as it was done for level 1. Icon 3 “Segment with known angle e tangential n.f.” when selected and used correctly, allows access to Level 3, which includes the following list of icons:

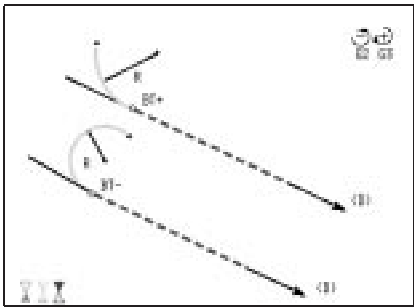
1. Button 3 icon: Close menu and return to Level 2
2. Arc with known center, rad. tangential to n.f.

3. Arc with known center, rad. & intersecting n.f.
4. Arc with known center, radius & angle
5. Arc with known center, radius & length
6. Arc with known center & end point

Icon 9 “Arc with known center, tangential to next fig.” when selected and used correctly, allows access to Level 3, which includes the following list of icons:

1. Button 3 icon: Close menu and return to Level 2
2. Segment with known end point & angle
3. Arc with known center, rad. tangential to n.f.
4. Arc with known center & intersecting n.f.
5. Arc with known center, radius & angle
6. Arc with known center, radius & length
7. Arc with known center & end point

These icons open programming windows similar to those seen before, containing parameters which are already known, and will not be illustrated in detail here.



Arc with known radius & tangential to n.f.:

1. BT
2. R
3. ROTATION

If the operations in the data programming window have been carried out correctly, other nine Level 2 Icons are associated to this icon. The Level 2 Icons relative to the Option “Arc with known radius & tangential to n.f.”, are:

1. Button 2 icon: Close menu and return to Level 1
2. Segment with known end point & angle
3. Segment with known angle e tangential n.f.
4. Arc with known center, rad. tangential to n.f.
5. Arc with known center, rad. & intersecting n.f.
6. Arc with known center, radius & angle
7. Arc with known center, radius & length
8. Arc with known center & end point
9. Arc with known center, tangential to next fig.

Each of these icons, except for the first one that is used to return to the previous level, opens a data programming window. Icons number 3 and number 9, moreover, open a third level. The parameters associated to the data programming windows have been defined already, and there is no need for each icon to be explained in detail here as it was done for level 1. Icon 3 “Segment with known angle e tangential n.f.”, when selected and used correctly, allows access to Level 3, which includes the following list of icons:

1. Button 3 icon: Close menu and return to Level 2
2. Arc with known center, tangential to next fig.
3. Arc with known center, rad. & intersecting n.f.
4. Arc with known center, radius & angle
5. Arc with known center, radius & length
6. Arc with known center & end point

Icon 9 “Arc with known center, tangential to next fig.”, when selected and used correctly, allows access to Level 3, which includes the following list of icons:

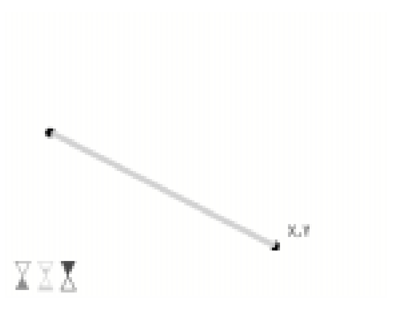
1. Button 3 icon: Close menu and return to Level 2
2. Segment with known end point & angle
3. Arc with known center, rad. tangential to n.f.
4. Arc with known center, rad. & intersecting n.f.
5. Arc with known center, radius & angle
6. Arc with known center, radius & length
7. Arc with known center & end point

These icons open programming windows similar to those seen before, containing parameters which are already known, and will not be illustrated in detail here.

10.9.2 Segments Icon

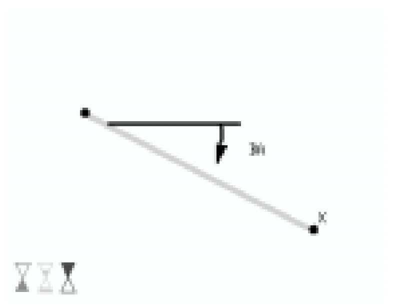
The “Segments” Icon provides access that part of the Standard Assisted Editor used to program linear movements that can be described by segments. When you click on the “Segments” Icon, a level 1 icons line is displayed. Six different cases are provided for programming a segment, each of them with a corresponding Level 1 icon. The “Segments” Icon is highlighted as a pressed button. When you position the mouse pointer on a Level 1 icon, the EGA window displays the drawing of the associated operation, and the corresponding description is displayed on the Title Bar. When a Level 1 Icon is clicked on, the Data Programming Window is opened for the parameter editor of the selected icon.
The icons of the “Segments” option are:

1. Button 1 Icon: Close menu
2. Segment with known end point
3. Segment with known angle & x coordinate
4. Segment with known angle & y coordinate
5. Segment with known length & angle
6. Segment with known length & x coordinate
7. Segment with known length & y coordinate



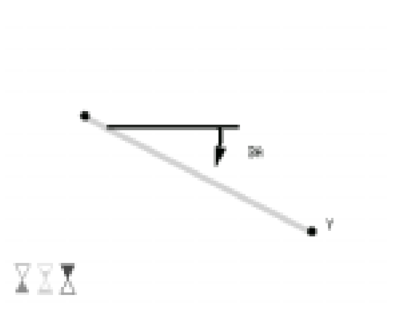
Segment with known end point:

1. X
2. Y
3. Z
4. C
5. CONNECTING ARC
6. CONNECTING SEGMENT



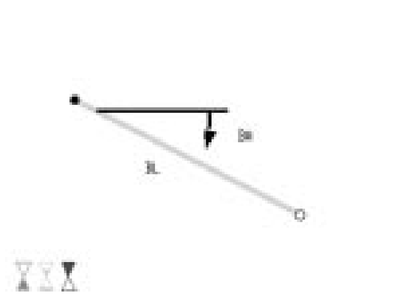
Segment with known angle & x coordinate:

1. X
2. Z
3. C
4. BA
5. CONNECTING ARC
6. CONNECTING SEGMENT



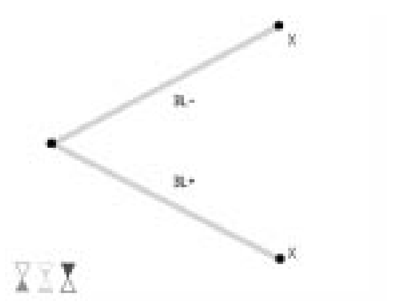
Segment with known angle & y coordinate:

1. Y
2. Z
3. C
4. BA
5. CONNECTING ARC
6. CONNECTING SEGMENT



Segment with known length & angle:

1. BL
2. BA
3. CONNECTING ARC
4. CONNECTING SEGMENT



Segment with known length & x coordinate:

1. X
2. Z
3. C
4. BL
5. CONNECTING ARC
6. CONNECTING SEGMENT

>> . . .

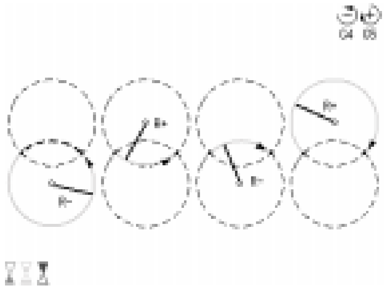
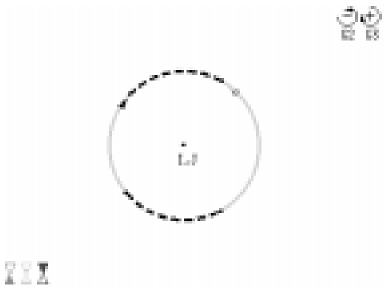
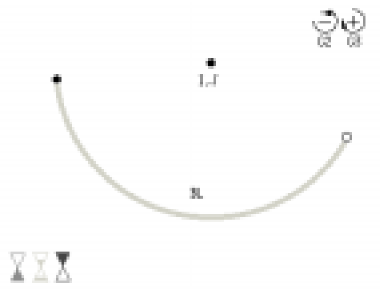
... <<	
	**Segment with known length & y coordinate:** 1. Y 2. Z 3. C 4. BL 5. CONNECTING ARC 6. CONNECTING SEGMENT

For the meaning of the parameters, consult Tab. 10.1.

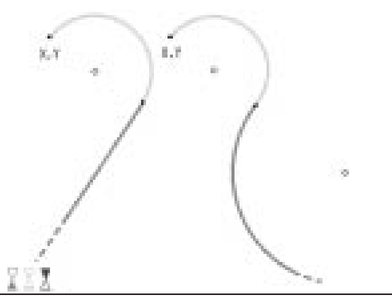
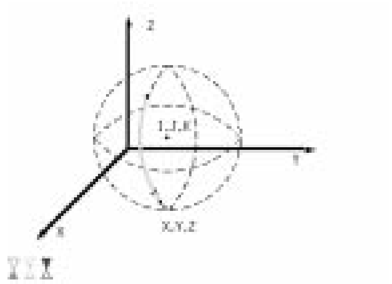
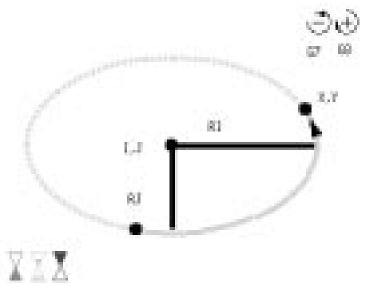
10.9.3 Arcs Icon

The Arcs Icon provides access to that part of the Standard Assisted Editor used to program circular movements that can be described by arcs of circles. When you position the mouse pointer on the Arcs Icon, the EGA window displays the drawing of the icon. If you select the “Arcs” Icon, a level 1 icons line is displayed. The “Arcs” Icon is highlighted as a pressed button. Seven possibilities of programming an arc of a circle are provided as Level 1 icons. When the pointer of the mouse is placed on a Level 1 Icon, the EGA window shows the drawing of the associated operation and the title bar shows its associated description. Click on a Level 1 icon to open the Data Programming window for the Parameter Editor of the selected icon. The icons of the “Arcs” option are:

1. Button 1 icon: close menu
2. Arc with known end point & radius
3. Arc with known center & end point
4. Arc with known center & length
5. Arc with known center & angle
6. Arc with known end point & tangential to n.f.
7. 3D Arc
8. Ellipse

	**Arc with known end point & radius:** 1. X 2. Y 3. Z 4. C 5. R 6. ROTATION 7. CONNECTING ARC 8. CONNECTING SEGMENT
	**Arc with known center & end point:** 1. X 2. Y 3. Z 4. C 5. I 6. J 7. ROTATION 8. CONNECTING ARC 9. CONNECTING SEGMENT
	**Arc with known center & length:** 1. I 2. J 3. BL 4. ROTATION 5. CONNECTING ARC 6. CONNECTING SEGMENT
	**Arc with known center & angle:** 1. I 2. J 3. BA 4. ROTATION 5. CONNECTING ARC 6. CONNECTING SEGMENT

>> . . .

. . . <<	
	**Arc with known end point & tangential to n.f.:** 1. X 2. Y 3. Z 4. C
	**3D Arc:** 1. X 2. Y 3. Z 4. C 5. I 6. J 7. K
	**Ellipse:** 1. X 2. Y 3. Z 4. C 5. I 6. J 7. RI 8. RJ 9. ROTATION

For the meaning of the parameters, consult Tab. 10.1.

10.9.4 Tool correction Icon

The “Tool correction” Icon provides access to the Tool Correction part of the Standard Assisted Editor When you position the mouse pointer on this Icon, the EGA window displays the drawing of the icon. If you select the “Tool correction” Icon, a level 1 icons line is displayed. The “Tool correction” Icon is highlighted as a pressed button. Tool Correction includes four different Level 1 cases. When the pointer of the mouse is placed on a Level 1 Icon, the EGA window shows the drawing of the associated operation and the title bar shows its associated description. Click on a Level 1 icon to open the Data Programming window for the Parameter Editor of the selected icon. The Tool Correction Icons are:

1. Button 1 icon: close menu
2. Linear attach
3. Circular attach
4. Linear detach

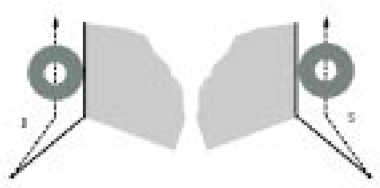
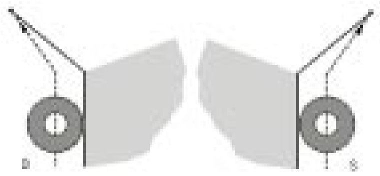
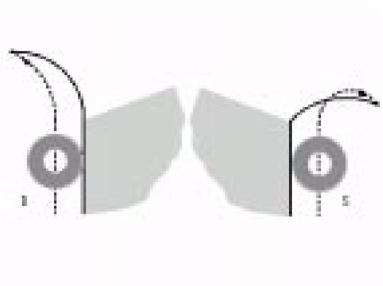
5. Circular detach

Tab. 10.10 contains a brief explanation of the meaning of the parameters that appear in the Boxes.

Table 10.10: Parameters for Tool correction

Parameter	Meaning
X	X co-ordinate of the attachment/detachment point.
Y	Y co-ordinate of the attachment/detachment point.
Z	Z co-ordinate of the attachment/detachment point.
SIDE (D/S)	Correction to the right or left of the profile
CORNERS (S/N)	Inserts the pitch of the circular connection with N and intersects the corrected paths with S (sharp corner).
R	Attachment radius. Must be a "large" value.

For further information, consult Chapter on *Tool Radius Correction* in the *Programming Reference* part of this manual.

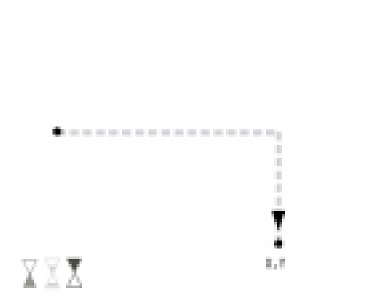
	**Linear attach:** 1. X 2. Y 3. Z 4. C 5. SIDE (D/S) 6. CORNERS (S/N)
	**Circular attach:** 1. X 2. Y 3. Z 4. C 5. SIDE (D/S) 6. CORNERS (S/N) 7. R
	**Linear detach:** 1. X 2. Y 3. Z 4. C
	**Circular detach:** 1. X 2. Y 3. Z 4. C 5. R

10.9.5 Positioning Icon

Entering a positioning step may be quite useful, not only to indicate the X, Y, and Z positions which a tool must move to, but also because it is the most convenient method to supply the program with a series of instructions and information. The following is the figure that corresponds to the Positioning icon, the parameters are displayed in the box. In Tab. 10.12 a brief explanation of the parameters in the Box is given.

Table 10.12: Parameters for Positioning

Parameter	Meaning
X	X co-ordinate of the position to be reached.
Y	Y co-ordinate of the position to be reached.
Z	Z co-ordinate of the position to be reached.
C	Additional axis, if any.
TP	Number of the selected pantograph.
L	Subroutine to be called.
G	Fixed cycle to be called.
F	Interpolation speed.
S	Tool rotation speed.
M	Line used for giving special instructions.



Positioning:

1. X
2. Y
3. Z
4. C
5. TP
6. L
7. G
8. F
9. S
10. M

11 A.P. Rover Tooling System

11.1 Introduction

The ROVER Tooling System is a software package designed to simplify and guide the operations for tooling up and for planning the work of the point to point boring machines.
It allows the user to configure the disposition of the various objects on the work table so that the piece to be machined can be suitably positioned, thus avoiding conflict with the tooling parts. The `A.P. ROVER Tooling System` is accessed as follows:

1. Open the `A.P. Editor` by clicking on the corresponding icon.
2. Use the OPEN option from the FILE menu of the `A.P. Editor` to load the program to be used with the `A.P. ROVER Tooling System`. See Section 10 for a complete description of how to load a file using the `A.P. Editor`.
3. Now, open the SERVICESmenu and select the option SUCTION CUP to launch the `A.P. ROVER Tooling System`.

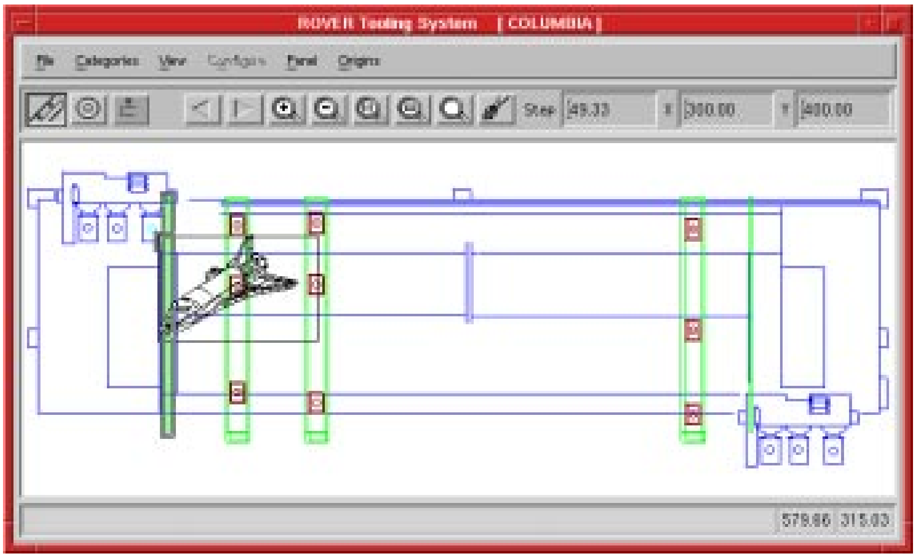


Figure 11.1: A.P. ROVER Tooling System

4. Once the `A.P. ROVER Tooling System` has been launched, it can be reduced to an icon; its icon is shown in Fig. 11.2.

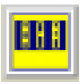


Figure 11.2: A.P. ROVER Tooling System Icon

11.2 Rapid user guide

This section illustrates some of the standard procedures used with the Rover Tooling System.
Contents:

- Selection commands.
- Moving commands.
- Creating a tooling file.
- Configuration of a tooling file.

11.2.1 Selection commands

Selection commands are commands that may be accessed by mouse or keyboard, and let the user select an object in the active category as the active object.

Ways to activate the command

- With the keyboard: press “Ctrl” + “Left arrow” or “Ctrl” + “Right arrow”.
- With the mouse: move near the object and press the left key.
- With instruments: select icon 11.3 or 11.4

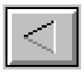


Figure 11.3: Left arrow

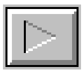


Figure 11.4: Right arrow

Purpose of the command

Changes active object within the same category.

Use of the command

If the active object is a bench, use the command to activate a place to the left/right of the current one; if it is a cup or a backstop, use the command to activate a place above or below it.

Note on the command

If you want to activate cups or backstops located on different benches by means of the keyboard, you first have to activate the bench containing them, then activate the category cup or backstop and select the one desired.

11.2.2 Movement commands

Movement commands are commands that may be accessed by mouse or keyboard, and let the user interact directly with the objects located in the graphics area, moving them as he wishes.

Ways to activate the command

- With the keyboard: use the arrow keys.
- With the mouse: use the left key.
- By typing positions.

Purpose of the command

Allows an object to be moved in the work area within the limits imposed by the presence of other objects in the same area.

Use of the command

With the keyboard:

1. press the arrow key corresponding to the direction in which you want to move the object;
2. release the arrow key to confirm the move.

With the mouse:

1. move near the object and press the left key;
2. drag the object by keeping the left key pressed;
3. release the left key to confirm the move.

By typing positions:

1. select the object by means of the **Selection commands**
2. with the Tab key, position the cursor in the edit field used to insert the “X” position; change the position and press Enter to confirm. Press the Tab key again to position the cursor in the edit field used to insert the “Y” position; change the position and press Enter to confirm.

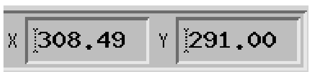


Figure 11.5: Typing positions

3. press Enter to confirm or Esc to cancel the changes.

Notes on the command

An object may be moved only in the directions permitted (see Movements command on the Configuration menu). Object movement by means of keyboard takes place in discrete steps. The step used is described in the edit field located on the status bar, directly above the graphics area. The step unit may be changed by using the **Step** command on the Configuration menu.

11.2.3 Creating a tooling file

This section describes the methods used to construct a generic tooling file. The construction of a tooling file may be divided into the following phases:

1. Insertion of machine.

2. Insertion of mobile benches.

3. Insertion of cups.

4. Insertion of backstops.

Phase 1: **Insertion of machine**.

Select “Insert” on main menu Configuration, then select “Machine” on secondary menu Insert. Select a name from the list in the Load Machine dialog box. A drawing of the selected machine will appear in the graphics area.

Figure 11.6: Insertion of machine

Phase 2: **Insertion of mobile benches**.

Select “Insert” on main menu Configuration, then select “Mobile benches” on secondary menu Insert. Select a name from the list in the Mobile benches dialog box. Type the position for the bench insertion point, or accept those proposed, by means of the Object position definition dialog box. A drawing of the selected bench will appear in the graphics area: confirm the operation or redefine the positions of the insertion point.

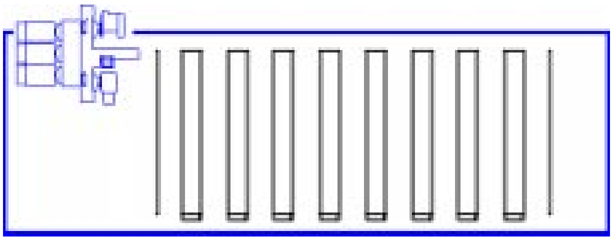


Figure 11.7: Insertion of mobile benches

Repeat the operation for each bench to be inserted.

Phase 3: **Insertion of cups**.

Using the Selection commands, select one of the benches in the graphics area. The cups insertion operation will relate to the bench selected. Select “Insert” on main menu Configuration, then select “Cups” on secondary menu Insert. Select a name from the list in the Load cups dialog box. Type the position for the cup insertion point, or accept those proposed, by means of the Object position definition dialog box. A drawing of the selected cup will appear in the graphics area: confirm the operation or redefine the positions of the insertion point. Repeat the operation for each cup to be inserted.

Phase 4: **Insertion of backstops**.

Using the Selection commands, select one of the benches in the graphics area. The backstops insertion operation will relate to the bench selected. Select “Insert” on main menu Configuration, then select “Backstops” on secondary menu Insert. Select a name from the list in the Load backstops dialog box. Use the Object position definition dialog box to type the positions for the backstop insertion point and enable movements, or link the backstop to an origin. By choosing to link the backstop to an origin, positions and movements will

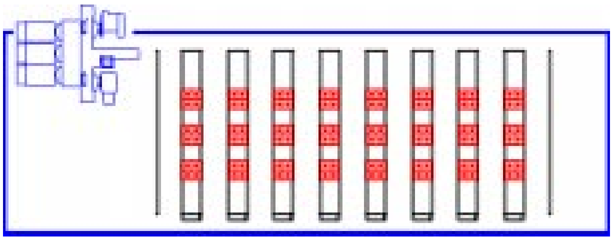


Figure 11.8: Insertion of cups

be automatically calculated (see backstops in the Glossary of technical terms) and it will not be necessary to insert them manually. A drawing of the selected backstop will appear in the graphics area: confirm the operation or redefine the positions.

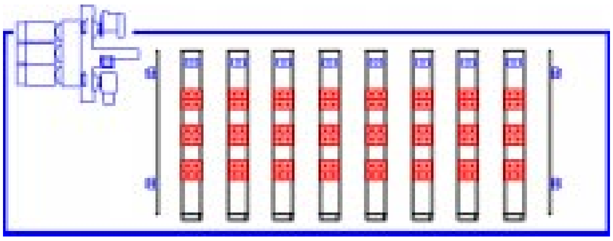


Figure 11.9: Insertion of backstops

Repeat the operation for each backstop to be inserted.

The insertion of cups and backstops relates to the bench selected or to the bench containing the object selected.

Warning! You cannot insert a bench after having inserted a cup or a backstop, just as you cannot insert a cup after having inserted a backstop.

11.2.4 Configuration of a tooling file

This section describes the methods used to position the panel and objects that make up tooling. Its purpose is to position the objects that support the panel in such a way as to avoid all interference with the tools performing work. Before inserting a panel, make sure that tooling is complete. After a panel is inserted, it will be impossible to add other objects to the tooling. To insert a panel, proceed as follows:

1. By means of the Origins menu, select the panel reference origin.

2. Select Load Panel from main menu Panel.

Once the panel is inserted, you may rotate it or mirror it (see secondary menus **Rotate** and **Mirroring**).
By means of the **Selection commands** and **Moving commands**, position the objects that support the panel in such a way as to avoid overlapping between work areas and tooling parts. For example, if a series of through holes has to be drilled in a panel, the drilling tool must not enter into contact with the objects (benches, cups, backstops) that support the panel. Fig. 11.10 shows two cups positioned in proximity of a work area where a series of through holes are to be drilled. In Fig. 11.11, the cups have been moved, and work on the piece will not cause damage to the supports.

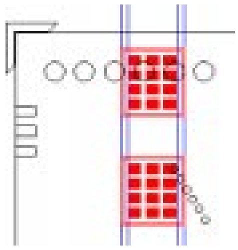


Figure 11.10: Incorrect position

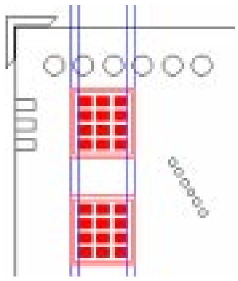


Figure 11.11: Correct position

11.3 Main menu: File

The following are the commands grouped under the term File on the menu bar, in the form of pull-down menu. This menu does not have a tool box.

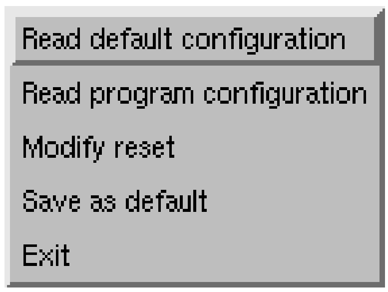


Figure 11.12: Pull-down menu for “File”

◇ Read default configuration

- Ways to activate command:
  With pull-down menu: select “File” and “Read default configuration”. This command does not have an icon.

- Purpose of command:
  Loads the default tooling.

- Use of command:
  The command has immediate effect.

◇ Read program configuration

- Ways to activate command:
  With pull-down menu: select “File” and “Read program configuration”. This command does not have an icon.

- Purpose of command:
  Loads the default tooling for a program.

- Use of command:

- Type the program name or select it from the list.

- Confirm by pushing the OK button.

◇ Modify reset

- Ways to activate command:
  With pull-down menu: select “File” and “Modify reset”. This command does not have an icon.

- Purpose of command:
  Cancels all changes made to the current tooling.

- Use of command:
  The command has immediate effect.

◇ Save as default

- Ways to activate command:
  With pull-down menu: select “File” and “Save as default”. This command does not have an icon.

- Purpose of command:
  Saves the current tooling as the default tooling.

- Use of command:
  The command has immediate effect.

◇ Exit

- Ways to activate command:
  With pull-down menu: select “File” and “Exit”. This command does not have an icon.

- Purpose of command:
  Exits the program.

11.4 Main menu: Categories

The following are the commands grouped under the term Categories on the menu bar, in the form of:

- Pull-down menus.

- Tool boxes.

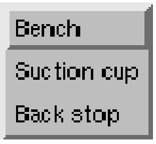


Figure 11.13: Pull-down menu for “Categories”

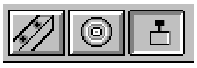


Figure 11.14: Pull-down menu and tool boxes for “Categories”

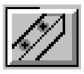


Figure 11.15: Icon to activate command Benchs

◇ Benchs

- Ways to activate command:
  With keyboard: press “Alt” + “C” + “P” or “Ctrl” + “B” With pull-down menu: select “Categories” and “Benchs”. With tool boxes: select icon 11.15.
- Purpose of command:
  Defines the benches category as active category.
- Use of command:
  The command has immediate effect, defining an object in the benches category as active object. The active object is highlighted graphically by means of a double border.
- Notes on the command:
  The command is available for visible objects only: see the **Filters** command on the View menu. By using the Selection commands you may define any object in the active category as the active object. By using the Moving commands you may move the active object in the permitted directions (see **Moving** commands on the Configuration menu).

◇ Cups

- Ways to activate command:
  With keyboard: press “Alt” + “C” + “V” or “Ctrl” + “C”. With pull-down menu: select “Categories” and “Cups”. With tool boxes: select icon 11.16.

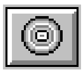


Figure 11.16: Icon to activate command Cups

- Purpose of command:
  Defines the cups category as active category.

- Use of command:
  The command has immediate effect, defining an object in the cups category as active object. The active object is highlighted graphically by means of a double border.

- Notes on the command:
  The command is available for visible objects only: see the **Filters** command on the View menu. By using the Selection commands you may define any object in the active category as the active object. By using the Moving commands you may move the active object in the permitted directions (see **Moving** commands on the Configuration menu).

◇ Backstops

- Ways to activate command:
  With keyboard: press “Alt” + “C” + “B” or “Ctrl” + “T”. With pull-down menu: select “Categories” and “Backstops”. With tool boxes: select icon 11.17.

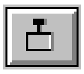


Figure 11.17: Icon to activate command Backstops

- Purpose of command:
  Defines the backstops category as active category.

- Use of command:
  The command has immediate effect, defining an object in the backstops category as active object. The active object is highlighted graphically by means of a double border.

- Notes on the command:
  The command is available for visible objects only: see the **Filters** command on the View menu. By using the Selection commands you may define any object in the active category as the active object. By using the Moving commands you may move the active object in the permitted directions (see **Moving** commands on the Configuration menu).

11.5 Main menu: View

The following are the commands grouped under the term “View” on the menu bar, in the form of pull-down menus.

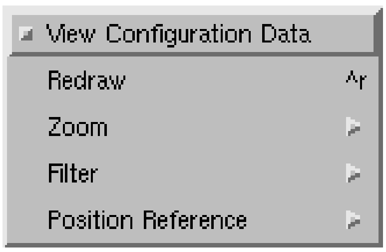


Figure 11.18: Pull-down menu for View

◇ View Configuration Data

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “V”. With pull-down menu: select “View” and “View Configuration Data”.

- Purpose of command:
  Enable or disable the display of axis position related to work on piece.

- Use of command:
  The “View Configuration Data” option changes the drawing area with the table of machine axis position. The axis position showed are related to work on piece.

- Note on the command:
  The command has immediate effect and does not alter the current tooling.

◇ Redraw

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “R” or “Ctrl” + “R”. With pull-down menu: select “View” and “Redraw”. With tool boxes: select icon 11.19.

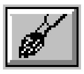


Figure 11.19: Icon “Redraw”

- Purpose of command:
  Up-dating of graphics area.

- Use of command:
  The command redraws all of the objects inserted in the current tooling in order to clean it of any lines left from insertion or movement of the objects.

- Note on the command:
  The command has immediate effect and does not alter the current tooling.

◇ Secondary menu:Zoom

- Ways to activate secondary menu:
  With keyboard: press “Alt” + “V” + “Z”. With pull-down menu: select “View” and “Zoom”. The following are the commands grouped under the term “Zoom” on the main menu, in the form of:

  – Pull-down menus.
  – Tool boxes.

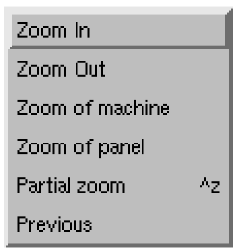


Figure 11.20: Pull-down menu for “Zoom”

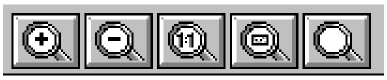


Figure 11.21: Pull-down menu and tool box for “Zoom”

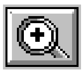


Figure 11.22: Icon “Zoom In”

◇ ◇ *Zoom In*

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “Z” + “A”. With pull-down menu: select “View”, “Zoom” and “Zoom in”. With tool boxes: select icon 11.22.
- Purpose of command:
  Zooms current screen, incrementing the scale by a constant factor.
- Use of command:
  When activated, the command enlarges the current screen.
- Note on the command:
  The command has immediate effect and does not alter the drawing being constructed.

◇ ◇ *Zoom Out*

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “Z” + “I”. With pull-down menu: select “View”, “Zoom” and “Zoom out”. With tool boxes: select icon 11.23.

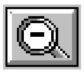


Figure 11.23: Icon “Zoom Out”

- Purpose of command:
  Zooms current screen, decreasing the scale by a constant factor.
- Use of command:
  When activated, the command reduces the current screen.
- Note on the command:
  The command has immediate effect and does not alter the drawing being constructed.

◇ ◇ *Zoom Machine*

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “Z” + “M”. With pull-down menu: select “View”, “Zoom” and “Zoom Machine”. With tool boxes: select icon 11.24.
- Purpose of command:
  Restores initial display conditions of drawing.

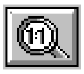


Figure 11.24: Icon “Zoom Machine”

- Use of command:
  When activated, displays the entire tooling in the centre of the screen (standard condition). In other words, the display conditions obtained with zoom commands are cancelled.
- Note on the command:
  The command has immediate effect and does not alter the drawing being constructed.

◇ ◇ *Zoom Panel*

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “Z” + “P”. With pull-down menu: select “View”, “Zoom” and “Zoom Panel”. With tool boxes: select icon 11.25.

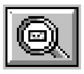


Figure 11.25: Icon “Zoom Panel”

- Purpose of command:
  Displays and enlarges the panel on the active origin.
- Use of command:
  When activated, displays the entire panel in the centre of the screen.
- Note on the command:
  The command has immediate effect and does not alter the drawing being constructed.

◇ ◇ *Partial zoom*

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “Z” + or “Ctrl” + “Z”. With pull-down menu: select “View”, “Zoom” and “Partial zoom”. With tool boxes: select icon 11.26.

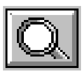


Figure 11.26: Icon “Partial zoom”

- Purpose of command:
  Displays and enlarges a part of the tooling.
- Use of command:
  Define the rectangular area to be enlarged as follows:
  - Position the cursor on one of the four corners of the area
  - Press the left mouse key and keep it pressed

  - Move diagonally with the mouse to the opposite corner
  - Release the mouse key

- Notes on the command:
  When the command is activated, the cursor arrow will change to a magnifying lens until the selected area has been defined. The command may be repeated more than once. This is a display command and does not change the tooling being constructed.

◇ ◇ *Previus*

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “Z” + “C”. With pull-down menu: select “View”, “Zoom” and “Previus”.
- Purpose of command:
  Cancels the last view obtained with the zoom commands.
- Use of command:
  When activated, the command restores the view previous to the current one.
- Notes on the command:
  Only one previous zoom level may be restored. The command has no effect if used twice in a row. The command has immediate effect and does not alter the tooling being constructed.

◇ Filters

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “F”. With pull-down menu: select “View” and “Filters”.
- Purpose of command:
  Turns on and off the display of objects present in the tooling.
- Use of command:
  Activates setup boxes for objects to be displayed. Confirm by pushing the OK button.

◇ Secondary menu: Position reference

- Ways to activate secondary menu:
  With keyboard: press “Alt” + “V” + “Q”. With pull-down menu: select “View” and “Position Reference”. The following are the commands grouped under the term “Position Reference” on the main menu in the form of pull-down menus.

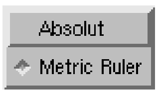


Figure 11.27: Pull-down menu for “Position Reference”

◇ ◇ *Absolut*

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “Q” + “A”. With pull-down menu: select “View”, “Position Reference” and “Absolut”.
- Purpose of command:
  Refers positions of objects and cursor in relation to machine zero.
- Use of command:
  The command has immediate effect.

◇ ◇ *Metric Ruler*

- Ways to activate command:
  With keyboard: press “Alt” + “V” + “Q” + “R”. With pull-down menu: select “View”, “Position Reference” and ”Metric Ruler”.
- Purpose of command:
  Refers positions of objects and cursor in relation to the ruler, i.e., a metrical reference attached to the machine.
- Use of command:
  The command has immediate effect.

11.6 Main menu: Configure

The following are the commands grouped under the term “Configure” on the menu bar, in the form of pull-down menu. This menu does not have tool boxes.

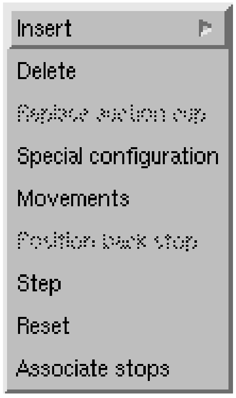


Figure 11.28: Pull-down menu for “Configure”

◇ Secondary menu: Insert

- Ways to activate secondary menu:
  With keyboard: press “Alt” + “G” + “I”. With pull-down menu: select “Configure” and “Insert”.

The following are the commands grouped under the term Insert on the menu bar, in the form of pull-down menu. This menu does not have tool boxes.

Figure 11.29: Pull-down menu for “Insert”

◇ ◇ *Machine*

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “I” + “M”. With pull-down menu: select “Configure”, “Insert” and “Machine”.

- Purpose of the command:
  Activates a Dialog box for insertion of machine.
- Use of command:
  Type the name of the machine or choose one from the list. Confirm by pushing the OK button.
- Note on the command:
  The command is available only after the current tooling has been deleted from memory by means of the Reset command or after all objects have been deleted.

◇ ◇ *Benchs*

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “I” + “P”. With pull-down menu: select “Configure”, “Insert” and “Benchs”.
- Purpose of the command:
  Activates a Dialog box for insertion of benches.
- Use of command:
  Type the name of the bench or choose one from the list. Confirm by pushing the OK button: the dialog box for setting of positions will be displayed. Set the positions for the bench insertion point or accept the default positions. Activate the edit fields for the moves that you want to assign to the bench, then push OK to accept the data entered. Confirm the insertion operation by pushing the OK button, or push the NO button to reset the insertion positions.
- Note on the command:
  The insertion operation is allowed within the limits imposed by the presence of other objects in the current tooling.

◇ ◇ *Cups*

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “I” + “V”. With pull-down menu: select “Configure”, “Insert” and “Cups”.
- Purpose of the command:
  Activates a Dialog box for insertion of cups.
- Use of command:
  Type the name of the cup or choose one from the list. Confirm by pushing the OK button: the dialog box for setting of positions will be displayed. Set the positions for the cup insertion point or accept the default positions. Activate the edit fields for the moves that you want to assign to the cup, then push OK to accept the data entered. Confirm the insertion operation by pushing the OK button, or push the NO button to reset the insertion positions.
- Note on the command:
  The cup insertion operation concerns the active bench, and is allowed within the limits imposed by the presence of other objects (cups or backstops) on the bench.

◇ ◇ *Backstops*

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “I” + “B”. With pull-down menu: select “Configure”, “Insert” and ”Backstops”.
- Purpose of the command:
  Activates a Dialog box for insertion of backstops.
- Use of command:
  Type the name of the backstop or choose one from the list. Confirm selection by pushing the OK button: the dialog box for insertion of positions will be displayed. By means of the Dialog box for the setting of positions, you may:

1. set positions for insertion point of the backstop;
2. activate the edit fields for the moves that you want to assign to the backstop position the backstop inside or outside the active bench;
3. link the backstop to an origin. In this case, the positions for the insertion point and moves of the backstop are implicitly redefined.

NOTE: special illustration with sensitive context Confirm the insertion operation by pushing the OK button, or push the NO button to reset the insertion positions.

- Note on the command:
  The backstop insertion operation concerns the active bench, and is allowed within the limits imposed by the presence of other objects inside or outside the bench For further information about linking a backstop to an origin, see Backstops in the Glossary.

◇ Delete

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “C”. With pull-down menu: select “Configure” and “Delete”.

- Purpose of the command:
  Deletes the active object in the current tooling.

- Use of command:
  Before deleting the object you must confirm the operation.

◇ Change

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “S”. With pull-down menu: select “Configure” and “Change”.

- Purpose of the command:
  Activates a Dialog box for change of active cup-object.

- Use of command:
  Type the name of the cup or choose one from the list. Confirm by pushing the OK button.

- Note on the command:
  The command is available only for objects in the cups category.

◇ Special Toolings

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “T”. With pull-down menu: select “Configure” and “Special Toolings”.

- Purpose of the command:
  Activates a Dialog box for special tooling of benches.

- Use of command:
  For each side of the bench (left and right), select the special tooling that you want to fit. Confirm by pushing the OK button.

- Note on the command:
  When it opens, the dialog box gives the name of the special tools fit on the left and right sides of the active bench. The command is available only for objects in the bench category. The command involves the active bench.

◇ Movings

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “M”. With pull-down menu: select “Configure” and “Movings”.
- Purpose of the command:
  Activates a Dialog box for configuration of moves of the active object.
- Use of command:
  Activate the setup boxes for the moves you want to give the active object. Confirm by pushing the OK button.

◇ Backstop repos.

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “R”. With pull-down menu: select “Configure” and “Backstop repos.”.
- Purpose of the command:
  Activates a Dialog box for linking of backstops.
- Use of command:
  The command activates a dialog box that lets you:

  1. activate the edit fields for the moves that you want to assign to the backstop;
  2. link the backstop to an origin. In this case, the positions for the insertion point and moves of the backstop are implicitly redefined.

  NOTE: special illustration with sensitive context Confirm the insertion operation by pushing the OK button, or push Cancel to cancel the changes and close the dialog box.
- Note on the command:
  The repositioning operation regards the bench on which the backstop is fit, and is allowed within the limits imposed by the presence of other objects inside or outside the bench. For further information about linking a backstop to an origin, see Backstops in the Glossary.

◇ Step

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “P”. With pull-down menu: select “Configure” and “Step”.
- Purpose of the command:
  Allows setting of step unit for movement of objects by means of the keyboard.
- Use of command:
  The command lets you change the edit field located on the status bar directly above the graphics area. After setting the new step unit, press Enter to confirm the changes and exit the command, or Esc to cancel the operation. See also Moving commands.

◇ Reset

- Ways to activate the command:
  With keyboard: press “Alt” + “G” + “A”. With pull-down menu: select “Configure” and “Reset”.
- Purpose of the command:
  Deletes current tooling from memory.
- Use of command:
  The command has immediate effect.
- Note on the command:
  After having activated the command, you must confirm the operation.

◇ Associate stops

- Ways to activate the command:
  with the keyboard: press “Alt” + “G” + “B” with the pull-down menu: select “Configure” and “Associate stops”
- Purpose of the command:
  To automatically reposition all the stops associated to an origin in X (or Y). The table on which the stop is installed is repositioned with the stop. The command has no effect on the stops which are not associated to an origin.
- Use of command:
  The command has an immediate effect.
- Note on the command:
  The command is available only with version WRB: 0.1.8.6 and successive versions. The command has no effect on toolings created with previous versions of the package, unless all of the stops to be automatically repositioned have been associated.

11.7 Main menu: Panel

The following are the commands grouped under the item “Panel” on the menu bar, in form of pull-down menu. This menu does not have tool boxes (Fig. 11.30).

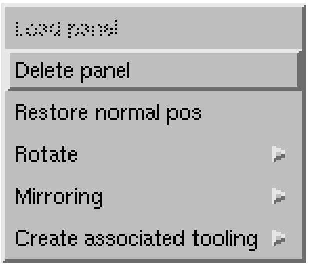


Figure 11.30: Pull-down menu for “Panel”

◇ Load panel

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “C”. With pull-down menu: select “Panel” and “Load panel”.
- Purpose of command:
  Adds a panel to the current tooling, positioning it on the active origin.
- Use of command:
  The command has immediate effect.

◇ Delete panel

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “E”. With pull-down menu: select “Panel” and “Delete panel”.
- Purpose of command:
  Deletes the panel positioned on the active origin.
- Use of command:
  Before deleting the panel, you have to confirm the operation.

◇ Normal Position

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “N”. With pull-down menu: select “Panel” and “Normal position”.
- Purpose of command:
  Immediately cancels all rotation, flip, or mirror operations applied to the panel on the active origin.
- Use of command:
  The command has immediate effect.

◇ Secondary menu: Rotate

- Ways to activate secondary menu:
  With keyboard: press “Alt” + “P” + “R”. With pull-down menu: select “Panel” and “Rotate”. The following are the commands grouped under the item “Rotate” on the menu bar, in form of pull-down menu. This menu does not have tool boxes.

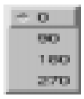


Figure 11.31: Pull-down menu for “Rotate”

◇ ◇ *0 degrees*

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “R” + “0”. With pull-down menu: select “Panel”, “Rotate” and “0”.
- Purpose of command:
  Cancels all rotations applied to the panel positioned on the active origin.

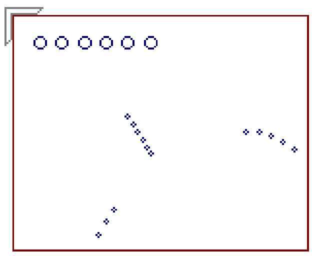


Figure 11.32: Panel in normal position

- Use of command:
  The command has immediate effect.
- Note on the command:
  All panel rotations are clockwise with respect to the origin.

◇ ◇ *90 degrees*

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “R” + “9”. With pull-down menu: select “Panel”, “Rotate” and “90”.

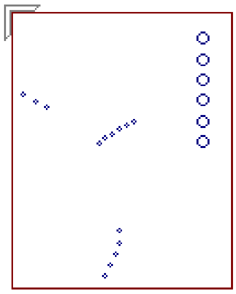


Figure 11.33: Panel rotated $90°$

- Purpose of command:
  Rotates the panel positioned on the active origin $90°$.
- Use of command:
  The command has immediate effect.
- Note on the command:
  All panel rotations are clockwise with respect to the origin.

◇ ◇ *180 degrees*

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “R” + “1”. With pull-down menu: select “Panel”, “Rotate” and “180”.
- Purpose of command:
  Rotates the panel positioned on the active origin $180°$.

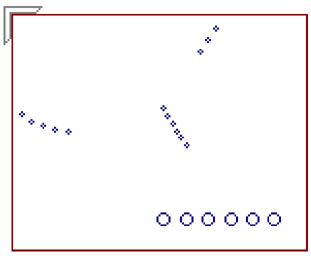


Figure 11.34: Panel rotated $180°$

- Use of command:
  The command has immediate effect.
- Note on the command:
  All panel rotations are clockwise with respect to the origin.

◇ ◇ *270 degrees*

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “R” + “2”. With pull-down menu: select “Panel”, “Rotate” and “270”.
- Purpose of command:
  Rotates the panel positioned on the active origin $270°$.

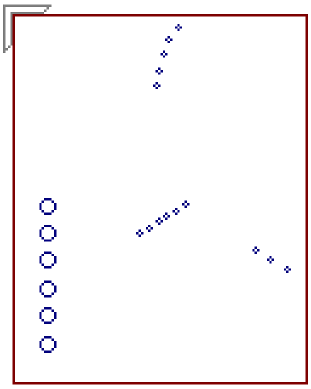


Figure 11.35: Panel rotated $270°$

- Use of command:
  The command has immediate effect.
- Note on the command:
  All panel rotations are clockwise with respect to the origin.

◇ Secondary menu: Mirroring

- Ways to activate secondary menu:
  With keyboard: press “Alt” + “P” + “S”. With pull-down menu: select “Panel” and “Mirroring”. The following are the commands grouped under the term “Mirroring” on the menu bar, in form of pull-down menu. This menu does not have tool boxes.

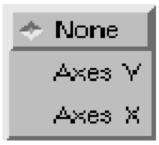


Figure 11.36: Pull-down menu for “Mirroring”

◇ ◇ *None*

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “S” + “None”. With pull-down menu: select “Panel”, “Mirroring” and “No”.
- Purpose of command:
  Cancels all mirroring applied to the panel positioned on the active origin.
- Use of command:
  The command has immediate effect.

◇ ◇ *Axes X*

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “S” + “X”. With pull-down menu: select “Panel”, “Mirroring” and “Axes X”.
- Purpose of command:
  Mirrors the panel positioned on the active origin on its horizontal axis.

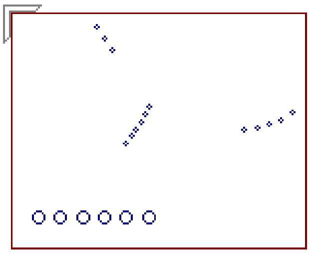


Figure 11.37: Panel mirrored on X axis

- Use of command:
  The command has immediate effect.

◇ ◇ *Axes Y*

- Ways to activate command:
  With keyboard: press “Alt” + “P” + “S” + “Y”. With pull-down menu: select “Panel”, “Mirroring” and “Axes Y”.
- Purpose of command:
  Mirrors the panel positioned on the active origin on its vertical axis.

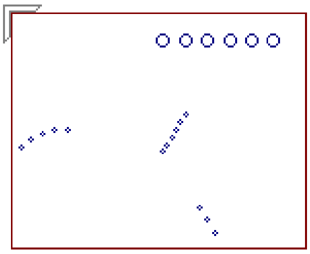


Figure 11.38: Panel mirrored on Y axis

- Use of command:
  The command has immediate effect.

◇ Secondary menu Create associated tooling

- Ways to activate the command:
  with the keyboard: press “Alt” + “P” + “A” with the pull-down menu: select “Panel”, “Create associated tooling”.

Below are listed the commands grouped under the heading “Create associated tooling” on the main menu, in the form of: Pull-down menu. This menu does not have a tool-box

Figure 11.39: Pull-down menu under the heading Create associated tooling

Several premises need to be made to better understand the use of the commands in this menu. Creating an associated tooling means automatically arranging several objects (tables, suctions cups or stops) using previously

arranged objects as the point of reference. In this particular context, the term tooling will not be used to indicate the set of all of the objects installed on the machine, but only those that act as support to a specific panel. Let us suppose, for example, that a panel is loaded on origin 1, and therefore the tables, the suctions cups and the stops that function to support the panel are suitably arranged. The set of tables, suction cups and stops involved in this operation constitute the tooling relative to origin 1. In the final analysis, every panel present on the work surface needs its own tooling. The commands grouped in this menu allow the user to create a translated or symmetric tooling, of a pre-existing tooling relative to a specific origin.
Example 1:
The following figure represents a tooling relative to a panel loaded on origin 1 (Fig. 11.40).

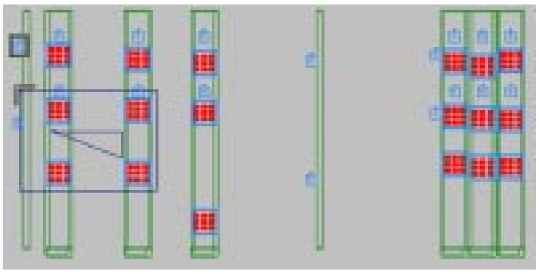


Figure 11.40: Tooling relative to a panel loaded on origin 1.

The following figure represents the tooling “Translated in X” of the tooling relative to origin 1 (Fig. 11.41).

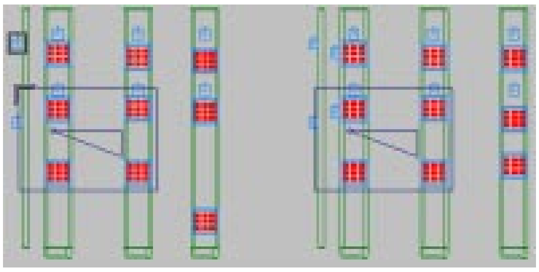


Figure 11.41: Tooling Translated in X of the tooling relative to origin 1.

Example 2:
The figure represents a tooling relative to a panel loaded on origin 1 (Fig. 11.42).

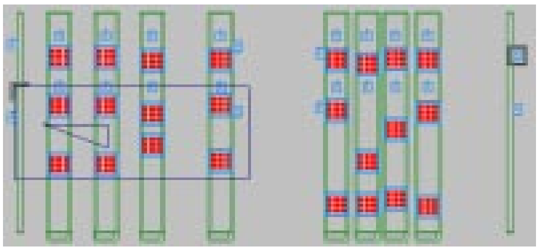


Figure 11.42: Tooling relative to a panel loaded on origin 1.

The following figure represents the tooling “Symmetric in X” of the tooling relative to origin 1 (Fig. 11.43).
To determine the origin on which the associated tooling is to be created, refer to the ORIGINS table of the Machine Data Editor, where, the translated origin (short or long) and the symmetric origin (short or long) is specified for

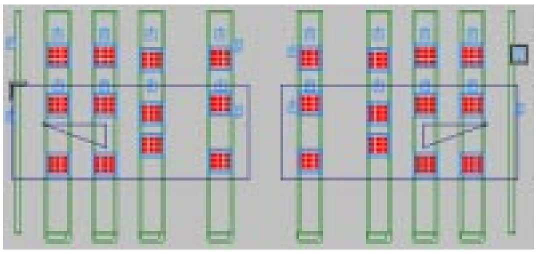


Figure 11.43: Tooling Symmetric in X of the tooling relative to origin 1.

each origin. The choice between the short or long associated origin is made based on the panel size: if the size of the panel exceeds the maximum length for short panels (system table TRANSLATION DATA of the Machine Data Editor) the long associated origin is chosen, in the contrary case, the short one is chosen. The tables and the suctions cups not involved in the associated tooling are moved outside of the panel. The minimum shift from the panel can be specified (system table TRANSLATION DATA of the Machine Data Editor).

◇ ◇ *Translated in X*

- Ways to activate the command:
  with the keyboard: press “Alt” + “P” + “A” + “T”. with the pull-down menu: select “Panel”, “Create associated tooling” and “Translated in X”
- Purpose of the command:
  By using the panel loaded on the active origin as a reference, to load a second panel on the translated origin and to try to arrange the tables on the second panel in the same way as the tables are arranged on the panel loaded on the active origin.
- To ensure the correct function of the command, check that:
  there exists al least one stop in X associated to the active origin on which the panel is loaded the translated origins (long and short) relative to the active origin are specified in the ORIGINS table (Machine Data Editor) the maximum length of the short panel is specified in the TRANSLATION DATA system table (Machine Data Editor) there exists at least one stop in X associated to the translated origin The choice of the associated origin on which the second panel will be loaded depends on the panel length: if the length of the first panel exceeds the maximum length of the short panel (TRANSLATION DATA system table), the long translated origin will be chosen, in the contrary case, the short translated origin will be chosen.
- Use of command:
  The command has an immediate effect.
- Note on the command:
  The command is only available with version WRB: 0.1.8.6. and successive versions. The command may have an undesired outcome if the placement of the mobile tables is not suitable for the type of tooling that is to be created. For example, if the available space for the construction of the associated tooling is not sufficient to contain all of the necessary tables, some overlapping of the tables will probably occur. Furthermore, the corresponding tables in the first and second tooling must have the same dimensions. Otherwise, some overlapping of the tables may occur.

◇ ◇ *Symmetric in X*

- Ways to activate the command:
  with the keyboard: press “Alt” + “P” + “A” + “S”. with the pull-down menu: select “Panel”, “Create associated tooling” and “Symmetric in X”
- Purpose of the command:
  By using the panel loaded on the active origin as reference, to load a second panel on the symmetric origin

and to try to arrange the tables on the second panel in symmetry to those on the panel loaded on the active origin.

- To ensure the correct function of the command, check that:
there exists al least one stop in X associated to the active origin where the panel is loaded the symmetric origins (long and short) relative to the active origin are specified in the ORIGINS table (Machine Data Editor) the maximum length of the short panel is specified in the TRANSLATION DATA system table (Machine Data Editor) there exists at least one stop in X associated to the translated origin The choice of the associated origin on which the second panel will be loaded depends on the panel length: if the length of the first panel exceeds the maximum length of the short panel (TRANSLATION DATA system table), the long symmetric origin will be chosen, in the contrary case, the short symmetric origin will be chosen.

- Use of command:
The command has an immediate effect.

- Note on the command:
The command is only available with version WRB: 0.1.8.6. and successive versions. The command may have an undesired outcome if the placement of the mobile tables is not suitable for the type of tooling to be created. For example, if the number of mobile tables available is not sufficient for constructing the tooling relative to the panel loaded on the symmetric origin, some tables relative to the first tooling may be used to complete the second tooling, thus compromising the final outcome of the entire operation. In this case, it is better to exit the program without saving, or reread the original tooling. Furthermore, the corresponding tables in the first and second tooling must have the same dimensions. Otherwise, some overlapping of the tables may occur.

11.8 Main menu: Origins

The following are the commands grouped under the item “Origins” on the menu bar, in the form of pull-down menu. This menu does not have tool boxes (Fig. 11.44).

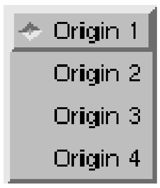


Figure 11.44: Pull-down menu for Origins

◇ Origins 1..16

- Ways to activate command:
With keyboard: press “Alt” + “R” + “1..16”. With pull-down menu: select “Origins” and “Origin 1..16”.

- Purpose of command:
Activates origin number 1..16.

- Use of command:
The command has immediate effect. The active origin is displayed by means of a right angle (Fig. 11.45). The inner corner of the right angle coincides with the position of the origin.

- Note on the command:
Once an origin is defined as the active origin, all panel insertion, rotation, flip, or deletion operations will relate to that origin. The number and position of the origins in the work area relate to the type of machine being used (see Reading of origins data in the appendix).

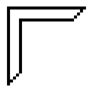


Figure 11.45: Right angle showing active origin

11.9 Creating a drawing of an object

Objects making up tooling are represented by means of individual drawings in D.X.F. format. By using a graphics editor that is able to read and save in D.X.F. format, you may create drawings of objects and use them with this package. To do this, the following instructions must be followed:
Divide the drawing into 3 layers:

DRAW layer contains all of the entities that describe the object. A few objects are shown in the following figure: 11.46, 11.47, 11.48.

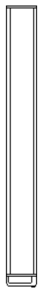


Figure 11.46: Bench

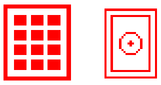


Figure 11.47: Cups

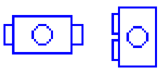


Figure 11.48: Backstops

EXT layer contains a rectangle (created with lines or multiple lines) that defines the external dimensions of the object. External dimensions means the smallest rectangle that can contain the object, or all the entities of the DRAW layer.

INT layer contains a rectangle (created with lines or multiple lines) that defines the internal dimensions of the object.

The internal dimensions of an object are used differently according to the type of object: They are used in the drawing of the machine to define x and y limits for bench movements. In the drawing of the bench, they define an area in the bench used for insertion and movement of cups (Fig. 11.49).

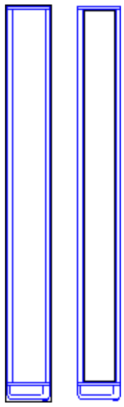


Figure 11.49: External and internal dimensions of the bench

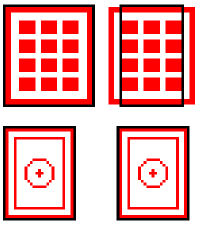


Figure 11.50: External and internal dimensions of some types of cups

They are used in the drawing of the cup to define the useful dimensions for insertion of the cup on the bench. They usually coincide with external dimensions, and must not exceed the internal dimensions of the bench (Fig. 11.50). In the drawing of the backstop, they coincide with the square around the inner cylinder used as reference for linking a backstop to an origin (Fig. 11.51).

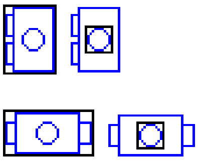


Figure 11.51: External and internal dimensions of some types of backstops

The entities pertaining to the EXT and INT layers are not displayed in the representation of objects. If blocks have been used to create the drawing, the drawing will have to be exploded into single entities before exporting it to D.X.F. format.

11.10 Glossary of technical terms

Tooling means the group of objects that make up the structure of the work bench. Generally, a tooling is composed of two fixed benches that define the limits of the work bench, plus a series of mobile benches, each of which has a certain number of cups and backstops. For a complete description of the tooling organisation phase, see Creating a tooling file in the general section dedicated to the use of the Rover Tooling System package.

Special tools are mechanical supports that are attached to the sides of a bench and facilitate positioning of the panel on the work bench. In this program, special tools are not considered independent objects, but rather simple auxiliary supports for the benches. A bench may be fitted with special tools by means of the Special Toolings command on the Configure menu.

Backstops These are mechanical supports, attached directly to the machine or inside or outside the benches, used to define the position of the work piece.

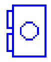


Figure 11.52: External backstop

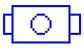


Figure 11.53: Internal backstop

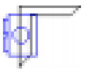


Figure 11.54: Backstop linked to origin

Linking a backstop on X (or on Y) to an origin, is the equivalent of inserting or repositioning the backstop at the same X (or Y) position as the origin. The bench on which the backstop is assembled is repositioned with it. Linking a backstop on X (or on Y) to an origin blocks the movement of the backstop on X (or on Y), as well as of the bench on which it is assembled. Linking is permitted within the limits imposed by the presence of other objects on the work bench.

C.A.D. 3 Graphics format in the package of the same name, used to store drawings.

Category means a class of objects, or a group of objects having the same characteristics and used for the same purpose. Therefore, objects have been divided into the following categories:

1. BENCHES (Fig. 11.15)
2. CUPS (Fig. 11.16)
3. BACKSTOPS (Fig. 11.17)

The Machine object is in its own class.

Active category The "Active category " is the category to which the active object belongs.

D.X.F. Draw eXchange Format between different C.A.D. or C.A.M. packages. Every C.A.D./C.A.M. system is structured to manage drawings by means of one or more storage formats for geometric and technical data. There are a number of standard formats used to exchange drawings between different softwares: D.X.F. (used by Autocad) is definitely one of the most popular.

Machine Defines the work area and acts as reference for tooling configuration. The machine is the first object to be loaded, and configuration of the graphics area is based on it.

Movement All objects except the machine may be moved in two directions (X and Y) on the work bench. Movement in X or in Y refers to an objects ability to be moved in direction X or Y, respectively. The movements of an object may be turned on or off with the Movements command on the Configuration menu.

Objects The term "objects" refers generically to one of the following elements available to configure tooling:

1. machine,
2. bench,
3. cup,
4. backstop.

In the Rover Tooling System package, objects are stored as drawings in DXF format. For a complete description of the tooling organisation phase, see Creating a tooling file in the general section dedicated to the use of the program.

Active object The "active object" is the object to which all positionings, insertion, changing, deletion, and movement operations on the work bench refer. The object is highlighted graphically by means of a double border.

Origin The "origin" is a reference position for insertion of the panel. Different origins are defined for each machine. One panel may be loaded on each origin. The "active origin" is the current origin, selected by means of the Origins 1..16 command on the Origins menu, to which all panel insertion, rotation, flip, or deletion operations refer. The active origin is highlighted by means of a right angle. The inner corner of the right angle coincides with the position of the origin. Right angle highlighting active origin (Fig. 11.45).

Panel A "panel" is generally a piece of wood, a sheet of glass, marble, plastic, aluminium, or any other parallelepipedon-shaped material to be worked. But this does not exclude the possibility of working rough pieces in a wide variety of shapes. For a complete description of the operations used for panel insertion and their positioning in the work area, see Configuring a tooling file in the general section dedicated to the use of the Rover Tooling System package.

Mobile benches Metal supports composed of a pair of parallel plates, used to bear the panels. Cups may be positioned inside a mobile bench, while backstops may be positioned both inside and outside the bench. There are also so-called fixed benches or halfbenches composed of only one plate. Generally, fixed benches are locked in both the X and Y direction, and are used to limit the work area (Fig. 11.46).

Cups Mechanical supports positioned in the benches, used to secure the panel to mobile benches. There are different types of supports included in the cups category (Fig. 11.56 e Fig. 11.55).

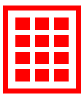


Figure 11.55: Cups

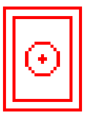


Figure 11.56: Cups

12 A.P. Technical data

12.1 Introduction

The `A.P. Technical Data` allows the following operations to be performed:

1. Display, modify, save Machine and Tooling data;
2. Print out the Tables of the various categories of defined data (print parameters can be personalised);
3. Enable the existing spindles and magazine tool-holders (facilitating manual tool change);
4. Display the set of available drawings (which can be associated to the tools, aggregates, etc.);
5. Change the password level for access to machine data and functions.

The `A.P. Technical Data` is iconised when the XNC is turned on. To display it, click with the left mouse button on the icon shown in Fig. 12.1.

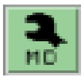


Figure 12.1: Icon for Technical Data A.P.

Once deiconized, `Technical Data` is displayed as in Figure 12.2.

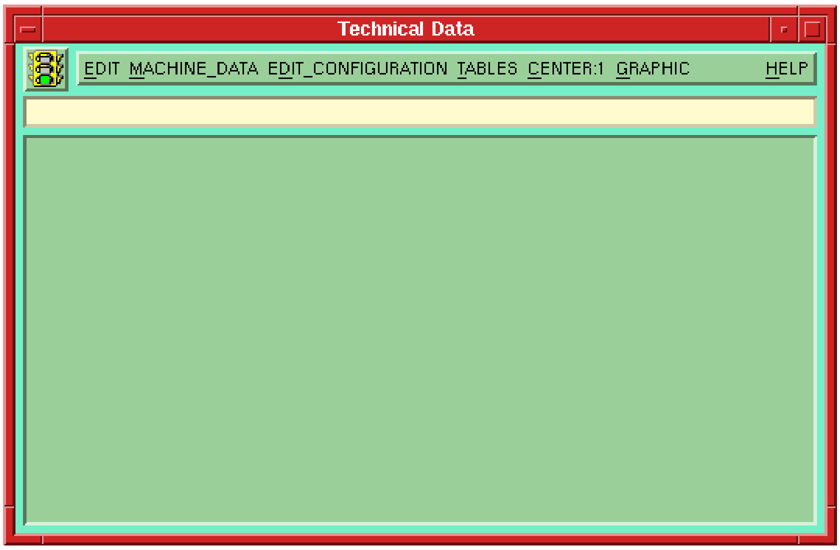


Figure 12.2: Technical Data A.P.

The following options are available on the Menu Bar:

- EDIT
- MACHINE_DATA
- TOOLING
- TABLES

- CENTER
- GRAPHIC
- HELP

These options will be explained in detail in the following sections.
To the upper left of the `A.P. Technical Data` there is an icon representing a traffic light. When the traffic light is green, the technical data can be changed; when the traffic light is red, data modification is not permitted. For example, data cannot be modified when the machine is in START; in this case the traffic light icon is red.

12.2 Edit

With access to this function, you may save changes made to data managed by the `Technical Data A.P.`, restore data changed but not yet saved, and change the level of access to such data. It is also possible to enable the print function, display graphic files containing the drawings of the tools, the aggregates, the heads, etc., and enable some editor functions (for example, the possibility to copy or cancel a line from a table).
To access the editor functions, deiconise the `A.P. Technical Data` and use the mouse to select the EDIT option. A menu with the following options will be displayed:

- SAVE (ˆs): saves data entered. The message WAIT!!! appears during saving.
- RELOAD TABLE (ˆt): cancels all changes made (after last save) to data on table displayed and restores old values. The message WAIT!!! appears during rereading.
- RELOAD ALL (ˆu): cancels all changes made (after last save) to all tables and restores old values. The message WAIT!!! appears during rereading.
- RENAME: when active, it changes the name of the selected object.
- COPY: when active, makes a copy of the selected object.
- DELETE: when active, deletes the selected object.
- TABLE PRINT : this option si enabled only when a table is displayed; prints the entire table of data displayed. The procedure for printing a table is described below:
  - Choose the option `Select Printer` from the sub-menu `Maintenance` of the Root Menu. The window displayed on the screen contains the `A.P. Printer Setup` used to set the type of printer as described in Section 2.5.6).
  - Press the option TABLE PRINT of the EDIT menu of the `A.P. Technical Data`.
  - If a print to file has been selected, a window is displayed where the user must enter the name of the file to which the print data will be sent. If a printer has been selected, the data is sent directly to the printer.
- PRINT JOB SELECTION : allows the print out of the tables which correspond to the various XNC data categories. When this option is selected the window in Fig. 12.3 is displayed.

  As shown, the software buttons available make it possibile to choose one or more data categories to be printed. When the Print software button is pressed, the tables which correspond to the various data categories selected are printed out. When the Exit software button is pressed, the window is closed and all the selections are cancelled. The ADVANCED software button is used to access another window used to choose the printed page format. In the boxes PAGE HEIGHT and PAGE WIDTH of this window, the printed page dimensions can be entered in mm. With the sofware buttons A4, A3, B5 the user can set the printed page dimensions to: 297x210 mm., 421x298 mm., 257x182 mm. rispectively.
- LIST OF DRAWINGS : opens a window containing a list of the graphic files which correspond to the drawings for the available tools, aggregates, heads, etc (Fig. 12.4).

  As seen in the figure, the drawing is displayed in the box next to the selected file that contains it. Use the option SORTING, from the window Menu Bar, to sort the various graphic files by name or by date.

Figure 12.3: Window dedicated to the selection of the data category to be printed

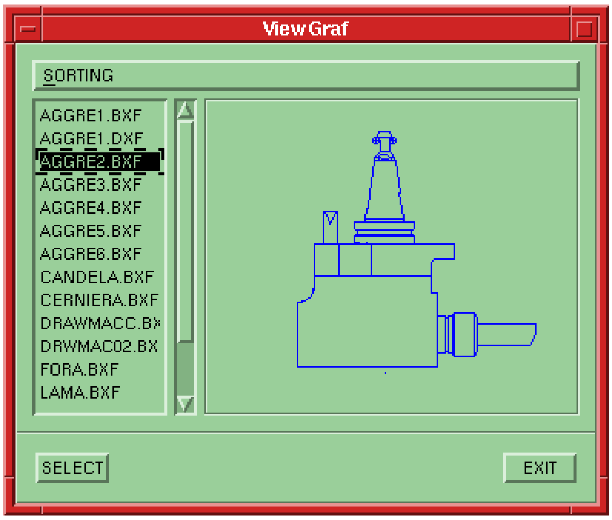


Figure 12.4: Window dedicated to displaying the graphic files.

With the SELECT software button, one of the memorised drawings can be associated to a specific tool or aggregate data. To do so, select the Connected drawing data which corresponds to one of the tools or aggregates present in the TOOLS or AGGREGATES tables in the TOOLINGTables. Now, select the graphic file containing the desired drawing. Finally, press the SELECT software button.

- PASSWORD : changes the access level to data tables and to other functions managed by the `Technical Data A.P.` Clicking on this term opens a window similar to the one in Figure 12.5.
  The level for display and change of data is shown at the side of the message “Level”; in the case of Figure 12.5 it is 1.
  To change such level, you must:
  - write the sequence of numbers and letters making up the password for the level desired in the data entry box,
  - click on Ok.

  Clicking on Cancel restores the previous level. There are 16 levels available.
- EXIT: closes the Technical Data menu window. If any data has been changed, the user is asked if the changes are to be saved or not.

Figure 12.5: Change level of access to data

12.3 Machine_data

Machine data are the variables to be assigned to Numerical Control, thus making it capable of "controlling" electric and mechanical parts of machine.
In this chapter all kinds of machine data together with their functioning will be described; examples on specific data will be made in order to make their meaning clearer.
Always take into account that values entered into machine data must be the result of precise and carefully-considered evaluations instead of sudden intuitions or uncertain tests, as a wrong compilation of these values can affect technical and safety features of the machine.

MACHINE DATA MUST BE MODIFIED BY SKILLED PERSONNEL ONLY.

The menu accessed by selecting MACHINE_DATA contains the following functions:

- AXES
- VERTICAL SPINDLE CONTROL
- HORIZONTAL SPINDLE CONTROL
- ROUTER SPINDLE CONTROL
- HEADS
- GENERIC
- ORIGINS
- TOOL CARRIER FOR TOOL CHANGE

12.3.1 Axes

CN can manage two classes of axes:

- Interpolating Axes
- Positioning Axes

Interpolating Axes are those whose movement is immediately correlated with at least another axe; they allow processing of curvilinear profiles in plane and space always following the programmed trajectory .
Positioning Axes are those whose movement is not correlated with other axes; they allow point to point movements without checking the trajectory.
The described information refers to both types of axes mentioned.
By selecting AXES you can enter the tables where all the data concerning machine mechanical axes are. The table is similar to the one in Figure 12.6.

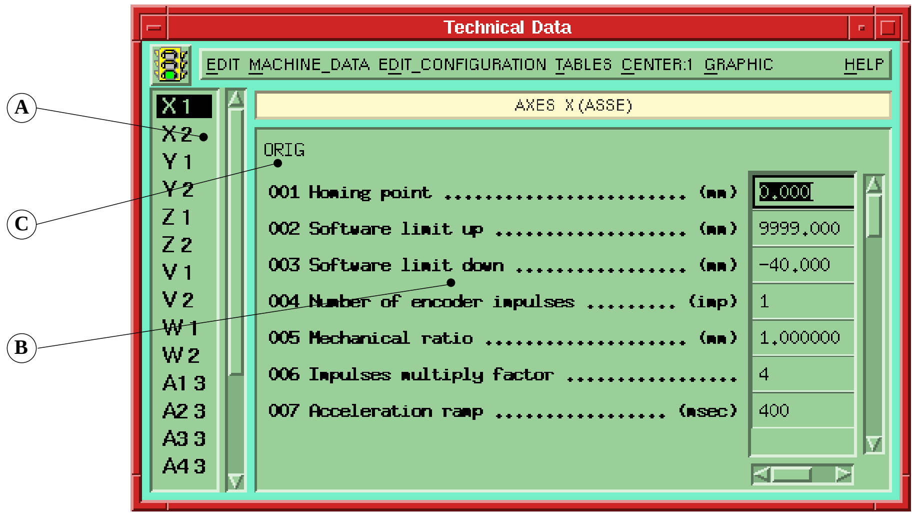


Figure 12.6: AXES Table

A list of machine axes is displayed on the left (Fig. 12.6-A) together with a list of data and values referred to them. (Fig. 12.6-B). Each piece of information displayed has its own initials displayed at the upper left (Fig. 12.6-C). These initials appear only if a high level of password has been entered and they serve as software reference for CNI. The axis, whose data are displayed, is highlighted on a dark background; click on it with mouse. to select another one.
It is possible to display and/or modify one of the data by using vertical and horizontal shifting bars or mouse.

ATTENTION! The units of measure for numerous data depend on the type of axis, which can be linear or angular. For example, the unit of measurement of the Park position data is expressed in mm if the axis is linear and in sexagesimal degrees if the axis is angular. In the following descriptions, it is presumed that the axes are linear.

001 Homing point (mm)

With reference to Fig. 12.7, it is possible to define the Homing point point as the distance between the machine zero (M) and the reference point (A). This point represents the position of the mobile reference system (T) when the resetting signal is given.

For example: during a standard resetting with limit switch normally open (a.n) and marker, the axis moves along resetting direction until it closes the resetting microswitch; then it moves towards the opposite direction until it releases the microswitch. Now the resetting signal is represented by the first marker of the encoder and the Homing point point value is assigned to the axis.

In this situation the axis value represents the position of the mobile reference system origin compared to the fixed reference system (M).

If, after a first resetting, the displayed value does not coincide with the measured one, it is necessary to modify the Homing point point and repeat the reset procedure. The difference between displayed and measured value must be subtracted from the machine Homing point, always considering its sign.

$$Onew = Oold - (Qv - Qm) \tag{12.1}$$

where:

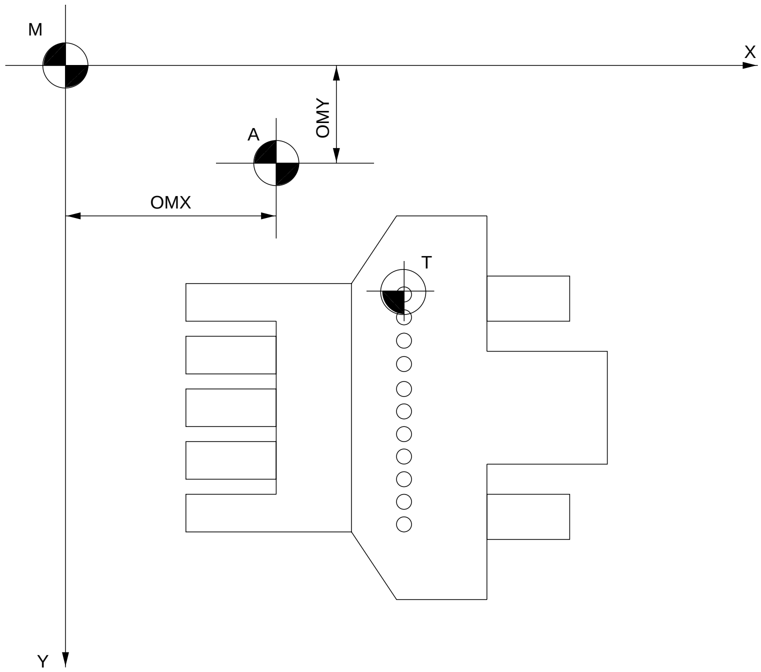


Figure 12.7: Machine Origin

- Onew is the New homing point,
- Oold is the Old homing point,
- Qv is the displayed value,
- Qm is the measured value.

The direction of the search for the microswitch depends on the flag setting Up homing in Table AXES belonging to the Machine Tables. If this flag is set to 0, the search direction of the microswitch is chosen according to: Software limit up, Software limit down and Homing point. The axis searches for the microswitch among decreasing values if Homing point point is closer to down software limit switch than to up software limit switch and vice versa.
If this flag Up homing is set to 1, the search direction of the microswitch is towards increasing co-ordinates.
Typical value: in the field of machine physical dimensions.

002 Software limit up (mm)

It is the software upper limit to the axis moving capability.
If, when interpolating, the software stop limit is reached, NC blocks all the motors controlling the axes and displays an "error" message; in this case limit switch can be exceeded because of the inertia of axes themselves.
When axes are manually moved, the software limit up can never be exceeded; at the most it can be exactly reached by means of a deceleration ramp.
Limit switch value refers to homing point and is not affected by any corrector (spindles, tools, etc.)
Typical value: in the field of machine physical dimensions.

003 Software limit down (mm)

It is the software lower limit to the axis moving capability.
This is analogous to the Software limit up point.
Typical value: in the field of machine physical dimensions.

004 Number of encoder impulses

It is the electric transmission ratio of the axis, i.e. the pulses number of a complete encoder rev.
A possible hardware multiplication inside CN is not considered.
Negative values are admitted so as to invert encoder counting direction.
Typical value: depending on encoder type.

005 Mechanical ratio (mm)

It is the mechanical transmission ratio of the axis, i.e. the distance corresponding to an encoder rev.
Typical value: it depends on the mechanical Transmission, on the Reducer, on the Slide, etc.

006 Impulses multiply factor

It is the hardware multiplying factor of the pulses, inside CN
Values higher than 1 do not guarantee pulses equidistance.
Admitted values: 1 and 4.

007 Acceleration ramp (msec)

It is the time required to bring an axis from initial speed to operating speed and from operating speed to final speed during independent movements (G0 mode).
In this way, axis acceleration is determined by the ratio between speed difference and set ramp time.
If required acceleration exceeds the maximum acceleration allowed, ramp time is automatically increased. For example, if you want to accelerate from zero speed to a speed of 100 m/min, once a constant acceleration of 300 msec has been set for the given axes, you will have an acceleration equivalent to:

$$\frac{100}{60 \cdot 0.3} = 5.55 \, \frac{m}{sec^2} \tag{12.2}$$

Typical value: $200 \div 400$ msec.

008 Maximum speed (m/min)

It sets maximum axis speed when drive is controlled by NC with cealing voltage (10 V).
Typical value: it depends on machine mechanics and on the motor type.

009 Jog high speed (m/min)

It assigns speed value for displacements carried out manually at rapid speed.
Typical value: it depends on machine mechanics and must be $<$ Vmax.

010 Jog low speed (m/min)

It assigns speed value for displacements carried out manually at low speed.
Typical value: it depends on machine mechanics and must be $<$ Vmax.

011 M.D.I speed (m/min)

It assigns speed value for displacements carried out in valued movement steps.
Typical value: it depends on machine mechanics and must be $<$ Vmax.

012 M.D.I. Step (mm)

Displacement value for valued movement.
Typical value: in the field of machine physical dimensions.

013 Max acceleration (m/sec*sec)

It is the maximum acceleration by means of which an axis can accelerate depending on load inertia and motor drive.
One way to estimate this datum is to count time axis takes to accelerate from a still position to the maximum speed, providing the drive with the ceiling voltage:

$$Amax = \frac{Vmax}{T} \tag{12.3}$$

where:

- Amax is the maximum acceleration,
- Vmax is the maximum speed,
- T is time taken.

For example, if an axis takes 400 mseconds to reach a maximum speed of 100 m/minute, its maximum acceleration will be:

$$\frac{100}{60 \cdot 0.4} = 4.16\ \frac{m}{sec^2} \tag{12.4}$$

Typical value: $2 \div 10 \frac{m}{sec^2}$.

014 Ring gain (KV) (1/sec)

It can also be called regulator ring Gain or Proportional Constant and defines feedback Gain of position regulator.
During positioning there is always a deviation of real value (Qr) from theoretical one (Qt), defined as tracking error (Ei):

$$Ei = (Qt - Qr) \tag{12.5}$$

Tracking error depends on axis speed and is inversely proportional to the ring gain.
Analogic output voltage is calculated by multiplying KV by the tracking error.
Too large ring gains may cause instability to the system.
If KV is equal to 0, axis can not move; if it is too low, trajectories may be beveled.
Negative values are allowed to invert output analogic voltage.
It is important to stress the fact that NC internally employs the following convention: KV and voltages being positive, axis moves among increasing values.
Typical value: $20 \div 30$ 1/sec.
By means of a valid calibration of Maximum speed (Vmax) and Ring gain (KV), it is possible to get the best precision in linear and circular interpolation.
As Maximun Speed gives NC the information about the characteristic voltage/speed of the axis, (drive + motor + mechanical transmission), its value must be as precise as possible, in order to get a tracking error (EI) equivalent to the theoretical one (EIt) provided for by the regulation rule:

$$EIt = \frac{VL}{KV} \tag{12.6}$$

Where VL is working speed.
If the tracking error is different from the one provided for in the previous relation, it is necessary to modify the Maximum speed proportionally:

$$Vmax' = Vmax\frac{EIt}{EI} \tag{12.7}$$

Now, set equal gains on the interpolating axes to get the smallest trajectory errors, according to machine characteristics. Trajectory error will be zero on rectilinear parts and minimum on circular parts. Approximate expression of the error on circular parts is as follows:

$$\Delta\_\epsilon = \frac{D}{2}\left\{\frac{1-[2\ F^2\ (1-\frac{2\ KV}{2\ \pi\ fT})]}{D\ (KV)^2}\right\} \tag{12.8}$$

where equation symbols have the following meaning:

- D: arc diameter of covered circumference (mm)
- F: feed speed (mm/sec)
- KV: ring gain (1/sec)
- fT: system pass-band (1/sec)

For example, with D=100 mm, F=100 mm/sec, KV=30, fT=11, it is possible to get a theoretical maximum error of about 0.03 mm.

015 In position for posit. (mm)

It is the advance with which a positioning is considered ended for program development. However, axis is taken on to the target.
Typical value: $0.5 \div 1$ (mm).

016 In position for interp. (mm)

It is also called: "positioned axis in case of interpolation". It is analogous to the previous one.
It is employed only for interpolation instructions.
Typical value : $0.1 \div 1$ (mm) .

017 Max tracking error (mm)

It assigns the limit value of tracking error (EImax). If, during an independent movement (G0) this value is exceeded, NC displays an error and stops the axis. If such value is exceeded during interpolation phase NC stops all the interpolating axes.
Typical value: it is obtained from other parameters previously set.
The following relation must always be tested:

$$EImax > \frac{Vmax}{KV} \tag{12.9}$$

018 Drive passband (1/sec)

It is also called drive Pole: it coincides with the pass-band of electromechanic system.
It is employed when Feed-Forward Type is 2.
It determines correction gain in acceleration feed-forward.
Axis pass-band value can be calculated by applying to the drive a sinusoidal reference signal and by determining by which frequency the signal of motor tachymetric dynamo is 45 degrees late compared to speed reference.
typical values:

- $50 \div 100$ with feed-forward Type=2
- not significant with feed-forward Type=1
- not significant with feed-forward Type=0

019 Homing speed (m/min)

Axis speed during searching phase of the resetting micro.
Micro releasing speed and marker search is automatically calculated so as to have a fixed counting frequency of encoder pulses.
Typical value: $<$ Vmax .

020 Max position speed (m/min)

Speed Maximum value in positioning.
This value must be lower than at least $5 \div 10$ % at the maximum speed so as to guarantee a regulation reserve.
Typical value : $90 \div 95\%$ Vmax .

021 Max interp. speed (m/min)

Speed maximum value in interpolation.
The minimum value is selected among the axes involved in the interpolation.
Typical value: maximum speed of tool feed.

022 Park position (mm)

Parking or rest value of the axis.
Such value can be recalled inside a processing program by means of "PRK" parameter.
Typical value: in the field of machine physical dimensions.

023 1st cam position (mm)

Electronic cam value.
Information is provided if axis is at a lower or higher value in relation to the cam value.
Typical value: in the field of machine size.

024 2nd cam position (mm)

Provided for electronic cam.
Typical value: in the field of machine physical dimensions.

025 3rd cam position (mm)

Provided for electronic cam.
Typical value: in the field of machine physical dimensions.

026 4th cam position (mm)

Provided for electronic cam.
Typical value: in the field of machine physical dimensions.

027 1st derivative time (msec)

See Natural frequency.

028 2nd derivative time (msec)

See Natural frequency.

029 Damping ratio

See Natural frequency

030 Natural frequency (1/sec)

The previous four data activate a dynamic regulator for axis control. A dynamic regulator can modify axis characteristics therefore improving its performance in relation to couple oscillation and disturbances. The dynamic regulator can belong to one of the three categories defined in the regulator Type whose allowed values are:

- 0: Proportional regulator (no pole); in this case none of the previous four data is examined.
- 1: Proportional-derivative regulator (one zero and no poles); in this case only the data of the first time constant is monitored.
- 2: Second order regulator with infinite poles (2 zeros); in this case only the data of the two time constants of the regulator are monitored.
- 3: Second order regulator with finite poles (2 zeros and 2 poles); in this case all four data of the regulator are monitored.

Typical values: they are empirically determined during NC installation when in phase of machine calibration.

031 Max interp. angular speed (grd/sec)

By means of it, it is possible to modify maximum angular speed allowed during the phase of circular interpolation. When it is equal to zero, maximun angular speed is calculated depending on sampling time:

$$VAmax = \frac{2.86}{tc} \tag{12.10}$$

where:

- VAmax is the interp. Maximum angular speed,
- tc is sampling time.

Typical value: it is empirically determined on the basis of the processing quality of circular parts.

032 Ramp type

It is a number defining acceleration ramp time of an axis.
The values admitted are the following:

- 0: it activates a linear ramp; acceleration value is costant.
- 1: it activates a sinusoidal ramp; speed profile is sinusoidal and guarantees continuity to acceleration even in initial and final points of the ramp. Ramp time being equal, sinusoidal ramp implies a maximum acceleration by 57% higher than the one of linear ramp.
- 2: it activates an S-shaped ramp; speed profile guarantees continuity to acceleration even in the initial and final points of the ramp. Ramp time being equal, sinusoidal ramp implies a maximum acceleration by 20% higher than the one of linear ramp.

033 Homing type

Gives NC information about resetting time preset on the machine.
Values admitted define:

- 0: standard resetting with limit switch normally open (n.o.) and marker. The value is assigned when the encoder marker is met.
- 4: resetting with limit switch normally closed (n.c.) and marker. The value is assigned when the encoder marker is met.
- 16: resetting only with the limit switch (n.o.). The value is assigned when releasing the micro.
- 20: resetting only with limit switch (n.c.). The value is assigned when releasing the micro.

034 Regulator type

It defines the type of dynamic regulator which will be used for axis control.
Possible Values define:

- 0: Proportional regulator (no pole).
- 1: Derivative-proportional regulator (one only zero and no pole); only the 1st time constant is examined.
- 2: Second order regulator with infinite poles (2 zeros); the data of the two time constants are monitored.
- 3: Second order regulator with finite poles (2 zeros and 2 poles); all four data of the regulator are monitored.

035 Feed-Forward type

The "feed-forward" type correction is entered to reduce tracking error.
Values belonging to the interval [0,1], or value 2 can be assigned.

- 2: Correction "in speed and acceleration": tracking error is eliminated even in parts with non-constant speed.
- 2: 100% correction in speed and acceleration correction. Tracking error is eliminated even in the parts where speed is not constant.

For example, if a value of 0 is set, no forward correction is made; by setting a value of 0.5 the tracking error is diminished by one half in the parts with constant speed; by setting a value of 1 tracking error is eliminated in the parts with constant speed.

060 Backlash compensation (mm)

Eliminates uncertainty on axis positioning caused by mechanical coupling between the lead nut and the screw. When a position has been programmed, depending on the direction of axis movement, the lead nut may rest on the screw at a different point due the tolerance with which they have been constructed. This error can be eliminated by making sure that the lead nut always rests on the screw at the same point in both directions of axis movement. Fig. 12.8 and Fig. 12.9 show the graphs of the positioning speed in the proximity of the target co-ordinates. In the case shown in Fig. 12.8, a direct positioning is observed; instead, Fig. 12.9 shows that the target co-ordinates have been passed, the axis stopped, a change in movement direction, and finally, positioning. The second case is referred to as play recovery.

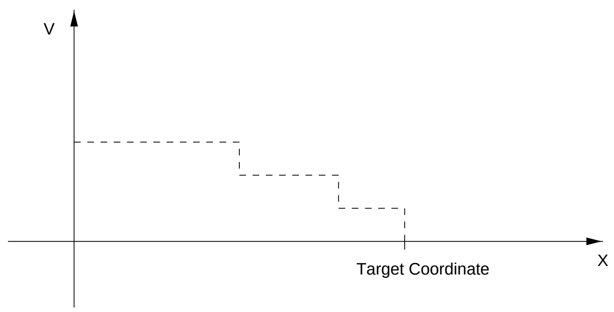


Figure 12.8: Direct positioning

The distance between the co-ordinates of the eventual change in direction and the target co-ordinates is called play recovery.
The following values can be set:

- 0 excludes the play recovery mechanism during axis positioning,
- a positive value in mm leads to play recovery in the direction of increasing co-ordinates,

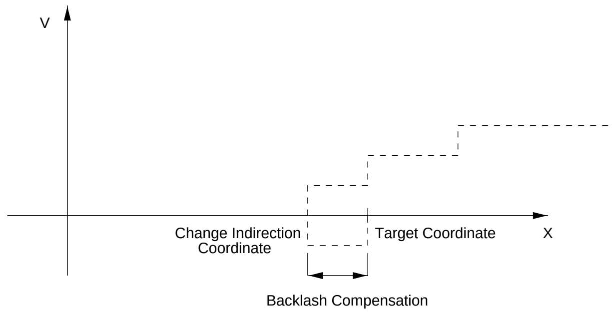


Figure 12.9: Backlash compensation

- a negative value in mm leads to play recovery in the direction of decreasing co-ordinates. In Fig. 12.9 the play recovery takes place towards decreasing co-ordinates, which means that the value entered is negative.

061 Integrative constant (msec)

It is the data defining the value of the supplementary constant for the control in retro-action.

062 Derivative constant (msec)

The data which defines the value of the constant derived from the control in retro-action.

063 Timeout alarm (msec)

Assigns the time interval after which an alarm sounds signalling "blocked axis" of the control in retro-action.

064 Ascent ramp time (msec)

Length of the ascent ramp.

065 Descent ramp time (msec)

Length of the descent ramp.

070 Starting tension (mVolt)

Voltage applied to the drive to start the movement of the axis.

071 Minimum mov. tension (mVolt)

Minimum voltage applied to the drive to allow the motor to move.

076 Auxiliary ring gain (1/sec)

Additional parameter of the control of the axis in retro-action.

077 Maximum value for slide (mm)

Indicates the maximum slide value in mm that can be recovered with point correction. Should this value be exceed, the program is blocked and signals a tracking error on the X1 axis (metric wheel).

078 AD converter resolution AD

It is a detection hardware feature used for axes with analogue position sensors (ADX2 card), (number of available bits). For example: with the ADX2 card, the converter is 12 bit and therefore the resolution is 4096.

079 Transducer length (mm)

A detection hardware feature used for axes with analogue position sensors (ADX2 card).

080 Enabling of metric wheel

If this value is set at 0 the slide recovery mechanisms are disabled and the metric wheel encoder is not used.

081 ip Filter

Indicates the number of consecutive scans during which the axis must remain in the *in position* before the positioning is declared complete.

082 Continuous activation

The value used to select the type of slide recovery.

- 0 sets point recovery.
- 1 sets continuous recovery.

083 Initial correction phase

Indicates the initial phase of continuous correction.

- 1 sets the entire positioning in continuous correction,
- 2 sets the beginning of the correction in the section at maximum operating speed,
- 3 sets the beginning of the correction in the section in deceleration.

090 Electronic handwheel pitch

Defines the "pace" of an axis controlled by a hand wheel. The set value is the movement executed by the axis in correspondence to a complete turn of the hand wheel.

091 Roll-over axis module

The maximum height that a "rollover" axis can reach before returning to 0. The "rollover" axis can be defined by means of flag Rotation 360, or Circumferential axis. Both of these flags are contained in Table AXES found in the MACHINE Tables.

094 Interpolation acceleration ramp time (msec)

The time the axis takes to reach the maximum operating speed starting from the initial speed, and therefore the final speed in the course of interpolated movements (modes `G1`, `G2`, ...).
In this way, the axis acceleration is determined by the proportion between the difference in speed and the set ramp time.
If the requested acceleration exceeds the maximum speed allowed, the ramp time is automatically increased. For example, to accelerate from 0 to 100 mt/min, having set an acceleration constant of 300 msec in the axis data, the acceleration obtained is equal to:

$$\frac{100}{60 \cdot 0.3} = 5.55\ \frac{m}{sec^2} \tag{12.11}$$

All interpolating axes must not necessarily have the same ramp speed, because in the interpolation phase, the NC chooses the greatest value from those of the axes in movement. If a value of 0 is set, the NC uses the Acceleration ramp value. Typical value: $200 \div 400$ msec.

12.3.2 Vertical spindle control

For a description of the option VERTICAL SPINDLE CONTROL, refer to Section 12.3.4.

12.3.3 Horizontal spindle control

For a description of the option HORIZONTAL SPINDLE CONTROL, refer to Section 12.3.4.

12.3.4 Router spindle control

The word *correctors* refers to all the data defining working position and the characteristics of a spindle fit on a specific head in relation to a reference point of head itself.
Since the vertical and horizontal spindle correctors are a subgroup of the pantograph spindle correctors, this section will describe the correctors for this last type of spindle only.

Terminology

It is useful to specify the meaning of some terms which will be used later on.

- Rotation centre: it is a fixed point in space according to which all the possible spindle rotations are considered.
- Power takeoff: it is the coupling point of the tool on the spindle.
- Cartesian reference tern: it is the set of cartesian axes X Y Z according to which distances among coordinates of different points in space are calculated.

By selecting ROUTER SPINDLE CONTROL, you can have access to a table similar to the one in Figure 12.10.

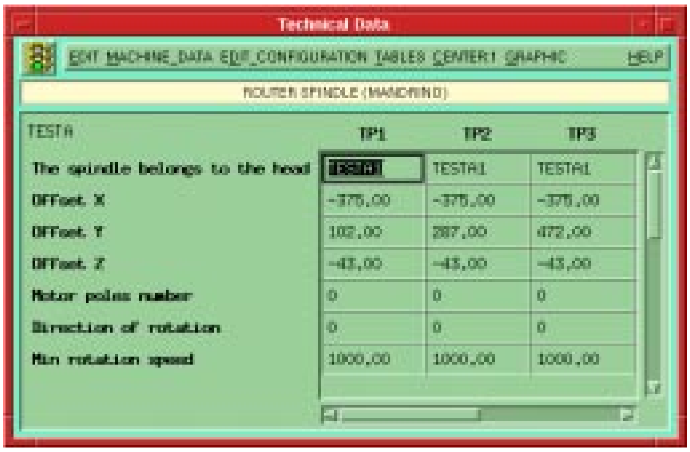


Figure 12.10: ROUTER SPINDLE CONTROL Table

As you can see, table is organized in the form of a matrix, each column identifies the data set for each spindle.
For example: column TP2 contains all of the data for the spindle identified by code TP2.
Each line of the matrix identifies one possible corrector.
To display and/or modify one of the data use shifting bars and mouse.

The spindle belongs to the head

Name of the head on which the spindle is installed.

Offset X (mm)

Component along X of the spindle mechanical centre distance in relation to the spindle with zero correctors.

Offset Y (mm)

Component along Y of spindle mechanical centre distance in relation to the spindle with zero correctors.

Offset Z (mm)

Jut of pantograph spindle centre distance in relation to the first vertical spindle.

Motor poles number

It specifies the poles of the motor employed in spindle rotation. These are the possible admitted values:

- 0 identifies a 2 pole motor
- 1 identifies a 4 pole motor

Direction of rotation

It is the spindle rotation direction when no tool has been fit. These are the possible admitted values:

- 0 refers to either a left-hand or a right-hand (without distinction) direction
- 1 refers to a right-hand direction
- 2 refers to a left-right direction
- 3 refers to an inverted right-hand direction
- 4 refers to an inverted left-hand direction

See the section regarding the setting of rotation directions for spindles, aggregates, and tools.

Min rotation speed (m/min)

It is the minimun spindle rotation speed.
When an aggregate is fit on the spindle , (i.e. a set of tools working simultaneously), this datum is not active and is replaced by the analogous one of the Pantograph Aggregate table.

Max rot speed (m/min)

It is the maximum spindle rotation speed. When an aggregate is fit on the spindle , (i.e. a set of tools which work simultaneously), this datum is not active and is replaced by the analogous one of the Pantograph Aggregate table

Acceleration ramp (sec)

It is the time necessary to have the motor reach the programmed speed.
Such datum is active only in serial link with the inverter.

Deceleration ramp (sec)

It is the time motor necessary to have the motor stop.
Such datum is active only in the serial link with the inverter.

Absorbation of motor

It assigns, in percentage, the maximun limit of spindle current absorption in relation to the to the current supplying capability of the inverter.
If the assigned value is 100 the inverter will command the spindle with the maximum current it is capable to supply; a lower value will limit pantograph spindle absorption protecting it from a possible overcurrent.

Base speed of inverter (m/min)

Sometimes it is referred to as HB; it assigns frequency value by which the inverter output voltage reaches the maximun level, as specified in Max voltage (remaining constant for higher frequencies). Figure 12.11 shows the diagram of a possible inverter response curve on which Base speed of inverter is dispayed.

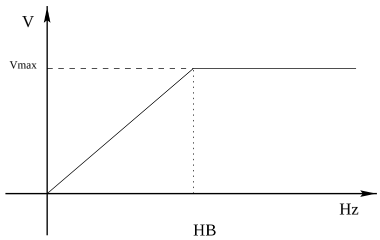


Figure 12.11: Inverter response Curve

The performance of the inverter response curve is linear; it is increasing for frequencies between 0 and Hb, constant for higher frequencies. To get this kind of performance it is necessary to set HB1=HB2=0

Inverter number

It displays the spindle controlling inverter. These are the possible admitted values:

- 0 refers to the first inverter
- 1 refers to the second inverter
- 2 refers to the third inverter
- 3 refers to the fourth inverter
- 4 refers to the fifth inverter
- 5 refers to the sixth inverter
- 99 means that the inverter number will be transmitted to NC by the PLC after the inverter command through an exchange signals bit CN - PLC.

Max voltage (V)

It is the voltage value provided by the inverter for frequency values higher than or equal to Base speed of inverter.

Horizontal angle (grd)

It is the angle that lies in the plane XY between the axis X and the projection of the straight-line identifying spindle working direction in the same plane. The maximum allowed values are contained in the range [0, 360] degrees.

Vertical angle (grd)

Assuming that the Main Plane coincides with XY plane, it assigns the angle made by the straight-line identifying spindle working direction with its projection on the XY plane.

HB1 , HB2 (1/sec)

Secondary basic speed.
It defines a frequency spacing [HB1, HB2] such that a suitable value of HB is calculated for each value of frequency. Figure 12.12 refers to a possible inverter response curve on which HB1 e HB2 data are displayed.

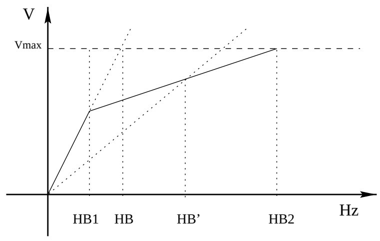


Figure 12.12: Inverter response curve

The setting of the data relative to the direction of rotation of the spindles, aggregates and tools

In order to correctly set a tool in rotation, you need to be aware of the chain of elements that makes it move. Generally, this chain may be described as follows: the NC acts on the inverter driving the motor which rotates the spindle on which the tool is fit. If an aggregate is fit on the spindle, the spindle will rotate the various subspindles of the aggregate on which the tools are fit.
The directions of rotation of all elements of the chain must be congruent in order to prevent mechanical problems; in other words, an element of the chain that rotates only to the right must not be connected to an element of the chain that rotates only to the left. The following classifications can be defined.

Classification of spindles according to direction of rotation

R Spindle: a spindle that can rotate from left to right only.

L Spindle: a spindle that can rotate from right to left only.

Indifferent Spindle: a spindle that can rotate both right to left and left to right.

Reverse R Spindle: a spindle that rotates to the left but, because of a series of gears, rotates the tool to the right.

Reverse L Spindle: a spindle that is caused to rotate to the right but, because of a series of gears, rotates the tool to the left.

Classification of aggregates according to direction of rotation

R Aggregate: an aggregate that rotates from left to right and rotates its subspindles from left to right.

L Aggregate: an aggregate that rotates from right to left and rotates its subspindles from right to left.

Indifferent aggregate: an aggregate that can rotate both left to right and right to left. The subspindles will rotate in the same direction as the aggregate.

Reverse Indifferent Aggregate: an aggregate that can rotate in both directions but reverses the rotation of its subspindles.

Reverse R Aggregate: an aggregate that rotates to the left but, because of a series of gears, rotates its subspindles to the right.

Reverse L Aggregate: an aggregate that rotates to the right but, because of a series of gears, rotates its subspindles to the left.

Classification of tools according to direction of rotation

R tool: a tool that can rotate from left to right only.

L tool: a tool that can rotate from right to left only.

Indifferent tool: a tool that can rotate both right to left and left to right.

The following tables give the various possible associations among spindle, aggregate and tool based on their direction of rotation and the command that the NC sends to the inverter so that it may correctly drive the motor.

With tool fit on spindle

Spindle on which a tool is mounted.

Spindle	Tool	Command to the inverter
Indiff.	Indiff.	rotation RH
Indiff.	RH	rotation RH
Indiff.	LH	rotation LH
RH	Indiff.	rotation RH
LH	Indiff.	rotation LH
RH INV	Indiff.	rotation LH
LH INV	Indiff.	rotation RH
RH INV	RH	rotation LH
LH INV	LH	rotation RH
RH	LH	ERROR
LH	RH	ERROR
RH INV	LH	ERROR
LH INV	RH	ERROR

With aggregate fit on spindle

In the case where the rotation direction of the aggregate is not important, the rules of the illustrated case apply. Tab. 12.1.
If an aggregate is fit on the spindle, the spindle may no longer have reverse R or reverse L rotation.

Aggregate mounted on a spindle.

Spindle	Aggregate	Tool	Command to the inverter
Indiff.	Indiff.	Indiff.	rotation RH
Indiff.	DX	Indiff.	rotation RH
Indiff.	SX	Indiff.	rotation LH
Indiff.	INV	Indiff.	rotation LH
Indiff.	INV	Indiff.	rotation RH
Indiff.	INV	Indiff.	rotation LH
DX	DX	Indiff.	rotation RH
DX	DX INV	Indiff.	ERROR
SX	SX	Indiff.	rotation LH
SX	SX INV	Indiff.	ERROR
DX	Indiff. INV	Indiff.	rotation RH
SX	Indiff. INV	Indiff.	rotation LH
Indiff.	Indiff.	DX	rotation RH
Indiff.	DX	DX	rotation RH
Indiff.	SX	DX	ERROR
Indiff.	DX INV	DX	rotation LH
Indiff.	SX INV	DX	ERROR
Indiff.	Indiff. INV	DX	rotation LH
DX	DX	DX	rotation RH
DX	DX INV	DX	ERROR
SX	SX	DX	ERROR
SX	SX INV	DX	ERROR
DX	Indiff. INV	DX	ERROR
SX	Indiff. INV	DX	rotation LH
Indiff.	Indiff.	SX	rotation LH
Indiff.	DX	SX	ERROR
Indiff.	SX	SX	rotation LH
Indiff.	DX INV	SX	ERROR
Indiff.	SX INV	SX	rotation RH
Indiff.	Indiff. INV	SX	rotation RH
DX	DX	SX	ERROR
DX	DX INV	SX	ERROR
SX	SX	SX	rotation LH
SX	SX INV	SX	ERROR
DX	Indiff. INV	SX	rotation RH
SX	Indiff. INV	SX	ERROR
DX	SX		ERROR
SX	DX		ERROR
DX	SX INV	SX	rotation RH
SX	DX INV	DX	rotation LH

◇ legend:

- indiff.= indifferent
- DX = RH
- SX = LH
- DX INV = reverse RH
- SX INV = reverse LH

12.3.5 Heads

By selecting HEADS a table similar to the one in Figure 12.13 can be accessed.

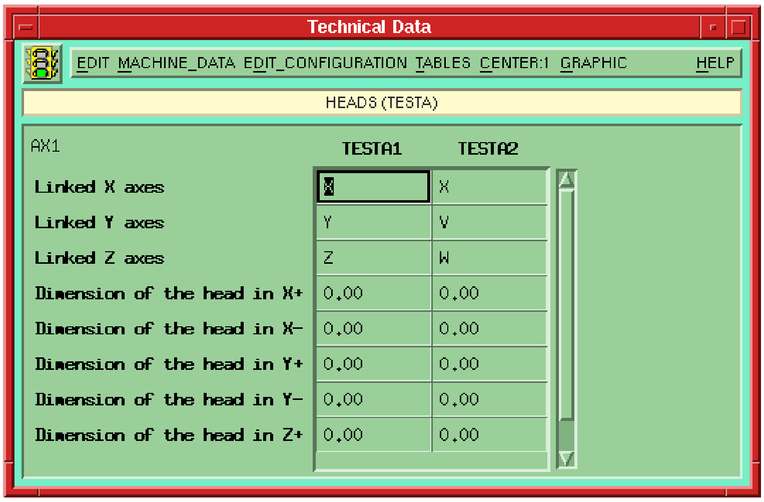


Figure 12.13: HEADS Table

The table is arranged in the form of a matrix, with each column identifying the set of data for each head.
For example: column TESTA1 contains all the data concerning the head identified by the code TESTA1.
Dimension data along X+, X-, Y+, Y-, Z+, Z- directions are used by NC to solve, if possible, all interference troubles among heads when processing. + and - signs, after X,Y,Z, locate the orientation of direction, in fact:

- + refers to the direction of increasing values,
- - refers to the direction of decreasing values.

Linked X axes

The code of the axis connected to the head along X direction.

Linked Y axes

The code of the axis connected to the head along Y direction.

Linked Z axes

The code of the axis connected to head along Z direction

◇ **Heads Data programming example** Here are some useful examples to explain these data and their usage.

◇ ◇ **Example 1** Assume we have a single-centre machine equipped with two integrated heads in x, z and independent in y (Figure 12.14).

The axes connected to HEAD 1 are X, Y, Z, the axes connected to HEAD 2 are X, U, Z; axes Y and U are parallel. Be M1 and M2 the reference spindles of the two heads. Call the distance between M1 and the edge of T1 head along y direction among increasing values MB1, and the distance between M2 and the edge of HEAD2 along y direction among increasing values MB2.
In order to avoid a collision between the two heads owing to a programming error, it is necessary that the distance

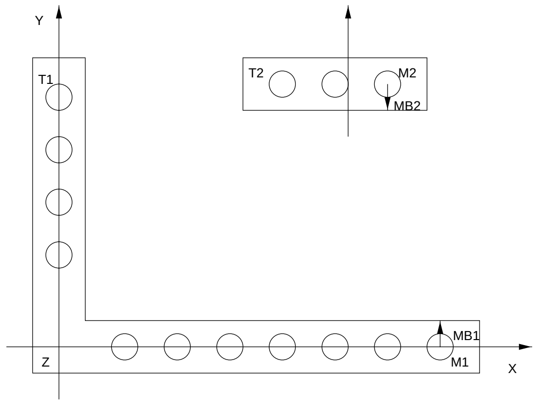


Figure 12.14: Example 1

between the respective reference spindles is always higher than the sum of distances between the reference spindles and the head edges along the direction where the contact may occur. In other words the following inequation must always be tested:

$$d(M1, M2) > MB1 + MB2 \tag{12.12}$$

By carefully programming the head dimension data it is possible to have the NC check that the given condition is valid during processing.
In this case it is necessary to entry in the head definition table the value MB1 in the Y+ Dimension of HEAD 1 and MB2 in the Y- Dimension of HEAD 2. NC checks the interference only when the Y+ Dimension of HEAD1 and the Y- Dimension of HEAD 2 are different from 0.

◇ ◇ **Example 2** Assume we have a two-centre machine, each with one head only.
Call the working centres C1 and C2 and their own heads HEAD 1 and HEAD 2.
Assume that HEAD1 is connected to axes X1, Y1, Z1, and HEAD 2 to axes X2, Y2, Z2.
Be all the axes independent, but X1 and X2 share the same screw (Figure 12.15).

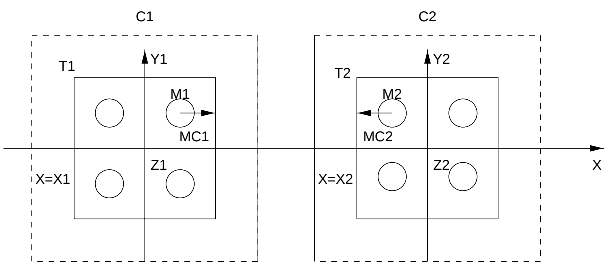


Figure 12.15: Example 2

Be M1 and M2 the reference spindles of the two heads. Call the distance between M1 and the edge of HEAD 1 along X direction among increasing values MC1 and the distance between M2 and the edge of HEAD 2 along x direction among decreasing values MC2.
In order to avoid a collision between the two heads owing to a programming error, it is necessary that the distance between the respective reference spindles is always higher than the sum of distances between the reference spindles and the head edges along the direction where they may touch
. In other words the following inequation must always be tested:

$$d(M1, M2) > MC1 + MC2 \tag{12.13}$$

By carefully programming the head dimension data, it is possible to have the NC control if given condition is valid during processing.
In this case it is necessary to set in the centre 1 head definition table the value MC1 in the X+ Dimension of HEAD 1 and MC2 in the X- Dimension of HEAD 2 in the centre 2 head definition table.

Dimension of the head in X+

Head mechanical space dimension in X+ direction.

Dimension of the head in X-

Head mechanical space dimension in X- direction.

Dimension of the head in Y+

Head mechanical space dimension in Z- direction

Dimension of the head in Y-

Head mechanical space dimension in Y- direction .

Dimension of the head in Z+

Head mechanical space dimension in Z+ direction

Dimension of the head in Z-

Head mechanical space dimension in Z- direction

12.3.6 Generic

By selecting GENERIC a table similar to the one in Figure 12.16 can be accessed.

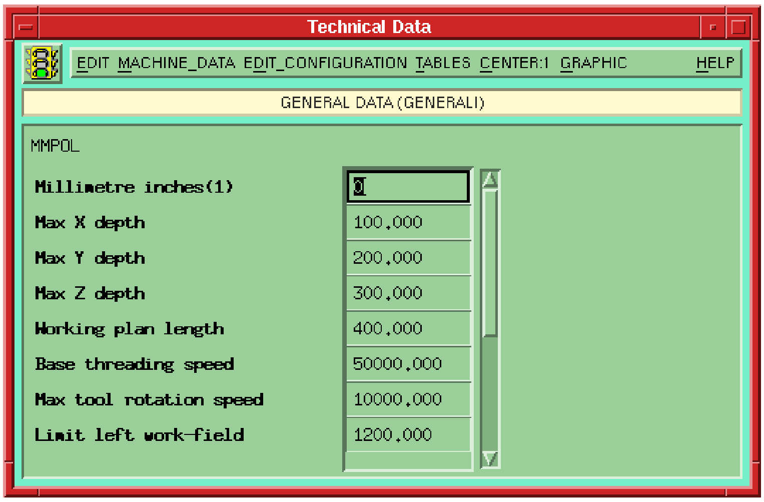


Figure 12.16: General Data Table

To display and/modify data use vertical and horizontal shifting bars or mouse.

Millimetre inches(1)

It assigns length unit of measurement
When starting the NC sets millimeters as unit of measurement if this datum has been given value 0, with value 1 the unit of measurement is inch.

Max X depth (mm)

The user may employ this datum to define the maximum drilling depth to perform when processing in the direction of X axis.

Max Y depth (mm)

The user may employ this datum to define the maximum drilling depth to perform when processing in the direction of Y axis.

Max Z depth (mm)

The user may employ this datum to define the maximum drilling depth to perform when processing in the direction of Z axis.

Working plan length (mm)

It refers to length of machine working area. It is the sum of left and right machine working areas.

Base threading speed (m/min)

It assigns the maximum rotation speed value for tools operating the workpiece thread.
Not used at the moment.

Limit left work-field

It assigns the left limit of the electronic cam.

Limit right work-field

It assigns the right limit of the electronic cam.

Max tool rotation speed (m/min)

It assigns the maximum value of rotation speed value for tools.

Trans. rate pusher

It is the divisor of Panel height stated in the execution program.

Metric line origin X

It is the offset along X with respect to 0 on the metric line. The metric line is a metric reference onboard the machine.

Metric line origin Y

It is the offset along Y with respect to 0 on the metric line.

Consecutive step ceiling toll.

This data refers to the angle formed by the straight lines tangent to the end point and starting point of two consecutive steps. If the angle between the tangents exceeds this data the steps are considered not tangent. This means that the NC will stop the axes in G47 mode. If the angle is less than this data, the steps are considered tangent. This means that the NC will continue the programmed trajectory in G46 mode.
For further information, consult the *Programming Reference* section of this manual.

Interp. Radius toll.

It is the maximum acceptable distance between the initial radius and the final radius of an arc having its circumference programmed in G2 or G3 mode.
For further information, consult the *Programming Reference* section of this manual.

12.3.7 Origins

The data shown in the ORIGINS table allow to:

- perform the same kind of processing from any point of the working table by using one only program, with no need to modify
- speculate a processing.

Every time a program is run it is necessary to set a reference point according to which it is possible to program axes movements, i.e. the origin of axes co-ordinates system. This point is generally the Homing point.
If you want the processing to be independent from the origin of axes co-ordinate system, it is necessary to provide the program with parameters, or modify the instructions on the origin, for each different processing. To modify or provide program parameters might not be convenient; sometimes it might be better to use Origin Data adequately.
Now we are going to describe all the different situations in the processing, considering for example the spatial direction X; the following instructions refer to the other spatial directions.

◇ **Non-specular processing without translation** Refer to Figure 12.17.

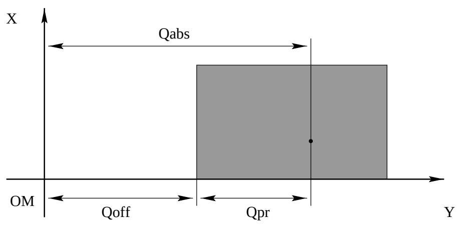


Figure 12.17: Processing with Offset Origin

By indicating:

- OM Homing point,
- Qpr programmed value,
- Qoff origin displacement value,
- Qabs real value in which axis is positioned during processing.

the following relation is valid:

$$Qass = Qoff + Qpr \tag{12.14}$$

◇ **Specular processing without translation** Refer to Figure 12.18.
the following relation is valid:

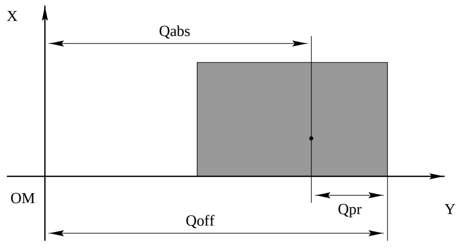


Figure 12.18: Specular processing with Offset Origin

$$Qabs = Qoff - Qpr \tag{12.15}$$

◇ **Specular processing with translation** Refer to Figure 12.19.
the following relation is valid:

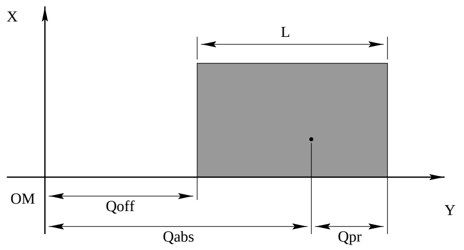


Figure 12.19: Specular processing with Offset Origin and Translation

$$Qabs = Qoff + L - Qpr \tag{12.16}$$

◇ **Non-specular processing with translation** Refer to Figure 12.20.
the following relation is valid :

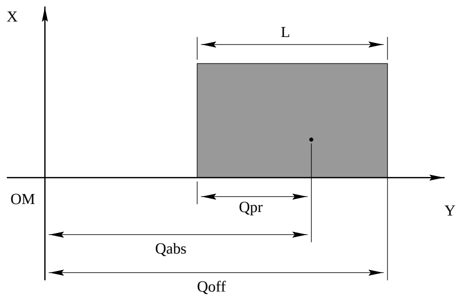


Figure 12.20: Non-specular processing with offset Origin and Translation

$$Qabs = Qoff - L + Qpr \tag{12.17}$$

By selecting Homing point a table similar to the one in Figure 12.21 can be accessed.

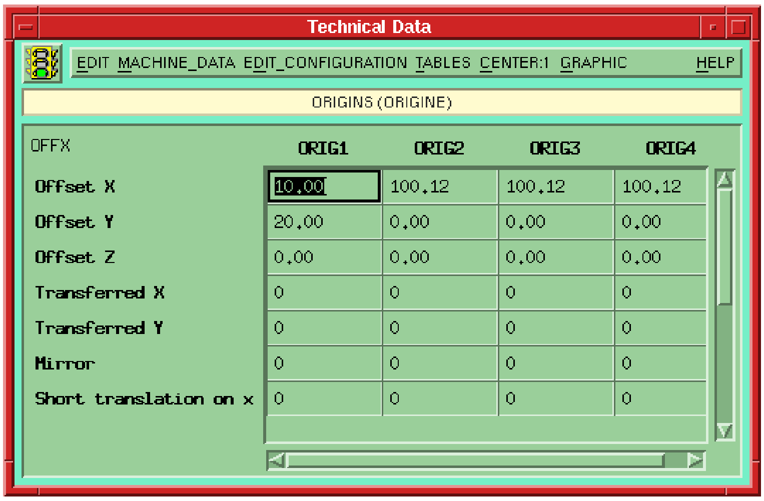


Figure 12.21: ORIGINS Table

To display and/or modify data use vertical and horizontal shifting bars and mouse.

Offset X , Offset Y , Offset Z

Offset data are values definying the distance between the Origin point, according to which processing is going to be carried out, and Homing point.
Each datum refers to the corresponding spatial direction.

Transferred X , Transferred Y , Mirror , Short translation on x , Long translation on x , Short symmetry on x , Long symmetry on x , Short translation on y , Long translation on y , Short symmetry on y , Long symmetry on y

These data define both a further translation to be added algebrically to that obtained from offset data, which is equal to the length of panel to be processed, and the processing specularization.
These data are employed by PLC, therefore all the numerical values entered must be defined by the PLC operator.

NC management of Origins Data

At the beginning of a program execution, the PLC transmits to the NC the number connected to the origin from which the program itself must berun. (16 different origins are available). Then, the NC can have access to the table concerning the origin set and it reads its Offset data. Once the PLC has given the NC the number of the active origin, it transmits information about the kind of processing to be executed; thus, the NC enables a correction of the programmed values, as already explained in the previous paragraph.
The PLC arranges the kind of processing "independently" or according to what has been specified in X Translata, ... and Specular. Since only PLC can interpret such data, the values to be assigned to data are arranged by the PLC programmers.

12.3.8 Tool carrier for tool change

The XNC can manage two types of tool cribs:

- Fixed,
- Revolver.

For an explanation on what the two types of tool cribs are, see the Section 13.8.
The information collected in the TOOL CARRIER FOR TOOL CHANGE table (Fig. 12.22) is used to define all the tool compartments of all the installed cribs.
The table is in matrix format. The columns of the table are associated to the compartments present. The number above each column is the absolute ordinal number of the various compartments.

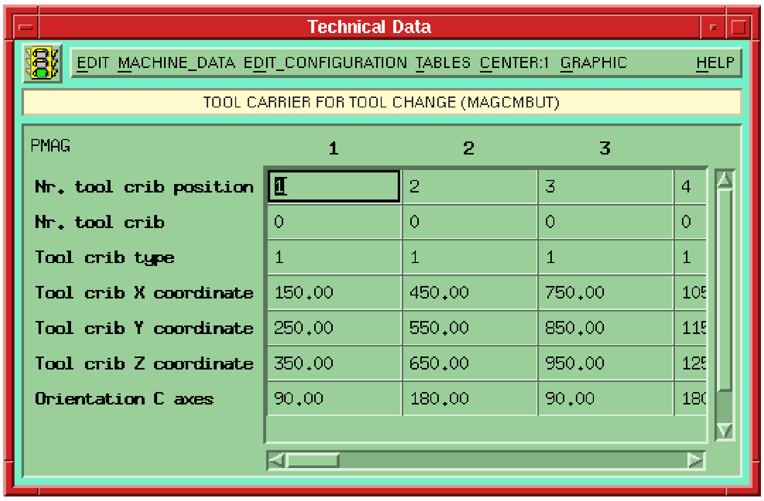


Figure 12.22: TOOL CARRIER FOR TOOL CHANGE

Nr. tool crib position

This data indexes the compartments of the tool crib identified by Nr. tool crib.

Nr. tool crib

This data identifies the tool crib to which the tool compartment belongs.

Tool crib type

This data identifies the type of tool crib to which the tool compartment belongs. The permitted values are:

- 1 "Fixed" tool crib,
- 2 "Revolver" tool crib.

Tool crib X coordinate

The coordinate X of the tool crib compartment.

Tool crib Y coordinate

The coordinate Y of the tool crib compartment.

Tool crib Z coordinate

The coordinate Z of the tool crib compartment.

Orientation C axes

The angle for the collection and deposit of the tool into the compartment.

Spindles off

This data specifies the incompatibility that can occur between tools and spindles such that these tools are not unloaded in the tool crib compartment.

12.4 Tooling

The tables accessed by selecting TOOLING on the `Technical Data A.P.` menu bar contain all of the data for the machine tools magazine and their association with the spindles or aggregates on which they may be fit.

Since the same set of tools may be used in different ways according to the type of work to be done, the concept of tool configuration may be introduced.

Tool configuration means a particular association among tools, aggregates, and spindles, chosen from all those possible. It is useful to store a certain number of configurations whenever a variety of operations must be performed which require different use of available tools. In this case, instead of setting new tool data, one may call up one of the stored tool configurations. Deiconize the `Technical Data A.P.` and click with the mouse on TOOLING, or press the Alt and “a” keys simultaneously. The Menu accessed by selecting TOOLING contains the following terms:

- CONFIGURATION
- RESET CONF.
- COPY CONF.
- VERTICAL SPINDLE
- HORIZONTAL SPINDLE
- ROUTER SPINDLE
- TOOLS
- AGGREGATES
- DRILLING TYPE
- CHANGE TOOL

12.4.1 Configuration

The CONFIGURATION selection makes available to the NC all information regarding spindles, groups, tools, and associations to be utilised.
15 different configurations may be stored. Obviously, only one may be active at any time.
By selecting CONFIGURATION on the tooling menu, a window similar to that in Fig. 12.23 will appear.

In the upper box a number corresponding to the active tooling configuration is displayed; this means that it is possible to make changes in this configuration.
To edit another configuration, type the desired configuration number in the data entry box and press the software key Ok. To modify the “Active equipment ” (that is the one used by the XNC to execute the work), use the corresponding function from the `A.P. QUOTE` (See Section 7.5.1). Therefore, it is important not to confuse the Active equipment with the active configuration.

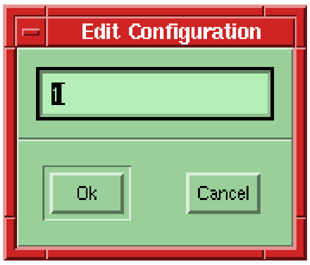


Figure 12.23: Edit Configuration Window

12.4.2 Reset conf.

This option is only active when the VERTICAL SPINDLE, the HORIZONTAL SPINDLE or the ROUTER SPINDLE are selected. By selecting it, the desired configuration is reset. This configuration is selected from the window that appears aver having clicked on RESET CONF..

12.4.3 Copy conf.

The window that appears after having selected this option allows the selection of the configuration that will be copied over the active configuration. This option is also active when the VERTICAL SPINDLE, the HORIZONTAL SPINDLE or the ROUTER SPINDLE are selected.

12.4.4 Vertical spindle

This section describes Vertical Spindle. Horizontal and Routing Spindles follow the same conventions. Selecting VERTICAL SPINDLE gives access to a table similar to that in Figure 12.24.

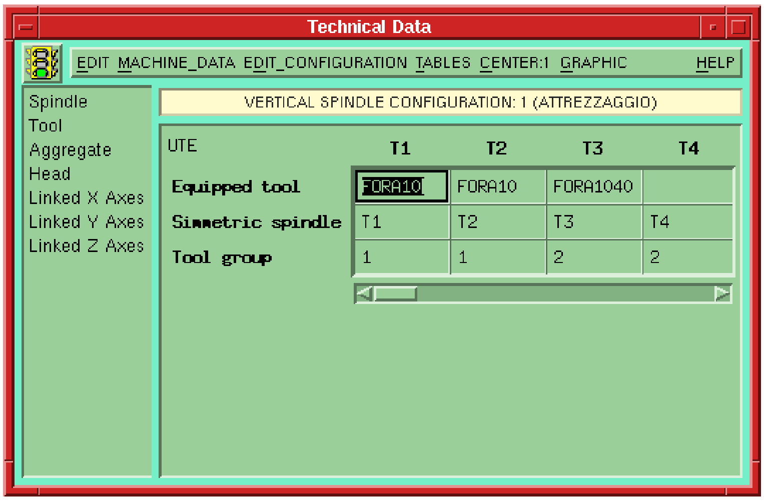


Figure 12.24: VERTICAL SPINDLE CONFIGURATION

As may be seen, the table is organised in the form of a matrix; each column of the matrix identifies the data for the "objects" associated with each spindle.

For example: column T2 contains all of the data for the objects associated with the spindle identified by code T2. The spindle selected is the one in whose column there is a datum displayed in insertion mode. A summary line is printed under the menu bar which gives the name of the active spindle configuration, the active tool configuration number and the type of table selected.
On the left side of the table there is a list of terms: Spindle, Point, etc. clicking on one of these calls up a window containing a list of data for the spindle selected.

1. Spindle
2. Tool
3. Aggregate
4. Head
5. Linked X Axes
6. Linked Y Axes
7. Linked Z Axes

Spindle By clicking on this option, the window shown in Fig. 12.25 appears. As can be seen in Fig. 12.25,

Figure 12.25: Window Spindle

the window contains a column of the data relative to the selected spindle. This data can be modified; press the software key which corresponds to the Ok icon to save the changes made in the data. Instead, by pressing the software key Cancel all of the changes are cancelled. Press the software key Print to print the displayed data. This table, uniting all of the spindles, can also be displayed by choosing the option VERTICAL SPINDLE CONTROL from the MACHINE_DATA menu.

Tool Click on this option to display the window shown in Fig. 12.26. Similar to that described for the option Spindle, the window contains the columns of the data relative to the tools associated to the selected spindle. If the spindle is not associated to any tool, the last column of data displayed appears. This data can be modified; in such case press the Ok software key to save the changes. Instead, press the Cancel to cancel all changes. The following software keys allow to fit or remove tools from the selected spindle.

Equip : associates the selected tool to the selected spindle or spindles.

Unring : cancels the relationship between the selected spindles and the mounted tool.

By means of the Search software key, the data relative to a particular tool may be searched for. To make a search, press the Search key, then type the name of the tool for which data is to be displayed, then press ENTER or the Ok button. If the name of a non existing tool is entered or if the Cancel key is pressed, the window closes without modifying the status of the table displayed.

By means of the software key Print the displayed data can be printed out. This table also appears if the option TOOLS from the TOOLING menu is chosen.

Figure 12.26: Tool Window

Figure 12.27: Aggregate window

Aggregate By pressing this software key, the window shown in Fig. 12.27 appears. The window displays the tables containing the data relative to the machine aggregates. Each column of the table corresponds to a group of data relative to one and only one aggregate: over each column appears an alphanumeric string that identifies the aggregate. The column in the table where the cursor is positioned identifies the selected aggregate. The various software keys associated with the icons have the same meaning of those described for the item Tool. The software key associated with the Spindles icon, instead, opens a window which displays the table showing the data for the sub-spindles belonging to the selected aggregate. The Title Bar of the window displays the name of the selected aggregate. In this new window, besides the usual icons, an icon associated to the option RELOAD TABLE appears; the option is described in Section 12.2. This table also appears if the AGGREGATES option is chosen from the TOOLING menu.

Head It opens a window similar to the one previously described, containing the data for the machine head (Fig. 12.28). This table also appears if the option HEADS is chosen from the MACHINE_DATA menu.

Linked X Axes Press this software key to display the window shown in Fig. 12.29. This window is also similar to those previously described and it is also displayed by selecting the option AXES from the menu MACHINE_DATA by clicking on X.

Linked Y Axes See description for Linked X Axes.

Linked Z Axes See description for Linked X Axes.

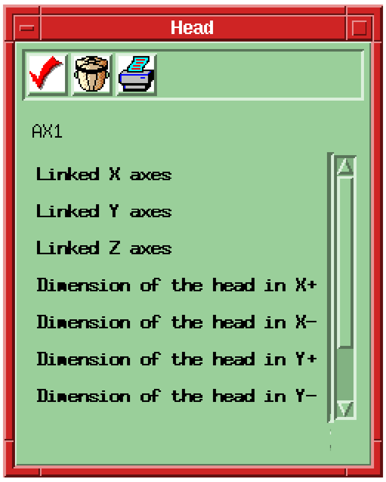


Figure 12.28: Head window

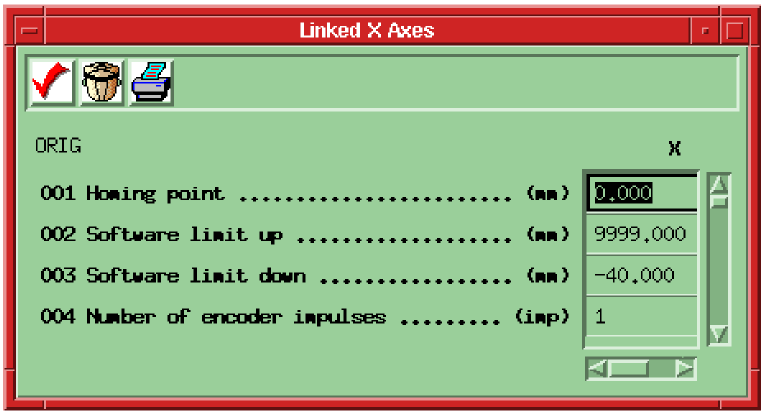


Figure 12.29: Linked X Axes Window

Equipped tool

Contains the code for the tool installed on the spindle whose data are given in the TOOLS table for TOOLING data.

Tool group

Defines the home group of the spindle.
(A set of spindles that may work simultaneously form a "group".)

Simmetric spindle

Specifies the symmetrical spindle number, i.e., the number of the spindle that will be activated in the event of specular execution by the work program.

12.4.5 Horizontal spindle

For a description of the option HORIZONTAL SPINDLE, refer to Section 12.4.4.

12.4.6 Router spindle

For a description of the option ROUTER SPINDLE, refer to Section 12.4.4.

12.4.7 Tools

The TOOLS table displays all available tool sets and their technical data.

Before describing Tool data in detail, we will explain how the NC manages such data in relation to the Tool-Spindle association.

As seen above, the NC can manage three types of spindles: VERTICAL SPINDLE, HORIZONTAL SPINDLE, ROUTER SPINDLE.
The difference between these three types is that, in general, Vertical Spindles and (possibly separately) Horizontal Spindles on the same head have a shared drive, whereas each Pantograph Spindle has its own drive. It follows that some movements for Vertical and Horizontal Spindles must be identical for all spindles belonging to the same head (for example, "drilling drop"), whereas each Pantograph Spindle is independent of the others.
Due to this distinction, the NC manages Tool data differently, depending on the type of spindle on which a tool may be fit. Specifically: if a tool is fit on a Vertical or Horizontal spindle, the NC does not consider any of the data pertaining to the tool itself.
For each datum described, its different use will be given in relation to the types of spindles usable.
Selecting TOOLS gives access to a table similar to that in Figure 12.30.

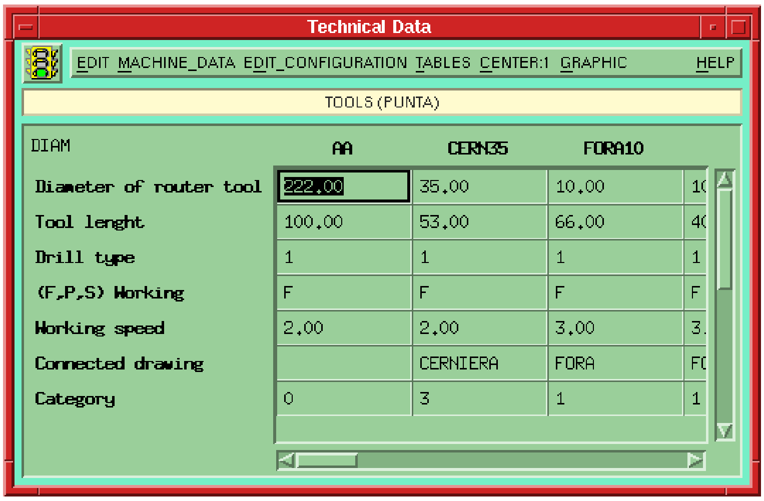


Figure 12.30: TOOLS Table

As may be seen, the table is organised in the form of a matrix; each column of the matrix identifies the data set for a specific tool.

For example: column CERN35 contains all of the data for the tool identified by code CERN35.
The tool selected is the one in whose column there is a datum displayed in insertion mode (dark background).

Diameter of router tool

Assigns tool diameter in mm.

Tool lenght

Defines tool length; i.e., how far the tool extends from the nose of the spindle

Drill type

Defines a code interpreted by the optimiser. Based on this cose, the optimiser inserts a defined routine into the optimisation program that executes the tool work cycle. The routine that executest the tool work cycle is defined in the DRILLING TYPE table.

(F,P,S,I) Working

Defines a code interpreted by the optimiser.
The optimiser, based on this code, decides if the tool can be used for boring, routing or both. The codes are:

F indicates a boring tool,

P indicates a routing tool,

F,P indicates a boring and routing tool.

Working speed

Assigns the drilling feed speed for drilling tools.

Connected drawing

This datum is managed by Graphic Configuration.
It indicates the drawing that must appear in the tools data display box in the Graphic Configuration window.

Category

This datum is managed by Graphic Configuration.
It assigns the tool to a specific subset of tools called Category.
Tables containing tools belonging to the same category may be displayed by means of the "Category Buttons" in Graphic Configuration.

Correction type

Not used for tooling on Vertical and Horizontal spindles.

If the tool is fit on a Pantograph Spindle, this datum is important for positioning the work point for the tool.
The NC reference is the point corresponding to the power takeoff of the spindle, and must correct the position levels programmed on the basis of tool length and/or diameter. To calculate these corrections, the NC must know the work directions for the spindle and tool.
There are the following possibilities:

- 0: indicates that the work direction of the tool is perpendicular to the work direction of the spindle.

  The NC makes a first correction to the work direction of the spindle in an amount equal to the length of the tool. The NC may make a second correction perpendicular to the work direction of the spindle in an amount equal to half the diameter of the tool if a Tool Radius Correction operation is programmed (G41, G42). The NC performs an additional correction perpendicular to the work direction of the spindle in an amount equal to half the value assigned to the Data for correction datum.

- 1: indicates that the correction takes place in the direction of the Z axis and has the same direction as the axis.

  The NC performs a first correction, in the work direction of the spindle, of an amount equal to the length of the tool.

  The NC performs a second correction, perpendicular to the work direction of the spindle, of an amount equal to one half of the diameter of the tool. The NC performs yet another correction, perpendicular to the work direction of the spindle, equal to one half of the value assigned to the Data for correction data.

  The direction of the projection on axis Z of the correction perpendicular to the work direction matches with the direction of axis Z

- 2: indicates that the correction takes place in the direction of the Z axis and has the opposite direction of the axis.

  The NC performs a first correction, in the work direction of the spindle, of an amount equal to the length of the tool.

  The NC performs a second correction, perpendicular to the work direction of the spindle, of an amount equal to one half of the diameter of the tool. The NC performs yet another correction, perpendicular to the work direction of the spindle, equal to one half of the value assigned to the Data for correction data.

  The direction of the projection on axis Z of the correction perpendicular to the work direction is opposite to the direction of axis Z.

- 14: indicates that the work direction of the tool is perpendicular to the work direction of the spindle.

  The NC makes a first correction to the work direction of the spindle in an amount equal to the length of the tool.
  The NC may make a second correction perpendicular to the work direction of the spindle in an amount equal to half the diameter of the tool if a Tool Radius Correction operation is programmed (G41, G42). The NC performs an additional correction in the work direction of the spindle in an amount equal to half the value assigned to the Data for correction datum.

  (In practice, this is similar to case "0" except for the correction for wear, which is performed on tool length instead of on tool diameter.)

Rotation speed

Not used for tooling on Vertical and Horizontal spindles.

Tool tickness

Defines the part of tool useful for work. The following relationship must always be checked:

Tool tickness < Tool lenght

◇ ◇ **Example** A bit used for boring may have:

- Tool lenght = 30 mm
- Tool tickness = 20 mm

Direction of rotation

Indicates direction of rotation of tool.

- 0: indicates that tool can rotate indifferently from right to left or from left to right.
- 1: indicates clockwise rotation,
- 2: indicates anticlockwise rotation.

Data for correction

This is a numerical value in thousandths of a millimetre that informs the NC how much the tool is worn as a result of work cycles performed.

Max rot speed

Not used for tooling on Vertical and Horizontal spindles.
Indicates the maximum speed at which the tool can rotate.

Min rotation speed

Not used for tooling on Vertical and Horizontal spindles.
Indicates the minimum speed at which the tool can rotate.

Acceleration ramp

Not used for tooling on Vertical and Horizontal spindles.
Assigns the time needed by motor to reach maximum speed. If no value is specified, the NC will use the value of the analogous datum in the ROUTER SPINDLE table in MACHINE_DATA.

Deceleration ramp

Not used for tooling on Vertical and Horizontal spindles.
Assigns the time needed by motor to stop. If no value is specified, the NC will use the value of the analogous datum in the ROUTER SPINDLE table in Machine Data.

12.4.8 Aggregates

AGGREGATES are objects that set various spindles in simultaneous rotation. (In general, the term "subspindles" is used when referring to spindles in an aggregate).
Selecting AGGREGATES gives access to a table similar to that in Figure 12.31.

As may be seen, the table is organised in the form of a matrix; each column of the matrix identifies the data set for a specific Aggregate.
For example: column AGGRE1 contains all of the data for the aggregate identified by code AGGRE1.
The aggregate selected is the one in whose column there is a datum displayed in insertion mode (dark background).
Next to the box where the name of the table is displayed there is a software button called `Spindles`. Clicking on this term calls up a window containing a list of data for the subspindles pertaining to the aggregate selected.
The Table and the data regarding the subspindles are described in Section 12.4.11.

X rotation centre , Y rotation centre , Z rotation centre (mm)

define the mechanical offsets of the aggregate points compared to the attachment point of same.

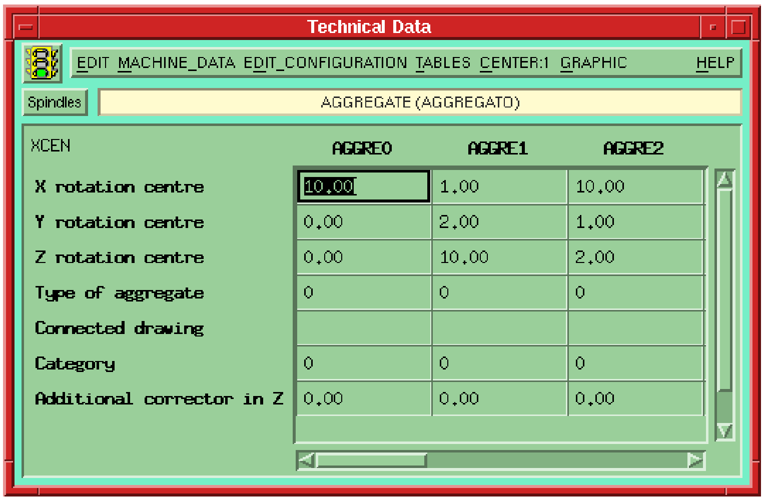


Figure 12.31: AGGREGATES Table

Type of aggregate

Defines a code interpreted by the optimiser.
Such code specifies:

1. if the work cycle for the aggregate must be optimised, and
2. the type of optimisation.

Connected drawing

This datum is managed by Graphic Configuration.
It indicates the drawing that must appear in the tools data display box in the graphics tooling window.

Category

This datum is managed by Graphic Configuration.
It assigns the aggregate to a specific subset of aggregates (and possibly tools) called Category.
Tables containing aggregates belonging to the same category may be displayed by means of the "Category Buttons" in Graphic Configuration.

12.4.9 Drilling type

This table is used to assign the boring fixed cycles to be executed by a tool for each side of the panel (see Fig. 12.32).
The table is in matrix format with indexed columns. Each column contains all the boring fixed cycles corresponding to the various sides of the panel. Each row of the table represents one side of the panel.

Name

It is the name of the set of fixed boring cycles which correspond to the various sides of the panel.

Up Side (Side 0)

the surface of the panel which is not in contact with the panel support.

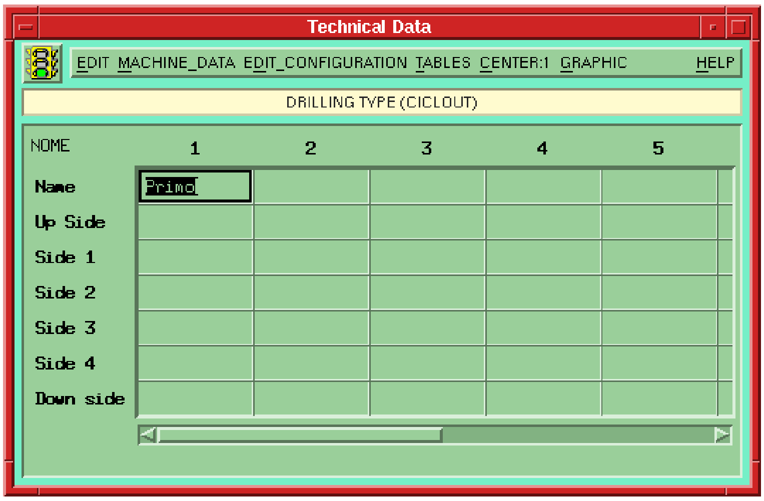


Figure 12.32: DRILLING TYPE Table

Side 1 , Side 2 , Side 3 , Side 4

are numbered counter-clockwise. Side 1 is the left side as seen on the panel displayed on the monitor of the XNC at the boring programming stage. Generally speaking, it is the side of the panel to the left of the machine operator.

Down side (Side 5)

the surface of the panel which is in contact with the panel support.

The DRILLING TYPE of the TOOLS Table in the TOOLING context must contain a number identifying the index of one column of this table.
This will ensure that all the boring fixed cycles will be assigned for a given tool.

12.4.10 Change tool

The CHANGE TOOL Table allows you to associate each tool crib location on the machine to the name of the tool loaded in it. On the left of the table is the list of the cribs present; the program displays the data for the crib with the name on a dark background (Fig. 12.33).
Each column of the table identifies a tool compartment. The number above each column may be considered as the identifier of a crib position. The number of columns in the table, and therefore the number of tooled compartments, is defined by the table CHANGE TOOL in MACHINE DATA.

Equipped tool

the name of the tool in the compartment.

Tool present

a number indicating if the tool is present in the compartment.

- 1 if the tool is present,
- 0 if the tool is not present.

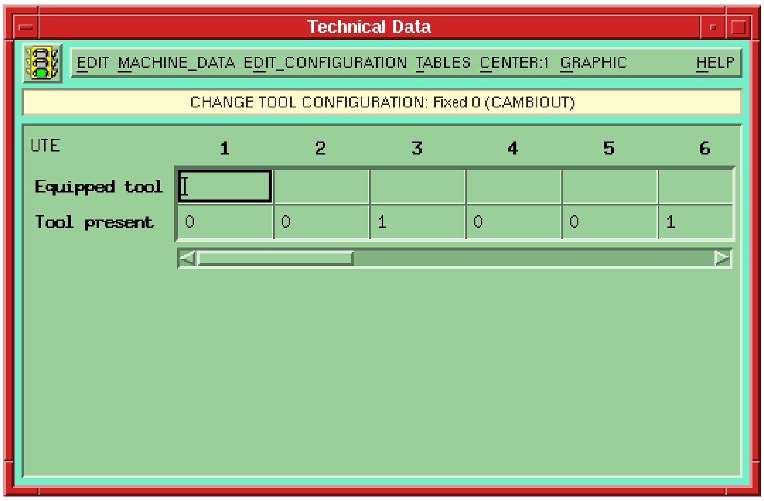


Figure 12.33: CHANGE TOOL Table

◇ **Example:** We want to define and tool up two fixed cribs, to be called FIXED0 and FIXED1. FIXED0 will consist of 4 tool compartments and FIXED1 will contain 2 tool compartments. The procedure to follow is:

1. Display the CHANGE TOOL table in MACHINE_DATA, select the compartments to be assigned to the two cribs; FIXED0 must contain compartments 1, 2, 3, 6; and FIXED1 must contain compartments 4, 5.
2. Assign the value 1 to the "Crib Type" of compartments 1-8.
3. Assign the value 0 to "No. Crib" of compartments 1, 2, 3, 6.
4. Assign the value 1 to "No. Crib" of compartments 4, 5.
5. Assign the position of the compartments of the cribs with "No. crib position" as follows:
   - On FIXED0, place compartment 1 as crib position 1, compartment 2 as crib position 2, compartment 3, as crib position 3, and compartment 6 as crib position 4.
   - On FIXED1, place compartment 4 as crib position 1, and compartment 5 as crib position 2.
6. Define the coordinate X,Y,Z of the position of the various compartments, and, if necessary, the rotation axis angle for collecting and depositing the tool.

If you now look at the CHANGE TOOL table of the TOOLING data, you will see that the names of the cribs set up are on the left (FIXED0 and FIXED1). The tables for FIXED0 and FIXED1 contain 4 and 2 columns respectively. You can now enter the names of the tools to be placed in the various positions of the crib.

12.4.11 Spindles

The Spindles table appears by clicking on the corresponding button of the `A.P.: Technical Data` when the AGGREGATES option has been selected from the TOOLING menu. Fig. 12.34 shows an example of a table which corresponds to the subspindles.

By means of this table the data corresponding to the sub spindles can be modified. To save the changes made, press the Ok software button. To cancel the changes made, press the Cancel software button. To print out a list of the data displayed, press the Print software button. The next icon, indicated with RELOAD TABLE permits the user to reread the original, unchanged data as specified in Section 12.2. The RENAME button allows the name of the currently selected subspindle to be changed. The button COPY allows the user to copy the data from

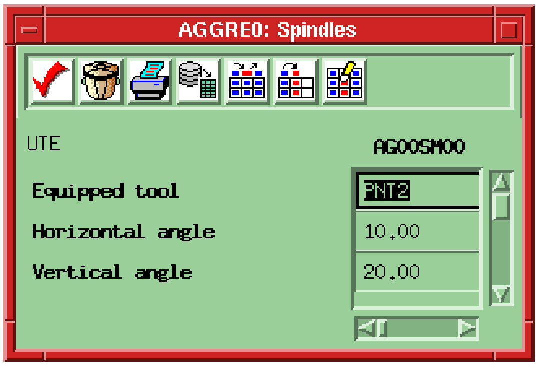


Figure 12.34: Table Spindles

one subspindle to another. When a new subspindle is created, the subspindle rename process is also activated. Finally, the button DELETE cancels the data of the selected subspindle.

Each column of the table identifies the data for a possible subspindle. The data corresponding to the subspindles are described below.

Equipped tool

This is the name of the tool installed on the subspindle.

Horizontal angle

This is the angle lying on plane XY between the X axis and the projection in the work direction of the subspindle on the same plane.
Values in the range of [0, 360] degrees are permitted.

In this case, the direction of work defined in the spindle data is not used. The orientation of the aggregate in space is therefore absolute and not relative to the direction of work of the spindle.

Vertical angle

This is the angle between the Z axis and the work direction of the subspindle.
Values in the range of [-90, 90] degrees are permitted.

In this case, the direction of work defined in the spindle data is not used. The orientation of the aggregate in space is therefore absolute and not relative to the direction of work of the spindle.

Min rotation speed

This is the minimum rotation speed for the subspindle.

Max rot speed

This is the maximum rotation speed for the subspindle.

Sottomandrino simm.

Indicates the symmetrical aggregate.

Direction of rotation

Direction of rotation of subspindle. The following values are allowed:

- 0 indicates LH or RH rotation (indifferent),
- 1 indicates RH rotation,
- 2 indicates LH rotation,
- 3 indicates reverse RH rotation,
- 4 indicates reverse LH rotation,
- 6 indicates indifferent reverse rotation.

See the section regarding the setting of rotation directions for spindles, aggregates, and tools.

Offset X , Offset Y , Offset Z

Are the coordinates of the power take-off of the tool relative to the connection point of the aggregate, considering nil the angles on the horizontal and the vertical planes.

12.5 Tables

The tables accessed with this option are used to configure the various application programs. The options displayed in the TABLES menu and in the corresponding sub-menus, depend on the level of password being currently used. For a description of the various tables, see the *Service Manual*, currently in the β *version*, prepared by the CNI documentation office. Other user defined tables are described in the *Appendices* part of this manual.

12.6 Center

All of the data contained in the tables accessed by means of the `A.P: Technical Data` are referred to a particular work center. In the case of a single-center machine, the data is to be considered relative to CENTER:1, even if this is not specified. In the case of a machine with multiple centers, the data present in the various tables are relative to the selected center. The number corresponding to the selected center appears alongside the option CENTER on the Menu Bar of the `A.P: Technical Data`. To modify the currently selected center, click on the option CENTER and select the number of the desired work center. In the case where data has been changed, before changing the currently selected center, a window is displayed which permits the changes to be saved or cancelled.

12.7 Graphic

The option GRAPHIC gives access to the `A.P: Graphic Configuration` which permits to tool-up and/or verify the tooling-up of a machine tool, easily and efficiently. Since the appearance of the `A.P: Technical Data` is evidently modified, Graphic Tooling will be discussed is a separate chapter. (See Section 13).

12.8 Help

The HELP option gives access to the on-line XNC manual. Specifically, if HELP is pressed when any one of the various data in the MACHINE_DATA or TOOLING table is selected, the on-line manual opens to where the selected data is discussed. If the selected data has not yet been inserted in the manual, an error message is displayed explaining that on-line information is not available for that data. Once opened, the manual can be browsed and utilised by the user in the desired language.

13 Graphic configuration

13.1 Introduction

Graphic Configuration is a function of the `Technical DataA.P.`, it allows you to tool and/or check the tooling of a machine simply and effectively. As described further in the manual, it is possible to display and change the technical data linked to each spindle, the data of the tool mounted on it, and activate one or more spindles to perform manual tooling or mechanical checks, etc. Using Graphic Tooling it is also possible to manage crib-related functions. If the XNC starts at password level 1, since the `A.P: Technical Data`, is non enabled, the Graphic Configuration window is displayed. Otherwise, to access the 'Graphic Configuration, the user must deiconize the `A.P: Technical Data` and select the option GRAPHIC displayed on the menu bar. The Graphic Tooling is shown in Fig. 13.1 and is made up of the following parts.

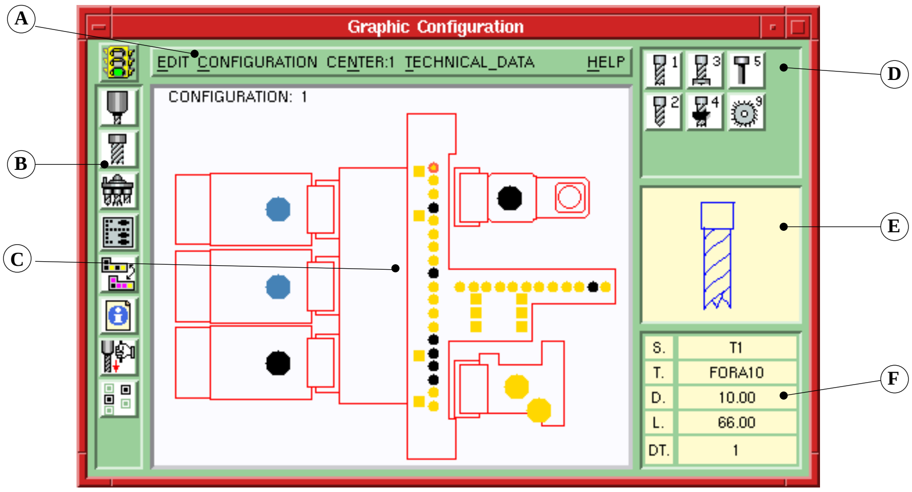


Figure 13.1: Graphic Configuration Window

- The Menu Bar (Fig. 13.1-A), which has the following options:
  - EDIT
  - CONFIGURATION
  - CENTER
  - TECHNICAL_DATA
  - HELP
- Along the left side of the window the Tooling Function Icons are displayed; they are used for accessing the tooling functions (Fig. 13.1-B).
- At the center of the window, the "Graphic Control Box", the drawing of the head is displayed with the various spindles installed and the number of the tooling configuration currently being edited or modified (Fig. 13.1-C).
- In the top right corner of the window, the User icons are displayed; these icons can be defined by the NC user. (Fig. 13.1-D).
- At the bottom of the window the "Tool Drawing Box" is displayed (Fig. 13.1-E) together with the Tool Data Box (Fig. 13.1-F); they contain, respectively, the drawing of the tool installed on the selected spindle and the data associated with it.

A detailed description of the various components of the Graphic Configurationwindow is given below.

13.2 Menu Bar

Several options already present in the `A.P: Technical Data` are displayed on the Menu Bar (Fig. 13.1-A); therefore, refer to Section 12 for further information on some of the displayed commands.

13.2.1 Edit

SAVE memorises all the information of all the tooling tables for the Edit Configuration being edited.

RELOAD ALL Cancels all changes made to the various tooling tables of the machine (following the last save procedure) and resets the old values.

RESET CONF. deletes all the information of all the tooling tables for the Edit Configuration being edited.

COPY CONF. copies the data from the "active configuration", i.e. the configuration used during work, onto the data of the Edit Configuration being edited.

PRINT JOB SELECTION This option prints out the tables containing the various categories of data of the XNC.

LIST OF DRAWINGS Opens a window that contains a list of the graphic files relative to the drawings of the tools, of the aggregates, of the heads, etc. available.

PASSWORD opens the window for entering the data protection password. A high level password enables the TECHNICAL_DATA item on the menu bar.

EXIT minimises to an icon the `Technical Data` A.P.

As stated previously, for a more detailed analysis of the functions presented above, refer to Sections 12.2 and 12.4.1.

13.2.2 Configuration

displays a window similar to the one shown in Fig. 12.23 allowing you to change the Edit Configuration being edited. To do so, enter the number of the required configuration and click on Ok. Cancel closes the window without changing the Edit Configuration being edited. For further information, consult Section 12.4.1.

13.2.3 Center

Allows selection of the work center to be tooled. In the case of a single-center machine, the data are to be considered relative to CENTER:1 even though not specified. In the case of a machine with multiple centers, the data present in the various tables are relative to the selected center. To modify the currently selected center, click on the option CENTER, then select the number of the desired work center. If any data has been modified, before changing the selected center a window appears that lets the user either save or cancel the changes.

13.2.4 Technical_data

provides access to the `Technical Data A.P.` tables. If a very low level password is active (e.g. level 1), this item is not enabled. For a complete description, see Section 12.

13.2.5 Help

If the HELP option is selected, a window is displayed that contains a legend giving the colours currently set for graphic tooling. These colours may be modified by means of the Graphic Tooling Colour Table, available from password level 2. This window is shown in Fig. 13.2.

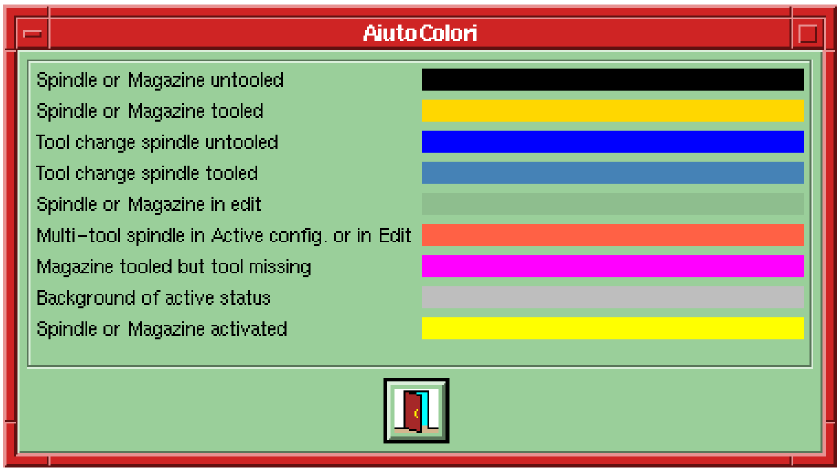


Figure 13.2: Graphic tooling colour table

13.3 Function Icons Tooling

The number of icons present in this box depend on the active password level (Fig. 13.1-B). If level 15 is active, the icons of Fig. 13.3 will be displayed. If you move the mouse pointer on any icon, a box will be displayed containing

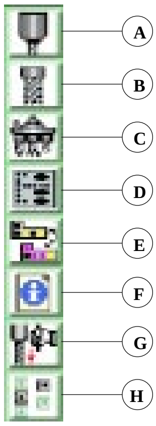


Figure 13.3: Tooling Function Icons

a string (function description string) describing the type of data or function that can be accessed by clicking on the icon.

13.3.1 Spindle

It is the function enabled by the icon in Fig. 13.3-A. By pressing this software key, a window is displayed as shown in Fig. 12.25 and already described in Section 12.4.4. As seen in Fig. 12.25 the window contains a column with the data that corresponds to the selected spindle which is outlined in red. When the colours of the graphic tooling are mentioned, reference is made to the default colours; obviously, if the user chooses other colours, it will be necessary to refer to them.
To select a spindle, click on it with the left mouse button. Instead, by clicking with the right mouse button, a red line is displayed inside the spindle; this line, which remains even after successive selections, indicates that the selection is to be maintained. To eliminate multiple selections, click again with the right mouse button to deselect.

13.3.2 Tool

It is the function enabled by the icon in Fig. 13.3-B. Press this software key to display the window shown in Fig. 12.26, already described in Section 12.4.4. Similar to that described for the Spindle Icon, the window contains a column with data relative to the tool associated with the selected spindle, i.e. the one outlined in red.
Referring once again to the information in Section 12.4.4, when the spindle is equipped, it becomes yellow, and if the spindle is not equipped, it is black. Moreover, when a spindle is equipped, the drawing of the selected tool and the data that corresponds to it appear in the Tool Drawing box and in the Tool Data box, respectively. If no tool is installed on the spindle, all of this data disappears, except for the spindle name.

13.3.3 Aggregate

It is the function enabled by the icon shown in Fig. 13.3-C. By pressing this software key the window shown in Fig. 12.27 is displayed; the window is described in Section 12.4.4.

13.3.4 Head

It is the function enabled by the icon in Fig. 13.3-D. By pressing this software key the window in Fig. 12.28 is displayed; this window is described in Section 12.4.4.

13.3.5 Equipement compare

It is the function enabled by the icon in Fig. 13.3-E. Compares the active configuration with the Edit Configuration being edited. The spindles equipped differently are displayed in magenta colour.

13.3.6 Infos

If the software button associated with this icon, shown in Fig. 13.3-F, is activated, the icons in Fig. 13.4 are displayed.

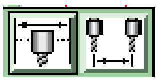


Figure 13.4: Spindle work field and Spindle distance Icons

The Spindle work field icon opens a window containing information on the maximum travel of the selected spindle in correlation with the fixed origin. The co-ordinates X+,Y+,Z+ represent the maximum positioning values, the co-ordinates X-,Y-,Z- represent the minimum positioning values. The minimum and maximum positioning values are calculated as follows:

- X+,Y+,Z+: (upper limit switch) - (origin offset) + (spindle offset)
- X-,Y-,Z-: (lower limit switch) - (origin offset) + (spindle offset)

The Spindle distance icon opens a window which displays the distances in X,Y, and Z of the various spindles in relation to the selected spindle. By clicking with the mouse on any one of the displayed spindles, the distances in X, Y, Z between that spindle and the selected spindle are displayed.

13.3.7 Spindle activation

It is the function enabled by the icon shown in Fig. 13.3-G. The function associated with this icon can be accessed only if the machine has been enabled for performing movements, that is only if the MANUAL MOVEMENT status or the MOVEMENT DATA INPUT status of the `A.P: QUOTE` have been activated. If this is the case, when you press this icon the background of the "Graphic Control Box" turns gray. This icon accesses the spindle activation function. By pressing the right mouse button, the selected spindle (outlined in red) moves up or down to allow manual tooling or checking. Spindles that have been activated once can be recognised by their bright yellow colour. If you press the right mouse button again, the spindle reverts to its normal colour to signal its de-activated state. To de-activate all spindles, click on the icon a second time. The background of the "Graphic Control Box" turns white.

13.3.8 Tool carrier configuration

Press this icon (Fig. 13.3-H), to access the program for equipping the tool cribs. The program will be described in detail in par. 13.8.

13.4 Graphic Control

Displays the head of the machine and all the spindles installed in it (Fig. 13.1-C). The configuration being edited is displayed at the upper left. Each spindle is represented by a circle or a square, according to its type, following the conventions below:

Small circle: vertical spindle.

Small square: horizontal spindle.

Large circle: routing spindle.

The colours of the squares or the circles representing the spindles have the following meaning:

Black: spindle not equipped.

Yellow: spindle equipped.

Magenta: spindle equipped differently in the active Edit Configuration than in the configuration being edited.

Bright yellow: active spindle. This colour may be displayed only if the Spindle Activation function is enabled.

To select a spindle, click on it with the left mouse button. If you click with the right button, a red mark is displayed, that persists even after selecting a different spindle. The red mark indicates a multiple selection.

13.5 User Icon

A group of icons that can be defined by the user, as in the example in Fig. 13.1-D. In the example, there are six icons, each associated to a tool. When you select one of these icons, you get the tool tables for the selected tools only, unlike the Tool Icon that displays tables for all tools.
Specifically, the figure shows the icons which correspond to the following group of tools.

1. BORING TOOLS
2. SPECIAL BORNG TOOLS
3. ROUTERS
4. HINGES
5. LARGE BORING TOOLS
6. BLADES

13.6 Tool Drawing

Displays the drawing of the tool mounted on the selected spindle, as in the example in Fig. 13.1-E. The drawings appear only when the selected spindle is equipped.

13.7 Tool Data

Displays a table with the data for the tool mounted on the selected spindle, as shown in Fig. 13.1-F. The data appears only when the selected spindle is equipped; if it is not equipped, only the name of the spindle appears. The table contains the following information:

S.: name of spindle.

T.: name of tool.

D.: diameter of tool.

L.: length of tool.

DT.: drilling type code.

13.8 Tool carrier configuration

The XNC can manage two types of tool cribs:

1. Machine-installed crib, or Fixed ,
2. Head-installed crib, or Revolver .

The Fixed crib is mounted on one side of the machine and consists of a certain number of compartments associated bi-univocally to the supported tools. That means that each tool is collected and deposited in the same compartment every time that an automatic tool change cycle is performed.
The Revolver crib is instead mounted on the head of the machine and moves following the movement of the head. Each tool compartment may be associated bi-univocally to a specific tool, or may be associated to no tool at all. In the first case, a tool change cycle collects and deposits the tool in the same compartment, as it happens with the Fixed crib. In the second case, instead, the tool is deposited in the first free compartment encountered. The XNC can manage simultaneously several cribs of both types.
To access the tools in the Tool Cribs click on the Tool carrier configuration icon displayed in the Tool Icon Box 13.3). The window shown in Fig. 13.5 is displayed.

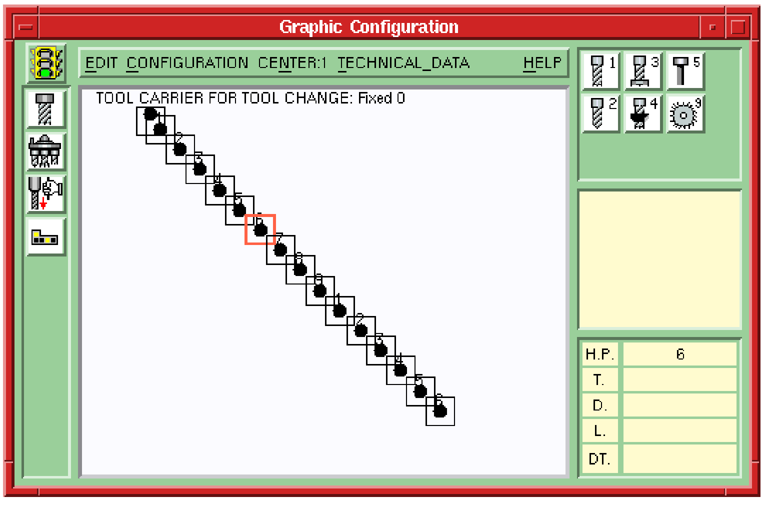


Figure 13.5: Tool carrier configuration Window

Each crib is associated to an icon, similar to the ones shown in Fig. 13.5 (Crib Type Icons), shown in the Tooling Function Box. More specifically, the icons containing a gray rectangle formed by small squares are associated to Fixed Cribs, while the icons containing six small squares arranged in a semicircle are associated to Revolver

Cribs. In the case of Fig. 13.5, there is a Fixed Crib and a Revolver Crib. Besides the magazine type icons, we also have the Tool, Aggregate, and Crib Activation icons, as well as the Spindle Equipment icon to return to the previous environment.

13.8.1 Equipping the Tool Cribs

To equip a tool crib, proceed as follows:

1. Select the type and the number of the required tool crib by pressing the corresponding icon. The Graphic Control Box will display a series of squares containing a circle and a number. The squares represent the tool compartments present and the number identifies the Position in the Crib of the compartment.
2. Select the required compartment by clicking in the square with the left mouse button or with the right mouse button for multiple selection. The edge of the selected square turns red. When selected with a click of the right mouse button, the horizontal red line appears, indicating that the selection is to be maintained.
3. Click on the Tool or the Aggregate icons to display the table containing the data for the tool or the aggregate.
4. Select the required tool or the aggregate and press the Equip software button to associate the tool or the aggregate to the tool crib. When the selected compartment is not equipped, it is blue; when it is equipped, it becomes yellow.

13.8.2 Tool carrier activation

When you click on the Tool carrier activation icon, the background of the Graphic Control Box turns gray. This indicates that it is now possible to activate the selected tool crib. In general, the activation of the tool crib causes the execution of a fixed cycle to prepare it for maintenance or manual tool change operations. To activate the selected tool crib, click with the right mouse button the square representing it. The circle in the square will turn bright yellow. To exit the Crib Activation function described above, click the Tool carrier activation icon again.
To leave Tool Crib Equipment and return to the main environment of the Graphic Equipment, click on the last icon at the bottom on the left, Spindle configuration.

Contents

1 CNI-ISO Instructions

The following paragraphs summarise all instructions used for the CNI-ISO programming language. These paragraphs may serve as a rapid guide.

1.1 List of Instructions

The following table contains all CNI-ISO instructions. The instructions are in alphabetical order; next to the syntax there is a brief description of the function performed and the number of the section where it is described.

Programming Instructions

Syntax	Meaning	Section
`%`	end of a program and of a subroutine	3.2
`%%`	immediate exit from the program	3.2
`:`*label*	block identifier (label)	3.1
`AR`*[=]expr*	horizontal angle of spindle orientation	4.2
array`(`*expr[*`,`*expr*`,... `*]*`)=`*expr*	vector element assignment	2.2.4
array`(`*expr[*`,`*expr*`,... `*]*`)=?`	display of a vector element value	3.6.2
axis[=]expr	Axis *axis*position assignment	3.12.1
axis`I`*[=]expr*	Axis *axis*position increment	3.12.2
axis`O`*[=]expr*	Axis *axis*origin movement	3.9.4
`AX=...`	set selection of the main axes triplet	3.11.1
`AZ`*[=]expr*	vertical angle of spindle orientation	4.2
`BA`*[=]expr*	line inclination angle, arc width	5.1
`BL`*[=]expr*	current step length	5.1
`BM`*[=]expr*	step for rounding	3.17.1
`BR`*[=]expr*	step connected to the next	3.17.2
`BS`*[*`+`|`-`*]*	step secant to the next	5.1
`BT`*[*`+`|`-`*]*	step tangent to the next	5.1
`D`*[=]expr*	delay	7.5
`E`*axis[=]expr*	Axis *axis*acceleration	3.12.4
`E`*[=]expr*	acceleration of interpolated axes	3.12.4
`F`*axis[=]expr*	Axis *axis*speed assignment	3.12.3

List of programming instructions >> ...

... <<

Syntax	Meaning	Section
F[=]*expr*	speed of interpolated axes	3.12.3
FREF(*expr_xy*,*expr_xz*,*expr_yz*)=*expr*	calculation of the new reference system	11.1
G[=]*expr*	G modal instruction	1.2
HC[=]*expr*	Head configuration number	7.1
I*axis*[=]*expr*	declaration of advance axis *axis*arrival	3.15.1
I[=]*expr*	X-coordinate of circumference center	3.16.2
J[=]*expr*	ordinate of circumference center	3.16.2
JM:*expr*	unconditional jump instruction	9.1
JM[!](*expr*):*expr*	conditional jump instruction	9.2
JP[!](*expr1*,*expr2*):*expr3*	PLC byte controlled conditional jump instruction	9.3
K[=]*expr*	circumference center height	3.16.2
KA[=]*expr*	Instruction for PLC	8.2
KB[=]*expr*	Instruction for tool change	7.6.2
KL[=]*expr*	Instruction for "axis car" programming'	12
L=*routine*	Call of external subroutine	10.5.1
L:*expr*	Call of internal subroutine	10.5.2
LO:[*expr*]	call for drilling section subroutine	10.5.3
LS[=]*expr$*	Indirect call of external subroutine	10.5
LX[=]*expr*	Piece length	2.2.3
LY[=]*expr*	Piece width	2.2.3
LZ[=]*expr*	Piece thickness	2.2.3
M[=]*expr*	"M" type instruction for the passage of variables and commands to the PLC	8.1
MS[=]*expr$*	Message transmission to console	3.6.1
N[=]*nnnn*	Program step number	3.4
parm=*expr*	Parameter assignment	2.2.1

List of programming instructions >> ...

. . . <<		
Syntax	**Meaning**	**Section**
parm=*expr$*	Alphanumeric parameter assignment	2.2.2
parm=?	Display of parameter value	3.6.2
R[=]*expr*	Circumference radius assignment (helix)	3.16.2
RDM(*expr$*, *expr$*, *expr$*[, *expr*])=*expr*	writing anumerical machine datum	14
RDM(*expr$*, *expr$*, *expr$*[, *expr*])=*expr$*	writing alphanumeric machine datum	14
REGS(*expr*)=*expr*	writing machine registry	15
R*nnn*=*expr*	writing machine registry	15
RI[=]*expr*	assignment of the semiaxis of an ellipse parallel to the X-coordinate	3.16.3
RJ[=]*expr*	assignment of the semiaxis of an ellipse parallel to the ordinate	3.16.3
ROTX[=]*expr*	X rotation of the new reference system	11.1
ROTX[=]*expr*	Y rotation of the new reference system	11.1
ROTX[=]*expr*	Z rotation of the new reference system	11.1
RP[=]*expr*	Step repetition number	3.5
RT[=]*expr*	Rotation angle value	3.11.2
RTI[=]*expr*	Value increment of the rotation angle	3.11.2
RTO[=]*expr*	Origin of rotation angle	3.11.2
S[=]*expr*	Assignment of spindle speed	7.4
S*axis*[=]*expr*	*axis*scale factor assignment	3.10.1
SF[=]*expr*	Total axis scale factor	3.10.2
List of programming instructions >> . . .		

. . . <<

Syntax	Meaning	Section
T*axis[=]expr*	Tracer parameter assignment for the X-axis	11
T*[=]spindle[:]tool[,spindle,...]*	select vertical spindles	7.2
T*[=]expr[:expr]*		7.2
T*[=]expr$*		7.2
T*[=]expr:<expr*	tool assignment to vertical spindle	7.6
T*[=]expr:<expr$*		7.6
TH*[=]spindle[:tool][,spindle,...]*	select horizontal spindles	7.2
TH*[=]expr[:expr]*		7.2
TH*[=]expr$*		7.2
TH*[=]expr:<expr*	tool assignment to horizontal spindle	7.6
TH*[=]expr:<expr$*		7.6
TP*[=]spindle[:tool][,spindle,...]*	select pantograph spindles	7.2
TP*[=]expr[:expr]*		7.2
TP*[=]expr$*		7.2
TP*[=]expr:<expr*	tool assignment to pantograph spindle	7.6
TP*[=]expr:<expr$*		7.6
TRSX*[=]expr*	X translation of the new reference system	11.1
TRSY*[=]expr*	Y translation of the new reference system	11.1
TRSZ*[=]expr*	Z translation of the new reference system	11.1
TRX*[=]expr*	corrector translation in spatial direction X	7
TRY*[=]expr*	corrector translation in spatial direction Y	7
TRZ*[=]expr*	corrector translation in spatial direction Z	7
WBT(*expr1*,*expr2*)=*expr3*	writing 1 byte datum for PLC	8.3
WBT(*expr1*,*expr2*)=*expr$*		8.3
WBY(*expr1*)=*expr2*	writing integer 1 byte datum for PLC	8.3
WW(*expr1*)=*expr2*	writing integer 2 byte datum for PLC	8.3

List of programming instructions >> . . .

... <<

Syntax	Meaning	Section
`WL(`*expr1*`)=`*expr2*	writing integer 4 byte datum for PLC	8.3
`WF(`*expr1*`)=`*expr2*	writing 4 byte floating datum for PLC	8.3

Table 1.2: Legend: List of programming instructions

Operand	Meaning
array	vector name: maximum 3 alphanumeric characters
axis	axis name: maximum 2 alphanumeric characters
expr	expression with numeric result
expr$	expression with alphanumeric result
label	label number: maximum 2 decimal figures
remark	comment description
n	decimal figure (0,1,...,9)
nn	integer constant maximum 2 decimal figures
nnnn	integer constant maximum 4 decimal figures
nnnnn	integer constant maximum 5 decimal figures
routine	subroutine name: maximum 11 alphanumeric characters
parm	parameter name (numeric or alphanumeric): maximum 3 alphanumeric characters
spindle	spindle number: maximum 3 decimal figures
tool	tool number: maximum 3 decimal figures

1.2 Modal instruction G

The syntax of this instruction is:

G*[=]expr*

where: *expr* is an expression with a numeric result.
These instructions are defined "modal" as they generally indicate the modality of operation of a movement step, or the manner of interpreting certain program data. The following instructions are available:

G0 * Movement independent of programmed speed axes. Reset by: G1, G2, G3, G4, G5, G6, G7, G8 G9, G10, G11.

G1 Linear interpolated movement with programmed speed. Reset by: G0, G2, G3, G4, G5, G6, G7, G8 G9, G10, G11.

G2 Anticlockwise circular interpolated movement with programmed tangential speed, with given centre co-ordinates. Reset by: G0, G1, G3, G4, G5, G6, G7, G8 G9, G10, G11.

G3 Clockwise circular interpolated movement with programmed tangential speed, with given centre co-ordinates. Reset by: G0, G1, G2, G4, G5, G6, G7, G8, G9, G10, G11.

G4 Anticlockwise circular interpolated movement with programmed tangential speed, with given radius. Reset by: G0, G1, G2, G3, G5, G6, G7, G8, G9, G10, G11.

G5 Clockwise circular interpolated movement with programmed tangential speed, with given radius. Reset by: G0, G1, G2, G3, G4, G6, G7, G8 G9, G10, G11.

G6 Circular interpolated movement with programmed tangential speed, tangential to previous movement. Reset by: G0, G1, G2, G3, G4, G5, G7, G8, G9, G10, G11.

G7 Anticlockwise elliptical interpolated movement with programmed angular speed, with given semi-axes and centre co-ordinates. Reset by: G0, G1, G2, G3, G4, G5, G6, G8, G9, G10, G11.

G8 Clockwise elliptical interpolated movement with programmed angular speed, with given semi-axes and centre co-ordinates. Reset by: G0, G1, G2, G3, G4, G5, G6, G7, G9, G10, G11.

G9 Circular interpolated movement in space, less than 180 degrees, with programmed tangential speed, with given center. Reset by: G0, G1, G2, G3, G4, G5, G6, G7, G8, G10, G11.

G10 Circular interpolated movement in space, greater than 180 degrees, with programmed tangential speed, with given center. Reset by: G0, G1, G2, G3, G4, G5, G6, G7, G8, G9, G11.

G11 Circular interpolated movement in space, with given intermediate point. Reset by: G0, G1, G2, G3, G4, G5, G6, G7, G8, G9, G10.

G27 Commands the axes to arrest upon movement end, for non-tangential steps, without waiting for the target co-ordinates to be reached, within positioning tolerance.

G28 Commands the axes to slow down upon movement end, for non-tangential steps, function of the angle formed with the successive step.

G30 * Used to set a functioning mode for instruction I*axis[=]expr*. In such mode, the programmed advance is active only in the step in which it is programmed with the allocation involved. The programmed advance resets automatically after use. Reset by instruction G31.

G31 Used to set a functioning mode for instruction I*axis[=]expr*. In such mode, the programmed advance stays active until it is reprogrammed.

G40 Cancellation of tool radius correction. Reset by: G41, G42.

G41 Tool radius correction on the right of the profile. Reset by: G40, G42.

G42 Tool radius correction on the left of the profile. Reset by: G40, G41.

G46 Commands the axes to arrest upon movement end, for non-tangential steps, while maintaining the attainment of the target co-ordinates within the positioning tolerance. Reset by G47, G27, G28.

G47 Avoids arrest or slowing of the axes on sharp edges formed between non-tangential steps. Reset by G46, G27, G28.

G48 C axis in independent rotation. Axis not interpolated tangentially. Can be interpolated with other axes in standard modes.

G49 C rotation axis in tangential interpolation. Axis follows tangent of trajectory followed by X and Y axes. If starting direction does not coincide with position of C, rotate to align. This function is active by default. Reset by G48.

G50

G51 Tool automatic input. Reset at step end.

G52 Tool automatic output. Reset at step end.

G53 Deactivation of tool corrections and origin movement The axes position value and the circumference centre and ellipsis are referred to the machine origin. Reset by G54.

G54 Activation of the tool corrections and origin movements. Reset by G53.

G55 Deactivation of tool corrections on all axes. Reset by G56 or by G54.

G56 Reactivation of tool corrections on all axes.

G58 Origin movement inside the piece. Reset by G59.

G59 Origin movement external to the piece. Next origin movements will be relative to the origin selected by the PLC, or they can be absolute (referred to the machine origin), according to activation of G54 or G53. Reset by G58.

G60 Definition of independent program flow. The operation of this instruction is explained in detail in section 3.15.2.

G61 Used to await physical positioning of all axes on which a mode G60 has been programmed.

G62 # Reset by G63.

G66 # Activates simultaneous start of more than one independent cycles.

G67 Forcing of end of cycle of all open cycles. Good only at step in which programmed. If programmed at step without open cycles, has no effect.

G68 Input of circular connection step in C.R.U. between non-tangential convex steps. Reset by G69.

G69 * Intersection of the trajectories corrected in C.R.U. (if possible). Reset by G68.

G70 Input of data in inches (only at the beginning of the program)

G71 * Data input in mm (only at the beginning of the program)

G74 Disables use of origin definition data for all axes. Reset by G75 or by G54.

G75 * Reactivates use of origin definition data for all axes. Reset by G74.

G77 * Resets programmed action with instruction G78.

G78 When calculating tool working position, declares active contribution of spindle corrector only. Reset by G77 or by G54.

G79 Activation of external tool compensation.

G80 * Deactivation of external tool compensation.

G81 Activation of external roto-translation.

G82 * Activation of external roto-translation.

G83 * Activation of spindle reference system.

G84 * Deactivation of spindle reference system.

NOTE: The symbol (*) indicates functions active at start of program. The symbol (#) refers to further explanations in following sections.

2 Expressions

The syntax of some instructions contains terms like *expr* and *expr$* for the use of expressions including a numeric as well as an alphanumeric result.
In most real cases such expressions only include a constant, nevertheless the possibility of assigning a value contained in an expression increases the programming capability, and in many cases it allows to simplify the compilation of a program or of part of it.
In addition to this, it is possible to assign parameter and vector expressions. This is useful for keeping the value of an expression which occurs often, or to make checks on the program.
One can write mathematical, alphanumeric or mixed expressions, with constants and parameters (according to the limits specified below).
The result of an expression will be alphanumeric or numeric, according to the operands and operations performed . It is often possible to use the syntax of an instruction, as a factor or addendum, within an expression, i.e. as a parameter. In this case, when the NC interprets the expression, the syntax of the instruction is substituted with its last programmed value. For example: supposing that the last programmed values in the instructions `X` and `F` are, respectively, 100 and 50.
The expression: `AAA=F+X` would be interpreted by the NC as: `AAA=100+50`. The following instructions cannot be utilised as parameters within an expression: `N`, `L`, `LC`, `LO`, `LS`, `JM`, `JP`, `T`, `TH`, `TP`, `TS`, `AX`, `MS`, `RP`, `RTI`, `BS`, `BT`, `RDM`, `FREF`.

2.1 Constants

There are two types of constants; numeric and alphanumeric. Both can be used for writing expressions.

2.1.1 Numeric constants

A numeric constant is a sequence of decimal figures that may be preceded by a “+" o “-", sign and may include a decimal point “.". Scientific notation is also permitted. The following are valid examples of numeric constants:

`0`, `9999`, `0123`, `.003`, `-0.0`, `+123`, `999.99`, `001.23`, `-10`, `123e2`, `99999.9999`, `00000.0123`

The following are not valid constants:

`0.0.0`, `123A2`

Numeric constants can also include the final characters “`P`" and “`M`" that indicates a quantity in inches and a quantity in millimetres respectively. This characteristic allows you to directly write the amounts read from a drawing without converting them to the unit of measure of the program.
For example, in case of a program in millimetres, the constant `12.345P` (inches) is equivalent to 313.56 (millimetres) and this last value is the one that is actually used, i.e. the constant 12.345P is converted right after its reading, and everything is exactly as if it were the constant 313.56.
Similarly, in case of a program in inches, the constant `63.12M` (millimetres) is equivalent to 2.485 (inches), and also in this case, it is the last value to be actually used.
Obviously, millimetre constants in programs with millimetres, are not converted and this also happens for inch constants in programs with inches.
When writing subroutines that can be used in programs with inches or millimetres, it is necessary that all the numeric constants referring to dimensions or displacements are defined with the relative postfixed symbol, so that the unit of measure can be forced.
It is also possible to write octal constants with a maximum of 3 figures to facilitate the writing of expressions referring to an address in the PLC memory area. To do this, put the symbol “`\`" before the numerical characters; i.e. the octal constant `\53` equals 43 decimal. As opposed to decimal constants, a unit of measurement specifier cannot follow an octal constant.

2.1.2 Alphanumeric constants

An alphanumeric constant or string is a sequence of max. 64 characters, excluding the characters “`@`” and *line-feed*, between brackets; for example `"STRING"`.

You can also insert blank characters in a string, but you must pay attention to the fact that they are considered just as any other character, so, for example, two strings `"A B C"` and `" A B C "`, with 5 and 7 characters respectively, are different.
The string `""` is the zero string and is equivalent to the 0 in numeric constants.

2.2 Parameters and vectors

As with the constants, there are two possible types of parameters: numeric and alphanumeric.

2.2.1 Numeric parameters

A numeric parameter is defined with a name created according to the following rules:

- beginning with the letter `P` and formed by a maximum of 4 alphanumeric characters. (The name of a parameter must not necessarily begin with the letter `P`, however, it is helpful. A widening of the set of programming instructions may mean that the syntax of some new instructions coincides with the names of parameters used in the normal work programs or fixed cycles. In this case the NC produces an error message that can only be eliminated by changing the names of the parameters. This unfortunate possibility will not occur if the name of the parameter begins with the letter `P`.)
- It cannot coincide with the name of an instruction.
- It cannot coincide with the name of an axis followed by “I” “O” or preceded by “E” “F” “I” “S” e “T”

The following, for example, are correct names for numeric parameters:

`PAAA`, `PBBB`, `PD1`;

The following are incorrect names for numeric parameters:

`XI`, `FY`.

The numeric parameter allocation is followed by:

parm=expr

the equal sign is necessary. For example: `PAA=3*1` or `PB1=25`
The first instruction of allocation to a numeric parameter, no matter where, automatically determines its creation, unless there is no more room available.
The value of an as-yet undefined numeric parameter used in an expression is 0.
The allocation of a string result to a numeric parameter causes an error.

> *ATTENTION: CNI reserves the possibility of widening the set of programming instructions at any time.*
> *If a new version of NC is installed, it is necessary to verify if the set of programming instructions has been modified.*
> *If it has been modified, a control must be made to see that the work programs used do not contain parameters with names that do not begin with the letter `P`, that coincide with the syntax of one of the newly introduced instructions.*

2.2.2 Alphanumeric parameters

Only 10 predefined alphanumeric parameters can be used:
`ST0`, `ST1`, `ST2`, `ST3`, `ST4`, `ST5`, `ST6`, `ST7`, `ST8`, `ST9`.
Among these parameters, parameter `ST0` is used in a special way: it is preloaded at the start of the program with the contents of field `COMMENT` on the list line.
The numeric parameter allocation is followed by:

parm=expr$

the equal sign is necessary. For example: `ST1="PIPPO 1 34"`.
The initial value of an alphanumeric parameter is `""` (string zero).

2.2.3 Special parameters

The following are special parameters meant for special use and they are predefined:

- workpiece dimensions,
- workpiece work origin,
- work list parameters,
- tool change parameters,
- reference spindle parameters,
- parking value,
- sampling value.

Workpiece dimensions

`LPX` Workpiece length

`LPY` Workpiece width

`LPZ` Workpiece thickness

These parameters are meant for the dimensions of the piece to process. Their value is preset through instructions `LX`, `LY` and `LZ`. The piece dimensions can be used at any point of the program without the necessity of allocation.

Workpiece work origin

`ORGX` X co-ordinate origin of work program.

`ORGY` Y co-ordinate origin of work program.

`ORGZ` Z co-ordinate origin of work program.

`ORTX, ORTY, ORTZ` Type of origin of work program. Possible values for this parameter are:

- 0: non-specular without translation,
- 1: specular without translation,
- 2: non-specular with translation,
- 3: specular with translation,

Work list parameters

`PRST` Value set in field `Q.TA` on list line for work program.

`CTPZ` Value set in field `CONT` on list line for work program.

Tool change parameters

Tool change parameters are loaded after interpretation of the tool change availability instruction. More detailed information is contained in section 7.6.2 of this manual. A brief description of such parameters appears below.

◇ **General Parameters** CUFL.

◇ **Tool discharge parameters** Such parameters refer to tool discharge magazine position, and are: CUSX CUSY CUSZ CUSA CUSP CUSM CUST.

◇ **Tool pickup parameters** Such parameters refer to tool pickup magazine position, and are: CUPX, CUPY, CUPZ, CUPA, CUPP, CUPM, CUPT, CUPI, CUSI.

Reference spindle parameters

Such parameters are loaded automatically upon interpretation of an instruction such as T, TH, TP with the number (1, 2, 3, ...) that identifies the reference spindle for each head. The various parameters are:
MR0 for the reference spindle for head 1, MR1 for the reference spindle for head 2, MR2 for the reference spindle for head 3, etc.
An instruction such as T0,TH0, TP0 resets all parameters MR.

Parking value "PRK"

The PRK parameter is a special parameter whose value is defined in the machine data (AXIS DATA) next to the message: PARKING VALUE. The PRK is often useful, during the programming phase, when an axis not involved in operations, has to be moved to a value where it is certain not to disturb the other axes
Assignment of the PRK is programmed as follows:
axis=PRK
*axis*I=PRK
*axis*0=PRK
The PRK can also be used inside an expression:
X=PRK-23
The use of PRK on an axis is not allowed in case of main couple when axis rotation is active, or when a geometrical blockage is not as yet defined. The PRK cannot be modified by the program. The PRK can be assigned to an axis indirectly via a parameter. For example:

```
N10 AAA=PRK ...
...
...
N50 X=AAA ...
```

The special nature of this assignment consists in the fact that the value of PRK defined in the machine data (which depends on the axis involved) is not assigned to parameter AAA. Rather, the parameter status in *alias_PRK*is changed. The parameter that has become *alias_PRK* may be used in expressions exactly as if it were PRK, and differs from it only to the extent that it can "regain" parameter status simply by assigning it a "normal" expression, i.e., without PRK or *alias_PRK*. The indirect assignment of parameter PRK is particularly useful when it is inserted in subprograms or internal subroutines.

Sampling device value "TST", T*axis*

Parameters TST, T*axis*, are assigned by the sampling device cycle, and remain valid until the next cycle (which may be on a different axis). The value read by the sampling device is relative to the reference system for the piece if G54, or absolute if G53.

2.2.4 Vectors

Vectors allow more than one value to be associated with a single object, thus indicated by a single name, and to identify each of the values associated with the vector by means of numbers (called indices) obtained by calculation. At present, only numeric type vectors may be used.
A vector element is indicated by the following type of writing:

array(*expr*[, *expr*, . . .]) = *expr*

where *array* is a generic vector name and follows the same rules given for parameter names, and *expr*are indices and numeric expressions.
The maximum number of indices or dimensions that a vector may have is set at 8. Indices may vary from 0 and the maximum value assigned by the user, but are always limited by the quantity of memory available for user data. The definition of a vector and of its dimensions is performed with the first assignment, with any value, of any element: the indices for this element will be the maximum indices desired. If there is sufficient space, the vector will be created and initialised at 0 (except for the element with maximum indices, which will take the value assigned), otherwise an error will be signalled. for example:

`VET(15)=0` creates a vector named VET, and the values contained are indicated by means of a number variable from 0 to 15, therefore, 16 elements, and the last element equals 0; on the other hand, the instruction:

`MAT(9,9)=5` creates a two-dimensional vector, more correctly called "matrix", named MAT, with both indices variable from 0 to 9, for a total of 100 elements, all initialised at 0 except for the last, which is initialised at 5. The elements are: `MAT(0,0)`, `MAT(0,1)`, ..., `MAT(0,9)`, `MAT(1,0)`, `MAT(1,1)`, ..., `MAT(9,9)`. The instruction:

`PRP(2,3,4)=100` creates a three-dimensional vector named PRP with variable indices: the first from 0 to 2, the second from 0 to 3, and the third from 0 to 4. The total number of elements is 3x4x5 = 60. The last element equals 100.

As opposed to parameters, it is not possible to read access an undefined vector element; this event will be signalled as an error. Obviously, read or write access of a non-existent element of a defined vector will be signalled as an error.
One limitation of the vectors is that it is not currently possible to assign them as *alias_PRK*; other than this, everything can be done that can be done with common parameters.

2.2.5 Visibility of parameters and vectors

The visibility of a parameter (numeric as well as alphanumeric) of a vector extends to the entire program and to all of the subroutines used in the program, independent of their level. This feature allows the rapid passage of the values from the active program to a subroutine and vice versa.

2.2.6 Allocation order

Within a program step, **absolute priority** is given to the allocation to parameters and vectors; if in a step there are several allocations to parameters simultaneously, the execution order of these allocations is from left to right. The allocations to the other instructions present in the step are made **after** having made all of the allocations to parameters.

2.2.7 Notes on use of user data memory

There is a certain quantity of memory available for user-definable data; this memory is divided between *symbols* and *data elements* . One symbol definable by the user is the name of a parameter or of a vector, whereas a *data element* is the basic element for the storage of numeric values. The maximum number of symbols available to the user has been set at 100 (in the worst of cases), while the maximum number of available *data elements* is 300. The difference between these two numbers is due to the fact that, as opposed to parameters, which each use a symbol and a*data element* , the number of *data elements* used by vectors depends on their dimensions. Specifically, the number of “data elements” used, indicated by *num_el*, can be calculated as follows:

$$num\_el = num\_dim + dim1 \times dim2 \times \ldots$$

where: *num_dim* is the number of dimensions (indices) of the vector and *dim1*, *dim2*, ... are the maximum possible values + 1 for the first, second, etc. index. Therefore, in the case of the three vectors in the example in the previous paragraph, we have:

- VET(15) uses: 1 + 16 = 17 *data elements*
- MAT(9,9) uses: 2 + 10*10 = 102 *data elements*
- PRP(2,3,4) uses: 3 + 3*4*5 = 63 *data elements*

for a total of 182 elements from only three symbols.

2.3 Operators and functions

The operators and functions listed below may be used to write expressions:

+ addition
- subtraction, sign inversion
* multiplication
/ division
% module
^ raising to a power
<? less than between two operands
>? greater than between two operands
< less than
> greater than
= equal to
>=, => greater than or equal to
<=, =< less than or equal to
<>, >< different from
! logical negation
~ and logic
# or logic
_B absolute value
_R square root
_S sine
_C cosine
_T tangent
_A arctangent
_M vector module
_I integer
_N rounding off
_E exponential
+ concatenation of two strings
$L left substring
$R right substring
$M centre substring
_D length of string
_V string value
_H ASCII code

`$S` number string

`$C` ASCII character

`_FO` file open

`_FC` file close

`_FD` file delete

`_FW` string write on file

`_FP` character write on file

`_FS` find file

`_P` read PLC variables

`__` various numeric information on system

`$_` various alphanumeric information on system

`_#` change in operative parameters

2.3.1 Priority and association levels

There are priority and association levels; these are organised into table 2.1: where:

Priorities	Operator descriptions	Symbols	Association
8	monadic operators, functions	(+, -, !, _f , $f)	sx ⇐ dx
7	raising to power	(^)	sx ⇐ dx
6	multiplication, division, module	(*,/,%)	sx ⇒ dx
5	plus, minus	(+, -)	sx ⇒ dx
4	select operators	(<?, >?)	sx ⇒ dx
3	relational operators	(=, >, <, ...)	sx ⇒ dx
2	and (multiplication logic)	(~)	sx ⇒ dx
1	or (plus logic)	(#)	sx ⇒ dx

Table 2.1: Priority and association levels

- sx ⇒ dx means association from left to right.
- sx ⇐ dx means association from right to left.

The operations (functions) with highest priority are executed first, those with lowest priority are executed last. Association determines the direction in which the sequences of operations (functions) that have the same priority will be executed. Priority and association, described in Table 2.1, can be modified by means of the use of parentheses:

- An open parenthesis “(" block start with higher priority,
- A closed parenthesis “)" end of block with higher priority,

It is possible to keep up to 20 operations pending.

2.3.2 Arithmetic operators

The principal arithmetic operators are: addition (+), subtraction (-), multiplication (*), division (/). These operators are associated from left to right. Multiplication and division have the same priority, which is greater than the priority of addition and subtraction.

Inversion of sign

Sign inversion (-) changes the sign of the operand that follows. It may be associated from left to right, cancelling in pairs.

Module

The module (%) operation calculates the remainder after the division between two operands (including non-integer). The value given by A%B is $A - n \times B$, where n is the quotient of A/B, rounded to a integer number, towards zero. The dividend and remainder have the same sign.

Raising to power

The operation of raising to power is (^). The exponent can also be fractional, provided that the base is greater than zero. The association is from right to left, therefore: A^B^C is equal to A^(B^C).

2.3.3 Selection operators

The selection operators (<?, >?) can be applied to two operands, either numeric or alphanumeric. The operators minor and greater return to the two operands in their original format.
In case of alphanumeric operands, the comparison is alphabetic; that is, a string is less than another if it is true that it would precede it in a hypothetical dictionary containing both.
The selection operators have association from left to right.

2.3.4 Relational operators

Relational operators are: <, >, =, >=, =>, <=, =<, <>, ><.
These can be applied to two operands both numeric or alphanumeric, and they give a result equal to 1 when the relation is true, or 0 otherwise.
In case of alphanumeric operands, see selection operators for the results of comparison.
Relational operators have association from left to right, nevertheless such association can hardly be used for practical purposes. In fact, 0<A<2 does not give the result "TRUE" if the A value is exactly between 0 and 2, as one would expect, but it always gives value 1 (TRUE), as the result of the comparison 0<A, no matter whether true or false, is always less than 2. In the case considered, the correct formulation would be 0<A~A<2.

2.3.5 Logical operators

Logical negation

The logical negation (!) can be applied to any operand, both numeric or alphanumeric and it gives a result equal to 1 if the operand value is 0 or the string value is 0, or it is equal to 0 otherwise.

And e *Or* logic

The *And* (~) and *Or* (#) can be applied to any two operands and they give a result in integer format equal to 1 or 0. The *And* has the result 0 if at least one of the two operand values or the string is 0, otherwise the value 1 will return. The *Or* gives the result 1 if at least one of the two operands is not 0 or the null string; otherwise, it gives 0.

2.3.6 Numerical functions

Numerical functions are: _B, _R , _S , _C, _T , _A, _M , _I, _E, _N.
These functions can be applied only to two operands of numeric type. Association is from right to left.

Absolute value

The absolute value function (`_B`) gives the value of its argument with plus sign. For example: `_B(-4)` gives a value of 4.

Square root

The square root function (`_R `) gives a value that, if multiplied by itself, gives the initial value. The subject cannot be negative. For example: `_R (4)` gives a value of `2`.

Sine, cosine and tangent

The functions sine (`_S `), cosine (`_C`) and tangent (`_T `) always have an argument expressed in sixtieths of a degree, so, for example, a 20 degree and 30 minute angle will have to be set in the following form: 20.5

Arctangent

The arctangent function (`_A`) gives a result expressed in sixtiesths of a degree between -90 and +90. If two arguments are given, an angle between -180 and 180 degrees is calculated. This is the angle that the vector forms with the positive direction of `x`, and has the first argument in y and the second in x.

Vector module

The vector module function (`_M `) gives a value equal to the length of the vector that has the function arguments as components. For example: `_M (3,4)` gives a value of `5`.

Integer

The integer function(`_I`) always has a result in integer format with a value equal to the largest integer number that is not greater than the operand. For example: `_I3` gives `3`; `_I3.7` also gives a result of `3`; `_I-3.7` gives `-4`.

Exponential Function

The exponential function (`_E`) calculates the number e (i.e. the natural logarithmic base) raised to the given argument. For example: `_E1` gives `2.71828...`, that is e.

Rounding off

The function of rounding off (`_N`) gives a result equal to the integer number nearest to the given argument. For example: `_N3` gives `3`; `_N3.7`gives `4`; `_N-3.7` gives `-4`.

2.3.7 Alphanumeric functions

The chaining of two strings is obtained with the operator `+`.
Functions `$L`, `$R `, `$M`, have a main alphanumeric argument and give alphanumeric results.

Left and right substrings

The left substring (`$L`) and right substring functions (`$R `) create a string obtained by taking a portion of a certain number of characters left or right of a specified string. The relevant syntax is as follows:

`$L(`*expr$*, *expr*`)`
`$R (`*expr$*, *expr*`)`

where *expr$* indicates the string from which the characters are to be taken, and *expr* indicates the number of characters to be taken. If the length of the string is less than or equal to the number of characters requested, the same string will be given as a result.

Central substring

The central substring function (`$M`) creates a string obtained by taking a portion of a certain number of characters from the specified string, starting from the character indicated. The syntax is as follows:

`$M(`*expr$*`,`*expr1*`,`*expr2*`)`

where *expr$* indicates the string from which characters are to be taken, *expr1* indicates the starting character, and *expr2* indicates the number of characters to take. If the length of the string is less than the number indicating the starting character, the result will be the string 0, and if the number of characters remaining, starting from the character indicated, is less than or equal to the number of characters requested, only the remaining part will be the result.

2.3.8 Alphanumeric-numeric conversion function:

Conversion functions are: `_D` , `_V` , `_H`, `$S` , `$C`. These functions have numeric results starting from alphanumeric subjects and vice versa.

String length

The length of string function(`_D`) has an integer result, the value of which corresponds to the number of characters of the specified string.

String value

The string value function (`_V`) gives a result equal to the numeric constant expressed by the characters of the specified string. The same rules apply as for numeric constants, and especially those for conversion of units of measurement. For example, in a program in millimetres, the expression `_V "12.345P"` gives the result 313.56 .

ASCII code

The ASCII code function (`_H`) gives a integer value between `0` and `255` which corresponds to the ASCII code of the first character of the string given as the argument. For example: `_H("ABCD")` gives `65`. In contrast with numeric constants, the strings that are converted into a number do not generate errors, in case these are bad constants. A wrong string is converted until possible and if it cannot be totally converted the value obtained is 0. For example:

`_V "-12.3.45P"` equals -12.3
`_V " 12+3.45P"` equals 12
`_V "A-12.3.45P"` equals 0

String of a number

The string of a number function(`$S`) gives a string of characters expressing the value of a numeric subject. The syntax is the following:

`$S` *expr*

where *expr* is the numeric value to be converted into a string. For example, suppose parameter A contains the value 123.45; then: `$S (A)` gives the string “123.45".

2.3.9 File operations

By means of the following functions, it is possible to perform simple writing operations to file. The maximum number of files that can be used simultaneously is 5.

Open file function

A file is opened with the `_FO` function. The instruction syntax is the following:

`_FO (`*expr$*`)`

where *expr$* indicates the name of the file to be opened. The value given is the number which corresponds to the opened file or `-1` in the case of an error. When the file is opened, the pointer is positioned in correspondence of the first character. This way, if a writing function is used, the characters of the file are overwritten.

Close file function

A file is closed by using the `_FC` function. The instruction syntax if the following:

`_FC (`*expr*`)`

where *expr* is the number which corresponds to the file opened using the `_FO` function. In the case of an error, a value of `-1` is given.

File cancellation function

The cancellation of a file is performed with the `_FD` function. The instruction syntax is the following:

`_FD (`*expr$*`)`

where *expr$* indicates the name of the file to be cancelled. In the case of error, a value of `-1` is given.

Writing string to file function

A string may be written to a file by means of the `_FW` function. The instruction syntax is the following:

`_FW (`*expr$*, *expr*`)`

where *expr$* indicates the string of characters to be written and *expr* is the number which corresponds to the opened file. The number of characters written to the file is given if the procedure is successful, or in the case of error, a value of `-1` is given.

Writing a character to file function

A character may be written to a file by means of the `_FP`function. The instruction syntax is the following:

`_FP(`*expr1*, *expr2*`)`

where *expr1* indicates the ASCII code of the character that is to be written to the file and *expr2* is the number which corresponds to the opened file. The result is a number which corresponds to the ASCII code of the character written if the procedure is successful, or `-1` in the case of an error.

File repositioning function

The repositioning of the point of access to a file is performed by the `_FS` function. The instruction syntax is the following:

`_FS (`*expr1*, *expr2*`)`

where *expr1* is the number which corresponds to the file opened and *expr2* is the number of bytes of forward movement of the access point. Any write operations, after a repositioning of the point of access to a file, will begin from the new point of access. The movement is referred to the beginning of the file. A value of `-1` is given in the case of error.

2.3.10 Special functions

Reading PLC variables

Variables from the PLC are read by means of the `_P` function. The instruction syntax is the following:

`_P (`*expr1[*, *expr2[*, *expr3[*, *expr4]]]*`)`

The function arguments can have different meanings; following are the possibilities.

1. *expr1* indicates the address of the variable to be read, therefore:
   - *expr2* is a integer number, equal to or less than `0`. If it is less than or equal to `0`it represents the index, with the sign inverted, of the bit to be read for a bit variable. If, instead, it is a positive value, it indicates a coded form as follows:

     `1`: byte without sign [`0, ..., 255`],
     `2`: byte with sign [`-128, ..., 127`],
     `3`: long variable [`-2.000.000.000, ..., -2.000.000.000`],
     `4`: float variable,
     `5`: double variable.

     If *expr2* is not given, the value is `1`.
   - *expr3* and *expr4* have no meaning.
2. *expr1* is the address of the first element of a vector of variables, therefore:
   - *expr2* assumes the same meanings already given in the previous case:
   - *expr3* is the index of the vector element.
   - *expr4* has no meaning.
3. *expr1* is the address of the first element of a matrix of variables; therefore:
   - *expr2* assumes the same meanings already given in the previous cases.
   - *expr3* is the index of the line of the matrix.
   - *expr4* is the index of the column of the matrix.

Numeric information on system

The function used to obtain numeric information on the system is indicated by the symbol “`__`" followed by a numeric argument which gives the code for the information requested. Obtainable information is listed in the table 2.2, by code order.

Table 2.2: Codes for system information.

Code	Information
0	operating mode 0=executor 1=graphic
1	number of free data elements
2	number of used data elements
3	total number of data elements
4	number of free user symbols
5	number of user symbols used
6	maximum number of user symbols
7	number of axes actually defined
8	maximum number of definable axes
9	current subroutine level
	>> ...

...<<	
Code	**Information**
10	maximum number of subroutine levels
11	index of first vector element
12	current scale factor (obsolete)
13	number of decimals for millimetres (obsolete)
14	number of decimals for inches (obsolete)
15	scale factor for millimetres (obsolete)
16	scale factor for inches (obsolete)
17	current unit of measurement 0=millimetres, 1=inches
18	maximum difference allowed on radii
19	maximum tolerance allowed for the ellipse
20	maximum angle considered tangent
21	radius of current tool
22	maximum discontinuity allowed

Alphanumeric information on system

The function used to obtain alphanumeric information on the system is indicated by the symbol "`$_`" followed by a numeric argument which gives the code for the information requested. Obtainable information are listed in Table 2.3, by code number.

Table 2.3: Alphanumeric system information

Code	Information
0	interpreter identifying string
1	name of current file
2	interpreter version number (ex. 4.15.7)
3	date of compilation (ex. Jan 31 1996)
4	time of compilation (ex. 10:12:46)
5	date of compilation in Italian format (ex. 31/01/1996)
6	standard identifying string

Modify operating parameters Function

With the Modify operating parameters function (`_#`) it is possible to alter the programming language interpreter behaviour.

ATTENTION: the use of this function by inexpert personnel is inadvisable. Modification of the parameters for interpreter operation must be executed by highly specialised technicians because these modifications can have repercussions both on machine operation and on the safety of the machine operator.

The syntax of the instruction for modifying the operation parameters is:

`_#(`*expr1*`,`*expr2*`)`

where: *expr1* is the code of the parameter, *expr2* is the integer number. When *expr2* is 0 the operation parameter is disabled, in all other cases it is enabled. Table 2.4 shows the codes for the operation parameters and their meaning.

Table 2.4: Operation parameter codes

Code	Meaning
34	changes the number of the current center
35	enables/disables the reading and writing of the machine data
37	enables/disables the (internal) tool radius correction
38	enables/disables immediate emission of end code
39	enables/disables arc data correction
40	enables/disables ellipse conversion
41	modifies the line display style
44	enables/disables lower case conversion
47	enables/disables speed correction in C.R.U. (Tool Radius Correction)

3 Programming

A valid program line must always start with one of these four characters: `:`, `%`, `;`, `N`.
The end of a line is identified with a *line-feed*, provided it is not preceded by the character `@`. This character is linked up to the following line, thus forming a single line.

3.1 Labels

A line starting with the character “`:`" contains a label, and cannot contain other instructions.

3.2 End of program or subroutine

A line containing `%` as a single character, indicates the end of the program or of a subroutine. A line that only contains the characters `%%` determines the immediate end of the program, independently of the current nesting level.

3.3 Comments

A line starting with the character “`;`" is completely ignored, regardless of its content. Nevertheless, it is displayed during the execution of the program. This can be useful to insert some comments in the program, or some lines with clear indications to be able to facilitate following of the program flow.

3.4 Program steps

The lines starting with the character `N` are the actual “steps" of the program. The `N` is in fact the instruction of the “step number", whose syntax is as follows:

`N`*[=]nnnn*

where *nnnn* is any whole number between `0` and `2 147 483 647`.
The step number of a line can be used to start the program execution of the program from a particular line, rather than from the beginning. In addition, it is useful for following the execution of the program in automatic. Such numbers should then be different from step to step and be in ascending order.
The various instructions in a program step, are separated from one another by one or more *blank*characters. Such characters cannot be used for any other purpose, so they cannot come between the name of an instruction and its data, nor inside an expression, apart from the case where it is inside a constant string, i.e. in inverted commas `" "`.
Comments may also be inserted in lines containing instructions by putting the character “`;`" first. Obviously, the comment must be put after the last instruction for the step and must be separated from it by at least one *blank*.
The end of a step may be conditioned by putting a conditional expression in parentheses first. For example, in the line:

`N10 ... (`*expr*`) ...`

the part of the line following `(`*expr*`)` is considered only if *expr* is true, i.e., other than 0.

3.5 Line repetitions

The same line may be repeated by means of instruction:

`RP`*[=]expr*

The value of the expression is converted to the integer immediately preceding it, and gives the number of repetitions of the line. Zero or negative values generate an error condition.
During execution of the program, the repeated lines (except for the first) are displayed together with a number in parentheses that indicates how many lines (including that line) are still to be executed. For example, program line: `N10 RP4` will cause the following display:

```
N10 RP4
N10 RP4   [3]
N10 RP4   [2]
N10 RP4   [1]
```

3.6 Messages

During execution of the program, messages may be sent to the display to highlight passage at defined points or to control the values of some parameters.

3.6.1 Printing of a string

Send a message string to the display by means of instruction:

`MS`*[=]expr$*

where *expr$* is the message to be sent, which in the simplest case will be a constant string, such as in the following instruction `MS="DATA ERROR "`. The message cannot be longer than 30 characters; if longer, it will automatically be cut.

3.6.2 Printing a parameter value

A parameter value at a given point of the program may be displayed by means of instruction:

parm`=?`

where *parm* is the name of any parameter except `PRK`.
The value of an element of a vector may be displayed by means of instruction:

array`(`*expr[*`,`*expr*`, ...` *]*`)=?`

where *array* is the name of a vector, and *expr* are the indices of the element requested.
The display request for a string parameter is effected in the same way. For example, if parameter `ST0` contains the string `"ABCDEF"`, instruction `ST0=?` will give the display of message: `ST0 = "ABCDEF"`.
A string parameter may contain up to 64 characters, however, the maximum length of the message displayed is 30 characters.
The display request for a *alias_PRK* generates the message: *parm* `= PRK`.

3.7 Units of measurement

The system is programmed in either inches or millimetres; when the system is switched on, the unit of measurement automatically set is the millimetre. Nevertheless, it is possible to write programs entirely in inches even when the set unit of measurement is millimetres or to insert displacements in inches in programs with millimetres or viceversa.

3.7.1 Programming in millimetres or in inches

To select inch programming, the `G70` modal instruction is used. To select millimetre programming, the `G71` modal instruction is used.
Instructions `G70` and `G71` must be inserted in the main program before any expression. In fact, the first expression evaluation implies the automatic setting of the unit of measure If the instructions `G70`or `G71` have not been programmed, the default unit of measurement is selected.
After the setting of the unit of measurement, it remains fixed even for all the subroutines used and up to the end of the program, and any further `G70` and `G71` will be ignored.

3.8 Axes

Each axis is indicated by a name containing a maximum of 3 alphanumeric characters. The first character must be a letter.
In addition to this, on indicating the general name of an axis with *axis* there must be no coincidence with the name of any other instruction:

axis instruction of absolute positioning

axis`I` instruction of incremental positioning

axis`O` instruction of change of origin

`F`*axis* instruction of speed assignment

`S`*axis* instruction of scale factor assignment

`E`*axis* instruction of acceleration assignment

`I`*axis* instruction of advance axis arrival

`T`*axis* instruction of sampling device level

If, for example, the system is actually equipped with 16 axes, whose names, determined in a specific file, are as follows:

X, Y, Z, U, V, W, A0, A1, A2, A3, A4, A5, A6, A7, A8, A9;

with which the following instructions are associated:

`XI`, `XO`, `FX`, `SX`, `EX`, `IX`, `TX`; `YI`, `YO`, ... `SA8`, `EA8`, `IA8`, `TA8`; `A9I`, `A9O`, `FA9`, `SA9`, `EA9`, `IA9`, `TA9`.

3.9 Origins

The following are several reference systems, according to the various origins one can have:

- Absolute or machine origin,
- External or piece origin,
- Internal or program origin.

3.9.1 Absolute or machine origin

This is a preferential point defined for each axis by the machine constructor via a machine parameter, setting its position according to the point used by the system for carrying out the axis automatic zero setting.

3.9.2 External or piece origin.

These are points referred by the absolute origin, on which it is possible to position the piece to be worked, by referring to appropriate units of measurement. The piece origin must then be selected by the operator among the fixed origins available in the machine parameters, before executing the program. It is also possible to assign any value from the whole program through an instruction of external origin change.

3.9.3 Program or internal origin

This origin is relative to the piece origin active at the moment, and by default it coincides with the last one. It is possible to change it through the instructions of internal change of origin. All the program relative displacements (non absolute ones) are referred to the internal origin, so the change of internal origin is equal to the program translation with regard to the piece.

3.9.4 Change of origin

The instruction for change of origin for each axis is the following:

axis`O`*[=]expr*

where *axis* is the axis name of which you wish to change the origin; use of the equals sign is necessary only if the expression starts with a parameter. For example: `WO300 YO=LPY/2` assigns a new origin to W (300) and to Y (LPY/2).
If mode `G58` is active, origin change is internal and is known only to the interpreter, which considers the new origin as reference for later values. If mode `G59` is active, origin change is external.

3.10 Zoom

The displacement assigned to an axis is considered in real scale by default, i.e. by default a scale factor equal to 1 is considered active for each axis. However it is possible to change the axis scale factors singly or collectively, in order to be able to obtain automatically the reduction or the enlargement of scale in a program.

3.10.1 Change of scale factor for an axis

The instruction of scale factor assignment for a single axis is as follows:

`S`*axis[=]expr*

where *axis* is the axis name of which you wish to modify the scale factor.

3.10.2 Change of global scale factor

The assignment of the same scale factor to all of the axes can be obtained with the following instruction:

`SF`*[=]expr*

Use of the equals sign is necessary when the expression starts with a parameter.

For example: `SW1.5 SY=LPY/1000` assigns a new scale factor to W (1.5) and to Y (LPY/1000).
When changing the scale factor, the internal origins of each axis will supply the co-ordinates of the only point of the drawing that will keep its position. This point will be such that the various programmed points will approach or withdraw from it, according to the scale factors.
To explain this, consider the fact that the projection of this particular point on the xy level, which is active in that moment, always coincides with the rotation pole. Therefore the change of the scale factor of one of the axes of the main plane may cause a change in the rotation pole, and viceversa the change of rotation angle may cause a change in the x y co-ordinates of the central zoom point.
If the scale factors of the axes of the main plane are different, steps in circular interpolation are not allowed.

3.11 Fundamental set of three axes

Of all the machine axes we can select three of them, that the program interpreter will consider forming, in the given order, a right-handed triplet, whose origin is defined as “rotation pole". This fundamental set of three axes has the following characteristics:

- On the main plane it is possible to carry out both circular and elliptical interpolation, and the tool radius correction can be activated (provided the axes of the plane are controlled by the same axis table).
- On the main plane you can use advanced geometrical instructions.
- The fundamental set of three axes can be rotated around its axis z, i.e. the displacements assigned to the axes of the main plane undergo transformation of co-ordinates corresponding to the rotation of axes.

The definition of the third axis of the triplet is necessary for using the interpolation modes `G9`, `G10`, `G11`.
By default, the fundamental set of three axes is formed by the X, Y, Z.

3.11.1 Selection of tern axes and slaves

The selection of the tern axes can be obtained by the following instruction:

`AX=`*m1[*`:`*s1_1[*`:`*s1_2...]],m2[*`:`*s2_1[*`:`*s2_2...]][,m3[*`:`*s3_1[*`:`*s3_2...]]][,...]*

where: *m1*, *m2*, *m3* are the codes of the axes that from the fundamental set of three axes, and *s1_n*, *s2_n*, *s3_n* are the codes of the axis slaves to the "masters" *m1*, *m2*, *m3*, respectively. Up to 6 axes can be identified as "master", while the number of "slave" axes is 12. The "slave" axes follow the movement of the "master" axis to which they are enslaved in all interpolation movements. The axes *m1* and *m2* define the main plane. The axis *m3* (optional) completes the main reference tern. For example: `AX=U,V,W` defines the right triplet formed by the axes U,V and W and the machine can then interpolate in a circular manner with the axes U and V. The axes not pertaining to the main pair permit linear interpolation only.

3.11.2 Rotation of tern axes

The axis rotation forming the main plane, around a rotation pole, can be carried out with the following instructions:

- `RT`*[=]expr*
- `RTI`*[=]expr*
- `RTO`*[=]expr*

where: *expr* indicates a value in sixtieths of a degree with positive orientation in a clockwise direction. The use of the equals sign is necessary if the expression starts with a parameter.
These instructions can be used also for setting the pole of rotation (i.e. the origin of the set of axes). Such a point must be then determined by the position of the internal origin when executing one of the instructions mentioned. The `RTO` instruction is necessary to fix the angle of origin from which we can consider how to have the rotation started, whose angle can be fixed through the instruction `RT`, or by modifying a certain quantity through the instruction `RTI`.
By default the angle of origin and rotation are set to zero. Therefore, for example, when you have the following set of instructions:

```
RTO=15 RT14.5 RTI-2
```

at the end of the axes of the main plane, the axes will have been rotated clockwise by approx. 27.5 sixtieths of a degree (i.e. 27 degrees 30 mins.); in fact, the origin of the rotation has been set to 15 degrees, the rotation angle initially set to 14.5 degrees has been subsequently decreased by two degrees, i.e. 15+14.5-2=27.5 .
The rotation angle and the relative origin are independent of the selection of the set of three axes, and they remain unchanged if the set is subsequently changed; in other words, the new main plane has the axes rotated by approx. the same angle as in the previous set of three axes.
To better explain how rotation of the axes and "freezing" of the rotation pole functions, let's look at the following program example for the drawing shown in Fig. 3.1:

```
N10 XO200 YO200 RTO0 RT45
N20 G0 X0 Y0
N30 G1 X100
N40 XO400 RT45
N50 G1 X0
N60 G1 Y100
```

3.12 Movement of axes

By indicating the general name of an axis with *axis* we can see which instructions are necessary for their operation.

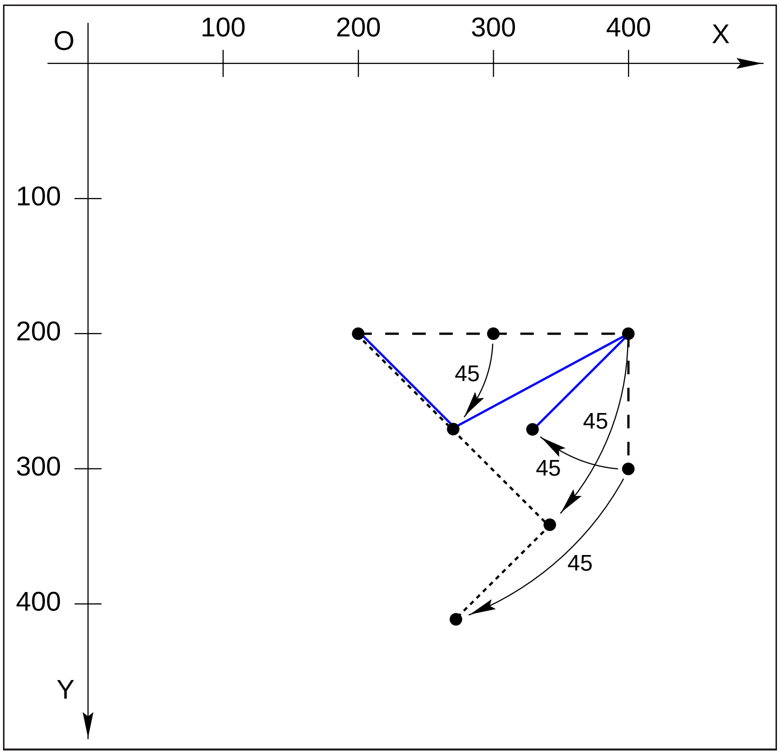


Figure 3.1:
Solid line: path followed with the above
Dashes: path followed without inserting any
Dotted line: path followed by eliminating the rotation from N40

3.12.1 Assignment of an absolute value

The following position of an axis is assigned through the instruction:

axis[=]expr

where: *expr* indicates the axis position according to the origin valid at that moment. Such an origin is the internal one if mode `G54` is active and the expression does not include the parameter `PRK`, otherwise it is the machine origin if mode `G53` is active or the expression includes the parameter `PRK`. Use of the equals sign is compulsory if the name of the axis ends with a number or if the expression starts with a parameter.

For example the instructions: `X100 Z=LPZ-50` cause the movement of X by displacement 100, and the movement of Z at displacement LPZ-50.

3.12.2 Assignment of an incremental value

It is also possible to assign the next axis position with regard to its last programmed position rather than at the origin, by using the following instruction:

axis`I`*[=]expr*

where the use of the equals sign is compulsory if the expression starts with a parameter.

Thus, for example: `XI1000 ZI-10` increases the last programmed position of 1000 for X and -10 for Z.

3.12.3 Assignment of operating speed

The operating speed for independent movements (mode `G0`) is selected, for each axis, by means of the following instruction:

`F`*axis[=]expr*

where: *expr* invariably refers to a speed value expressed in metres/minute both for programming in millimetres and in inches. The use of the equals sign is compulsory if the axis name ends with a number or if the expression starts with a parameter.
For example: `FX2.00 FZ0.5` assign the speeds 2 m/min to X and 0.5 m/min. to Z.
The operating speed for the movements of the interpolation axes on a trajectory (modes `G1`, `G2`, `G3`, `G4`, `G5`, `G6`, `G7`, `G8`), can be selected with the following instruction:

`F`*[=]expr*

Also in this case, the speed is always expressed in m/min. The use of the equals sign is compulsory if the expression starts with the name of a parameter.

3.12.4 Assignment of acceleration

With special software versions, accelerations to be used in speed changes may be assigned. The instructions for the above, where allowed, have the following syntaxes:

- `E`*[=]expr* for interpolated movements
- `E`*axis[=]expr* for independent movements

where *expr* indicates the acceleration percentage to be used compared to that in the machine data.

3.13 Reading of assigned positions and origins

The value of a position or of an internal origin assigned to an axis in the course of a program may be inserted in an expression. This is done by using the same name as the assignment instruction. For example, `X=100` assigns position 100 to the axis indicated by X, and `ABC=X` assigns the position value of X to parameter `ABC`. Likewise for the origins.
It should be kept in mind that the axis position value read refers to the value of the current internal origin for that axis. This means that if an axis position is read after its origin has been changed, you get a value differing from that assigned before the origin change.
In any case, the position read has nothing to do with the instantaneous real position of the axis during execution of the program.
The position read of an axis during a sequence of steps using Assisted Geometric Programming instructions (described below) may give a non correct value, while at the end of the sequence the requested value may be obtained.

3.14 Reading of sampling value of axis

For sampling in interpolation, the sampling value is deposited in an independent variable for each axis involved in the movement. The value for an axis is obtained with instruction `T`*axis*. For example: `AAA=TX` reads the sampling value for the X axis and enters it in parameter `AAA`.

3.15 Positioning

Positioning is a movement by the machine axes from one given point to the next. The movements of the machine axes are independent from one another, i.e. each axis is directed to the assigned displacement at its own speed, independently from the displacement and speed of the other axes. Positioning is performed when the mode is `G0`.

The displacements indicated for an axis undergo a translation of origin of the same axis. Nevertheless, change of origin of an axis does not in itself cause movement unless an instruction for position assignment is specifically expressed for that axis.
If the rotation angle of the set of three axes is different from zero, the displacements of the two axes which constitute the main plane undergo an appropriate transformation of the co-ordinates. In such a case, assigning a position to one of these axes is enough to make the interpreter calculate again the real positions of both the plane axes. Let us consider the following program:

```
N10 G0 XO100 YO100 X0 Y0
N20 X50
N30 RT90 X50
```

In the line 10 the mode `G0` is set for positioning, the internal origin for the co-ordinates xo=100 yo=100 and the co-ordinate point x=0 y=0 is indicated. Dependent on the piece one would then have the co-ordinates 100,100. In the line 20, x = 50 is set; dependant on the piece one would have the co-ordinates 150,100 and the movement of only one axis. In the line 30, the plane xy is rotated by 90 degrees anticlockwise around the internal origin (100,100), and the position x=50 is determined; this time one would have the co-ordinates 100,150 and movement of both the axes of the plane.

3.15.1 Advance declaration of “Axes positioned”

The positioning step is normally declared "executed" (and a signal sent to the PLC) only when, for each commanded axis, the distance from its point of arrival is less than that declared in the "Advance end of positioning" machine data. In special applications, it may be useful to declare "step executed" in advance. This is done with instruction:

`I`*axis[=]expr*

where *expr* indicates the distance in millimetres from the point of arrival of axis *axis*, within which the axis is considered already arrived.

3.15.2 Modal instructions “`G`*expr*” for positionings

Some modal instructions (`G`*expr*) modify the execution of positionings. These are:

Instructions `G60` and `G61`

By means of positioning programming in G60 mode, positioning "cycles" (regarding one or more axes) may be created, to be executed in an asynchronous manner compared to the execution of the program.
By means of instruction `G61`, the program can synchronise itself with the various cycles programmed in `G60` mode. In correspondence with a `G61` instruction, program execution is blocked until previous positionings activated with `G60` mode have been finished. In a step containing instruction `G60`, the following may be programmed:

- instructions regarding axis positioning (speed, acceleration, advance, delay),
- T instructions, which are managed ONLY with respect to axis correctors, but not with respect to exchange signals with the PLC.

Other types of instructions involving signals with the PLC (`M`, `KA`, `S`, ...) cannot appear in a step in which a `G60` instruction is inserted.

◇ **Example 1** In the following example, two asynchronous positionings are programmed for the X and Y axes (steps N20 and N30); the program does not wait for completion of the positionings programmed on lines N20 and N30, but immediately commands positioning of the Z axis (step N40).
Instruction `G61` is programmed at step N60, such programming blocks continuation of the program until the positionings in step N30 are completed.

```
N10 X500 Y500 Z100
N20 X100 Y100 G60
N30 X400 Y400 G60
N40 Z300
N50 Z800
N60 Z1000 G61
N70 X200 Y200 Z200
```

◇ **Example 2** The following program is equivalent to the program in Example 1, since the programming of instruction `G61` may take place in a step that does not contain positioning instructions.

```
N10 X100 Y100 Z100
N20 X100 Y100 G60
N30 X400 Y400 G60
N40 Z300
N50 Z800
N60 Z1000
N60 G61
N70 X200 Y200 Z200
```

Resetting of “normal” positioning mode

"Normal" positioning mode means positioning not in `G60` mode. An axis commanded in `G60` mode can be programmed in "normal" mode only after a G61 instruction.

◇ **Example 3:** incorrect programming.

```
N10 X100 Y100 Z100
N20 X100 Y100 G60
N30 X400 Y400 G60
N40 Z300
N50 Z800
N60 X100 Z1000   ;INCORRECT STEP
```

◇ **Example 4:** correct programming.

```
N10 X100 Y100 Z100
N20 X100 Y100 G60
N30 X400 Y400 G60
N40 Z300
N50 Z800
N55 G61
N60 X100 Z1000
```

Programming of multiple cycles in `G60` mode

Multiple cycles may be programmed in `G60` mode. These cycles are asynchronous with respect to execution of the program as well as with respect to each other.

◇ **Example 5:** positioning steps that are asynchronous with respect to the program and synchronous with respect to each other.
The following steps have been programmed in example 4:

```
N20  X100 Y100 G60
N30  X400 Y400 G60
```

such steps constitute a single asynchronous cycle with respect to the program and are executed in sequence. Step N30 is executed only after both N20 positionings have been completed.
If the positionings of `X` and `Y` are to be made asynchronous to each other, program 2 cycles in `G60` mode as follows:

```
N20 X100 G60
N30 X400 G60 ;FIRST CYCLE
;
N31 Y100 G60
N32 Y400 G60 ;SECOND CYCLE
```

The 2 programmed cycles will be asynchronous with respect to the program and to each other. In particular, since each cycle concerns only one axis, the steps are also connected to one another (they have no end of cycle).

Further information

Let's start with a situation in which there is no type of `G60` cycle in execution.
The first program step containing instruction `G60` identifies a set of axes constituting a `G60` cycle. Later steps in `G60` mode in which only axes in that set appear will still be part of that cycle (i.e., will be in synch).
When a step containing instruction `G60` is programmed in which only axes not in the previous set are contained, a second cycle is identified.
Later steps containing instruction `G60` in which only axes in the second set appear will be considered part of the second cycle (i.e., will be in synch).
A step programmed in `G60` mode is considered incorrect if there appear axes pertaining to the last defined set and at least one axis not in the set.
A single cycle programmed in `G60` mode may not contain more than 15 steps.

◇ **Example 7** correct programming.

```
N10 X100 Y100 Z100 U100 V100 W100
;
N20 X100 Y100 G60
N30 X400 Y400 G60
N20 X100 Y100 G60
N30 X400 Y400 G60 ;FIRST SET
;
N20 Z100 U100 G60
N30 Z400 U400 G60
N20 Z100 U100 G60 ;SECOND SET

N20 V100 W100 G60
N30 V400 W400 G60
N20 V100 W100 G60
N20 V100 W100 G60
N30 V400 W400 G60
N20 V100 W100 G60 ;THIRD SET

N40 A1=100 A2=100 A3=100
N40 A1=200 A2=200 A3=200
N40 A1=100 A2=100 A3=100
N55 G61 ;WAIT FOR ALL 3 CYCLES
;
N10 X100 Y100 Z100 U100 V100 W100
N60 X100 Z1000
;
;ETC. ETC.
```

◇ **Example 8** incorrect programming.

```
N10 X100 Y100 Z100 U100 V100 W100
;
N20 X100 Y100 G60
N30 X400 Y400 G60
N20 X100 Y100 G60
N30 X400 Y400 G60
;
                N20 X100 Z100 U100 G60  ;THIS STEP CONTAINS X AXIS
                                        ;(PERTAINING TO FIRST SET) AND Z,U
                                        ;WHICH DO NOT PERTAIN TO IT
```

◇ **Example 9** incorrect programming.

```
N10 X100 Y100 Z100 U100 V100 W100
;
N20 X100 Y100 G60
N30 X400 Y400 G60
N20 X100 Y100 G60
N30 X400 Y400 G60 ;FIRST SET
;
N20 Z100 U100 G60
N30 Z400 U400 G60
N20 Z100 U100 G60 ;SECOND SET
;
N41 X500 Y500 G60
N42 X600 Y600 G60
                N43 X700 Y700 G60       ;THIS CYCLE HAS AXES THAT PERTAIN
                                        ;TO A PREVIOUS CYCLE
```

correct programming:

```
N10 X100 Y100 Z100 U100 V100 W100
;
N20 X100 Y100 G60
N30 X400 Y400 G60
N20 X100 Y100 G60
N30 X400 Y400 G60 ;FIRST SET
;
N41 X500 Y500 G60
N42 X600 Y600 G60
N43 X700 Y700 G60
;
N20 Z100 U100 G60
N30 Z400 U400 G60
N20 Z100 U100 G60 ;SECOND SET
```

It is also incorrect to define a `G60` type cycle with axes managed by different axes cards, since the various steps can never be synchronised. In this case, divide the cycle into more than one cycle, each of which is managed by the same card.

`G66` instructions

`G66` makes it possible to give a simultaneous *start* to many independent cycles. Example:

```
N10 X0 Y0
```

```
N20 X100 Y100   [G66]
N30 X500 Y400  [G66]
N40 X600 Y700  [G66]
N50 X700
```

In a sequence of this kind, there will be 2 cycles (on X and Y), each having 3 positionings. The presence of G66 is essential in the opening step but superfluous in the others. The cycle will stop at the first step that does not contain all of the axes present in the opening step (in this case, there will be an end of cycle at the end of N40) (or due to other end of cycle conditions). If G66 were not programmed in step N20, there would be an end of cycle at the end of every step. In the step containing G66, and axis is commanded even if a confirmed value is programmed (which normally would not occur).

3.16 Interpolation

With interpolation in the movement to the next programmed point, in addition to the approaching of its co-ordinates, the trajectory followed is important, and depending on the case considered it can be: a line segment, a circular or an elliptical arc, or an arc of a cylindrical helix.
The machine axes movements are linked up together and they cause the point to move along the trajectory at the fixed interpolation speed.
As regards the interpolations, see positionings, translations and co-ordinate rotations of the programmed points.

3.16.1 Linear interpolation

With linear interpolation, the trajectory is a line segment linking up the starting point to the final point. To be able to perform the movements of the linear interpolation, mode G1 must be active.
The system can interpolate simultaneously on 6 axes; i.e., it can move a point along a line segment having 6 dimension space.

3.16.2 Circular interpolation

With circular interpolation, the trajectory is an arc of a circumference, linking up the starting point to the final point. This interpolation can only be performed on planes which are parallel to the main plane.
There are 5 modal instructions (G2, G3, G4, G5, G6) to be used to perform the movements in circular interpolation, according to the data supplied to complete the definition of the arc.
Assuming that the starting point and final point are known, the following possibilities are available:

Arc, with given centre (G2 or 3)

It can be performed using G2 when anticlockwise , or using G3 when clockwise .
The centre co-ordinates are determined with instructions I and J, respectively, for axes *x* and *y* of the main plane.
The NC checks that the distance between the initial point and the center is equal to the distance between the final point and the center, within the assigned tolerance (the default tolerance is 0.1 mm). If the check results are not correct, the NC performs a correction on the co-ordinates of the end point so that the difference between the two calculated distances is within the tolerance range. Beyond this value, the system indicates a fatal error and it stops. If the final point coincides with the starting point, a 360 degree arc is then performed.

Known radius arc (G4 or G5)

It is performed with mode G4 if the direction is anticlockwise , or with mode G5 if the direction is clockwise .
The value of the radius is specified with instruction R and the sign of the latter is necessary to determine which of the two possible arcs must be used. If the radius is positive, one follows the arc having the centre to the left of the oriented line going from the starting point to the final point, except if the arc is then followed by the centre on the right of the same line. The system checks that the distance between the starting point and final point is

not greater than double the radius determined, within the tolerance of 0.1 mm. Beyond this value, the system indicates a fatal error and stops. If the final point coincides with the starting one, no movement will be performed.

Arc tangent with previous step (`G6`)

It can be performed with mode `G6`. The system automatically generates an arc of circumference (or a line segment), which is continuously tangential with previous step, up to the programmed point. The line segment is performed in case the final point is exactly on the tangent coming out from previous step.

Definition of centre co-ordinates

The centre co-ordinates are defined with the following:

- `I`*[=]expr* for the first axis of the fundamental set of three axes
- `J`*[=]expr* for the second axis of the fundamental set of three axes
- `K`*[=]expr* for the third axis of the fundamental set of three axes

where: *expr* indicates the value (expressed with the unit of measurement selected) of the co-ordinate with regard to the origin valid at that moment. The origin is internal if mode `G54`, is active, or is the machine origin if mode CODEG53 is active. The use of the equals sign is compulsory if the expression starts with a parameter.
For example, the instructions: `I100 J=LPZ-5` set the co-ordinates of the centre to 100,LPZ-50.
The co-ordinates of the centre undergo the transformations due to the translation and rotation of the set of three axes, exactly as the displacements of the axes forming the main plane.

Definition of radius length

The radius is defined by means of instruction:

`R`*[=]expr*

where: mode *expr* indicates the length of the radius in millimetres or inches according to the unit of measurement selected, while the sign is necessary for the discriminator for the solution of the arc, as described above. The use of the equals sign is necessary when the expression starts with a parameter.
If any of the values requested has not been defined, the system will use the last value determined. In order to generate a movement, at least one co-ordinate of the arrival point must be set.

Circular interpolation in space, with given center co-ordinates

Execute with mode `G9` if the arc is less than 180 degrees, or with mode `G10` if it is greater than 180 degrees. The center co-ordinates are defined by means of the instructions `I`, `J`, `K` for the axes x, y, z, of the fundamental set of three axes, respectively. The NC checks that the distance between the initial point and the center is equal to the distance between the end point and the center within the assigned tolerance (the default tolerance is 0.1 mm). Beyond that value the system signals a fatal error and stops. If the initial point, the center and the end point are aligned (180 degree arc), it signals a fatal error.

Circular interpolation in space, with given intermediate point

Execute with mode `G11`. The co-ordinates of the intermediate point are defined by instructions `I`, `J`, `K` for the x, y, z, axes of the fundamental set of three axes, respectively. The initial, intermediate, and end point must be distinct and non aligned. If the contrary is true, the system signals a fatal error.

3.16.3 Elliptical interpolation

With elliptical interpolation, the trajectory is an elliptical arc; the trajectory occurs on a plane parallel to the main plane. There are two modal instructions (`G7`, `G8`) to perform the movements in elliptical interpolation, with regard to anticlockwise (`G7`) or clockwise (`G8`) directions.

For the definition of an elliptical arc to the final point, the co-ordinates of the centre must also be specified, as well as for the circumference, and the length of the semi-axes, which is set with the instructions:

- RI*[=]expr* for the semi-axis parallel to x (1st axis) and
- RJ*[=]expr* for the semi-axis parallel to y (1st axis)

where: the mode *expr* indicates the length of the semi-axis, in millimetres or inches, according to the unit of measurement selected. The use of the equals sign is compulsory if the expression starts with a parameter.
If one of the values has not been defined, the system uses the last value set.
The system checks that the starting points and final points pertain to the ellipse foci and semi-axes indicated, with a tolerance of 0.1 mm. Should this value be exceeded, the system indicates a fatal error and stops.

3.16.4 Helicoidal interpolation

In helicoidal interpolation, the trajectory is a helical arc with the longitudinal axis perpendicular to the main plane, linking up the starting point to the final point.
The projection of the movement on the main plane can be a circular or elliptical arc. The definition of an helicoidal interpolation step is very similar to that of a step in circular or elliptical interpolation, with the only difference that a change on one or more axes (max. 4) is specified. These axes interpolate in a linear manner between one another and an angular quantity used by the system when building the arc.
The same checks are performed by the system in the case of circular or elliptical interpolation, and are performed as if no change occurred on the axes of the helix.
With G2 or G3 it is possible to perform a 360 degree arc, so that a complete helix step can be performed. If one wishes to perform more steps, it is enough to repeat the same movement n times, for example:

```
N10 X100 Y0 Z0 G0              ;POSITIONING
N20 X100 I0 J0 ZI20 G3 RP10    ;10 COMPLETE REVS. OF A 20MM STEP
```

With helicoidal circular interpolation the speed set refers to the actual trajectory.

3.17 Bevel and contiguous segments

3.17.1 Bevel

It is possible to insert a step which bevels the angle formed between two contiguous segments lying in a plane parallel to the main plane and not tangential to one another. This step is calculated automatically by the system via instruction:

BM*[=]expr*

where: *expr* indicates the length of the part, in millimetres or inches according to the unit selected, by which each of the two segments will be shortened, starting from their point of contact. The use of the equals symbol is mandatory if the expression starts with a parameter.
The system naturally checks that the length of each of the two segments in question are longer than that of the bevel itself. Should this not be the case then a fatal error is registered and program execution is aborted.
The condition that the segments lie in a plane parallel to the main plane is not necessary for calculation of the bevel, although the latter will only be carried out correctly in this case. In contrast, the system calculates the bevel with respect to the projections of the two segments onto the plane parallel to the main plane, the former containing their point of contact and the bevel itself. This also modifies the remaining sections of the segments with respect to the original trajectory. This is specified in the program example below; Fig. 3.2 shows the programmed movement of the axes.

```
G0 X=500 Y=100 Z=0
G1 Y=600 Z=300 BM=100
G1 X=100 Z=500
```

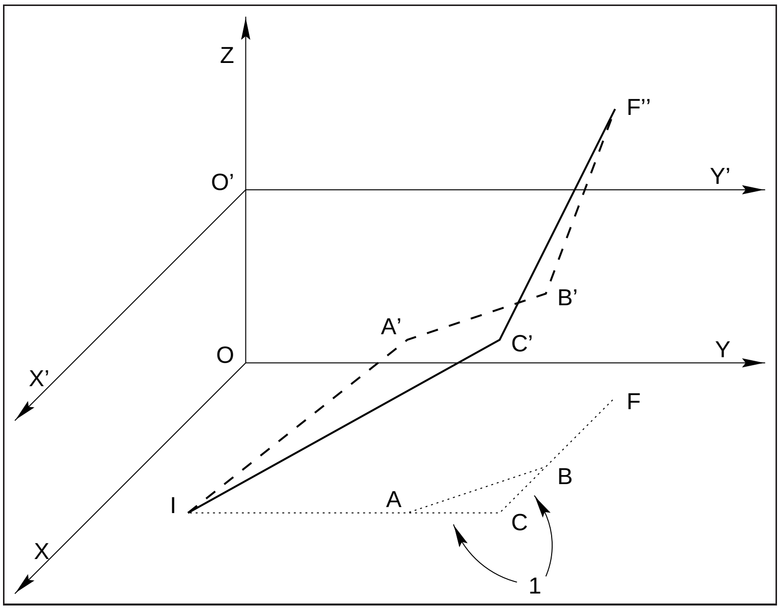


Figure 3.2:

segment AB (1)	bevel
X'Y'	plane parallel to main plane XY
Continuous Line:	original segments
Dashes:	trajectory followed after calculation of bevel
Dotted Line:	segments projected on main axis

3.17.2 Contiguous elements

It is possible to insert a circular arc step which bevels the angle between two quasi-contiguous elements lying in a plane parallel to the main plane and not tangential to each other. This step can be calculated automatically by the system using the instruction:

BR*[=]expr*

where: *expr* indicates the length of the radius of the connecting arc, in mm or inches according to the selected length unit. The use of the equals sign is mandatory if the expression starts with a parameter.
The system of course checks that the starting and ending points of the connecting arc are contained within the elements being connected. Should this not be the case, (probably because the radius of the arc is too large) then an error is flagged and program execution is aborted.
As regards the condition that the two elements lie in a plane parallel to the main plane, the discussion made for the bevel remains valid, i.e. the calculation of the connecting arc is performed correctly only in this case. Otherwise the connecting arc is calculated with respect to the projections of the two elements.

4 Programming of spatial work directions

4.1 Spatial orientation of spindles

Each spindle may take on any spatial direction determined by its spatial offset (angle on horizontal plane and angle on vertical plane) defined in the Correctors tables in the Technical Data application program. Tool work point is calculated based on spindle offsets and length of tool fit.

4.2 Spatial orientation of aggregates

An aggregate is an object composed of one or more subspindles. The geometry for the aggregate is defined in the Aggregates Table included with the Tooling Data in the technical Data application program. These definition data refer to a clockwise Cartesian tern having an origin coinciding with the power takeoff of the aggregate itself.
Each subspindle belonging to an aggregate may take on any spatial direction determined by its spatial offset (angle on horizontal plane and angle on vertical plane) defined in the Subspindle tables in the Technical Data application program.
It is also possible to program rotations to add to default rotations in the same way described for the spindles. These rotations relate to the centre of rotation of the aggregate and they are programmed by the instructions:

- `AR`*[=]expr*
- `AZ`*[=]expr*

where *expr* is an expression whose result must be a number whose unit of measurement is 60ths of a degree.

◇ Example of programming

```
N20 TP2:2 AR=90 AZ=45
```

The rotation of the aggregate fit on pantograph spindle 2 is programmed in step N20; final orientation is given by the algebraic sum of the programmed angles of rotation and of the angular offsets of subspindle 2.

◇ N.B.: Every time you program an instruction type `TP` it is good practice to program instructions `AR` and `AZ` as well.

5 Assisted Geometric Programming

The Assisted Geometric Programming (P.G.A.) package is a facility which is active only on the main plane and which is used to enter steps for which the end point co-ordinates are not known, but for which one knows the relation to the previous step (e.g. tangent or intersection), the value of an angle, of a length or, more generally, of data directly derivable from the design, but which are not directly usable in the normal method of programming.
The totality of blocks which are both necessary and sufficient to permit the system to calculate all the co-ordinates of a geometric element (point of arrival and/or centre of a circle) constitutes a *geometric sequence*.
A geometric sequence has as its origin the starting point of its first element. Such a point can either be programmed in the preceding step or calculated by the system. In fact, the first block in a geometric sequence can be the last of the previous sequence.
The system is capable of resolving sequences of up to three such incompletely defined steps. Nevertheless it is not capable of resolving all possible combinations of data which can make up a geometrically determined sequence; i.e., it is not able to "invent" a solution on demand (a problem which, in general, is not easy to solve). The system is able to recognise the solution of only a certain number of different sequences that have been stored, and can use only these. Their number should nevertheless be sufficient to cover the majority, if not all, of those cases which are likely to occur in practice.
The list of recognised sequences is given at the end of this chapter.

5.1 Instructions for Geometric Programming

When defining steps with Assisted Geometric Programming, the following instructions are added:

- `BS`*[*`+|-`*]*block intersects with its successor
- `BT`*[*`+|-`*]*block is tangential to its successor

where: *[*`+|-`*]* indicates either "+" or "-", used to discriminate between the two possible solutions, where the programmed sequence permits this. Whenever the discriminator is omitted, it is treated as a "+".
Other instructions used are:

`BA`*[=]expr*

where *expr* is a value in sixtieths of a degree (minutes) which indicates the angle that an oriented straight line segment passing from start to end point makes with the X-axis, or the angle traversed by a circumferential arc. and finally:

`BL`*[=]expr*

where *expr* is a value in mm or inches, according to the unit used, which indicates the linear length of a segment or a circumferential arc. The use of the equals sign is mandatory if the expression starts with a parameter.
The value of the expressions given in the preceding instructions can also be negative. In the case of the instruction `BA` applied to a segment, the meaning is obvious, although this cannot be said for an arc or for the instruction `BL`. The effect produced in such situations will be described later with the aid of some examples.
For an incompletely defined step to be part of a sequence in Assisted Geometric Programming, at least one of these four instructions must be present. If not, the information referring to the two axes in the main plane may ignored and/or poorly interpreted.
The instruction indicating that a step is tangential to its successor (`BT`) can be omitted where the step also contains a `BA` instruction. The instruction that a step intersects with its successor (`BS`) can never be omitted.
Finally, certain instructions cannot be performed within a sequence using P.G.A., for example: a displacement of the origin of the main plane or a change of the set of three axes. Use of the above instructions blocks execution of the program.

5.2 Use of discriminator

Certain sequences can have more than one solution, as in the case of the intersection of a straight line with a circle or a circle with a circle, in which cases there can be two solutions, or in the calculation of elements tangential

to each other, in which there can also be more than two solutions. In this cases, it is necessary to point out that the number of solutions is therefore limited to a maximum of two, due to the fact that the system realises only the two "continuous" tangents, i.e. without withdrawal.
Where two solutions are possible, a discriminator is used to eliminate uncertainty. Programming of the discriminator is included in instructions `BT` and `BS`, via the option "+" or "-". This sign option serves to specify the position of a characteristic point (intersection, tangent, centre of arc) of both solutions with respect to a particularly oriented straight line (which we indicate by D). The oriented straight line D is:

1. the straight line belonging to a segment defined via instruction `BA`, if there is an element so defined among the two elements in question. If there are two such defined elements, the first of the two is used; otherwise it is:
2. the straight line which joins a known point in the first element (a centre of arc if known, otherwise a start point, in order of priority), with the first of the points known between the second and the final element (a possible centre of arc always having precedence over an end point).

The characteristic point subject to discrimination is:

- the point of tangency/intersection in the case where the straight line (D) is determined as in case a), otherwise it is:
- the centre of arc if this is not known, or otherwise,
- the point of tangency/intersection.

Having determined oriented straight line (D) and the characteristic point, there can be two cases:

1. The two possible solution points are to be found on oriented straight line (D). In this case, "+" defines the point close to "$+\infty$" on the oriented straight line, while "-" defines the point closest to "$-\infty$".
2. The two possible solution points are on two parts of oriented straight line (D). In this case "+" defines the point on the right of the oriented straight line, while "-" defines that on the left .

In addition, there is special case of discrimination which uses the sign of the expression of `BL` when calculating a segment for which ones knows, in addition to the starting point, only one of the end point co-ordinates. In this case, a positive value of the expression indicates the larger value for the two possible co-ordinates, viceversa for a negative value.
The tables of examples shown in section 5.4, associated with the list of possible cases, will clarify the way in which these system rules are applied.

5.3 List of cases resolved by P.G.A.

When one activates Assisted Geometric Programming, instructions `G4` and `G5` are automatically converted into `G2` and `G3`, respectively, and are seen as such by the geometric interpreter. For this reason, instruction `G4(5)` never appears in the following table, a fact which is permitted.
Instructions `X` and `Y` indicate the assignments to the two axes of the main plane.
The blocks marked with (*) give the solution for those blocks which precede the asterisk but remain incomplete. For this reason, they become the first block of the following program description. Table 5.1 organises all of the cases provided by geometric programming.

FIRST STRAIGHT BLOCK		
Step 1	**Step 2**	**Step 3**
G1 BA... X... G1 BA... Y... G1 BA... BL... G1 BL[+|-]... X... G1 BL[+|-]... Y...		
		>>...

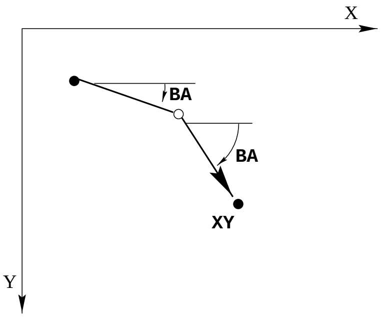
... <<		
Step 1	**Step 2**	**Step 3**
G1 BA... BS	G1 BA... X... Y...	
	G1 BA... [BT]	G2(3) I... J... R... BT (*) G2(3) I... J... R... BS (*) G2(3) I... J... R... BA... G2(3) I... J... R... BL... G2(3) I... J... X... Y...
G1 BA... BS[+|-]	G2(3) I... J... R... BT (*) G2(3) I... J... R... BS (*) G2(3) I... J... R... BA... G2(3) I... J... R... BL... G2(3) I... J... X... Y...	
	G2(3) I... J... BT	G1 BA... X... Y...
	G2(3) I... J... BT[+|-]	G2(3) I... J... R... BT (*) G2(3) I... J... R... BS (*) G2(3) I... J... R... BA... G2(3) I... J... R... BL... G2(3) I... J... X... Y...
G1 BA... [BT]	G2(3) I... J... BT (*) G2(3) I... J... BS (*) G2(3) I... J... BA... G2(3) I... J... BL...	
G1 BA... [BT[+|-]]	G2(3) R... X... Y...	
G1 BA... [BT]	G2(3) R... BT	G1 BA... X... Y...
G1 BA... [BT[+|-]]	G2(3) R... BT	G2(3) I... J... R... BT (*) G2(3) I... J... R... BS (*) G2(3) I... J... R... BA... G2(3) I... J... R... BL... G2(3) I... J... X... Y...
G1 BT...	G2(3) I... J... R... BT (*) G2(3) I... J... R... BS (*) G2(3) I... J... R... BA... G2(3) I... J... R... BL... G2(3) I... J... X... Y...	
	G2(3) I... J... BT	G1 BA... X... Y...
	G2(3) I... J... BT[+|-]	G2(3) I... J... R... BT (*) G2(3) I... J... R... BS (*) G2(3) I... J... R... BA... G2(3) I... J... R... BL... G2(3) I... J... X... Y...

FIRST STRAIGHT BLOCK		
Step 1	**Step 2**	**Step 3**
G2(3) BL... I... J...		
G2(3) BA... I... J...		
G2(3) BT I... J...	G1 BA... [BT] (*) G1 BA... BS (*) G1 BA... BL... G1 BA... X... G1 BA... Y... G1 X... Y...	
	G1 BT	G2(3) I... J... R... BT (*) G2(3) I... J... R... BS (*)
		>> ...

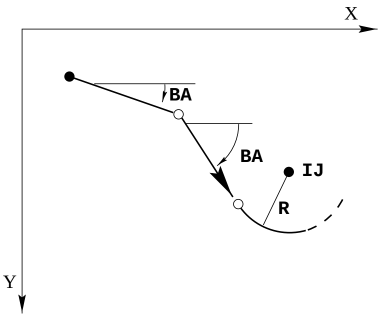
<table>
<tr><td colspan="3">... <<</td></tr>
<tr><th>Step 1</th><th>Step 2</th><th>Step 3</th></tr>
<tr><td></td><td></td><td>G2(3) I... J... R... BA...
G2(3) I... J... R... BL...
G2(3) I... J... X... Y...</td></tr>
<tr><td>G2(3) BT[+|-] I... J...</td><td>G2(3) I... J... BT (*)
G2(3) I... J... BS (*)
G2(3) I... J... BA...
G2(3) I... J... BL...
G2(3) R... X... Y...</td><td></td></tr>
<tr><td></td><td>G2(3) R... BT</td><td>G1 BA... X... Y...
G2(3) I... J... R... BT (*)
G2(3) I... J... R... BS (*)
G2(3) I... J... R... BA...
G2(3) I... J... R... BL...
G2(3) I... J... X... Y...</td></tr>
<tr><td>G2(3) BS[+|-] I... J...</td><td>G1 BA... X... Y...</td><td></td></tr>
<tr><td></td><td>G1 BA... [BT]</td><td>G2(3) I... J... R... BT (*)
G2(3) I... J... R... BS (*)
G2(3) I... J... R... BA...
G2(3) I... J... R... BL...
G2(3) I... J... X... Y...</td></tr>
<tr><td></td><td>G2(3) I... J... R... BT (*)
G2(3) I... J... R... BS (*)
G2(3) I... J... R... BA...
G2(3) I... J... R... BL...
G2(3) I... J... X... Y...</td><td></td></tr>
<tr><td></td><td>G2(3) I... J... BT</td><td>G1 BA... X... Y...</td></tr>
<tr><td></td><td>G2(3) I... J... BT[+|-]</td><td>G2(3) I... J... R... BT (*)
G2(3) I... J... R... BS (*)
G2(3) I... J... R... BA...
G2(3) I... J... R... BL...
G2(3) I... J... X... Y...</td></tr>
<tr><td>G2(3) BT[+|-] R...</td><td>G1 BA... X... Y...</td><td></td></tr>
<tr><td></td><td>G1 BA... [BT]</td><td>G2(3) I... J... R... BT (*)
G2(3) I... J... R... BS (*)
G2(3) I... J... R... BA...
G2(3) I... J... R... BL...
G2(3) I... J... X... Y...</td></tr>
<tr><td></td><td>G2(3) I... J... R... BT (*)
G2(3) I... J... R... BS (*)
G2(3) I... J... R... BA...
G2(3) I... J... R... BL...
G2(3) I... J... X... Y...</td><td></td></tr>
<tr><td></td><td>G2(3) I... J... BT</td><td>G1 BA... X... Y...</td></tr>
<tr><td></td><td>G2(3) I... J... BT[+|-]</td><td>G2(3) I... J... R... BT (*)
G2(3) I... J... R... BS (*)
G2(3) I... J... R... BA...
G2(3) I... J... R... BL...
G2(3) I... J... X... Y...</td></tr>
</table>

Table 5.1: P.G.A. Table

5.4 Examples of possible P.G.A.

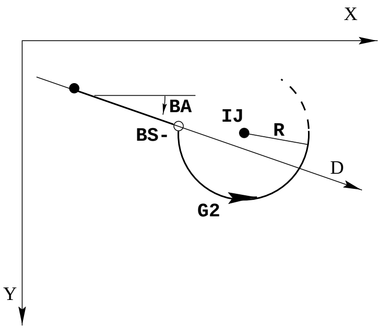


G1 BA... BS G1 BA... X... Y...



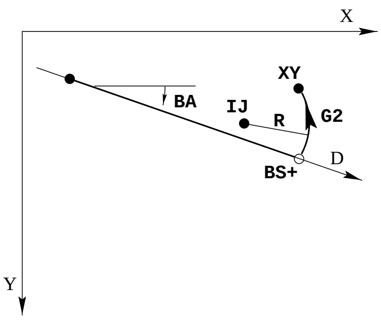
G1 BA... BS G1 BA... [BT]

- G2 I... J... R... BT(∗)
- G2 I... J... R... BS(∗)
- G2 I... J... R... BA...
- G2 I... J... R... BL...
- G2 I... J... X... Y...



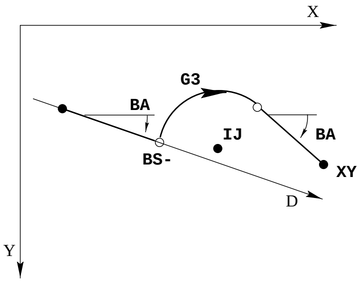
G1 BA... BS-

- G2 I... J... R... BT(∗)
- G2 I... J... R... BS(∗)
- G2 I... J... R... BA...
- G2 I... J... R... BL...
- G2 I... J... X... Y...

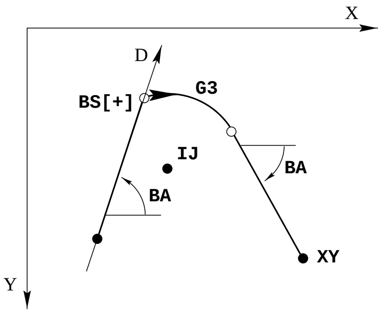


G1 BA... BS[+]

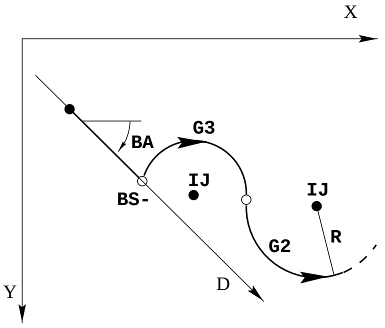
- G2 I... J... R... BT(∗)
- G2 I... J... R... BS(∗)
- G2 I... J... R... BA...
- G2 I... J... R... BL...
- G2 I... J... X... Y...



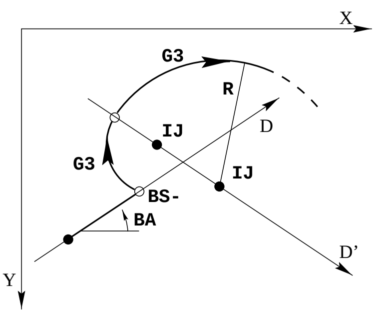
G1 BA... BS- G3 I... J... BT G1 BA... X... Y...



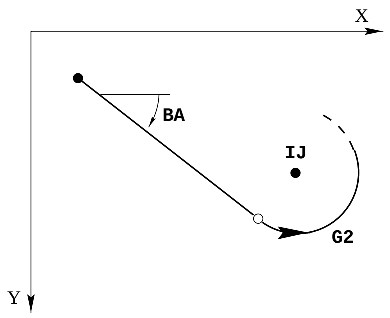
G1 BA... BS*[+]* G3 I... J... BT G1 BA... X... Y...



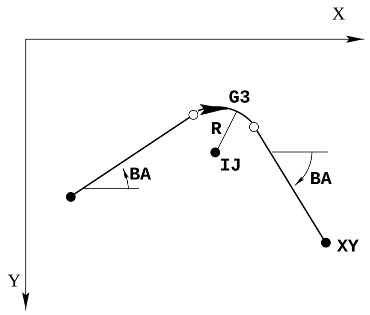
G1 BA... BS- G3 I... J... BT*[+]*
- G2 I... J... R... BT(∗)
- G2 I... J... R... BS(∗)
- G2 I... J... R... BA...
- G2 I... J... R... BL...
- G2 I... J... X... Y...



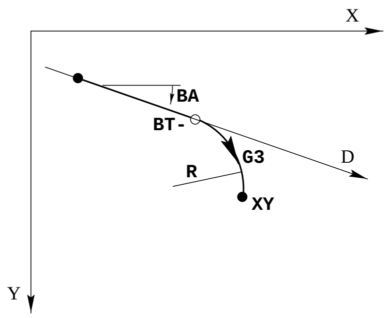
G1 BA... BS- G3 I... J... BT-
- G3 I... J... R... BT(∗)
- G3 I... J... R... BS(∗)
- G3 I... J... R... BA...
- G3 I... J... R... BL...
- G3 I... J... X... Y...



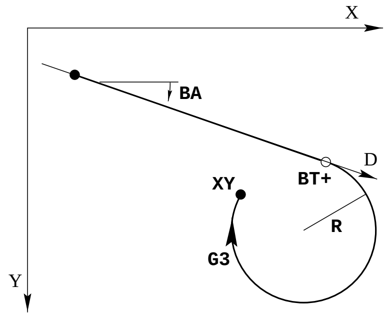
G1 BA... [BT] { G2 I... J... BT(*) / G2 I... J... BS(*) / G2 I... J... BA... / G2 I... J... BL... }



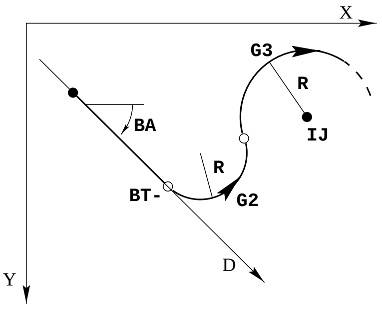
G1 BA... [BT] G3 R... BT G1 BA... X... Y...



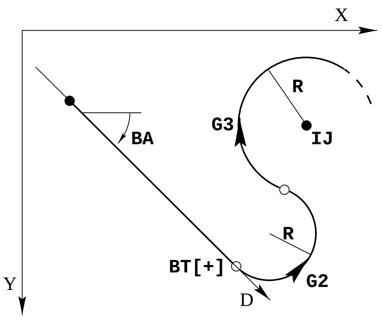
G1 BA... BT- G3 R... X... Y...



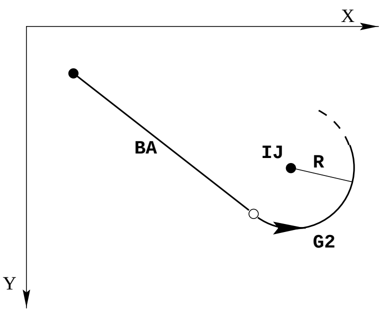
G1 BA... [BT[+]] G3 R... X... Y...



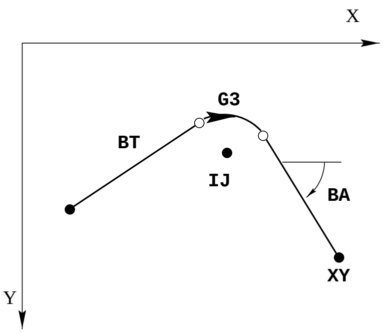

```
G1 BA... BT-   G2 R... BT  { G3 I... J... R... BT(*)
                             G3 I... J... R... BS(*)
                             G3 I... J... R... BA...
                             G3 I... J... R... BL...
                             G3 I... J... X... Y...
```



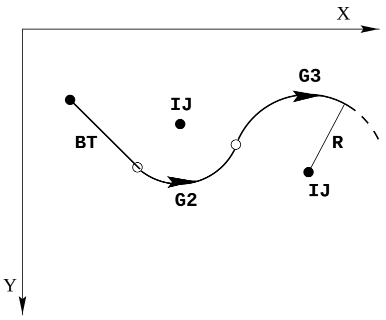

```
G1 BA... [BT[+]]   G2 R... BT  { G3 I... J... R... BT(*)
                                 G3 I... J... R... BS(*)
                                 G3 I... J... R... BA...
                                 G3 I... J... R... BL...
                                 G3 I... J... X... Y...
```




```
G1 BT...  { G2 I... J... R... BT(*)
            G2 I... J... R... BS(*)
            G2 I... J... R... BA...
            G2 I... J... R... BL...
            G2 I... J... X... Y...
```

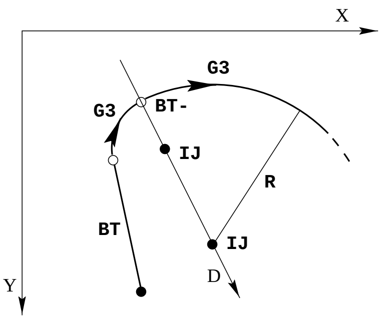



```
G1 BT...    G3 I... J... BT   G1 BA... X... Y...
```



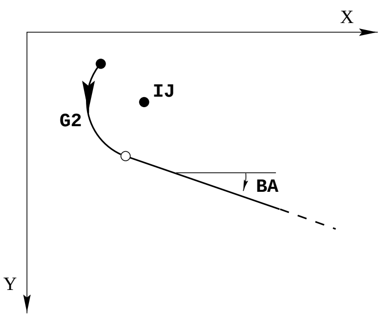
G1 BT... G2 I... J... BT

- G3 I... J... R... BT(*)
- G3 I... J... R... BS(*)
- G3 I... J... R... BA...
- G3 I... J... R... BL...
- G3 I... J... X... Y...



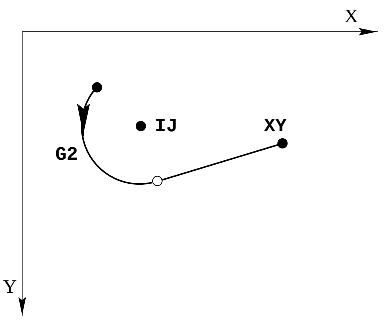
G1 BT... G3 I... J... BT-

- G3 I... J... R... BT(*)
- G3 I... J... R... BS(*)
- G3 I... J... R... BA...
- G3 I... J... R... BL...
- G3 I... J... X... Y...

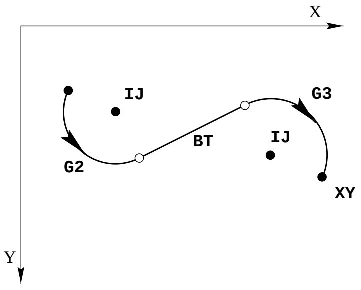


G2 BT I... J...

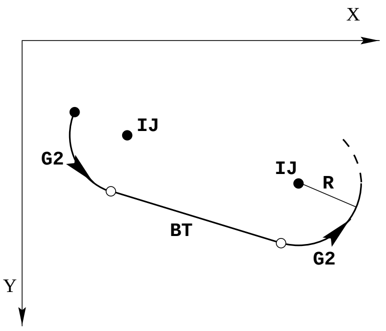
- G1 BA... [BT](*)
- G1 BA... BS(*)
- G1 BA... BL...
- G1 BA... X...
- G1 BA... Y...



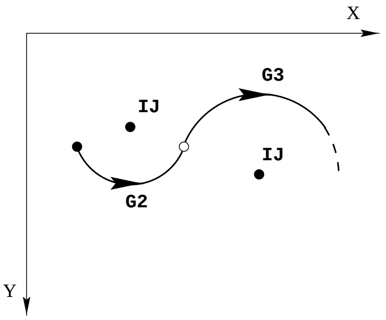
G2 BT I... J... G1 X... Y...



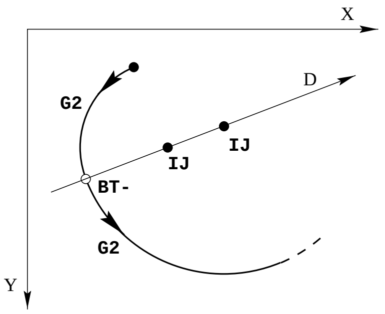

```
G2 BT I... J...    G1 BT { G3 I... J... R... BT(*)
                           G3 I... J... R... BS(*)
                           G3 I... J... R... BA...
                           G3 I... J... R... BL...
                           G3 I... J... X... Y...
```



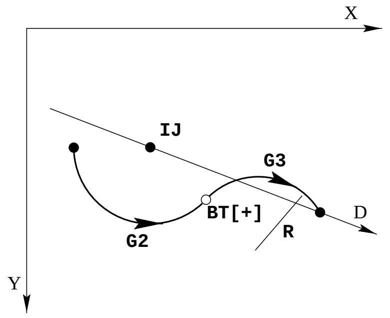

```
G2 BT I... J...    G1 BT { G2 I... J... R... BT(*)
                           G2 I... J... R... BS(*)
                           G2 I... J... R... BA...
                           G2 I... J... R... BL...
                           G2 I... J... X... Y...
```



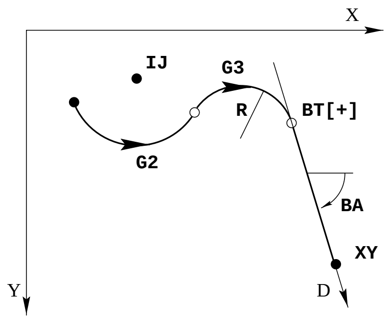

```
G2 BT I... J...  { G3 I... J... R... BT(*)
                   G3 I... J... R... BS(*)
                   G3 I... J... R... BA...
                   G3 I... J... R... BL...
```



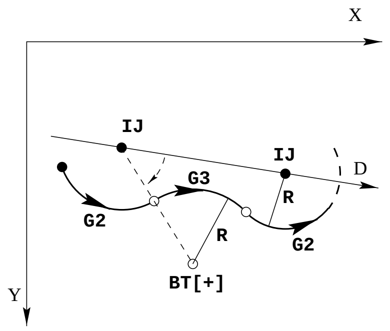

```
G2 BT- I... J...  { G2 I... J... R... BT(*)
                    G2 I... J... R... BS(*)
                    G2 I... J... R... BA...
                    G2 I... J... R... BL...
```



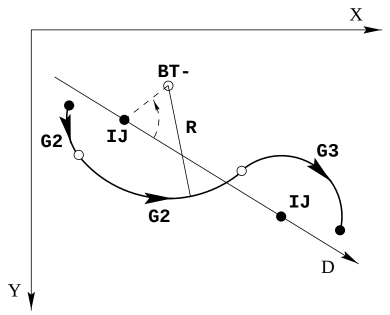
G2 BT[+] I... J...   G3 R... X... Y...



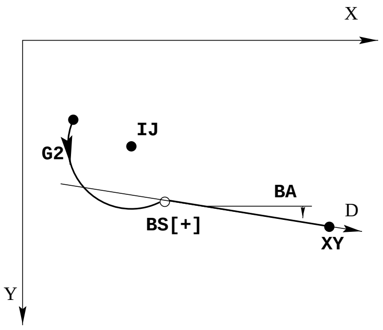
G2 BT[+] I... J...   G3 R... BT   G1 BA... X... Y...



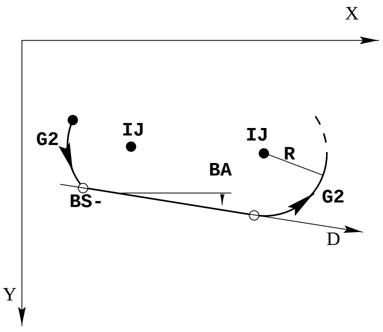
G2 BT[+] I... J...   G3 R... BT
G2 I... J... R... BT(∗)
G2 I... J... R... BS(∗)
G2 I... J... R... BA...
G2 I... J... R... BL...
G2 I... J... X... Y...



G2 BT- I... J...   G2 R... BT
G3 I... J... R... BT(∗)
G3 I... J... R... BS(∗)
G3 I... J... R... BA...
G3 I... J... R... BL...
G3 I... J... X... Y...

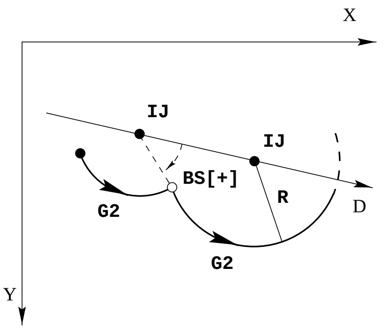


G2 BS[+] I... J... G1 BA... X... Y...



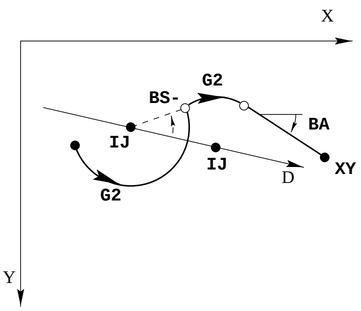
G2 BS- I... J... G1 BA... [BT]

G2 I... J... R... BT(∗)
G2 I... J... R... BS(∗)
G2 I... J... R... BA...
G2 I... J... R... BL...
G2 I... J... X... Y...

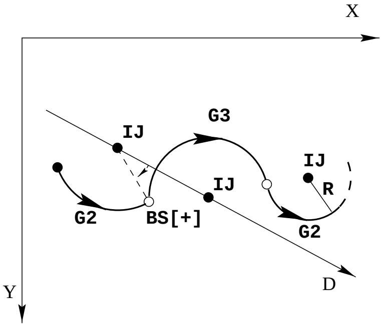


G2 BS[+] I... J...

G2 I... J... R... BT(∗)
G2 I... J... R... BS(∗)
G2 I... J... R... BA...
G2 I... J... R... BL...
G2 I... J... X... Y...

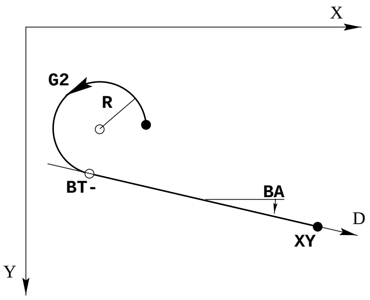


G2 BS- I... J... G3 I... J... BT G1 BA... X... Y...



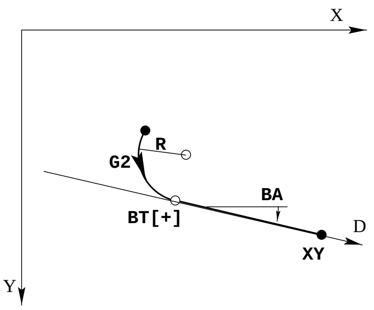
G2 BS[+] I... J...

.... G3 I... J... BT $\left\{\begin{array}{l}\texttt{G2 I... J... R... BT(*)}\\\texttt{G2 I... J... R... BS(*)}\\\texttt{G2 I... J... R... BA...}\\\texttt{G2 I... J... R... BL...}\\\texttt{G2 I... J... X... Y...}\end{array}\right.$

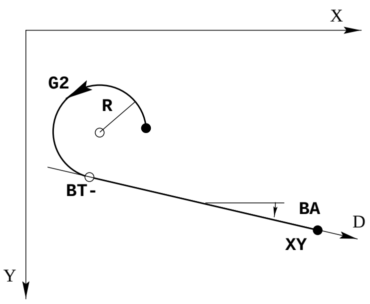


G2 BS- I... J...

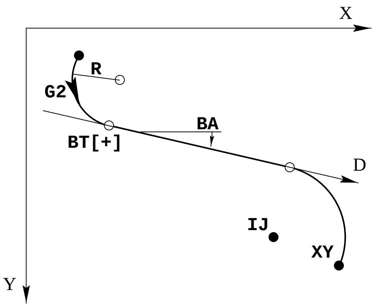
.... G3 I... J... BT[+] $\left\{\begin{array}{l}\texttt{G3 I... J... R... BT(*)}\\\texttt{G3 I... J... R... BS(*)}\\\texttt{G3 I... J... R... BA...}\\\texttt{G3 I... J... R... BL...}\\\texttt{G3 I... J... X... Y...}\end{array}\right.$



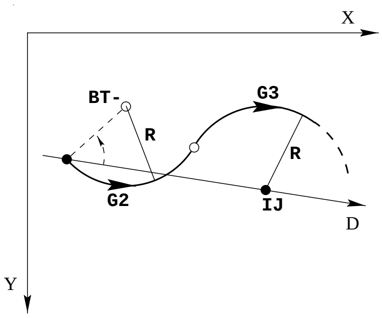
G2 BT[+] R...   G1 BA... X... Y...



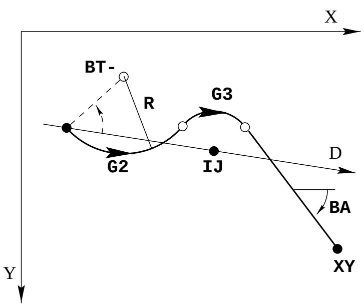
G2 BT- R...   G1 BA... X... Y...



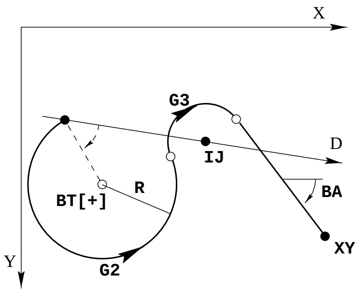

```
G2 BT[+] R...    G1 BA... [BT]  { G3 I... J... R... BT(*)
                                  { G3 I... J... R... BS(*)
                                  { G3 I... J... R... BA...
                                  { G3 I... J... R... BL...
                                  { G3 I... J... X... Y...
```



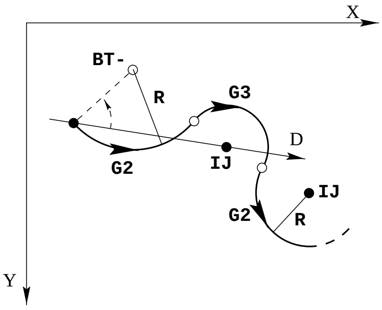

```
G2 BT- R...  { G3 I... J... R... BT(*)
             { G3 I... J... R... BS(*)
             { G3 I... J... R... BA...
             { G3 I... J... R... BL...
             { G3 I... J... X... Y...
```



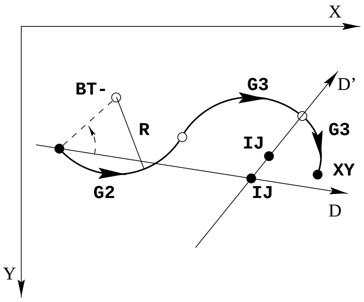

```
G2 BT- R...   G3 I... J... R... BT   G1 BA... X... Y...
```




```
G2 BT[+] R...   G3 I... J... R... BT   G1 BA... X... Y...
```



G2 BT- R...   G3 I... J... BT $\left\{\begin{array}{l}\text{G2 I... J... R... BT}(*)\\ \text{G2 I... J... R... BS}(*)\\ \text{G2 I... J... R... BA...}\\ \text{G2 I... J... R... BL...}\\ \text{G2 I... J... X... Y...}\end{array}\right.$



G2 BT- R...   G3 I... J... BT*[+]* $\left\{\begin{array}{l}\text{G2 I... J... R... BT}(*)\\ \text{G2 I... J... R... BS}(*)\\ \text{G2 I... J... R... BA...}\\ \text{G2 I... J... R... BL...}\\ \text{G2 I... J... X... Y...}\end{array}\right.$

5.5 Example program

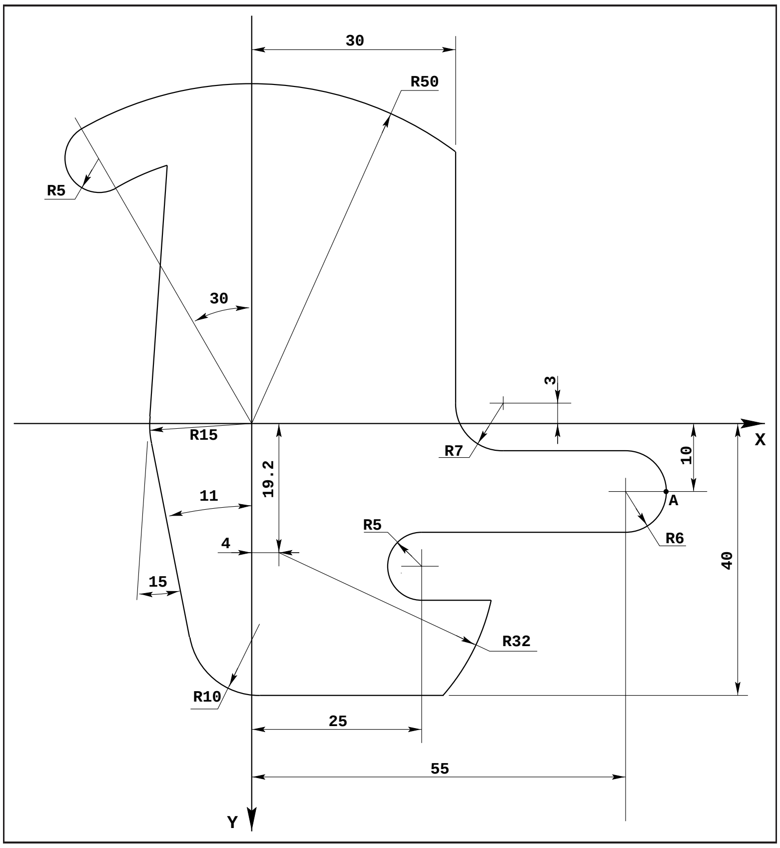


Figure 5.1:

```
N10 PAX=55+6 PAY=10 X=PAX Y=PAY
N20 G2 BT I55 J=PAY
N30 G1 BT
N40 G3 I30+7 J-3 R7 BT
N50 G1 BA-90 BS+
N60 G2 I0 J0 R50 BT
N70 G2 RR=50-5 AN1=-90-30 I=RR*_CAN1 J=RR*_SAN1 BA180
N80 G3 I0 J0 BS-
N90 G1 BA90-11+15
N100 G2 R15 I0 J0 BT
N110 G1 BA90-11 Y40 BR10
N120 G1 BA0 BS+
N130 G2 I4 J19.2 R32 BS-
N140 G1 BA180
N150 G3 I25 J=PAY+6+5 R5 BT
N160 G1 BT
N170 G2 I55 J=PAY X=PAX Y=PAY
```

6 Tool Radius Correction

A tool diameter is associated with each of the tools present in the machine, which is accounted for when the control works with tool radius correction set. The system compensates automatically for tool diameter, permitting the user to create a work program which is independent of the diameter of the tools employed.
The tool radius correction is performed only on planes parallel to the main plane. With simultaneous interpolations of more than two axes, the correction will only be made on the projection of the trajectory on the main plane.

6.1 Instructions for Correction of Tool Radius

In addition to modal instructions `G1`, ..., `G8`, needed for interpolation, Correction Tool Radius (C.R.U.) uses the following modal instructions:

`G40`***** Cancellation of C.R.U. Reset by: `G41`, `G42`

`G41` C.R.U. to right of profile. Reset by: `G40`, `G42`

`G42` C.R.U. to left of profile. Reset by: `G40`, `G41`

`G68` Entry of connecting arc step in C.R.U. between non-tangent convex steps. Reset by `G69`.

`G69`***** Intersection of trajectories corrected in C.R.U. (if possible). Reset by `G68`.

The asterisk (*) indicates functions that are active at the start of the program.
A work program with C.T.R. must start with a step of linear or circular engagement with the profile, in which instructions `G41` or `G42` are used and which terminate with a step of disengagement from the profile, this also being linear or circular, in which instruction `G40` is used.
The tool used for work must be activated prior to the setting of C.T.R. and deactivated on or after resetting of C.T.R.
A program employing instructions `G41`, `G42`, can be used without C.T.R., simply by setting the tool radius to the value of 0.

6.2 Linear engagement and disengagement

An example is shown in the Fig. 6.1.

```
N10 G0 X200 Y400 T5
N20 G1 X500 Y700 G42 F2  ; LINEAR ENGAGEMENT STEP
N30 X900
N40 X1000 Y200 G40 T0    ; LINEAR DISENGAGEMENT STEP
```

Engagements and disengagements are performed, which are non-tangential with respect to the profile. This implies a stop after the initial engagement step and before the final disengagement step.

6.3 Circular engagement and disengagement

An example is shown in the Fig. 6.2.

```
N10 G0 X200 Y400 T5
N20 G4 X500 Y700 R660 G42 F2  ; CIRCULAR ENGAGEMENT STEP
N30 G1 X900
N40 G4 X1000 Y200 R660 G40 T0   ; CIRCULAR DISENGAGEMENT STEP
```

The corrected trajectory in this case engages and disengages tangentially to the workpiece profile and therefore does not cause stops.
It is not important how steps `N20` and `N40` are defined, the essential aspect is that they are performed without tool correction with circular interpolation.
Thus the modification of the `G4` in `G5`, or that of the radius from 660 to -500 for example, would have caused only a change in the non-corrected trajectory, while the tool correction would have remained unchanged.

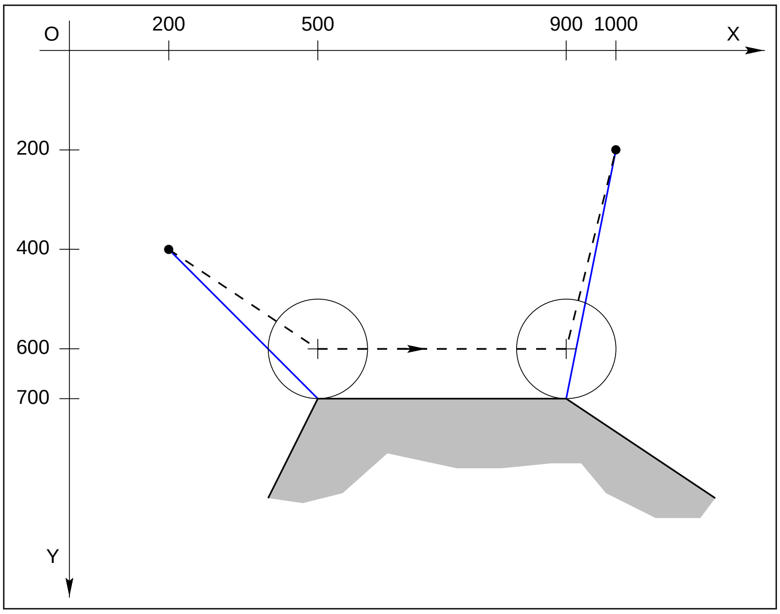


Figure 6.1:

Tool radius	100
Continuous line:	non-corrected trajectory
Dashes:	corrected trajectory

6.4 Immediate change in correction direction

The insertion of an instruction `G41` while an instruction `G42` is enabled, or vice versa, the insertion of an instruction `G42` while an instruction `G41`is enabled, causes the immediate change in the correction direction. If the instructions `G42`, `G41` operate on a program step in which the `G1` instruction is set, the change in correction direction is linear. In other situations it is activated by means of two circumference arcs. These arcs are tangent one to the other: one at profile entry and one at profile exit. If the change in correction direction is not executed linearly, it is advisable to test it out very carefully.

6.5 Correction for different types of intersections

The correction of tool radius is performed in different ways, depending on the form of the programmed trajectory. Following are the various cases of correction foreseen. The series of cases is organised based on the type of intersection of the geometric entities used to program the trajectory of the angle they form. In the following list, instructions given by default are indicated with a (*).

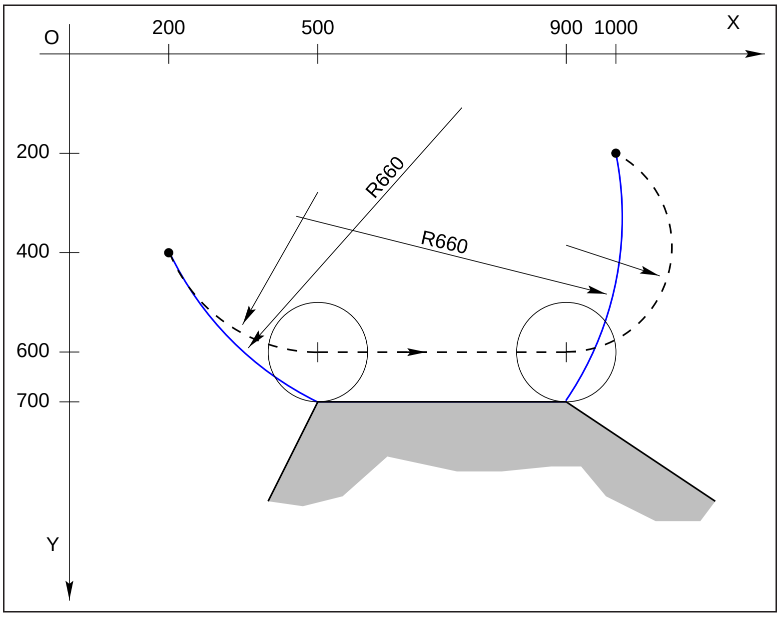
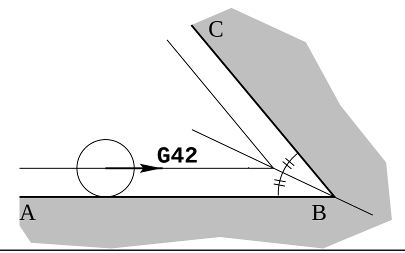
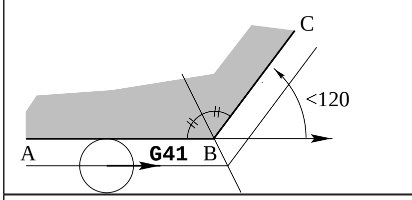
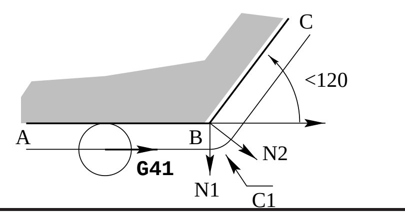


Figure 6.2:

Tool radius	100
Continuous line:	non-corrected trajectory
Dashes:	corrected trajectory

Table 6.1: **Line-line intersection**

	**Concave Angle:** The compensation is calculated on the bisector of the angle between the lines AB and BC as shown in figure.
	**Convex angle $<$ 120 degrees and `G69` *:** If the angle is less than or equal to $120°$ and `G=69`, compensation is performed on the bisector of the two lines AB and BC as shown in figure.
	**Convex angle $<$ 120 degrees and `G68`:** If the angle is less than or equal to $120°$ and G68, the system automatically generates a connecting arc C1 bounded by the two normals N1 and N2 emerging from the point of intersection B as shown in figure. (see also additional connecting arc).

>> . . .

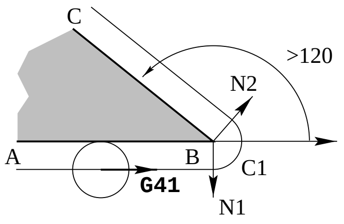
. . . <<	
	**Convex angle $>$ 120 degrees:** If the angle between the two lines is greater than $120°$ the system automatically generates a connecting arc C1, bounded by the two normals N1 and N2 emerging from the point of intersection B. The corrected trajectory in `G41` is the segment of the straight line parallel to AB, the circular arc C1 and the segment of the straight line parallel to BC, as shown in figure. (see also additional connecting arc).

Table 6.2: **Intersection line-circumference**

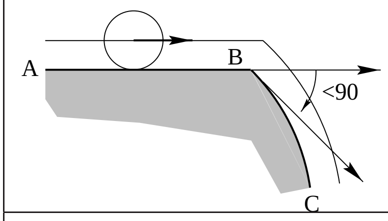
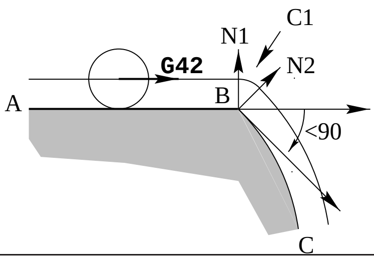
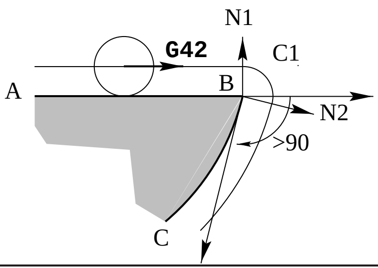
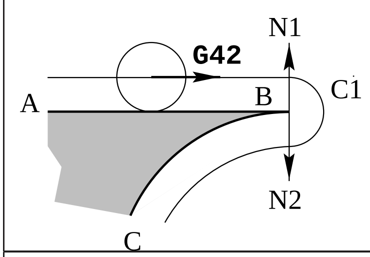
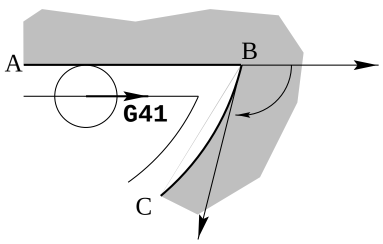
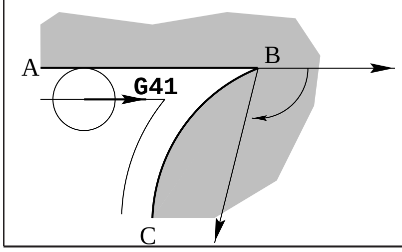
	**Convex angle $<$ 90 degrees and G69 *:** If the angle between the tangent at the circumference at the point of intersection with the straight line and the straight line itself is less than $90°$ and G69, compensation is performed at the intersection D of the two compensated trajectories as shown in figure.
	**Convex angle $<$ 90 degrees and G68:** If the angle between the tangent at the circumference at the point of intersection with the straight line and the straight line itself is less than $90°$ and G68, the system automatically generates a connection arc C1, bounded by the two normals N1 and N2 emerging from the point of intersection B as shown in figure.
	**Convex angle $>$ 90 degrees:** If the angle between the tangent to the circumference at the point of intersection with the straight line and the straight line itself is greater than $90°$, the system automatically generates a connecting arc bounded by the two normals emerging in the point B.
	**Angle $=$ 180 degrees:** If the angle between the tangent at the circumference at the point of intersection with the straight line and the straight line itself is equal to 180 degrees, the compensation is performed as shown in the figure (circumference tangential with the point of return).
	**Concave angle :** Whatever the value of the angle between the tangent to the circumference at the point of intersection and the straight line, compensation is performed at the intersection of the two compensated curves as shown in the figure.

Table 6.3: **Intersection Circumference-Circumference**

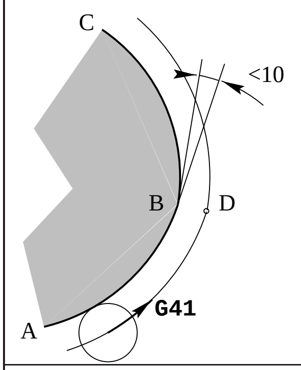
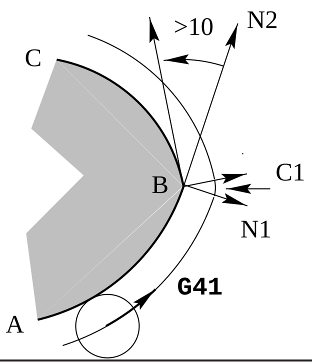
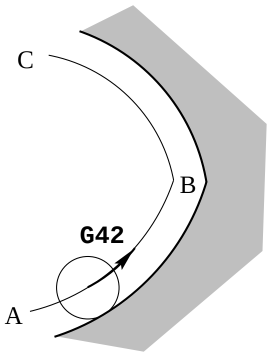
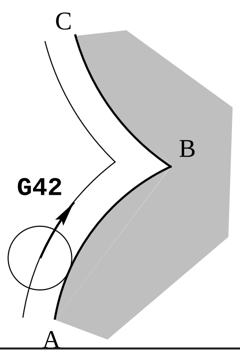
	**Convex angle $<$ 10 degrees and `G69` *:** The correction is performed by intersecting the two correct trajectories as shown in figure.
	**Convex angle $>$ 10 degrees and `G68`:** The system automatically generates a circular connecting arc C1 between the two normals N1 and N2 emerging from the point of intersection B as shown in figure.
	**Concave angle :** Whatever the value of the angle between the two tangents to the circumference at point B, the compensation is performed at the intersection of the two compensated curves as shown in the figures.

Table 6.4: **Intersezione Retta-Ellisse**

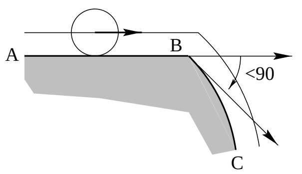
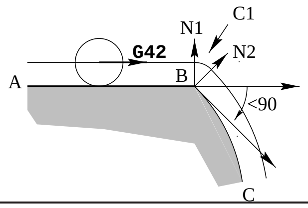
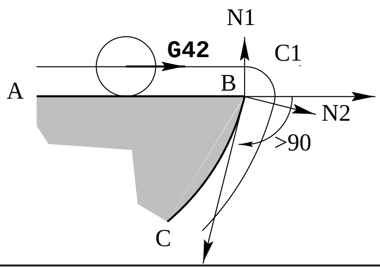
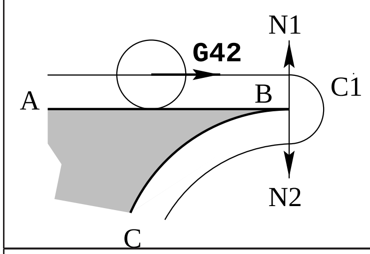
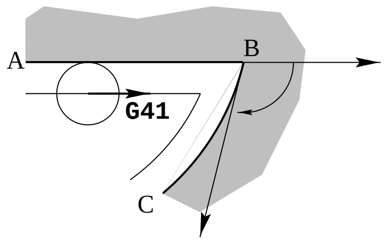
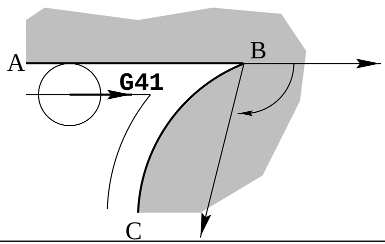
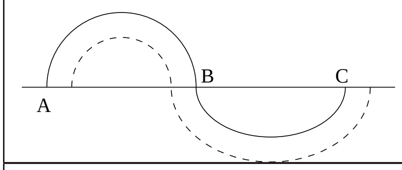
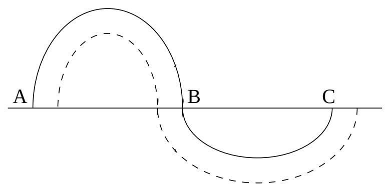
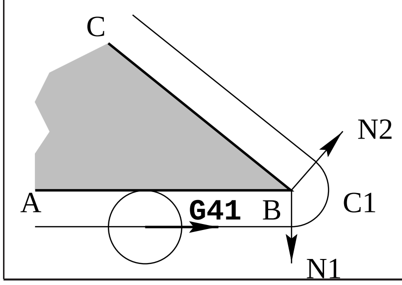
<table>
<tr><td></td><td>Convex angle $<$ 90 degrees and <code>G69</code> *: If the angle between the tangent to the ellipse at the point of intersection with the straight line and the straight line itself is less than $90°$ and <code>G69</code>, compensation is performed at the intersection D of the two compensated trajectories, as shown in figure.</td></tr>
<tr><td></td><td>Convex angle $<$ 90 degrees and <code>G68</code>: If the angle between the tangent to the ellipse at the point of intersection with the straight line and the straight line itself is less than $90°$ and <code>G68</code>, the system automatically generates a circular connecting arc C1, bounded by the two normals N1 and N2 emerging from the point of intersection B, as shown in figure.</td></tr>
<tr><td></td><td>Convex angle $>$ 90 degrees: If the angle between the tangent to the ellipse at the point of intersection with the straight line and the straight line itself is greater than $90°$, the system automatically generates a circular connecting arc between the two normals N1 and N2 emerging from the point of intersection B, as shown in figure.</td></tr>
<tr><td></td><td>Angle $=$ 180 degrees: If the angle between the tangent to the ellipse at the point of intersection with the straight line and the straight line itself is equal to 180 degrees, the compensation is performed in the same way.</td></tr>
<tr><td></td><td>Concave angle : Whatever the value of the angle between the tangent to the ellipse at the point of intersection with the straight line, compensation is performed at intersection D of the two compensated trajectories as shown in figures.</td></tr>
</table>

Table 6.5: **Intersection with Ellipses**

	**Intersection Ellipse-Circumference:** A connection between an ellipse and a circumference or a circumference and an ellipse is permitted only where the trajectories have the same tangent at the point of intersection as shown in figure.
	**Intersection Ellipse-Ellipse:** A connection between two ellipses is permitted only where the trajectories have the same tangent at the point of intersection as shown in figure.
	**Additional circular connection:** In the insertion phase of a circular connecting step, the centre of the tool will travel along a trajectory parallel to AB, go through arc C1 and the trajectory parallel to BC without stopping on normals N1 and N2, as shown in figure.

6.6 Examples of work

Examples of work (internal and external) on a square profile with two sides connected with elliptical trajectories and with two circular arcs. The program is set so that the tool never stops while it is in contact with the profile, as shown in Fig. 6.3 and Fig. 6.4.

6.6.1 Examples of external work

```
N10 G0 X0 Y0 Z0 F5 T1
 N20 G1 Y300 G41
 N30 G3 X200 Y500 I0 J500
 N40 G1 Y1100
 N50 G7 X400 Y1500 I400 J1100 RI200 RJ400
 N60 G1 X1100
 N70 G7 X1300 Y1100 I1100
 N80 G1 Y500
 N90 G2 X1100 Y300 J500
 N100 G1 X400
 N110 G2 X200 Y500 I400
 N120 G3 X0 Y700 I0
 N130 G1 X0 Y0 G40 T0
```

6.6.2 Examples of internal work

```
N10 G0 X400 Y1100 Z0 F5 T1
N20 G1 Y900 G42
N30 G2 X200 Y1100 I400 J1100
N40 G7 X400 Y1500 I400 J1100 RI200 RJ400
N50 G1 X1100
```

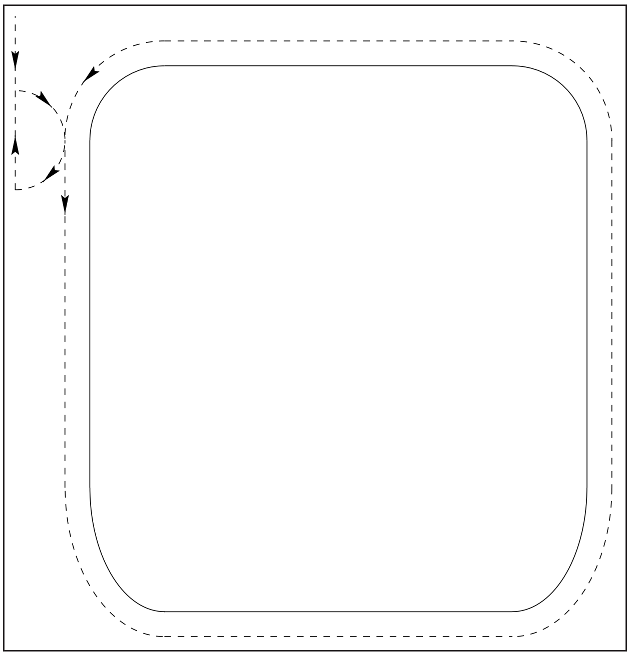


Figure 6.3:

```
N60 G7 X1300 Y1100 I1100
N70 G1 Y500
N80 G2 X1100 Y300 J500
N90 G1 X400
N100 G2 X200 Y500 I400
N110 G1 Y1100
N120 G2 X400 Y1300 J1100
N130 G1 Y1100 G40 T0
```

6.7 Control of speeds and accelerations

The system controls the speeds and accelerations of the axes and, if necessary, makes modifications to the values specified by the program.
The first control is made on the maximum speeds and accelerations sustainable by any axis and, where necessary, the NC unit reduces the speed until the conditions are satisfied.
During circular interpolation, for reasons of precision, one ensures that the angular velocity does not exceed the value: Vang_max = 6.25 rad/sec. Thus for example, an arc of radius R=3mm can be traversed with a maximum tangential speed of 1.125 m/min.
During interpolation, if two steps are not tangential within the permitted tolerance range (the default tolerance is 0.01rad), a stop is inserted at the end of the first step. The stop can by inhibited by setting mode `G47` (reset by `G46`).
If two steps with the same speed are to be performed without a stop, the system inserts an acceleration (deceleration) to connect the speeds of the two steps. If the step which follows has a speed less than that of its predecessor then the deceleration is inserted at the end of the first step. If, however, the following step has a higher speed then the acceleration is inserted at its start.
With the correction for tool radius on, circular steps undergo variations in radius. If the radius should diminish, i.e. work is performed within a concavity, there is a proportional decrease in tool travel speed over the trajectory. The point of working thus continues to move at the nominal speed. If, however, the radius increases, i.e. during work on a convex part, tangential speed is not modified.

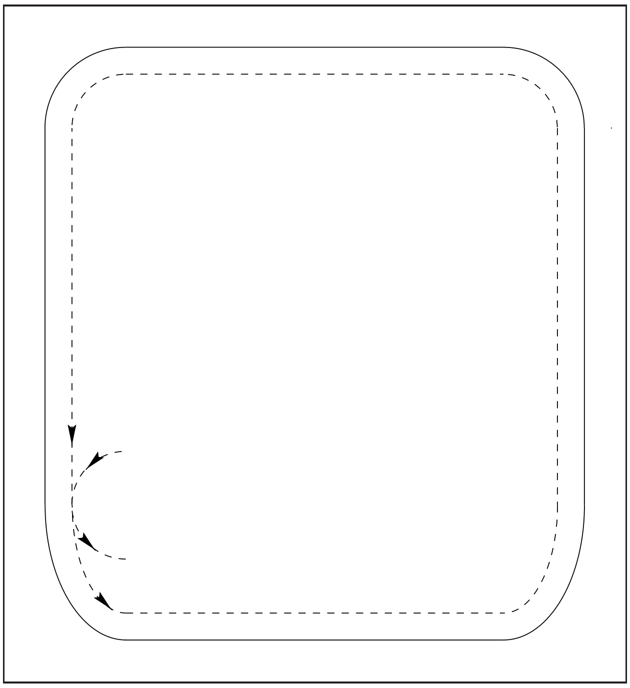


Figure 6.4:

7 Translation for Pantograph Spindle Correctors

For type TP spindles, default corrector values may be changed from the program with the following instructions:

- `TRX`*[=]expr*
- `TRY`*[=]expr*
- `TRZ`*[=]expr*

where *expr* is an expression whose result must be a real number in mm.
Programmed values are added algebraically to the correctors of the active spindle. Every time an instruction of this type is programmed, recalculation of correctors is performed starting from the default corrector value.

Corrections programmed with the above instructions remain active until reprogrammed. Such corrections are deactivated in case of machine shutdown, saving of Technical Data, performance of tool change.

CHSpindles and tools Let us now look at the instructions pertaining to spindles and tools.

7.1 Configuration of head

The configuration of the tool head is selectable from those in memory using the instruction:

`HC`*[=]expr*

where *expr* is an expression with a positive integer result. This instruction must be placed at the start of the program.

7.2 Selection of spindles

The selection of the spindles which must work at a certain time is specified with the following instructions:

- `T`*[=]spindle[*:*]tool[*,*spindle*,... *]*
- `TH`*[=]spindle[*:*tool][*,*spindle*,... *]*
- `TP`*[=]spindle[*:*tool][*,*spindle*,... *]*

where: *spindle*,*spindle*,... indicates the series of identification numbers of the spindles to be activated from that point on, and :*tool* which may as an option follow only the first spindle identification number, indicates (in the case of a multi-tool spindle) which of the tools is to be activated. The use of the equal sign is optional. A maximum number of 128 spindles can be simultaneously activated.
With the above-indicated synthesis, both spindle and tool are whole number constants. It is also possible to select spindles indirectly based on the result of an expression. There are two possibilities; the first is:

`T`*[=]expr[*:*expr]*

where *expr$* is an expression with alphanumeric result used as a tool list as if they were declared directly, i.e., such as "*spindle*:*tool*,*spindle*,...". The other possibility is:

`T`*[=]expr[*:*expr]*

where *expr* is an expression with numerical result indicating the number of a single spindle, followed by an expression indicating tool number if the spindle is multi-tool. The use of the "=" sign is optional if the expressions do not start with a parameter. Such selection modes function for instructions `TH`, `TP`.
The selection remains active up to the next selection which makes changes, or up to a reset of selections, which can be obtained with instructions `T`*[=]*`0`, `TH`*[=]*`0`, ecc..., indicating '0' as the only tool '0'.

7.3 Reference spindle

Where several tools have been selected simultaneously, the specified displacement is respected by the first of the tools selected, i.e. its corrections are used. Example: `N300 G0 X300 Y200 Z=PRK T5,2,12` serves to position three vertical points, ready for boring, at the co-ordinates 300,200, and such a point will be effectively reached from the point number 5.

7.4 Rotation speed

The rotation speed of the pantograph tools is set with instruction:

`S`*[=]expr*

where: *expr* indicates the rotation speed in rpm. The use of this is obligatory if the expression starts with a parameter.

7.5 Delays

If the working phases require defined waiting intervals, these can be specified using the delay instruction:

`D`*[=]expr*

where: *expr* has a value greater than 0 and expresses the delay time in hundredths of a second, before execution of the next step.
N.B. This instruction has effect only in steps in which at least one positioning is programmed. The delay is effected only after the axis has completed positioning.

7.6 Instructions for tool change

7.6.1 Instructions for pre-setting tool change

`TP`*[=]expr*`:<`*expr$*

where:

- *expr$* is the name of the tool or of the aggregate to be fit on the pantograph spindle.
- *expr* is the number of the pantograph spindle involved in tool change.

if *expr$* `""`, (null string) is set, only unloading of the current tool is performed. This instruction has two results:

1. it makes the spindle indicated by *expr* the reference spindle,
2. it preloads all special parameters for tool change.

Description of special parameters

◇ **Parameter CUFL** This may be considered a three-stage variable that is preloaded with the following values:

- 0 if the tool to be fit is already on the spindle,
- 1 if there is any tool already on the spindle, (includes empty tool and null tool name),
- -1 if the spindle has no tool fit at the time of execution of the tool change instruction.

Different sets of parameters are preloaded based on the values of parameter `CUFL`, as described below.

◇ **Loading parameters** These parameters are preloaded only if parameter `CUFL`=-1; these are:

`CUPX`, `CUPY`, `CUPZ`, pickup co-ordinates for the tool to be fit

`CUPA` Orientation for pickup

`CUPP` No. magazine position for pickup

`CUPI` No. of column in the `TOOL CHANGE MAGAZINE` table, displayed in the `MACHINE DATA` menu of the `Technical Data` A.P. , relative to the pickup position.

`CUPM` No. magazine for pickup

`CUPT` Type of magazine for pickup

◇ **Unloading parameters** These parameters are preloaded only if parameter `CUFL`=1; these are:

`CUSX`, `CUSY`, `CUSZ` co-ordinates for unloading of currently fit tool,

`CUSA` orientation for unloading,

`CUSP` no. magazine position for unloading,

`CUSI` No. of column in the `TOOL CHANGE MAGAZINE` table, displayed in the `MACHINE DATA` menu of the `Technical Data` A.P. , relative to the unload position.

`CUSM` no. magazine for unloading,

`CUST` type of magazine for unloading.

In the case described here, if the tool name is other than "" (null string), the set of special parameters for tool pickup is also preloaded.

7.6.2 Tool change data update instructions

`KB`*[=]expr*

This instruction is always executed after a pre-setting instruction.

- `KB=0` determines that the spindle involved has no tool fit.
- `KB=1` determines that on the spindle there is a tool whose name has been defined in the pre-setting instruction.

◇ **Example: programming a tool change routine**

```
;
:
; ------------------------------------
;  TOOL CHANGE ROUTINE
; ------------------------------------
;
;  INPUT: NMAN = NUMBER TP SPINDLE INVOLVED (0,1,...)
;    ST1  = STRING CONTAINING NAME OF TOOL TO BE FIT
;
;
;
;   PRE-SETTING TOOL CHANGE
;
N10 TP=NMAN:<ST1
;
;   TEST IF TOOL TO BE FIT = CURRENT TOOL
;
N20 JM(CUFL):20  ;IN SUCH CASE OMIT PICKUP AND UNLOADING
; ;BUT NOT KB
;
;                        ;TOOL TO BE FIT = TOOL FIT
;
N21 JM(ST1=""):21
N22 KB=1
N23 JM:22
:21
```

```
N24 KB=0
N24 JM:22
;
;
;   NOTE:  G74 DEACTIVATES CORRECTION BY MEANS OF ORIGINS,
;  G78 CONSIDERS ONLY CONTRIBUTION OF SPINDLE AS TOOL  CORRECTOR.
;   GO TO MAGAZINE POSITION CO-ORDINATES (ABSOLUTE  CO-ORDINATES) WITH SPINDLE ONLY.
;
:20
N25 G74 G78
N30 JM(CUFL<0):10  ; IF NO TOOL IS CURRENTLY FIT, OMIT
; ; unloading phase
;
;   UNLOADING MANAGEMENT
;
N40 X=CUSX Y=CUSY
N50 Z=CUSZ
;
;   ;THIS INVOLVES STEPS FOR THE PLC (M,..)
;
N60 KB=0  ;COMMUNICATES EFFECTED UNLOADING TO NC.
;
;
N65 JM(ST1=""):22
;
;   PICKUP MANAGEMENT
;
;   POSITIONING ON PICKUP CO-ORDINATES
;
:10
N70 X=CUPX Y=CUPY
N80 Z=CUPZ
;
;   THIS INVOLVES STEPS FOR THE PLC (M,..)
;
N90 KB=1  ; COMMUNICATES EFFECTED PICKUP TO NC
N100 G54  ;REACTIVATES ALL CORRECTIONS (ORIGINS+POINT) (IN ADDITION TO ; SPINDLE)
:22
;
```

8 Interface with PLC

8.1 Instructions M for PLC

Instructions M for PLC have the following syntax:

M*[=]expr*

where *expr* is any expression with the integer part of the result from 0 to 65535.
This instruction allows commands to be sent to the PLC. There are 4 categories of commands for the PLC, identified by number.

M00-M63, M256-M16383 Cause axes to stop at end of step and remain valid until next instruction M.

M128-M191, M32768-M49151 If machine is an interpolator, do not cause axes to stop at end of step and remain valid until next instruction M.

M192-M255 M49152-65535 Cause axes to stop at end of step and remain valid until next instruction M. In addition, cause block of interpretation of next steps, until actual execution of current step (synchronisation of interpretation with execution).

M252 Positioning according to stop with retention of command to axis.

M253 Positioning according to stop.

M254 Activation of sampling device (the micro sampling device is normally closed and opens in data acquisition phase).

M255 Activation of sampling device (the micro sampling device is normally open and closes in data acquisition phase).

8.2 Passage of values to PLC

Instruction KA is used to pass values to the PLC memory.
The syntax is:

KA*[=]expr*

where *expr* is any expression with the integer part of the result from 0 to 65535. For further details, see the PLC manual.

8.3 Direct writing in PLC memory

The contents of the variables in the exchange signal zone from NC to PLC may be changed directly from the program by means of write instructions containing single bits, bytes, words (2 bytes), long-words (4 bytes), and floating points (4 bytes). The exchange signal zone in question is composed of 256 bytes and is indicated with the conventional name "GENERAL". In the following instructions, the operands enclosed in brackets are expressions whose result is an integer number; they form the identification indexes of byte and bits that will be written in the "GENERAL" data zone.

- WBT(*expr1*,*expr2*)=*expr3*
  *expr*1 is an expression which must supply a result consisting of a number from 0 to 255 and represents the index of the byte to be written. *expr*2 is an expression which must supply a result consisting of a number from 0 to 7 and represents the index of the bit to be written belonging to the byte selected by *expr*1. *expr*3 is an expression used as a logic value. For example: instruction WBT(200,4)=10 writes a 1 in bit 4 of byte 200.

- WBT(*expr1*,*expr2*)=*expr$*
  This instruction is similar to the one above; the only difference is that *expr$*has logic value 0 in case of a null string; 1 in other cases.

- `WBY(`*expr1*`)=`*expr2*
  *expr*1 is an expression which must supply a result consisting of a number from 0 to 255 and represents the index of the byte to be written. *expr*2 is an expression which must supply a result consisting of a number from 0 to 255 and represents the datum to be written in the byte selected by *expr*1.

- `WW(`*expr1*`)=`*expr2*
  *expr*1 is an expression which must supply a result consisting of a number from 0 to 127 and represents the index of the word to be written. *expr*2 is an expression which must supply a result consisting of a number from 0 to 65535 and represents the datum to be written in the word selected by *expr*1.

- `WL(`*expr1*`)=`*expr2*
  *expr*1 is an expression which must supply a result consisting of a number from 0 to 63 and represents the index of the long-word to be written. *expr*2 is an expression which must supply a result consisting of a number from 0 to $256^4 - 1$ and represents the datum to be written in the long-word selected by *expr*1.

- `WF(`*expr1*`)=`*expr2*
  *expr*1 is an expression which must supply a result consisting of a number from 0 to 63 and represents the index of the float to be written. *expr*2 is an expression which must supply a real number (floating-point) and represents the datum to be written in the float selected by *expr*1.

9 Program jumps

Program flow can be modified via jump instructions, of which there are 3 kinds:

- unconditional,
- conditional,
- conditional dependent on PLC

9.1 Unconditional jump

The unconditional jump instruction has the following syntax:

`JM:`*expr*

This instruction involves continuation of program execution starting from the label indicated by the value of *expr*. The ability to insert expressions to define the label to be jumped to permits the writing of shorter programs if the point of continuation must be chosen from many points on the basis of one parameter.

9.2 Conditional jump

The conditional jump instruction has the following syntax:

`JM`*[*`!`*]*`(`*expr*`):`*expr*

This instruction involves continuation of program execution starting from the label indicated by the value of *expr*, if the expression in round parentheses is true. Otherwise the next step is performed. If the negation operator (`!`) is placed before the round parentheses then the jump is performed if the expression is false.
An expression is taken to be false if its value is zero, otherwise it is true. The relational operators (`<`, `>`, `=`, etc.) give the following result when applied to two values:

"1" if the relation is true,
"0" if the relation is false.

9.3 Conditional jump dependent on PLC bit

The syntax is as follows:

`JP`*[*`!`*]*`(`*expr1*`,`*expr2*`):`*expr3*

In the instruction described, the operands in parentheses are expressions whose result is a whole number; they are indices of identification of the bytes and bits to be tested and which pertain to the exchange signals area conventionally called "GENERAL". *expr*1 is an expression which must supply a result consisting of a whole number from 0 to 63 and indicates a long-word; *expr*2 is an expression which must supply a result consisting of a whole number from 0 to 31 and indicates the bit in the long-word identified by *expr*1. This instruction involves continuation of program execution starting from the label indicated by the value of *expr*3 if the logic level of the bit indicated is 1 (or 0 if there is `!`); otherwise, the program continues from the next step.
If the logic level of the test signal is not fixed, block interpretation of the program by means of a suitable `M` (from 192 to 255) to synchronise the signal read level with interpreter advance. If the test signal is preselected, do not interrupt interpretation, because the time at which signal read occurs is not critical.

10 Subroutines

Subroutines may be the following types:

- internal,
- external user,
- external "Fixed Cycles ",
- optimised boring sections.

10.1 Internal subroutines

These consist of a section of the program bounded by a starting label and the delimiter '%'. This type of subroutine is therefore contained within the main program.

10.2 External user subroutines

These are in practice a completely separate program, residing in a separate file. Their names should not begin with G or P. It is distinguished from a main program because it is in the subroutine directory and has program steps containing the piece dimensions preceded by comment characters.

10.3 External "Fixed Cycles" subroutines

These are similar to user subroutines, but are in a special directory. Their name must begin with G or P.

10.4 Optimised boring sections

These are subroutines generated by the boring optimiser. It is therefore possible to execute the boring part at any point in the program, should you wish to modify the normal order of execution (first contouring and then boring).

10.5 Subroutine call

10.5.1 External subroutine

An external subroutine, whether user-defined or fixed cycle, is called using the instruction:

`L=`*routine*

where *routine* is the name of a user-defined subroutine, should its initial letter not be G or P, or that of a fixed cycle. One can perform an indirect call of an external subroutine, whether user-defined or fixed cycle, by using the instruction:

`LS`*[=]expr$*

where *expr$* is an expression with an alphanumeric string as its result, this string being the name of the subroutine to be called. The reason for the designation "indirect" given to this instruction is due to the fact that it is possible to pass the name of the subroutine to the call via a string parameter, which can be modified as required beforehand.

10.5.2 Internal subroutine

On the other hand, an internal subroutine can be called with the instruction:

`L:`*expr*

where *expr* is the number of the label which indicates the start of the internal subroutine.

10.5.3 Boring section

Finally, a boring section is called via the instruction:

`LO:`*[expr]*

where, by analogy with the previous paragraph, *expr* is the number of the label which indicates the start of the boring section required.
The label itself is optional: if omitted, the first boring section is performed, up to the delimiter '%'. If the boring section is subdivided into several blocks, the label permits it to be executed separately at various points.

10.6 Subroutine levels

Subroutines may be called from within subroutines, up to a maximum nesting level of 3. The nesting level is visible during execution thanks to the names of the subroutines which precede the start of the program step.

11 Sampling device

It is possible to perform measurements directly from the machine by using a sampling device. The following instructions are available to do this:

M255 Open a sampling cycle with sensor normally open.

M254 Open a sampling cycle with sensor normally closed.

The value read in the sampling cycle is saved in parameter (TST) and in a parameter whose name is "composed" as follows: T *axis* where *axis* is the name of the axis programmed in the sampling step.
An example of a sampling cycle follows:

```
N20 X-50 Y200 Z-100 T20
N30 Z-25
N40 X100 FX.1 M255
N50 X-50 FX5
N60 Z-100 T0
N70 X0=TST
;               PARAMETER TX MAY BE USED INSTEAD OF TST
IN THE PREVIOUS STEP
```

During step N20 the cycle is opened, positioning the sampling (T20 in our example) at the co-ordinate -50, 200, -100. The sampling is then lowered by the displacement -25 (one assumes that z increases downwards). In N40 the sampling cycle is made in the x-direction moving slowly (0.1 m/min) towards the co-ordinate X=100. Upon contact with the workpiece, the displacement along the X-axis is "captured" and saved in the parameter TST and TX. At the same time the movement is halted.
The displacement read from the sampling is relative to the workpiece reference system if we are in G54, and absolute if we are in G53.

11.1 Detection of the reference system of the piece

A group of point co-ordinates, detected by the sampling device, can be used to determine a new reference system in space. This detection is useful, for example, when it is not possible to put the piece against suitable stops that fix the co-ordinate reference for the N.C. To perform the detection procedure, the following instruction is used:

FREF(*expr_xy*,*expr_xz*,*expr_yz*)=*expr*

where: *expr_xy expr_xz expr_yz* are three expressions with whole number results that indicate the number of sample points acquired for the determination of the planes xy, xz, yz, respectively. *expr* is a logic expression that indicates whether the instructions TRSX, TRSY, TRSZ, ROTX, ROTY, ROTZ must also be automatically performed for the system change, or if only the calculation is to be performed. The co-ordinates of the sample points are organised into three matrices of the Nx3 type (i.e. N lines and 3 columns) denominated TSXY, TSXZ, TSYZ. These matrices must be declared by the user based on the maximum number of points that are to be sampled. If the calculation of the reference system is successful, the obtained values are saved, independently of the value of *expr*, in the data structure of the instructions TRSX, TRSY, TRSZ, ROTX, ROTY, ROTZ and can be utilised successively.
The minimum number of samples necessary for the exact determination of the system are: 3 for xy, 2 for xz, 1 for yz. A greater number of points leads to solutions that approximate the sets of the points given. This is useful for approximating uneven surfaces. The reference system, however, is calculated so that the result is a clockwise tern having:

- the $\bar{k}'$ (new system versor $\bar{k}$) component in z, non negative,
- the $\bar{i}'$ (new system versor $\bar{i}$) component in x, non negative,
- the $\bar{j}'$ (new system versor $\bar{j}$) component in y, non negative.

12 Programming of coincidences

The term "coincidence" means the positioning of one or more axes commanded by the PLC and programmed with instruction `KL`.
The syntax of instruction `KL` is as follows:

`KL`*[=]expr*

where *expr* is an expression whose value must be a whole number from 1 to 16 and indicates one of the possible components of a data vector in the PLC-NC exchange signal memory called START_CAR.
The following is a typical example of programming of a coincidence:

```
N10 X100 Y200 Z32 KL6
```

When the NC interprets a step similar to that in the previous example, it does not perform the axes movements programmed in it, but executes the program, periodically testing the sixth datum of vector START_CAR.
The NC will activate the positionings programmed in the step containing instruction `KL6` only in correspondence with the rise front of the sixth datum of vector START_CAR.
The dynamic for execution of a coincidence is as follows:

1. The NC interprets a step containing instruction `KL` *nn* and tests datum *nn* of vector START_CAR;
2. The NC detects the rise front of datum *nn* of vector START_CAR, sets datum *nn* of vector ACK_CAR to 1, and performs the positionings programmed in the step containing instruction `KL` *nn*;
3. After the above-described positionings, the NC returns datum *nn* of vector ACK_CAR to 0.

In PLC programs, the rise front of ACK_CAR is normally used to return START_CAR to 0. The descent front of ACK_CAR is instead used as condition of coincidence effected.
The PLC can use the vector of STOP_CAR signals to interrupt the execution of a coincidence.
The program step containing instruction `KL` must contain one or more positionings and possibly other instructions affecting the positionings (speed, advance, acceleration); in addition, it may contain type T instructions, which have effect only with regard to correction of axes values.

13 Spindle Axis

The term "Spindle Axis" refers to a specific axis the speed of which can be controlled by direct assignment of rotation speed; rather than by positioning instructions.

13.1 Definition of a Spindle Axis

In order to define this type of axis, both the Rotation flag (which defines a rotation axis) and the altax09flag must be set to 1; these flags are found in the AXES table, being part of the SYSTEM_TABLES set of the A.P: Technical Data. Only one Spindle Axis can be defined for each center.

13.2 Programming a Spindle Axis

A Spindle Axis is normally programmed by means of suitable instructions of the `M` type, through which it is possible to control the axis according to the following modes:

- speed control,
- stop control,
- position control.

13.3 Speed control

Programmed with the instructions: `M=3`, `M=4`. The value of the axis speed depends on the cases described below.

- In the case where a `S` type instruction is present in a program step, the axis speed is assigned by the operand of the instruction `S`. The unit of measurement is rpm (rotations per minute).
- In the case where a `S` type instruction is not present in a program step, there are various possibilities:
  - if a tooled-up pantograph spindle is enabled, a speed equal to that of the tool installed on the spindle is assigned;
  - if no pantograph spindle is enabled or if there is a pantograph spindle enabled, but it is not tooled-up, a speed equal to the Max rot speed datum present in the AXES table of the A.P: Technical Datais assigned.

The rotation direction of the axis depends on the cases described below:

- If a pantograph spindle is enabled, the rules established in the User's Manual of the N.C. relative to the setting of the rotation direction of the spindles, aggregates, and tools, are used.
- If no pantograph spindle is enabled, the rotation direction depends on the programmed `M` instruction: `M=3` assigns a counter clockwise rotation, `M=4` assigns a clockwise rotation

The acceleration ramp of the axis depends on the following cases:

- If an acceleration instruction relative to the spindle axis is present in the program step, this instruction determines the value for the acceleration ramp.
- If there is no acceleration instruction relative to the spindle axis present in the program step, the following cases are possible:
  - A tooled-up pantograph spindle is enabled; in this case, the acceleration ramp of the tool installed on the spindle is used.
  - An untooled pantograph spindle is enabled; in this case, the acceleration ramp of the spindle itself is used.
  - No pantograph spindle is enabled; in this case, the reference is pantograph spindle 1. If this spindle is tooled-up, the acceleration ramp of the installed tool is assigned; if it is untooled, the acceleration ramp of the spindle itself is assigned.

13.4 Stop control

Programmed by means of the instructions: `M=5`. The deceleration ramp of the axis depends on the following cases:

- If there is an acceleration instruction relative to the spindle axis present in the program step, it determines the value of the deceleration ramp.
- If there is no acceleration instruction relative to the spindle axis present in the program step, the following cases are possible:
  - A tooled-up pantograph spindle is enabled; in this case, the deceleration ramp of the tool installed on the spindle is used.
  - An untooled pantograph spindle is enabled; in this case, the deceleration ramp of the spindle itself is used.
  - No pantograph spindle is enabled; in this case, the reference is pantograph spindle 1. If this spindle is tooled-up, the deceleration ramp of the installed tool is assigned; if it is untooled, the deceleration ramp of the spindle itself is assigned.

13.5 Position control

Programmed by means of the instruction: `M=19`. The position of the Spindle Axis depends on the following cases:

- If there is an `S` instruction present in the program step, the value of the instruction is assumed as the axis position.
- If in the program step there is no `S` instruction, the value of the Orientation position found in the AXES of the A.P: Technical Datatable is assigned as the position.

The positioning speed depends on the following cases:

- If a speed instruction relative to the spindle axis is present in the program step, it determines the value of positioning speed.
- If no speed instruction relative to the spindle axis is present in the program step, the value of the Homing speed datum in the AXES table of the A.P: Technical Data is assigned as the positioning speed value.

The acceleration ramp is assigned, as follows:

- If there is an acceleration instruction relative to the spindle axis present in the program step, it determines the value of the acceleration ramp.
- If no acceleration instruction relative to the spindle axis is present in the program step, 100

14 Machine data and tool data read and write

Machine data and tool data may be read and/or written with instruction `RDM`. The syntax of instruction `RDM` for writing is as follows:

`RDM(`*expr$*`,`*expr$*`,`*expr$*[`,`*expr*]`)=`*expr*

for assignment of a number value, or:

`RDM(`*expr$*`,`*expr$*`,`*expr$*[`,`*expr*]`)=`*expr$*

for assignment of an alphanumeric value.
The three alphanumeric expressions *expr$* which appear as the first three arguments of instruction `RDM`, indicate, respectively: the name of the table containing the data to write, the index (name) of the column and the identifying name of the data. Numerical expression *expr* (optional) indicates the number of the centre referred to; if not specified, it considers the current centre. The use of the equals sign is obligatory if the expression to be assigned begins with a parameter.
A machine or tool datum is read by using only the part that appears as the first member of in the previous syntaxes. The identifying names of tables, columns and data are the same as those that appear in *editing* of the machine data. Since they are easily reconfigured, they are not listed here. Refer to other parts of the machine manual. For purposes of example, the assignment of maximum speed of the X axis to parameter `MVEL` could be done with instruction:

```
MVEL=RDM("AXES_DATA","X_AXIS","MAX_VEL")
```

Obviously, the type of value written or read (numeric or alphanumeric) will depend on the particular datum to be written or read. Incompatibility of type (numeric or alphanumeric) of a datum read (or written) may be detected only by reading (or writing), and cannot therefore be prevented with simple syntactic control after *editing* of a program.

15 Reading and writing registers

The registers are specific machine data, organised in the form of vectors; they are accessed by means of index. A register is indicated with the following syntaxes

R*nnn*=*expr*

or

REGS(*expr*)=*expr*

In the first syntax *nnn* indicates an integer constant from 0 to 999, in the second syntax *expr* is an expression with an integer result from 0 to 999. The assignment is of the type: Rnnn=*expr* or REGS(*expr*)=*expr* The registers have the advantage of remaining memorised even after the machine has been turned off, and can be edited by means of the machine data editor.

16 Example of program: panca

Main program "PANCA":

```
N10 G71 LX=1000 LY=700 LZ=53 HC1 Z=PRK
N15 XO5 YO5
N20 L=CPAN
N30 XO830 YO630 RT180
N40 L=CPAN
%
```

Subroutine "CPAN":

```
;N10 G71 LX=CPAN LY=600 LZ=53 HC1 Z=PRK
N20 X0 Y-20 Z=PRK PRZ=35 F6 G42 TP1 L=PON
N25 G4 X0 Y0 R50
N30 G1 X770 Y0
N35 G1 X770 Y53 BR20
N40 G1 X456.6 Y96.3 BR46
N45 X400 Y150 R44 G4 BR46
N50 X399.5 Y465 G1
N70 BT- I364 J465 G3
N80 BT+ I349 J444 G3
N90 BT+ I224 J566 G2
N100 BT+ I296 J429.5 G3
N110 G1 BT- BA240
N120 X98 Y434 R81 G4
N130 G6 X84 Y463
N140 BT+ I12.5 J424.5 G3
N150 X0 Y509 G5 R-150
N160 G1 X0 Y0
N170 X-20 Y-20 G1 G=40
N180 G0 L=POFF
N190 X15 Y40 T13 PRZ=20 L=G99
N195 X15 Y420 T13 PRZ=20 L=G99
N210 X390 Y170 T12 PRZ=20 L=G99
N220 X500 Y79 T12 PRZ=20 L=G99
N230 X700 Y45 T12 L=G99
```

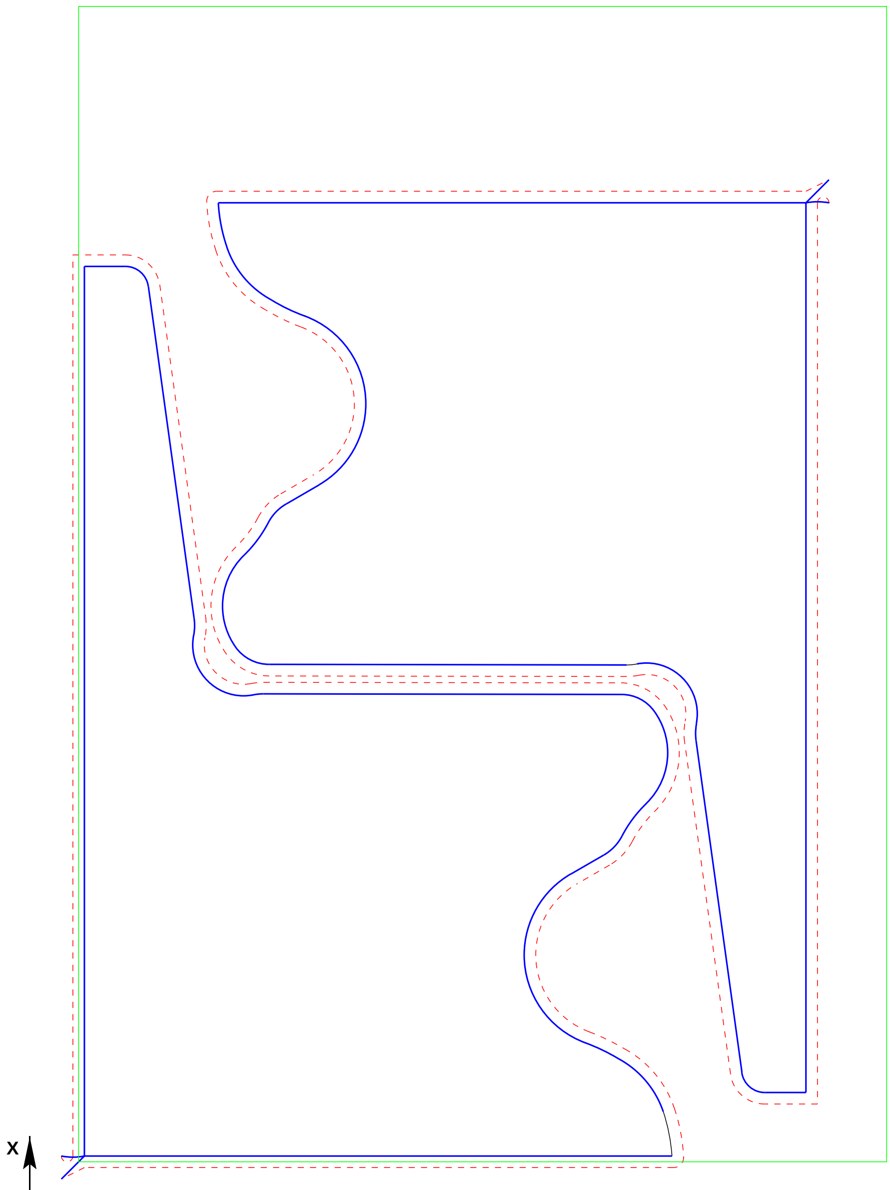


Figure 16.1: Example of a program: panca

Table of contents

Chapter 5. Tracer

Chapter 6. On-line multicentre machines

Chapter 7. Statistics management

Introduction

The software can be used with a numerical control (NC) or with a personal computer (PC) connected to a NC. The PC software is optional, and will be supplied separately only when requested by the client.

Field of application and limits of the manual

This manual describes the normal operations and procedures required to create programs that can be run using the software. The manual is aimed at users of the machine to which the software is connected. Before reading this manual, please consult the MACHINE USER'S MANUAL and relative ENCLOSURES, in order to obtain a thorough knowledge of the machine and how to operate it safely.

Documents supplied with the machine

MACHINE USER'S MANUAL. This contains the fundamental information required by the operator in order to use the machine. It also provides the instructions necessary to perform proper machine maintenance operations.

SPARE PARTS CATALOGUE. This is used to order components that must be replaced, following the instructions given in the introduction to the manual.

CIRCUIT DIAGRAMS. These describe the main plants of the machine (electric, pneumatic, etc.) and are provided for the technician responsible for solving problems. This technician must be expert and competent in his job.

ENCLOSURES. These contain information on any special parts of the machine. In order not to miss any important information, each Enclosure must be consulted together with the document to which it refers.

Warning signs

Paragraphs that should not be overlooked are highlighted and preceded by the symbols described and illustrated below:

DANGER

Paragraphs marked with this symbol indicate an imminent danger, and the contents must therefore be taken into careful account in order to prevent a serious accident.

CAUTION

Paragraphs marked with this symbol indicate procedures to be used and actions to be taken to avoid any damage to goods and property.

INFORMATION

This symbol is used to indicate points of particular importance that must not be overlooked.

Warnings

Before using the machine, read the safety information provided in the MACHINE USER'S MANUAL.

Chapter 1. Graphic Editor

1.1 Vertical boring

In the Editor environment (Figure B.1) clicking with the mouse on the VERTICAL BORING button (Figure B.2) the following box will open (Figure B.3), whose fields are described in Figure B.4.

Figure B.1: EDITOR environment

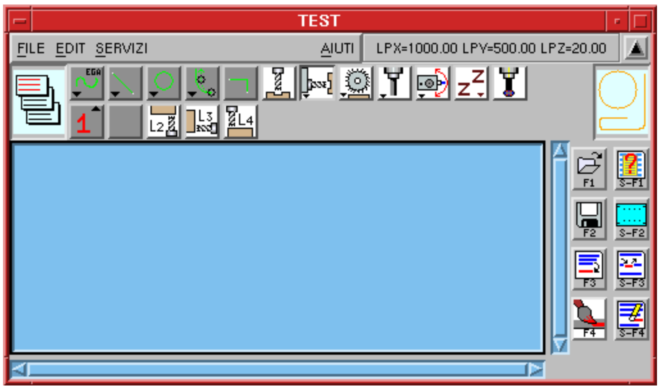


Figure B.2: Vertical Boring: Icon

Figure B.3: Vertical Boring: Data edit box

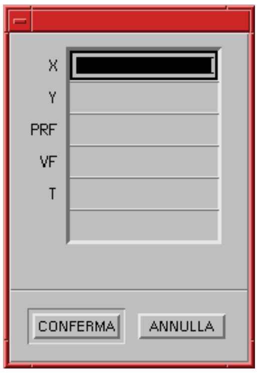
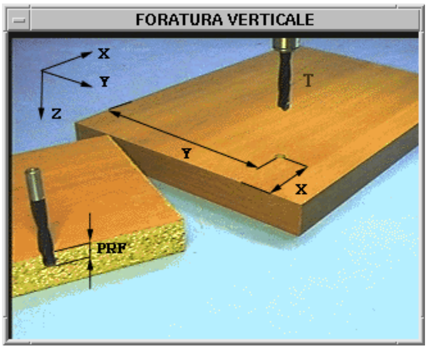


Figure B.4: Vertical Boring: EGA Window



1.2 Horizontal boring

In the Editor environment (Figure B.1) clicking with the mouse on the HORIZONTAL BORING button (Figure B.5) the following sublevel of buttons will open (Figure B.6) to select the side on which to make the horizontal boring.

Figure B.5: Horizontal Boring: Icon

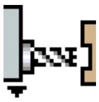
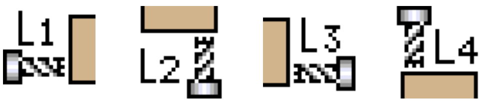


Figure B.6: Horizontal Boring: Icon Level 1



Clicking on the icon relative to side 1, the following box will open (Figure B.7) described in Figure B.8.

Figure B.7: Side 1: Data edit box

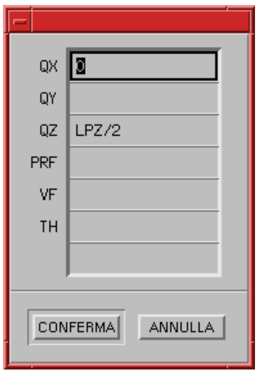
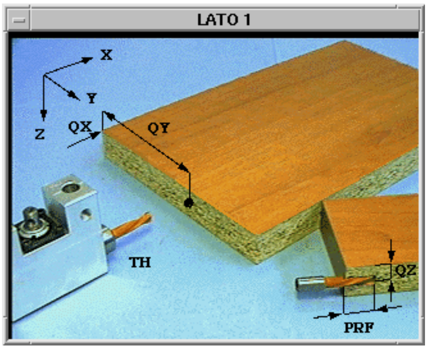


Figure B.8: Side 1: EGA Window



Clicking on the icon relative to side 2, the following box will open (Figure B.9) described in Figure B.10.

Figure B.9: Side 2: Data edit box

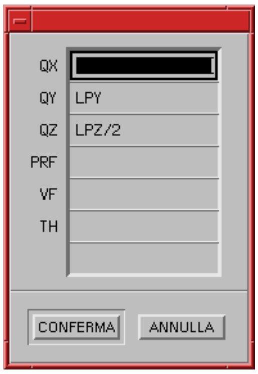
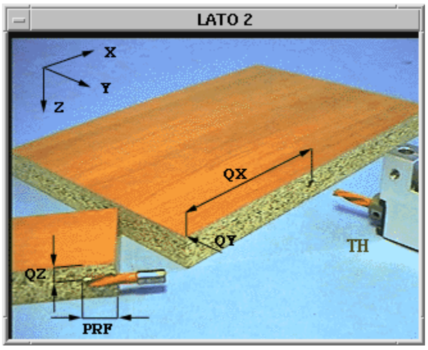


Figure B.10: Side 2: EGA window



Clicking on the icon relative to side 3, the following box will open (Figure B.11) described in Figure B.12.

Figure B.11: Side 3: Data edit box

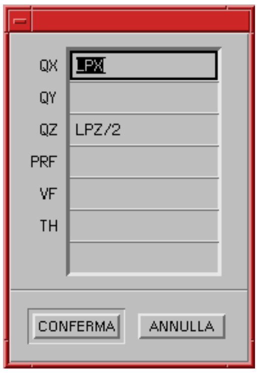
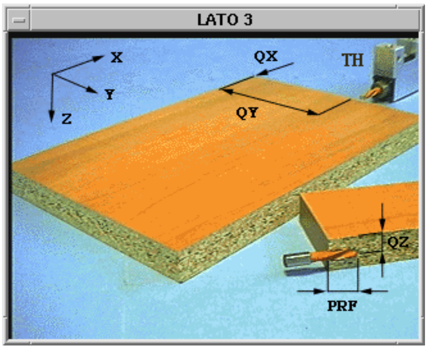


Figure B.12: Side 3: EGA window



Clicking on the icon relative to side 4, the following box will open (Figure B.13) described in Figure B.14.

Figure B.13: Side 4: Data edit box

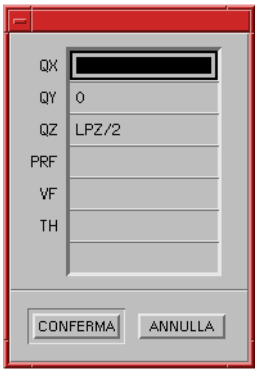
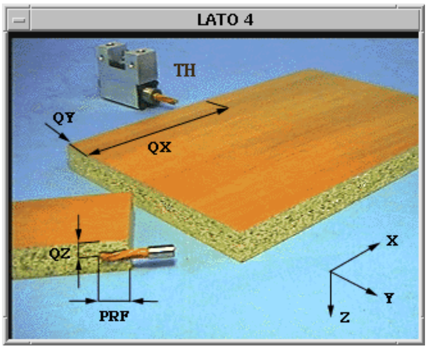


Figure B.14: Side 4: EGA window



1.3 Disk blade

Clicking on the button relative to the BLADE (Figure B.1) represented in Figure B.15, the following sublevel will open (Figure B.16).

Figure B.15: Disk blades: Icon

Figure B.16: Disk blades: Icons Level 1

Clicking on the icon relative to the BLADE X, the following box will open (Figure B.17) described in Figure B. 18.

Figure B.17: Data edit box

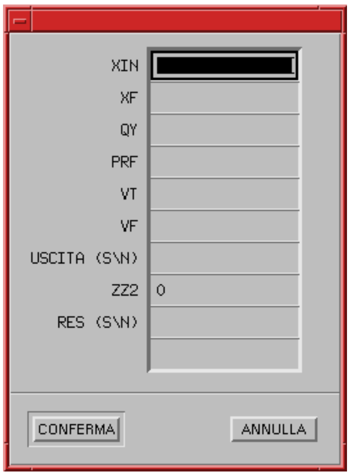
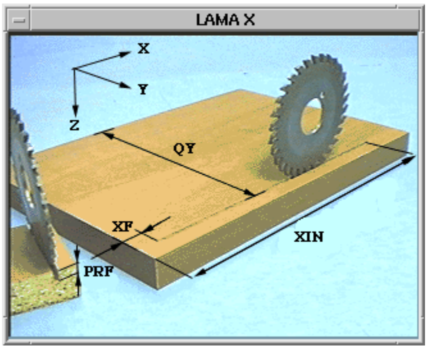


Figure B.18: EGA Window



Clicking on the icon relative to the BLADE Y, the following box will open (Figure B.19) described in Figure B.20.

Figure B.19: Data edit box

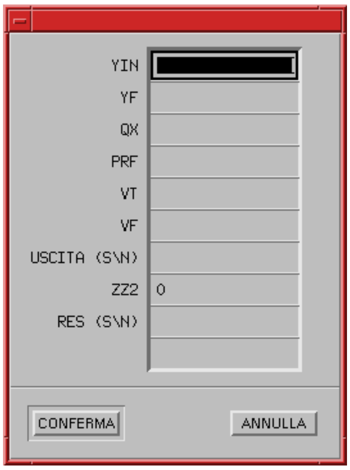
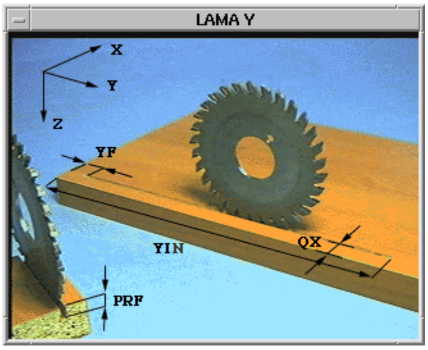


Figure B.20: EGA Window



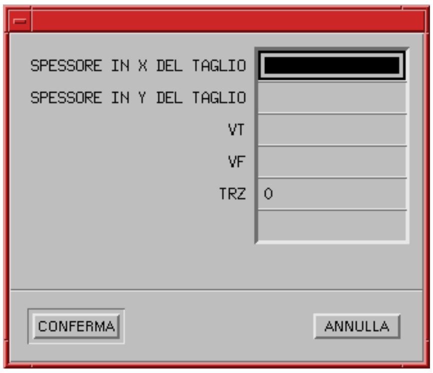
RES (Y/N): Y indicates that at the end of machining the disk blade must exit from the piece and turn off. N indicates that at the end of machining the disk blade must exit from the piece, but not turn off; at this point another cut with disk blade can be inserted: the disk blade will remain on between the two cuts.

EXIT (Y/N): Y indicates that at the end of machining the disk blade must exit from the piece and turn off. N indicates that at the end of machining the disk blade must run over the cut again in the opposite direction with an <u>increment</u> in depth of ZZ2.

ZZ2 (value): Indicates the increment in depth to use in case of wanting to run over the cut again in the opposite direction; if=0 the cut will not be run over again (as if EXIT=Y).

Clicking on the icon relative to FORMATTING, the following box will appear (Figure B.21), whose fields have the following meaning:

Figure B.21: Formatting: Data edit box



THICKNESS IN X OF CUT: X-value of how much to cut the panel.

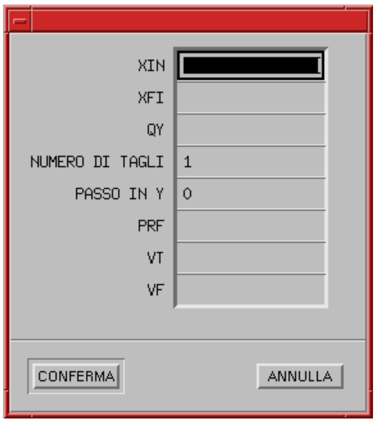
THICKNESS IN Y OF CUT: Y-value of how much to cut the panel.

F: working speed of the Disk Blade.

VF: Input speed of the Disk Blade.

Clicking on the icon relative to SERIES OF CUTS, the following box will appear (Figure B.22).

Figure B.22: Series of Cuts: Data edit box



CUT THICKNESS (value): Indicates the thickness of the "frame" to remove from each part with respect to the panel dimensions set in the parameters.

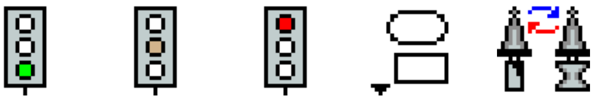
TRZ (value): The GFORMAT cycle executes panel formatting: whatever the thickness of the panel, the cut executed is passing. If the panel is positioned on the jig and if the value corresponding to the panel thickness + jig thickness is set in LPZ, the cycle would also cut the jig. To work correctly, LPZ must be set to the real thickness of the panel and all formatting be translated above the value of the jig thickness. Setting TRZ to this value, the cycle will cut the panel only.

1.4 Routing

Clicking on the button relative to ROUTING (Figure B.1) represented in Figure B.23, the following sublevel will open (Figure B.24).

Figure B.23: Routing: Icon

Figure B.24: Routing: Icon sublevel 1



Clicking on the icon relative to PON (green light) (Figure B.25), the following box will appear (Figure B.26), whose fields are described in Figure B.27.

Figure B.25: PON (green light): Icon

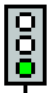


Figure B.26: PON (green light): Data edit box

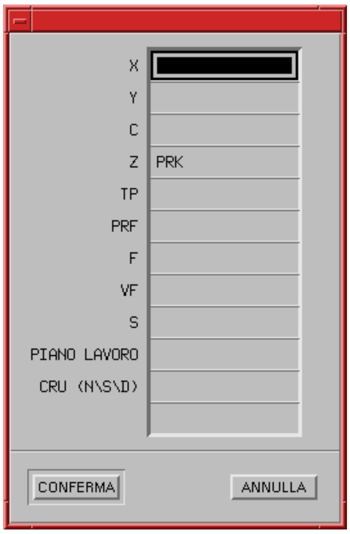
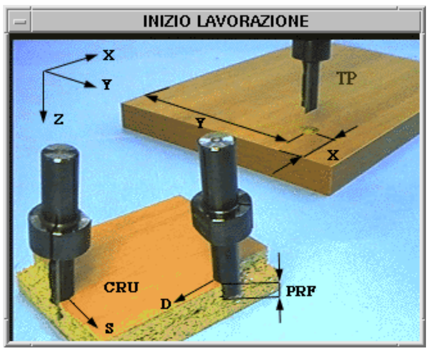


Figure B.27: PON (green light): EGA window



F: Allows setting the interpolation speed.

VF: Allows setting the boring speed on the Z-axis.

S: Allows setting the tool rotation speed.

WORKING TABLE: Allows defining the pair of axes to be used for circular interpolation and a possible third axis for linear interpolation (See 3.11.1 of the reference manual for programming) (Syntax: "X,Y").

TOOL RADIUS CORRECTION: N = the programmed trajectory is described from the centre of the cutter. L = the programmed trajectory is described from the left part of the cutter, viewed from behind with respect to the feed direction (the cutter corrects its trajectory by moving to its right with respect to case N). R = the programmed trajectory is described from the right part of the cutter, viewed from behind with respect to the feed direction (the cutter corrects its trajectory by moving to its left with respect to case N).

Clicking on the icon relative to PSU (orange light), the program line L=PSU is automatically generated.
Clicking on the icon relative to POFF (red light), the program line L=POFF is automatically generated.
Clicking on the button relative to the ROUTING MACROS represented in Figure B.28, a further sublevel will open (Figure B.29).

Figure B.28: Routing Macros: Icon

Figure B.29: Routing Macros: Icon sublevel 2

Clicking on the icon relative to RECTANGLE WITH CONNECTION (Figure B.30), the following box will appear (Figure B.31), whose fields are described in Figure B.32.

Figure B.30: Rectangle with connection: Icon

Figure B.31: Rectangle with connection: Data edit box

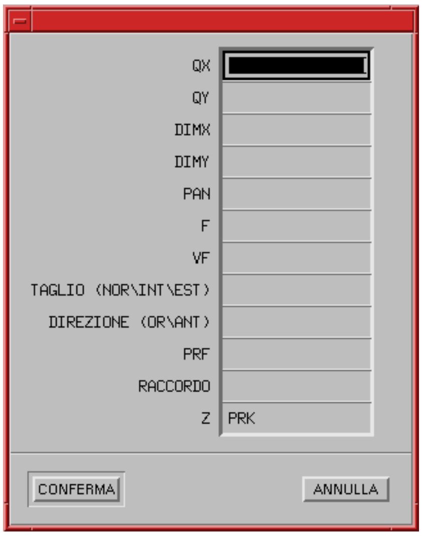
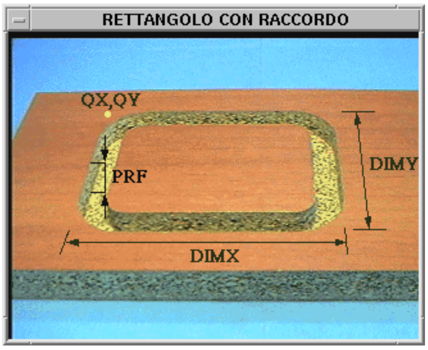


Figure B.32: Rectangle with connection: EGA window



CUT: NOR = the set trajectory is described from the centre of the cutter. INT = the “good” rectangle is the inner one. EXT = the “good” rectangle is the outer one.

CONNECTION (value): Joint circumference arc radius between the sides of the rectangle.

Clicking on the icon relative to the RECTANGLE WITH ROUNDING (Figure B.33), the following box will appear (Figure B.34), whose fields are described in Figure B.35.

Figure B.33: Rectangle with rounding: Icon

Figure B.34: Rectangle with rounding: Data edit box

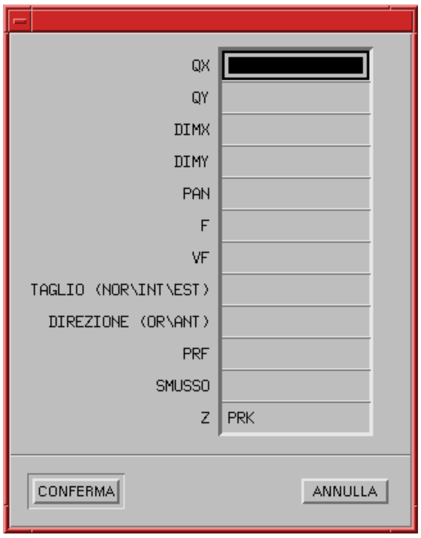
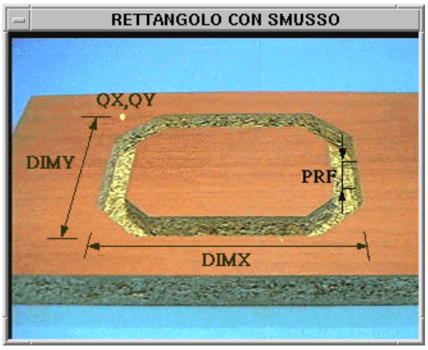


Figure B.35: Rectangle with rounding: EGA window



CUT: NOR = the set trajectory is described from the centre of the cutter. INT = the “good” rectangle is the inner one. EXT = the “good” rectangle is the outer one.

ROUNDING (value): Length of the cathet of the rectangle-isosceles triangle of which the hypotenuse represents the chamfer.

Clicking on the icon relative to the CIRCLE (Figure B.36), the following box will appear (Figure B.37), whose fields are described in Figure B.38.

Figure B.36: Circle: Icon

Figure B.37: Circle: Data edit box

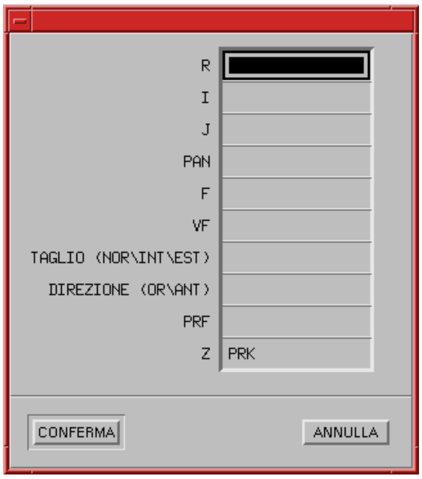
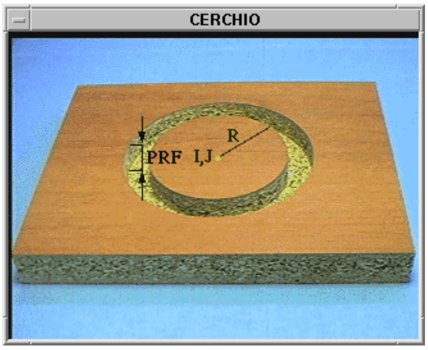


Figure B.38: Circle: EGA window



Clicking on the icon relative to the ELLIPSE (Figure B.39), the following box will appear (Figure B.40), whose fields are described in Figure B.41.

Figure B.39: Ellipse: Icon

Figure B.40: Ellipse: Data edit box

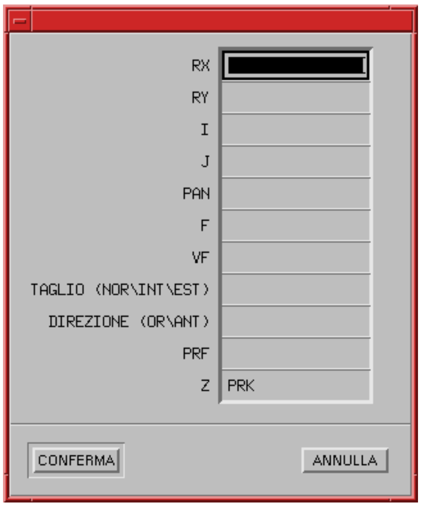
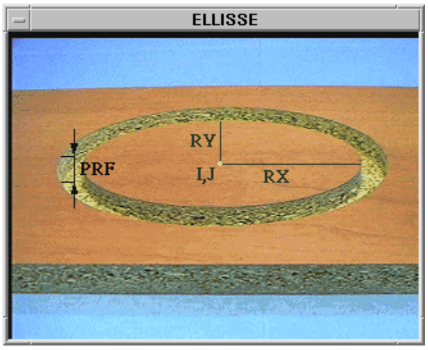


Figure B.41: Ellipse: EGA window



Clicking on the icon relative to AUTO TOOL CHANGE (Figure B.42), the following box appears (Figure B.43).

Figure B.42: Auto Tool Change: Icon

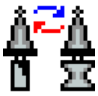
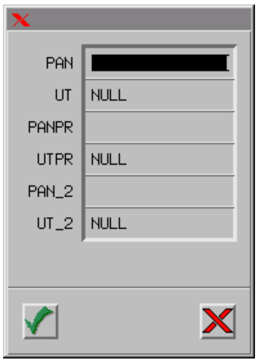


Figure B.43: Auto Tool Change: Data edit box



PAN: specify the number of the router on which the tool is to be changed.

UT: specify the name of the tool to be installed on the router. If the router is to be tooled down, specify “NULL” .

PANPR: specify the number of the router for which a tool is to be reserved.

UTPR: specify the name of the tool to be used in the reservation.

PAN_2: specify the number of the router to be used for simultaneous tool change with the router defined in the field “PAN”.

UT_2: specify the name of the tool to be fitted on the electrospindle PAN_2, for simultaneous changing operations. If the electrospindle is not to be tooled up, set the value “NULL” .

INFORMATION

For simultaneous tool change, tools UT and UT2 must belong to the same tool magazine.

1.5 C-axis

Clicking on the button relative to the AXIS C (Figure B.1) represented by Figure B.45, the following sublevel will open (Figure B.46).

Figure B.45: C-axis: Icon

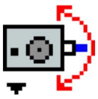


Figure B.46: C-axis: Icon sublevel 1

Clicking on the icon relative to ORIENTABLE ON LINE (Figure B.47), the following box will appear (Figure B.48), whose fields are described in Figure B.49.

Figure B.47: C-axis-Orientable on line: Icon

Figure B.48: C-axis-Orientable on line: Data edit box

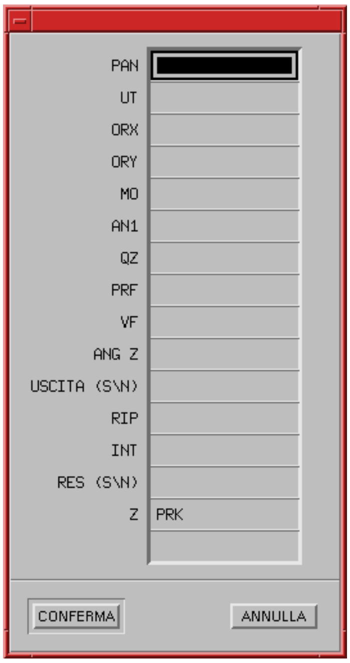
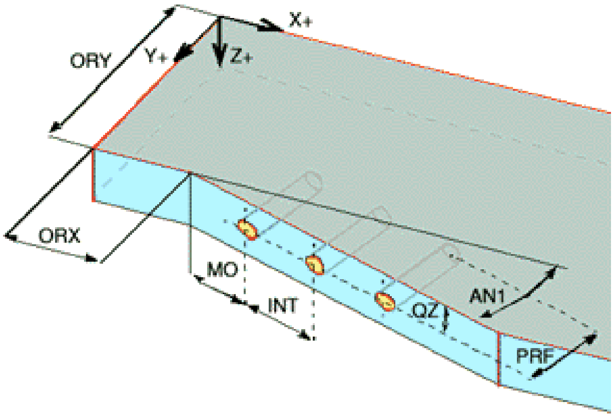


Figure B.49: C-axis-Orientable on line: EGA window



ORX - ORY: starting point coordinates of the inclined straight line.

MO: distance of the first hole on the inclined straight line.

AN1: straight line inclination (caution: AN1 is the angle formed between the straight line and the X-axis and increases by clockwise rotation).

QZ: Z-value at which to make the hole, starting from the upper surface of the panel.

PRF: hole depth.

ANGZ: hole inclination (not enabled: the subspindle orientation is taken since our machines do not have an axis to control this angle).

EXIT: Y = the tool bores and exits. N = the tool remains in the panel to execute subsequent routing steps (e.g. locks).

RIP: number of hole repetitions.

INT: distance between centres for hole repetitions.

RES: Y = the tool bores, exits and the motor is turned off. N = the tool bores, exits, but the motor is not turned off.

PCT: N = disable the profile follower. The profile follower is a device that keeps the angle between the tangent of the profile and the tool axis constant at 90°.

Clicking on the icon relative to ORIENTABLE ON ARC (Figure B.50), the following box will appear (Figure B.51), whose fields are described in Figure B.52.

Figure B.50: C-axis-Orientable on arc: Icon

Figure B.51: C-axis-Orientable on arc: Data edit box

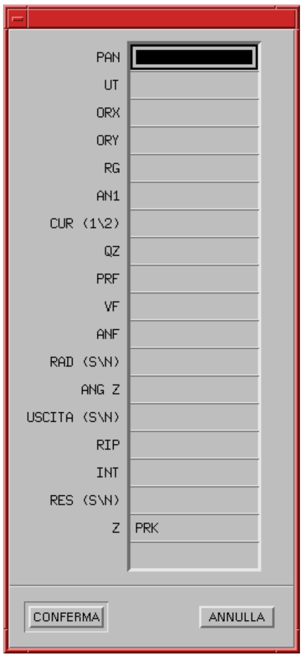
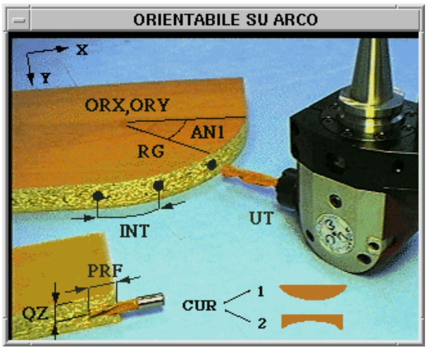


Figure B.52: C-axis-Orientable on arc: EGA window



ORX - ORY: arc centre coordinates on which to execute boring.

RG: arc radius on which to execute boring.

AN1: angle formed between the X-axis and the joint between the arc centre and the hole. The angle increases by clockwise rotation.

CUR: type of curve.
1) convex (hole executed towards the arc centre).
2) concave (hole executed in the opposite direction of the arc centre).

QZ: Z-position at which to execute the hole starting from the upper surface of the panel.

PRF: hole depth.

ANF: valid only in case of non-radial holes, it is the hole inclination angle, formed by the hole direction and the X-axis. The angle increases by clockwise rotation.

RAD: Y = radial holes: the hole direction is given by the join between the arc centre and the hole; in case of repetitions, the angle varies. N = non-radial holes: the hole direction is indicated in ANF; in case of repetitions the angle does not vary.

ANGZ: Hole inclination (not enabled: the subspindle orientation is taken since our machines do not have an axis to control this angle).

EXIT: Y = the tool bores and exits. N = the tool remains in the panel to execute subsequent routing steps (e.g. locks).

RIP: number of hole repetitions.

INT: distance between centres for hole repetitions.

RES: S = the tool bores, exits and the motor is turned off. N = the tool bores, exits, but the motor is not turned off.

Clicking on the icon relative to MILLING CUTTER ON ORIENTED AXIS (Figure B.53), the following box will appear (Figure B.54), whose fields are described in Figure B.55.

Figure B.53: C-axis-Cutter on oriented axis: Icon

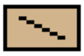


Figure B.54: C-axis-Cutter on oriented axis: Data edit box

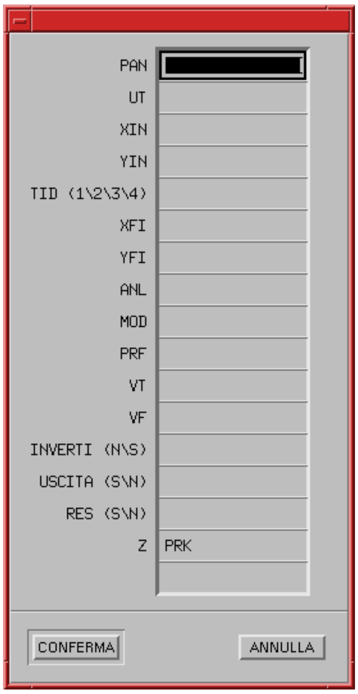
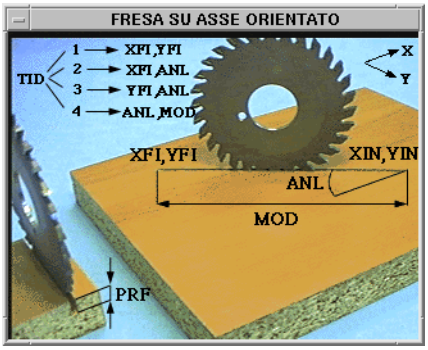


Figure B.55: C-axis-Cutter on oriented axis: EGA window



XIN - YIN: inlet point coordinates of the disk blade.

TID: type of input to determine the end point.
1) if the XFI,YFI coordinates of the end point are known.
2) if the cutting direction (ANL) and the x-coordinate XFI of the end point are known.
3) if the cutting direction (ANL) and the y-coordinate YFI of the end point are known.
4) if the (ANL) direction and the cutting length are known.

XFI - YFI: X, Y coordinates of the end point.

ANL: angle formed by the cutting direction and the X-axis. The angle increases by clockwise rotation. If ANL=0 the cut is executed in direction X+.

MOD: length of cut.

PRF: depth of cut.

INVERT: inverts the cut. N = normal machining. Y = inverted machining. The inlet and outlet points are exchanged, but the C-axis is controlled at the same value at which it would be set for the corresponding non-inverted machining.

EXIT: N = after having completed machining, the disk blade rises to the safety height without turning off, ready to be used in a subsequent program step. The value set in RES is uninfluential. Y = after having completed machining the disk blade rises up to the parking height. The motor is turned off only if the value set in RES is Y.

RES (influential only if EXIT = Y). Y = the motor is turned off. N = the motor is not turned off.

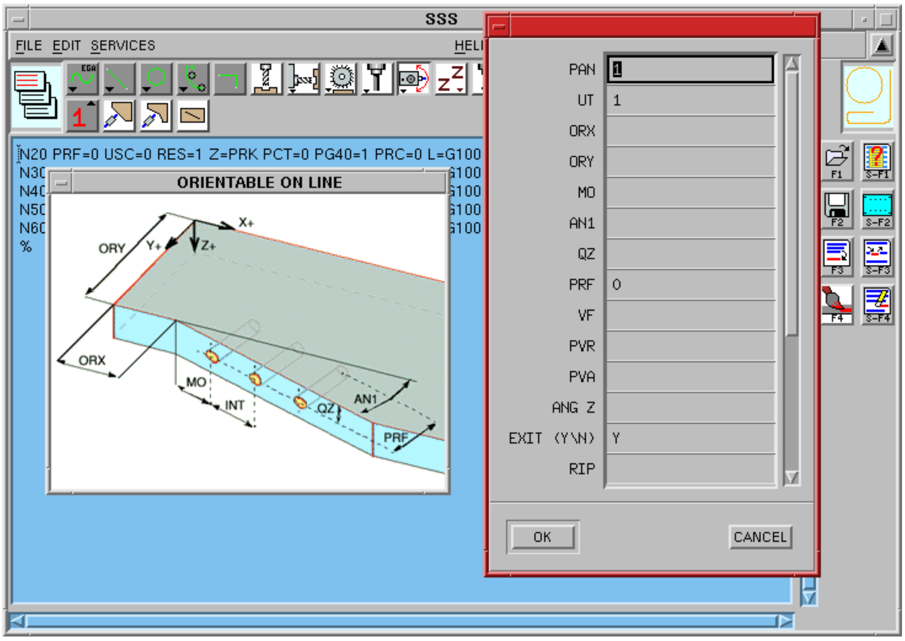
1.6 C-axis with auto-tracking of the tangent

The method in question allows obtaining automatic control of the C-axis in such a way that it maintains a prefixed angle with respect to the programmed X-Y profile tangent. This means that only the initial angle of the C-axis at the point where machining is started needs to be programmed; the rest of the profile will automatically be managed by the NC.

The programmed X-Y profile can moreover be corrected automatically by a few millimetres in the direction and sense of the tool.

Programming the start of machining

The start of machining is programmed through the fixed cycle G100 with the already known rules:



The aggregate is positioned by programming the following data:

PAN: spindle.

UT: subspindle.

ORX - ORY: coordinates of the machining start point.

MO: 0 (zero).

AN1: initial angle of the C-axis; this is the angle formed between the profile tangent at the machining start point and the X-axis and is increasing in clockwise direction (see figure).

QZ: machining start value on Z-axis starting from the upper surface of the panel.

PRF: distance between the machining start point and the Z-axis descent point measured on the tool axis.

VF: lead-in speed into the piece.

PVR: tool rotation speed.

PVA: feed speed for any interpolation which may follow G100.

ANGZ: not programmed.

LEAD-OUT: N indicates that the tool must remain active and in position.

RIP: 0 (zero).

INT: 0(zero).

RES: indifferent.

Z: PRK.

PCT: S enables the tangent tracking mode for the C-axis.

AGC: S\D to be programmed only if the profile is to be corrected. Indicates whether the tool must be to the left or to the right of the profile.

PRC: 0 .. 30 to be programmed only if the profile is to be corrected. Indicates by how much the profile is to be corrected.

The G100 cycle thus allows activating the aggregate and positioning it on the machining start point. The PRC and CRU data are used only if the set profile is subsequently to be corrected. See the next paragraph for details.

Profile programming

Profile programming follows the same rules as programming of a profile for a vertical cutter.

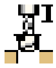
For example, it is possible to use the same profile programmed for a vertical cutter and for a horizontal pantograph on the C-axis.

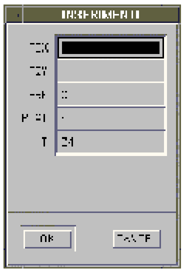
In this case it will also be possible to "recut" a profile with the vertical cutter and trim it with the horizontal pantograph on the C-axis correcting the profile by a few millimetres. To obtain the profile correction a value greater than 0 must be specified in the PRC field, and the CRU data should specify whether the tool is to the right or to the left of the profile. This correction is seen by the NC as a tool radius correction, therefore, an arc or a connecting segment will be necessary so that the NC can execute the correction. Moreover, it will need to be reset with a G40 programmed on an output step at the end of machining.

Programming the end of machining

The end of machining can be programmed with a POFF or a PSU which will automatically reset the tangent tracking mode for the C-axis.

1.7 Insertion unit

Clicking the icon of the insertion unit  , the following box will be displayed for parameter entering:

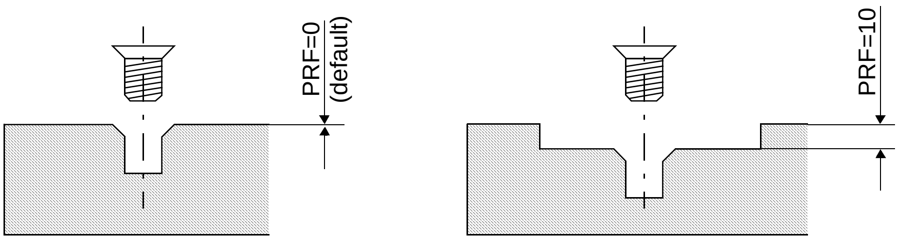


where:

PQX: is the X-coordinate of the insertion point.

PQY: is the Y-coordinate of the insertion point.

PRF: indicates the insertion depth: if PRF=0 the bush is inserted on the panel surface. Default value: 0.



PLAT: indicates the panel side on which to insert. Default value: 5 (not yet controlled).

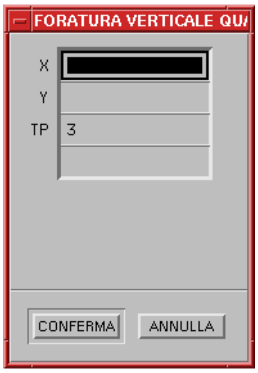
T: indicates the spindle or spindles to be engaged. Default value: 34.

The ISO code line produced will be the type shown below:

```
N10  PQX=200  PQY=100  PRF=0  PLAT=5  ST1=”34”  L=GINS
```

1.8 Square holes

A square hole is programmed by selecting the icon for square holes  and setting the X and Y coordinates of the hole in the relevant parameter box:



The TP field is initialised at the default value 3. To change this value, intervene in the fixed cycle GFQ in the CONFIGURATION section on the line

/TTP/L15/=TP/D3.

1.9 M instructions for suspension of the program

M200 - Suspension with unlocking

Suspends the machining operation after commanding parking of the axes*. The piece is unlocked to allow manual intervention by the operator. Machining continues after the piece has been re-locked on the origin on which it was originally locked.

M201 - Suspension for transfer to the mirror origin

Suspends the machining operation after commanding parking of the axes*. The piece is unlocked to allow it to be re-locked on the mirror origin. A machining operation carried out on the mirror origin is not a mirror image of the one carried out on the origin on which the piece was originally locked. The mirror origin is selected automatically by the PLC, according to the dimensions of the piece and those of the work table.

M203 - Suspension for transfer to a row of stops

Suspends the machining operation after commanding parking of the axes*. The piece is unlocked to allow it to be re-locked on a different row of stops, specified using the FIL parameter in the ISO row that also contains M203

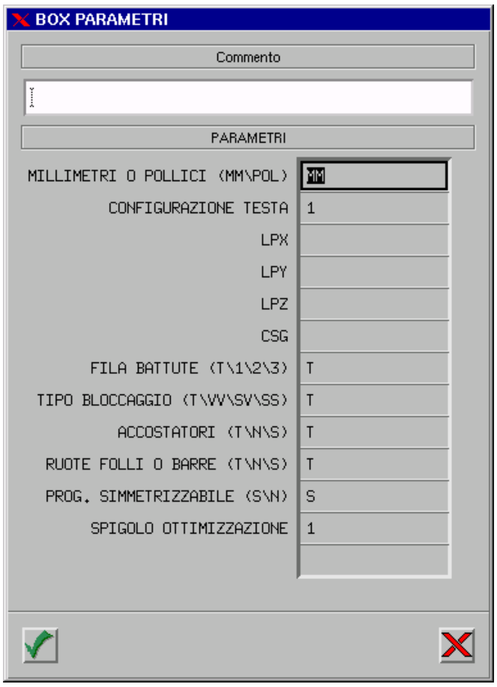
M212 - Suspension without unlocking

Suspends the machining operation after commanding parking of the axes*. The piece remains locked on the work tables. Machining continues when the same start button used to lock the piece is pressed.

Chapter 2. PARAMETERS Options: parameter box

The Parameter Box is a window through which some parameters relating to a program may be defined. This box is automatically activated when a new program is created, or can be called through the PARAMETERS option of the FILE menu of the P.A. Editor, or using the key combination Ctrl R. This window appears as in Fig. C.1.

Figure C.1: Parameter Box Window



The parameters which may be defined are described below:

MILLIMETRES OR INCHES (MM\IN): MM selects millimetres, while IN selects inches.

HEAD CONFIGURATION: tooling field number.

STOPS ROW (T\1\2\3): number of row of stops selected; T allows selecting the row from the keyboard.

LOCKING TYPE (T\VV\SV\SS): T allows selecting the type of clamping from the keyboard, VV selects clamping with suction cups only, SV with clamps and suction cups, while SS with clamps only.

PUSHERS (K\N\Y): K allows activating the front pushers from the keyboard, N does not activate them, Y activates them.

IDLE WHEELS OR BARS (K\N\Y): K allows activating the ball-type or bar-type supports from the keyboard, N does not activate them, S activates them.

LPX: panel length.

LPY: panel width.

LPZ: panel thickness.

CSG: Jig thickness.

AUTOMATIC WORK AREA (LH\RH): area to which the stop on which the first panel to be clamped belongs (automatic machines only).

AUTOMATIC PENDULAR MODE (N\Y): enabling of pendular machining on automatic machine starting from the area specified above (automatic machines only).

PASSAGE PANEL (N\Y): the option YES declares that the panel must not be worked on the machine, but must only transit (automatic machines only).

PRESSURE CYCLE (N\Y): enabling of pressure cycle during panel clamping (automatic machines only).

XPR: pressure point x-coordinate during panel clamping (automatic machines only).

YPR: pressure point y-coordinate during panel clamping (automatic machines only).

SYMM. L.O. PROG. (Y\N): S activates symmetrical programming, while N does not activate it.

OPTIMISATION CORNER: number of corner selected.

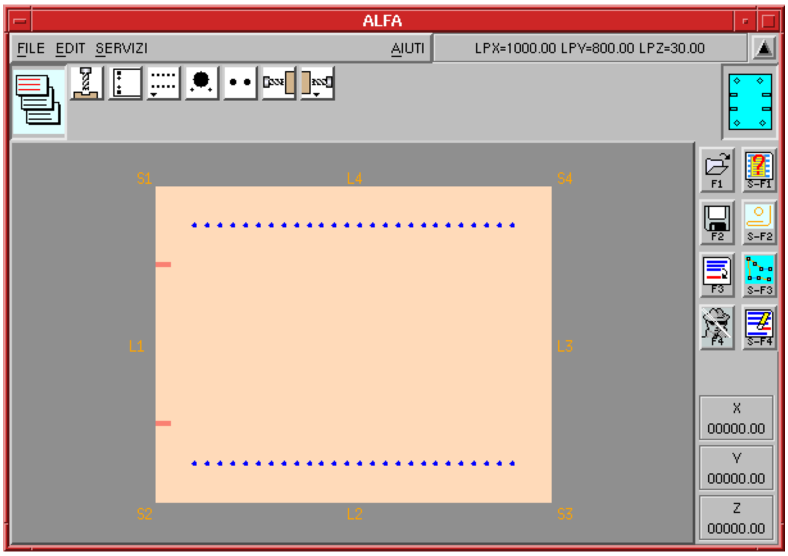
An automatic machine means a machine set up to work on-line with other machines. With this machine the panel clamping operations are carried out automatically without any need for operator intervention.

Chapter 3. Optimised boring

Clicking on the button S-F2 (Fig. D.1) the EDIT HOLES environment (Fig. D.2) is accessed where optimised boring may be executed.

Figure D.1: Edit Holes: Icon

Figure D.2: EDIT HOLES Environment

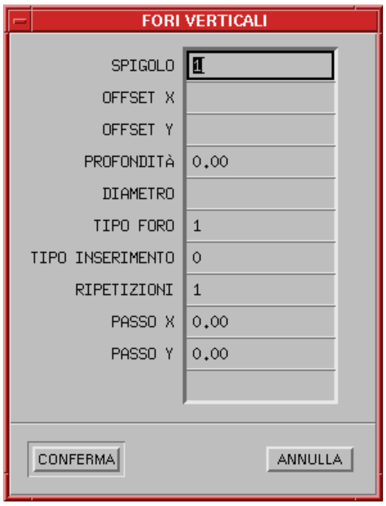


3.1 Vertical Holes

Clicking on the VERTICAL HOLES icon (Fig. D.3) the box as in Fig. D.4 will appear, whose fields have the following meaning:

Figure D.3: Vertical Holes: Icon

Figure D.4: Vertical Holes: Data edit box



CORNER: reference corner.

OFFSET X: X-coordinate of the hole.

OFFSET Y: Y-coordinate of the hole.

DEPTH: hole depth.

DIAMETER: hole diameter.

HOLE TYPE: type of hole (1 for flat, hinged, or countersunk point, 2 for through point).

INSERTION TYPE: type of insertion.

REPEATS: number of hole repetitions.

STEP X: distance on X-axis between one hole and the next.

STEP Y: distance on Y-axis between one hole and the next.

3.2 Insertions

Clicking on the INSERTIONS icon (Fig. D.5), the box as in Fig. D.6 will appear, whose fields have the following meaning:

Figure D.5: Insertions: Icon

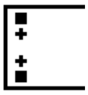
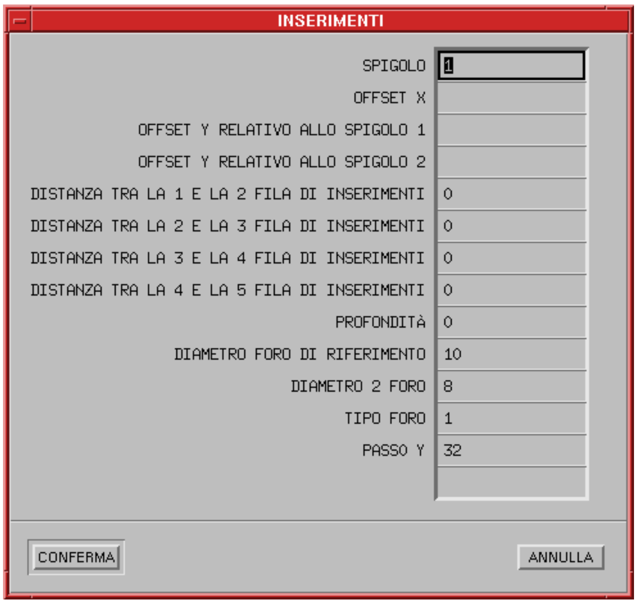


Figure D.6: Insertions: Data edit box



CORNER: reference corner.

OFFSET X: X-coordinate of the hole.

OFFSET Y: Y-coordinate of the hole.

DISTANCE BETWEEN 1 AND 2 ROW OF INSERTIONS: distance on X-axis.

DISTANCE BETWEEN 2 AND 3 ROW OF INSERTIONS: distance on X-axis.

DISTANCE BETWEEN 3 AND 4 ROW OF INSERTIONS: distance on X-axis.

DISTANCE BETWEEN 4 AND 5 ROW OF INSERTIONS: distance on X-axis.

DEPTH: hole depth.

REFERENCE HOLE DIAMETER: hole diameter.

2ND HOLE DIAMETER: hole diameter.

HOLE TYPE: type of hole (1 for flat, hinged, or countersunk point, 2 for through point).

STEP Y: distance on Y-axis between one hole and the next.

3.3 System 32

Clicking on the SYSTEM 32 icon (Fig. D.7), a series of level 1 icons will appear (Fig. D.8).

Figure D.7: System 32: Icon

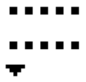
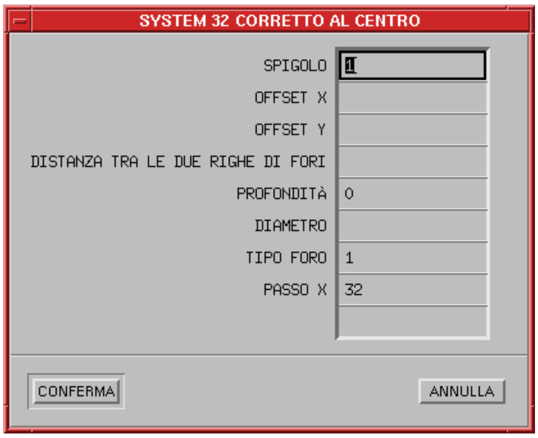


Figure D.8: System 32: Icon level 1

Clicking on the icon CENTRE-CORRECTED SYSTEM 32 , the box as in Fig. D.9 will appear.

Figure D.9: System 32 centre corrected: data box



CORNER: reference corner.

OFFSET X: X-coordinate of the hole.

OFFSET Y: Y-coordinate of the hole.

DISTANCE BETWEEN THE TWO ROWS OF HOLES: distance on Y-axis.

DEPTH: hole depth.

DIAMETER: hole diameter.

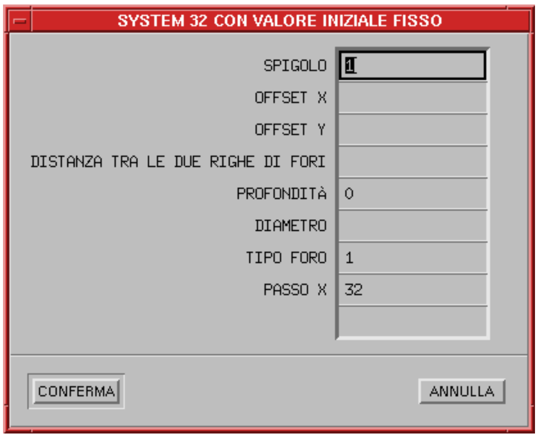
HOLE TYPE: type of hole (1 for flat, hinged, or countersunk point, 2 for through point).

REPEATS: number of hole repetitions.

STEP X: distance on X-axis between one hole and the next.

Clicking on the icon SYSTEM 32 WITH FIXED BEGINNING VALUE, the box as in Fig. D.10 will appear.

Figure D.10: System 32 with fixed initial value: data box



CORNER: reference corner.

OFFSET X: X-coordinate of the hole.

OFFSET Y: Y-coordinate of the hole.

DISTANCE BETWEEN THE TWO ROWS OF HOLES: distance on Y-axis.

DEPTH: hole depth.

DIAMETER: hole diameter.

HOLE TYPE: type of hole (1 for flat, hinged, or countersunk point, 2 for through point).

REPEATS: number of hole repetitions.

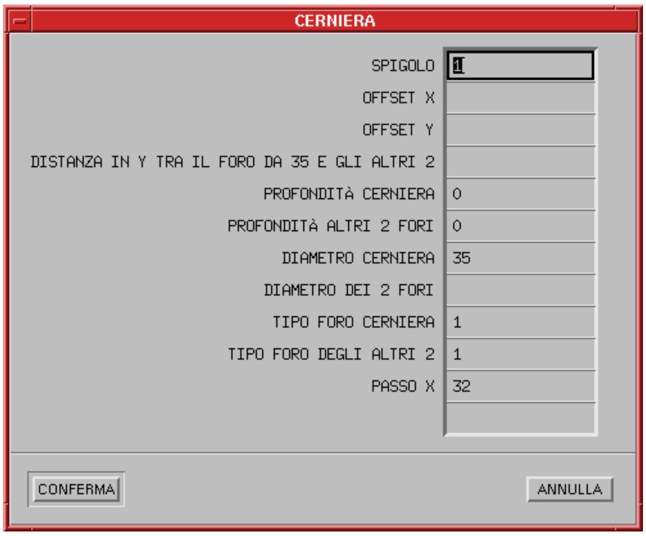
STEP X: distance on X-axis between one hole and the next.

3.4 Hinge

Clicking on the HINGE icon (Fig. D.11), the box as in Fig. D.12 will appear, whose fields have the following meaning:

Figure D.3: Hinge: Icon

Figure D.4: Hinge: Data edit box



CORNER: reference corner.

OFFSET X: X-coordinate of the hole.

OFFSET Y: Y-coordinate of the hole.

DISTANCE IN Y BETWEEN THE 35MM HOLE AND THE OTHER TWO:

DEPTH: hole depth.

HINGE DIAMETER: hole diameter.

DIAMETER OF THE 2 HOLES: hole diameter.

HOLE TYPE: type of hole (1 for flat, hinged, or countersunk point, 2 for through point).

STEP X: distance on X-axis between one hole and the next.

3.5 Mounting plates

Clicking on the icon MOUNTING PLATES (Fig. D.13), the box as in Fig. D.14 will appear, whose fields have the following meaning:

Figure D.3: Mounting Plates: Icon

Figure D.4: Mounting Plates: Data edit box

CORNER: reference corner.

OFFSET X: X-coordinate of the hole.

OFFSET Y: Y-coordinate of the hole.

DISTANCE BETWEEN 1 AND 2 MOUNTING PLATE: distance on X-axis.

DISTANCE BETWEEN 2 AND 3 MOUNTING PLATE: distance on X-axis.

DISTANCE BETWEEN 3 AND 4 MOUNTING PLATE: distance on X-axis.

DEPTH: hole depth.

HOLE TYPE: type of hole (1 for flat, hinged, or countersunk point, 2 for through point).

STEP X: distance on X-axis between one hole and the next.

3.6 Horizontal Holes

Clicking on the HORIZONTAL HOLES icon (Fig. D.15), the box as in Fig. D.16 will appear, whose fields have the following meaning:

Figure D.15: Horizontal Holes: Icon

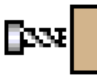
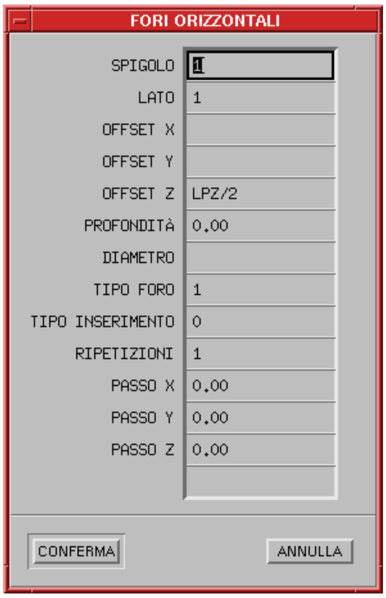


Figure D.16: Horizontal Holes: Data edit box



CORNER: reference corner.

OFFSET X: X-coordinate of the hole.

OFFSET Y: Y-coordinate of the hole.

OFFSET Z: Z-coordinate of the hole.

DEPTH: hole depth.

DIAMETER: hole diameter.

HOLE TYPE: type of hole (1 for flat, hinged, or countersunk point, 2 for through point).

INSERTION TYPE: type of insertion.

REPEATS: number of hole repetitions.

STEP X: distance on X-axis between one hole and the next.

STEP Y: distance on Y-axis between one hole and the next.

STEP Z: distance on Z-axis between one hole and the next.

3.7 Series of Horizontal Holes

Clicking on the SERIES OF HORIZONTAL HOLES icon (Fig. D.17), two level 1 icons will appear (Fig. D.18).

Figure D.17: Series of Horizontal Holes: Icon

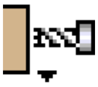
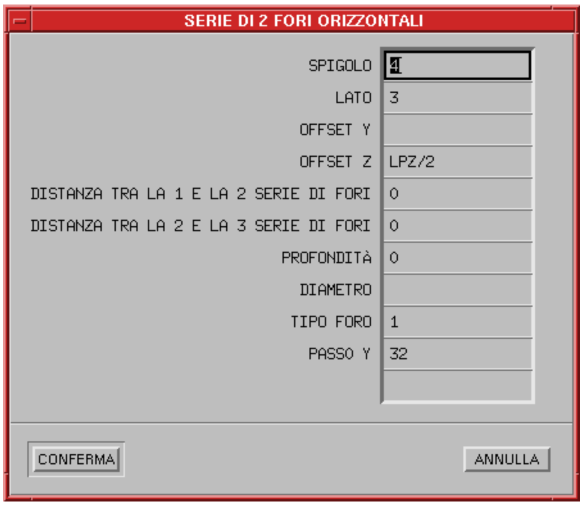


Figure D.18: Series of Horizontal Holes: Data edit box

Clicking on the SERIES OF 2 HORIZONTAL HOLES icon, the box as in Fig. D.19 will appear, whose fields have the following meaning:

Figure D.19: Series of 2 Horizontal Holes: Data edit box



CORNER: reference corner.

SIDE: reference side.

OFFSET Y: Y-coordinate of the hole.

OFFSET Z: Z-coordinate of the hole.

DISTANCE BETWEEN 1 AND 2 SERIES OF HOLES: distance on Y-axis.

DISTANCE BETWEEN THE 2^{ND} AND 3^{RD} SERIES OF HOLES: distance on Y-axis.

DEPTH: hole depth.

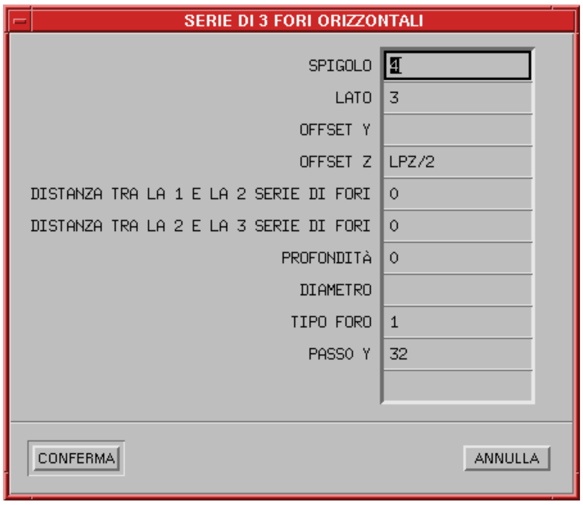
DIAMETER: hole diameter.

HOLE TYPE: type of hole (1 for flat, hinged, or countersunk point, 2 for through point).

STEP Y: distance on X-axis between one hole and the next.

Clicking on the SERIES OF 3 HORIZONTAL HOLES icon, the box as in Fig. D.20 will appear, whose fields have the following meaning:

Figure D.20: Series of 3 Horizontal Holes: Data edit box



CORNER: reference corner.

SIDE: reference side.

OFFSET Y: Y-coordinate of the hole.

OFFSET Z: Z-coordinate of the hole.

DISTANCE BETWEEN 1 AND 2 SERIES OF HOLES: distance on Y-axis.

DISTANCE BETWEEN 2 AND 3 SERIES OF HOLES: distance on Y-axis.

DEPTH: hole depth.

DIAMETER: hole diameter.

HOLE TYPE: type of hole (1 for flat, hinged, or countersunk point, 2 for through point).

STEP Y: distance on Y-axis between one hole and the next.

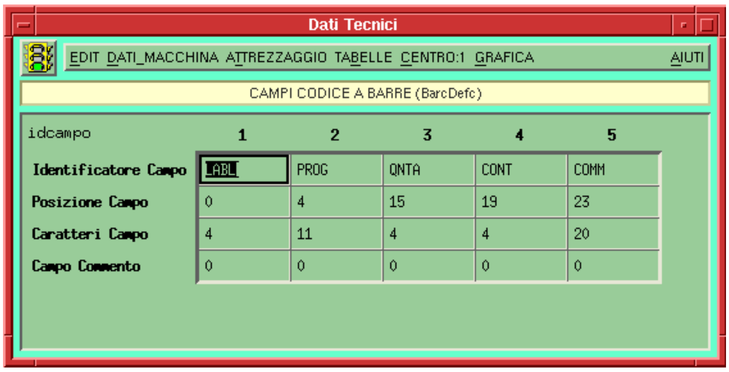
Chapter 4. Bar code reader

To configure the XNC control for connection to the DL910 reader, the Technical Data Tables below must be modified.

4.1 Data fields for bar codes

The table represented in Figure 1 is used to format the various fields which make up the code to be read.

Figure 1: Data fields for bar codes



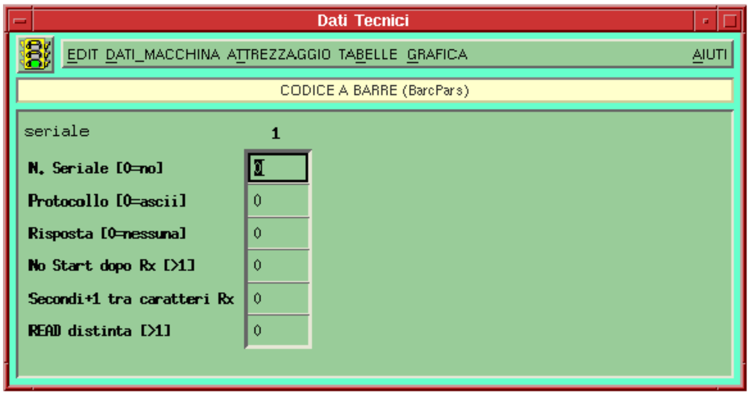
For example, with the table of Fig. 1 a code formatted in the following way is defined:

Field	Characteristics
LABEL	4 characters starting from the first character (character 0)
PROG	11 characters starting from the fifth character (character 4)
QNTA	4 characters starting from the sixteenth character (character 15)
CONT	4 characters starting from the twentieth character (character 19)
COMM	20 characters starting from the twenty-fourth character (character 23)

4.2 Serial connection

With this table (Fig. 2) the serial port to which the bar code reader is connected is declared (in the example figure it is connected to the serial port COM1).

Figure 2: Bar code



Serial line: number of the port which is intended to be used for connection of the reader (1, 5 or 6).

No Start after Rx: 0 to enable automatic start of a program after its reading, 2 to disable it.

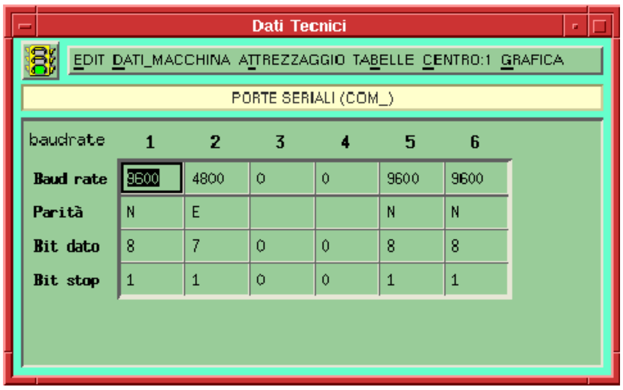
READ worklist: 0 to not accept READ worklist, 2 to accept READ worklist.

The other fields must assume the value 0.

Serial port configuration

Through the table of Figure 3 the characteristics of the serial ports on the control are described. In particular for the bar code reader, COM1 must be used. If COM1 is occupied by another application (for example, serial connection with PC), either COM5 or COM6 must be used (these two ports must be added by installing the SER2 expansion board).

Figure 3: Serial Ports



4.3 Bar code reader configuration (Data Logic DL910)

The 9-pin female connector must be connected to the serial port 1 (COM1) located near the keyboard and mouse connectors.

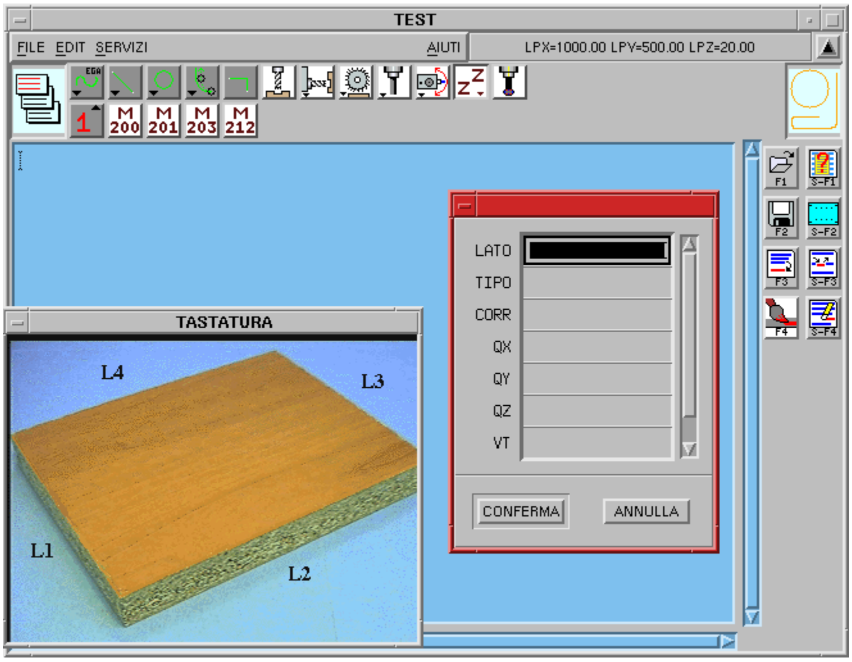
To configure the DL910 reader for connection to the XNC control, the following code sequence must be entered (c.f. DL910 Operator Manual):

$+	Configuration start
CE1	software (XON/XOFF)
EA11	Definition of first character of code end, e.g. 0D
EA12	Definition of second character of code end, e.g 00
$-	Save and exit configuration

Chapter 5. Tracer

Clicking on the button relative to the tracer (in Fig. H.1 the one near the button relative to the C-axis) the Tracing box and the box of the associated image will open.

Figure H.1: Data edit box and images for TRACING cycle



SIDE: side on which tracing is to be executed.

TYPE: type of tracer with which tracing is to be executed. 0 (default) vertical tracer. 1 cross tracer.

CORR: disables origin or piece dimension correction with the value read by the tracer. 0 (default) correction enabled. 1 correction disabled.

The value for the correction available in the QTS variable.

QX: X-value at which tracing is to be executed.

QY: Y-value at which tracing is to be executed.

QZ: Z-value at which tracing is to be executed.

VT: axis speed at which tracing is to be executed.

Chapter 6. On-line multicentre machines

The on-line machines are multicentre machines. Normally there are three centres of which two correspond to "physical" work centres (centre 1 and 2), while the third is a "logic" centre (centre 3) used for programming of some functions. All the sections of a program (cut-out, boring, etc.) are arranged by centre. The logic centre is the first of all the centres to execute a program and communicates the characteristic information of the program to the PLC like, for example, the type of clamping to execute on the panel, the work origin, etc. This data is fundamental for proper machine functioning, thus logic centre programming is indispensable. The logic centre is programmed through the Parameter Box which appears each time a new program is created, or can be called through the PARAMETERS option of the FILE menu of the P.A. Editor.

6.1 Modes of operation

This paragraph describes the modes of operation through which a panel can be clamped and machined.

Filling mode

The filling mode allows for simultaneous machining two identical pieces. Each centre executes all the machining operations of one piece. For this reason the only type of panel which can be machined in this mode is the medium-short panel (panel occupying only one transport).

Single tandem mode

The single tandem mode allows for machining a piece always on the same origin which must be specified. If the panel is medium-short, it is machined by the centre associated with the stop on which it has been clamped; if it is long, it is machined by both the centres simultaneously.

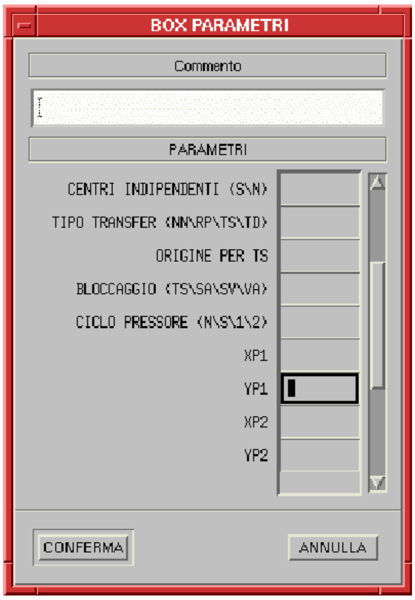
Double tandem mode

The double tandem mode allows for machining a piece executed with two clamps. The panel is clamped and machined on the first origin requested; when this first machining operation has been completed, the panel is translated on the second origin requested, where machining is completed.

6.2 Parameter Box

The Parameter Box window appears as in Figure 1.

Figure 1: Parameter Box



The parameters which may be defined are described below.

INDEPENDENT CENTRES: Y = makes the two centres independent during machining. N = synchronises the two centres. When the centres are synchronised they behave as follows:

- on a machine with the panel inlet from the left, the centres operate in the direction of the increasing X-axes: centre 1 follows centre 2;

- on a machine with the panel inlet from the right, the centres operate in the direction of the decreasing X-axes: centre 2 follows centre 1.

TRANSFER TYPE: Indicates how the panel must transit. The options are:
NN = the panel must transit without being machined;
RP = the panel must be machined in Filling mode;
TS = the panel must be machined in Single Tandem mode on the origin specified in the field ORIGIN *FOR TS*;
TD: the panel must be machined in Double Tandem mode.

ORIGIN FOR TS: This should only be set in case of having selected to operate the machine in Single Tandem mode, to specify the stop on which the panel must be clamped (1 or 2 may be valid).

LOCKING: Indicates how the panel must be clamped. The options are:
SA = only with front pushers;
VA = with suction cups and front pushers;
SV = only with suction cups.

If nothing is specified, the clamping selected with the key dedicated to type of clamping is used.

ROW OF STOPS 1,2,3: Through these fields a row of stops may be disabled, so that it is not used in the panel clamping phase. Thus any stop which interferes with a protruding part of the panel (e.g. a pin) can be disabled.

CLAMP CYCLE: Indicates on which centres to use the presser during the panel clamping phase. The options are:
N = disables use of the presser;
S = implies use of the presser. If the panel is long, both pressers are used;
1 = implies that the presser must be used only by centre 1;
2 = implies that the presser must be used only by centre 2.
The pressure positions of the two pressers must be specified through the fields **XP1,YP1** for the presser of centre 1, and the fields **XP2,YP2** for the presser of centre 2. If the pressure positions are not specified, the following values are taken as default depending on the type of panel:
- medium-short panel, XP1=XP2=LPX/2;
- long panel with two pressers, XP1=100, XP2=LPX-100;
- long panel with only one presser (on centre i), XPi=LPX/2.
Also in the three cases YP1=YP2=LPY/2.

X1 TO PRK AFTER CLAMP CYCLE, X2 TO PRK AFTER CLAMP CYCLE: An Y in one of these fields selects parking of the corresponding X-axis after the presser cycle

6.3 Dynamic control of interference between the work centres

The basic problem which comes into play when writing programs including interpolations is to prevent an interpolation being suspended by the control, since the centre performing the interpolation will be interfering with the other: this suspension would cause damage to the panel because of the overheating caused by the tool which continues to rotate with the axes firm inside the panel. To solve this problem all machining is arranged in "indivisible blocks". Indivisible blocks are program sections related to machining which cannot be interrupted. Each indivisible block must be preceded by the line:

`N100 L=GIN XT1=...` for centre 1,

`N100 L=GIN XT2=...` for centre 2.

and must be followed by the line:

N200 L=GOUT

The *limit* parameter XT1 represents the maximum absolute X-value achievable by centre 1 with block machining operations (taking into account the dimensions of the centre head). Similarly, the parameter XT2 represents the minimum absolute X-value achievable by centre 2 with block machining operations.

By retrieving the GIN cycle, the centre reserves a space in the area it has as limit, XT1 or XT2 (depending on the centre). The PLC makes a comparison between the limits declared by the centres and, if necessary, suspends the centre which in the instant it executes the GIN cycle declares a value (interference) conflicting with that declared by the other centre. If a centre does not declare any limit, it means that the centre must not carry out any machining operation and is set at a safety value (e.g. PRK).

When a centre completes execution of an indivisible block, it retrieves the GOUT cycle to declare that it has completed the block. In this case, the PLC process evaluates if the current centre is in a position which prevents machining by the other centre (which may be locked on a call to the GIN cycle) and in this case the centre is set (by the PLC process) out of interference in order to leave useful space to the other centre. Therefore, by means of the GOUT cycle the centre executing the cycle can be moved enough to allow the other to operate. One centre can move the other centre (if it has completed program execution) if it does not have room for the next machining operation (through the GIN cycle).

Below the different cases of indivisible blocks are shown. In the right column of the table the start and end of block lines are listed (routing), or the single line which constitutes the block (cuts with circular cutter). In case of boring, an indivisible block can contain more than one boring sink.

Type of machining operation	Indivisible block

Routing	`N100 ... L=PON ...`
	`...`
	`N200 ... L=POFF`

	`N100 ... L=PON ...`
	`...`
	`N200 ... L=PSU`

Cuts with circular cutter	`N100 ... L=G7 ...`
	`N100 ... L=G9 ...`
Vertical and horizontal boring	Grouped into an indivisible block are: ■ boring drops for horizontal holes on the same side; ■ boring drops for vertical holes whose limits differ by a quantity less than a certain delta (definable by CAM through the parameter *X-interval for grouping of holes in indivisible blocks*). In this way it is the user who can decide how to group the boring drops. In fact, a low parameter value results in indivisible blocks with very close boring drops; increasing the value of the parameter, the number of boring drops contained in the various blocks are increased. The ideal condition is to have blocks with very close boring drops: in this case the probability of suspensions because of interference of the centres is reduced.

By means of the parameter *Enable / disable GIN / GOUT cycles* engagement parameter of the CAM programs generated by retrieved GIN and GOUT cycles can be obtained with the values XT1 and XT2 calculated by the optimizer.

A fundamental aspect regarding dynamic control of interference between centres should be emphasised. The program lists must all be written using the arrangement in indivisible blocks (entering of the GIN and GOUT cycles). This is necessary because it is the only way to let the numerical control know (in particular the PLC) the current status of machining in progress on the two centres. If a list of programs without dynamic GIN and GOUT cycle dynamic control is to be executed, the parameter NOGG=1 must be set for each program on the list line in the COMMENT field.

6.3.1 Writing programs with the Graphic Editor

If GIN and GOUT cycle calls are to entered manually, the Graphic Editor may be used (in OPTIMIZED DRILLINGS call entering of both cycles is done by the optimiser). To manually enter the two cycle calls Graphic Editor buttons shown in Figure 2 are available.

Figure 2: Buttons to enter the GIN and GOUT cycles.

In this programming mode it is not necessary (though it is possible) to calculate the limits. The calculation of these values is done by the GIN cycle. Selecting the button relative to this cycle, the dialog window as in Figure 3 appears.

Figure 3: Dialog window of GIN cycle.

In the SPINDLE field the reference spindle for the indivisible block which will follow must be specified. In the XT field the relative limit which will be reached by the reference spindle must be specified (without having to take into account the physical dimensions of the work centre). Through these two data, the GIN cycle calculates the XT1 and XT2 values (on the basis of the reference spindle and its declared limit).

If, for example, we wish to machine a segment from X=100 to X=1300 with the spindle TP1, the string TP1 must be indicated in the SPINDLE field, while in the XT field 1300 must be indicated if writing the program in the section of centre 1, or 100 if writing the program in the section of centre 2. If we wish to machine a circle with a radius of 200 and centre with X=1200 with the spindle TP2, the string TP2 must be indicated in the SPINDLE field, while in the XT field, 1400 (1200+200) must be indicated if writing the program in the section of centre 1, or 1000 (1200-200) if writing the program in the section of centre 2.

The following table shows further programming examples.

Indivisible block	Parameters for the GIN cycle

Vertical boring
 	
`N20 X100 Y100 T=13,14,15 VF=3 PRZ=10 L=G99`
`N30 X100 Y300 T=13,14,15 VF=3 PRZ=10 L=G99`
	.
	
	`SPINDLE=T13`
	`XT=100 (centre 1)`
	`XT=100 (centre 2)`

Horizontal boring
 	
`N20 QX=0 QY=100 QZ=LPZ/2 TH=4,6,8 PRF=10 VF=3 L=G1`
	.
	
	`SPINDLE=TH4`
	`XT=10 (centre 1)`

Horizontal boring
 	
`N20 QX=LPX QY=100 QZ=LPZ/2 TH=3,5,7 PRF=10 VF=3 L=G3`
	.
	
	`SPINDLE=TH3`
	`XT=`*LPX-PRF*
	`(centre 2)`

Horizontal boring
 	
`N20 QX=100 QY=0 QZ=LPZ/2 TH=2 PRF=10 VF=3 L=G4`
	
	`SPINDLE=TH2`
	`XT=100 (centre 1)`
	`XT=100 (centre 2)`

Routing
 	
`N20 X100 Y200 Z=PRK TP=2 PRF=5 F=3 VF=3 G40 L=PON`
`N30 X1600 G1`
`N40 L=POFF`
	.
	
	`SPINDLE=TP2`
	`XT=1600 (centre 1)`
	`XT=100 (centre 2)`

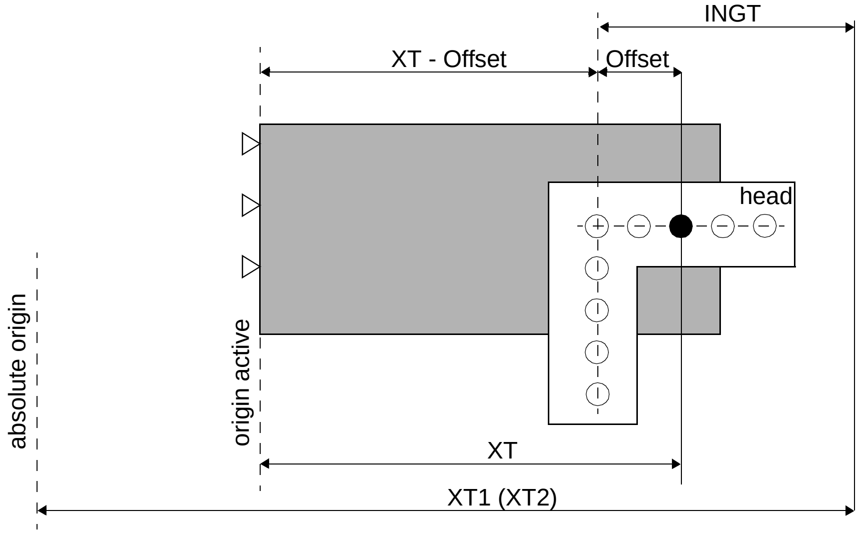
6.3.2 Limit calculation

Within the GIN cycle the limits are calculated using the following formulae:

> XT1 = XORI + (XT – Spindle Offset) + Head Dimensions on X+ centre 1;
> XT2 = XORI + (XT – Spindle Offset) – Head Dimensions on X- centre 2.

If the active origin is origin 1, *XORI* = Calibrator Origin 1; if the active origin is origin 2, *XORI* = Calibrator Origin 2 - LPX. The parameter *XT* is the limit declared through the dialog window of the GIN cycle. The *Spindle Offset* is read from the relevant CALIBRATOR table of the machine data on the basis of the name inserted in the SPINDLE field of the GIN dialog window. The *Head Dimension* is read from the HEAD table on the basis of the centre.

Figure 4: Limit calculation.



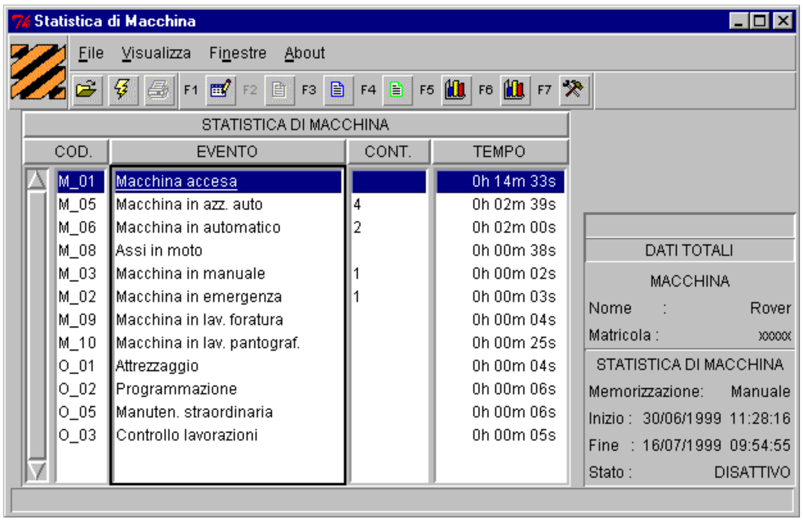
Chapter 7. Statistics management

Statistics is an environment in which information on machine and operator events is stored, in order to check productivity and reliability. Two main categories of events can be distinguished: those relating to machine statistics and those relating to production statistics. It is possible to record the duration of each event and the number of times it occurs.

Machine statistics events are all the events that relate to the machinery, and more specifically they are divided into Machine Events and Reliability Events.

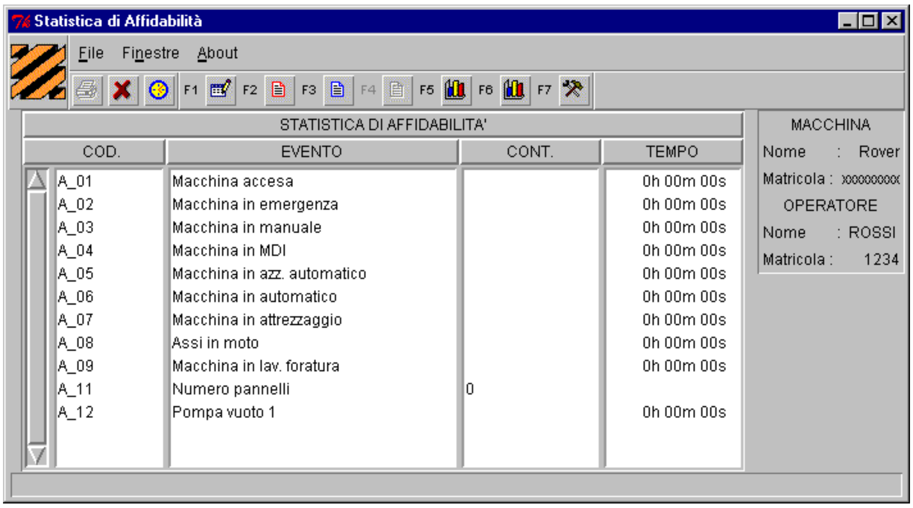
Machine Events

These data represent machine events that are not directly dependent on the specific type of machine, and they provide information that is of use both to the client in order to plan maintenance operations, and to the manufacturer to check whether or not technical choices or solutions used are appropriate.



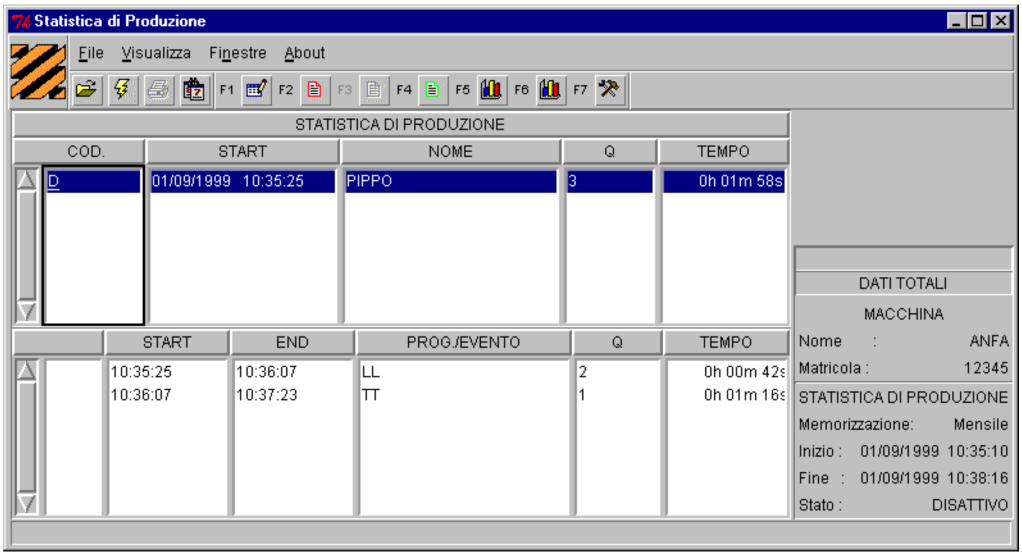
Reliability Events

These data are related to the type of machine and its set-up. In certain cases, as well as representing an excellent way of checking the coherence of the choices made, they can be used as a way of supporting guarantee recognition and can suggest the causes of malfunctions deriving from stress to certain devices following use beyond the tolerance limits.

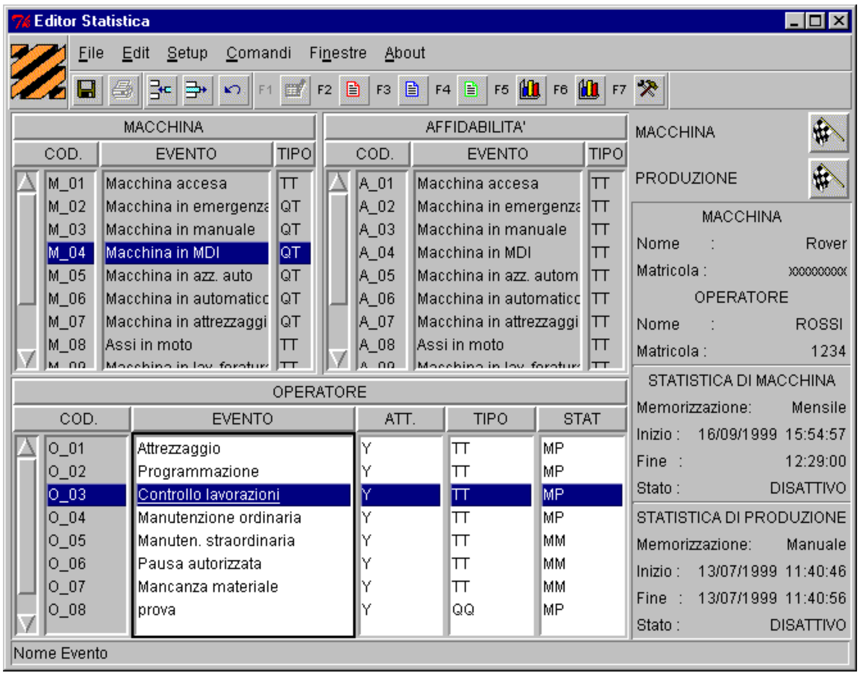


Production Events

Production statistics data provide information relating to the operations performed by the machine, or necessary to prepare the latter for machining operations.

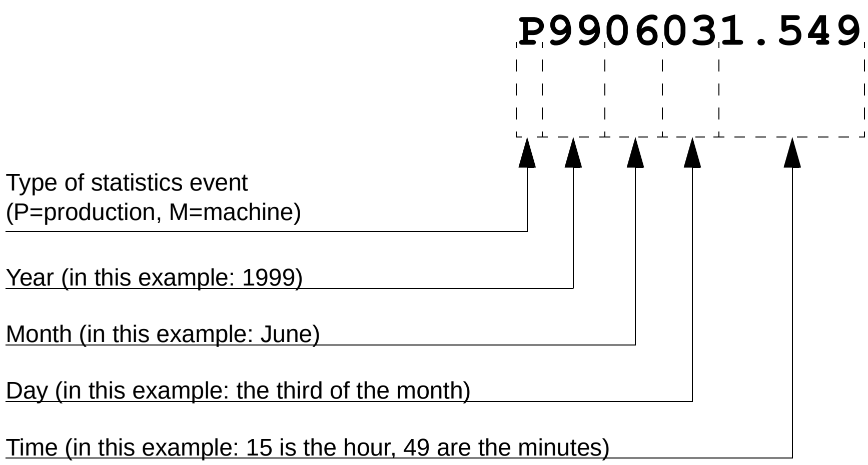


All questions relating to statistics, that is to say the various settings, programming operations, enabling/disabling, etc., take the Statistics Editor window as their basic reference.



Information on the names of statistics

Each time the active statistics event stops, it is automatically saved and stored in the software memory. Each statistics event is coded using the date and time of the day in which it stops. The information contained in the code or name of each statistics event is indicated in the following example.



7.1 How to use the statistics

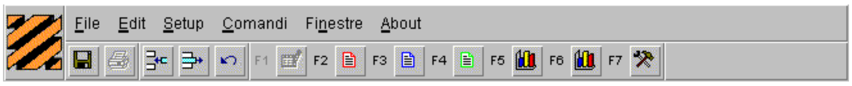
This information is aimed at providing the operator with a general view of how to use the statistics. The following are the various stages when using statistics.

1. Set the term for storage of statistics and the operator identification data.
2. Define which events are to be included in the statistics.
3. Enable statistics, then mark the start and the end of each event.
4. When necessary, disable statistics.

7.2 User interface

Menus and icons

The menus and icons bar is displayed at the top of each window in the statistics interface.



Each menu contains a list of options to be selected. The most frequently used options can be selected by clicking on the respective icons, or by pressing a combination of keys.

Files

This menu allows files to be managed in various ways, according to the window that is opened.

Save:  in the Statistics Editor window this saves the operator data configuration file, in the Planned Maintenance window it saves the data configuration file relating to planned maintenance.

Print:  Not managed.

Exit: Converts the interface to an icon.

Open:  opens the window for selection of the statistics file to be displayed.

Current Statistics Event:  displays the current statistics event.

Delete: opens the window for selection of the statistics file to be deleted.

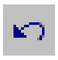
Delete by date: opens the window for selection of the statistics file to be deleted on the basis of the time interval indicated.

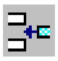
Copy to A: opens the window for selection of the statistics file to be saved to the floppy disk.

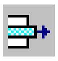
Copy to A: by date: opens the window for selection of a group of statistics files to be saved to the floppy disk on the basis of the time interval indicated.

Close: Resets the statistics window displayed.

Edit

Undo:  cancels the last modification made in the OPERATOR events table in the Statistics Editor window.

Insert:  inserts an empty row in the OPERATOR events table in the Statistics Editor window.

Delete:  deletes the selected row in the OPERATOR events table in the Statistics Editor window.

Setup

Machine: opens the window used to input machine data and save statistics.

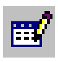
Operator: opens the window used to input operator identification data.

Commands

This menu displays the OPERATOR events to be marked when statistics mode is enabled.

Windows

The following options open the relative windows.

Statistics Editor: 

Machine Statistics: 

Production Statistics: 

Reliability Statistics: 

Machine Graphs: 

Production Graphs: 

Planned Maintenance: 

Display

All data: displays all data for the open statistics event.

Machine data: displays only data relating to MACHINE events in the open statistics event.

Operator N data: displays only data relating to OPERATOR events in the open statistics event.

1 operator data: displays only data relating to OPERATOR events for the selected operator in the open statistics event.

Percentage: displays graphs according to percentage.

Time: displays graphs according to time.

About

About : opens the window indicating the statistics graphic interface version.

7.3 Setting the memory time limit

1. From the Statistics Editor window select the Setup menu and the item Machine.

2. Input the following data.

   Serial number: type in the machine serial number (compulsory).

   Name: type in the name of the machine.

3. Set the memory time limit for both machine and production statistics by clicking the mouse on one of the following items:

   Manual: allows the user to decide when to stop saving the current statistics event.

   Daily: allows statistics to be saved at the end of each working day. To set this option, double-click on the field Daily, set the time in hours and minutes and press the OK button. If the machine is turned off before the set time, the data will be saved the first time it is turned on again.

Weekly: allows statistics to be saved at the end of each week. To set this option, double-click on the field Weekly, set the day of the week and the time in hours and minutes and press the OK button. If the machine is turned off before the set day and time, the data will be saved the first time it is turned on again.

Monthly: allows statistics to be saved at the end of each month. To set this option, double-click on the field Monthly, set the day of the month (from 1 to 31) and the time in hours and minutes and press the OK button. If the machine is turned off before the set day and time, the data will be saved the first time it is turned on again.

INFORMATION

After each save the software automatically opens another statistics file with the same settings, except when in Manual mode, where this is done by pressing the Stop machine stat. button for Machine Statistics or the Stop production stat. button for Production Statistics.

4. Press the Save button to confirm settings.

7.4 Setting operator identification data

INFORMATION

It is recommended that the data for each operator be typed in the same way every time, using the same upper/lower case characters, spaces, etc.. It must be noted that every difference, however small, will result in the creation of a new operator, and it will not be possible to correct subsequent statistics or attribute them to the proper operator.

1. From the Statistics Editor window select the Setup menu and the item Operator and then fill in the following data fields.

   Serial number: type in the serial number associated with the operator (compulsory).

   Name: type in the name of the operator.

   Shift: type in the working shift number.

2. Press OK to confirm settings.

7.5 Programming operator events

Unlike the machine and reliability events, which are established by BIESSE, it is possible to program the operator events. The items that appear initially in the OPERATOR table can be modified, deleted or completed with other items by the user.

INFORMATION

Modifications can only be made on condition that machine and/or production statistics are not enabled.

1. From the Statistics Editor window double-click the mouse on the name of the event required, or on an empty line.

2. Input the name and press OK.

3. For each row set the data fields for the following columns.

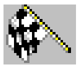
   ENABLE: Allows the event to be included or excluded in the statistics to be enabled. The value is changed from Y (include the event in the statistics) to N (exclude the event from statistics) and vice versa by clicking the mouse twice on the highlighted field.

   TYPE: Allows the event data detection method to be defined. Double-click the mouse on the item TT to detect the duration time only, on the item QQ to detect the number of times it occurs only, and on the item QT to detect both the duration time and the number of times it occurs.

   STAT: Allows definition of the type of statistics in which the event is to be stored. Double-click the mouse on the item MM to store in machine statistics only, on the item PP to store in production statistics only, and on the item MP to store in both machine statistics and production statistics.

4. To confirm the setting, select the File menu and the item Save.

7.6 Enabling statistics

From the Statistics Editor window select the Start machine stat. button  to enable machine statistics and/or the Start production stat. button  to enable production statistics.

INFORMATION

After having enabled statistics the operator must remember to mark each planned event.

7.7 Marking the events

This procedure is essential in order to achieve maximum precision in statistics data. Each event that occurs requires the participation of the operator, who must mark the time at which it begins and ends.

Example of marking operation

Let us suppose that production statistics have been enabled, with inclusion of the following events:

- tooling,
- programming,
- machining operation control,
- stoppage,
- out of material.

First of all, at the start of each shift the operator must input his own identification data. Following this, whenever he has to tool up the machine for a new machining operation, he must mark the start of tooling before proceeding with the actual operations, then when tooling has been completed he must mark the end of tooling, and so on for all the other events that occur until the end of his shift.

To mark an event after statistics have been enabled, proceed as follows.

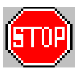
1. To mark the start of the event, from the Statistics Editor window select the Commands menu and the item for the event that is about to start.
2. When the event has finished, from the Statistics Editor window deselect the Commands menu and the item for the event that has just finished.

7.8 Real-time updating of statistics

Upon request, it is possible to display the situation of current machine and/or production statistics.

1. Select the Machine Statistics (Production Statistics) window.
2. Select the File menu and the item Current Statistics Event.

7.9 Disabling statistics

From the Statistics Editor window press the Stop Machine Stat. button 

to disable machine statistics and/or the Stop Production Stat. button 

to disable production statistics.

7.10 Opening and reading machine statistics

1. From the Machine Statistics window select the File menu and the item Open.
2. Select the statistics event to be displayed.
3. Press Open.

It is possible to display separately the data relating to machine events or operator events only by selecting the relative item on the Display menu.

It is possible to display separately the data for events that occur to a specific operator during his shift only.

- Select the item 1 Operator Data from the Display menu.
- Select the operator.
- Select the shift to be displayed.

7.11 Opening and reading production statistics

1. From the Production Statistics window select the File menu and the item Open.
2. Select the statistics event to be displayed.
3. Press Open.

It is possible to display separately the data for events that occur to a specific operator during his shift only.

- Select the item 1 Operator Data from the Display menu.
- Select the operator.
- Select the shift to be displayed.

7.12 Deleting statistics

1. From the Machine Statistics (Production Statistics) window, select the File menu and the item Delete.
2. Select the statistics event to be deleted.
3. Press Open.

7.13 Deleting a number of statistics

1. From the Machine Statistics (Production Statistics) window, select the File menu and the item Delete by date.
2. Type in the date starting from which statistics are to be deleted, and the date up to which statistics are to be deleted.
3. Press OK to confirm.

7.14 Copying statistics to floppy-disk

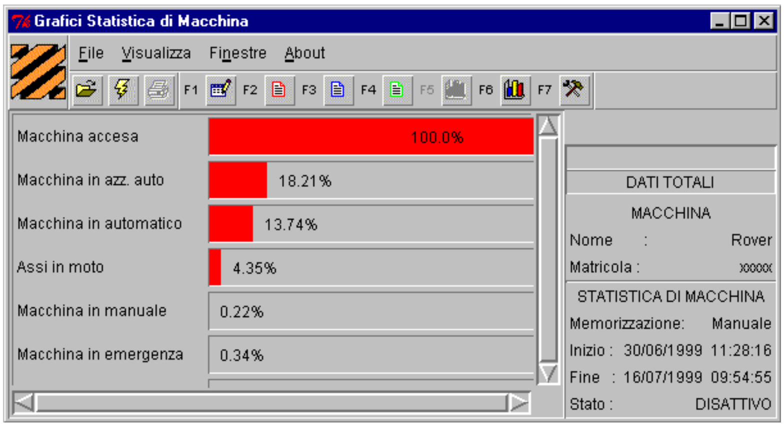
1. Insert a DOS floppy-disk in drive A:.
2. From the Machine Statistics (Production Statistics) window, select the File menu and the item Copy to A:.
3. Select the statistics event to be copied.
4. Press Open.

7.15 Copying a number of statistics to floppy-disk

1. Insert a DOS floppy-disk in drive A:.
2. From the Machine Statistics (Production Statistics) window, select the File menu and the item Copy to A: by date.
3. Type in the date starting from which statistics are to be copied, and the date up to which statistics are to be copied.
4. Press OK to confirm.

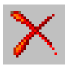
7.16 Graphic display of statistics

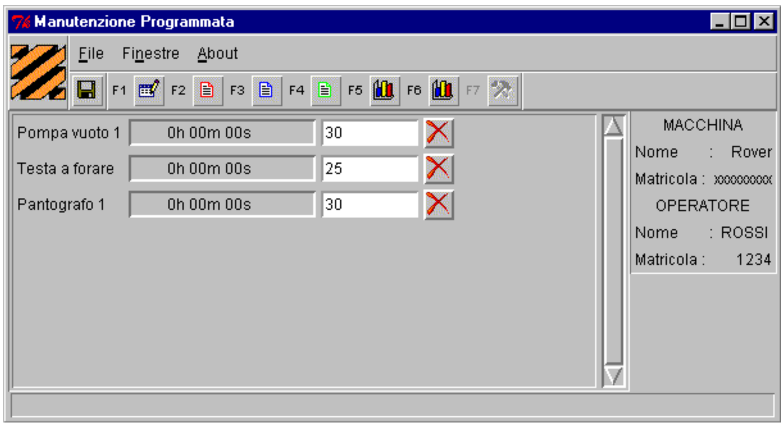
It is possible to display in graphic form either current machine and/or production statistics or those already saved, by selecting the Machine Graphs window for machine statistics or the Production Graphs window for production statistics.



7.17 Planned maintenance

Planned maintenance designed to ensure that the operator is always updated on the state of wear in parts that require revision after a number of working hours established in advance by the BIESSE technician.

When the working time for the piece exceeds the number of working hours established by the technician, the statistics will display a message informing the operator which part requires revision. Once revision has been performed the operator can reset the timer by clicking on the relative reset button  .



Analytical Index

Contents

1 User's Error List

◇ **Error 1** Access to directory denied.

◇ ◇ **Help** An attempt was made to access a directory without having the required permissions. That directory cannot be accessed.

◇ **Error 2** Unformatted diskette or no disk in drive.

◇ ◇ **Help** An attempt was made to either select a drive, copy a file, display the contents of a diskette in a drive containing no diskette or an empty diskette. Insert a correctly formatted diskette or format the diskette.

◇ **Error 3** Unrecognised diskette.

◇ ◇ **Help** The diskette inserted in the drive is either damaged or not formatted in standard DOS and UNIX format. Diskettes containing work programs are formatted in CNI format and cannot be used by the copier.

◇ **Error 4** Diskette with invalid compression or empty.

◇ ◇ **Help** An attempt was made to display the contents of a diskette compressed with an unrecognised format or empty.

◇ **Error 5** No file or toggle button selected.

◇ ◇ **Help** If files are to be copied to or from a standard DOS- formatted diskette, the source files or the toggle buttons corresponding to the different file types must be selected. If files are to be copied from the HARD DISK to a standard UNIX-formatted diskette, the source files must be selected.

◇ **Error 6** Illegal configuration.

◇ ◇ **Help** You cannot copy a file when both the source and the destination are Drive A.

◇ **Error 7** Write-protected disk.

◇ ◇ **Help** You cannot write data to a protected diskette. Slide open the protection tab.

◇ **Error 8** Not enough space in DOS disk.

◇ ◇ **Help** The capacity of the diskette is not sufficient to hold all the selected files. Select a smaller amount of files or insert a new diskette.

◇ **Error 9** Disk display not complete. Progressive number of multi-volume diskette incorrect.

◇ ◇ **Help** A disk was inserted belonging to a multi-volume backup set. It is possible to display the files contained in it except for the files shared with the previous diskette. If you want to display all the files of a multi-volume backup, insert all diskettes in the correct sequence.

◇ **Error 10** Incomplete copy from diskette. Progressive number of multi-volume diskette incorrect.

◇ ◇ **Help** A disk was inserted belonging to a multi-volume backup set. It is possible to restore all the files contained in it except for the files shared with the previous diskette. If you want to restore all the files of a multi-volume backup, insert all diskettes in the correct sequence

◇ **Error 11** Failure to copy directories to diskette.

◇ ◇ **Help** If the destination diskette is a DOS-formatted diskette, directories cannot be copied. To copy an entire directory to a DOS diskette, enter in the directory and select all files. The directory copy operation is only permitted if the destination diskette is UNIX formatted.

◇ **Error 12** Incomplete copy on diskette. Compression of individual files impossible.

◇ ◇ **Help** The compression mode only allows compression of directories. Individual files can be copied only in non compressed mode.

◇ **Error 13** Operation not permitted.

◇ ◇ **Help** The following operations are permitted only from within program, subprogram, or work list directories: Creation of new directories, deletion of directories, deletion of files.

◇ **Error 14** Illegal sort on diskette.

◇ ◇ **Help** You tried to sort a diskette. Sorting is only permitted on the hard disk.

◇ **Error 15** Machine in start.

◇ ◇ **Help** This operation is not possible because the NC is in START. Try again when the NC is in STOP.

◇ **Error 16** Data write error.

◇ ◇ **Help** The data has not been saved due to an error which occurred when opening or writing to the file. Be sure that the writing rights of both the file and directory are valid.

◇ **Error 17** Data read error.

◇ ◇ **Help** The data has not been read due to an error which occurred when opening the file. Be sure that the reading rights of both the file and directory are valid.

◇ **Error 18** Table write error.

◇ ◇ **Help** It is not possible to save the data table due to an error which occurred when opening or writing to the file. Be sure that the reading/writing rights of both the file and directory are valid.

◇ **Error 19** Table read error.

◇ ◇ **Help** The table was not read due to an error which occurred when opening the file. Be sure that the file and directory are available and that the reading rights are valid.

◇ **Error 20** Data not found.

◇ ◇ **Help** The data has not been found within the table. Check the initialization file for the presence and correct location of the data.

◇ **Error 21** Data type error

◇ ◇ **Help** The data type is not among the acceptable types of data: string, integer, double, etc.

◇ **Error 22** Head not found.

◇ ◇ **Help** The head has not been found among those in the center. Check the head table to be sure that it is actually available.

◇ **Error 23** Axis not found.

◇ ◇ **Help** The axis has not been found among those in the center. Check the axis table to be sure that it is actually available.

◇ **Error 24** Axis type not found.

◇ ◇ **Help** The axis has been declared to be of a type which has not been found among the possible types. Check the axis initialization file to be sure that the type is actually available.

◇ **Error 25** Spindle not found

◇ ◇ **Help** The spindle has not been found among those in the center. Check the spindle table to be sure that it is actually available.

◇ **Error 26** Spindle type not found

◇ ◇ **Help** The spindle has been declared to be of a type which has not been found among the possible types. Check the spindle initialization file to be sure that the type is actually available.

◇ **Error 27** Aggregate not found.

◇ ◇ **Help** The aggregate has not been found among those memorized. Check the aggregate table to be sure that it is actually available.

◇ **Error 28** Aggregate sub-spindle not found

◇ ◇ **Help** The aggregate subspindle has not been found among those memorized. Check the aggregate spindle table to be sure that it is actually available.

◇ **Error 29** Incorrect screw

◇ **Error 30** Tool not found

◇ ◇ **Help** The drill bit has not been found among those memorized. Check the drill bit table to be sure that it is actually available.

◇ **Error 31** Origin not found

◇ ◇ **Help** The origin has not been found among those memorized. Check the origin table to be sure that it is actually available.

◇ **Error 32** Wear not found

◇ **Error 33** Tool change not found - incorrect

◇ ◇ **Help** The position of the tool change has not been found among those memorized in the center. Check the tool change table to be sure that it is actually available.

◇ **Error 34** Spindle, sub-spindle not tooled-up

◇ ◇ **Help** Either the spindle or the aggregate subspindle has not been tooled up.

◇ **Error 35** Incorrect centre number

◇ ◇ **Help** The set center number is not available in the NC. Be sure that the number is greater than 0 and less than the number of centers declared in the NC.

◇ **Error 36** Incorrect tool-up number

◇ ◇ **Help** The researched tooling number is less than 1. Be sure that an acceptable number has been set.

◇ **Error 37** Incorrect tool

◇ **Error 38** Incorrect aggregate

◇ **Error 39** Incorrect data number

◇ ◇ **Help** An erroneous data number is being researched: less than 0 or greater than the maximum limit.

◇ **Error 40** Offset memorisation error

◇ **Error 41** Message queue error

◇ **Error 42** Duplicate name

◇ ◇ **Help** The set object name already exists. Set an object name which hasn't already been edited.

◇ **Error 43** Out of memory for new objects

◇ ◇ **Help** An attempt has been made to insert a new object in a table which is already full. Try the operation again after rebooting the machine.

◇ **Error 44** Incorrect requested element

◇ ◇ **Help** The requested element does not exist because it is either less than 0 or because it exceeds the maximum range.

◇ **Error 45** File write error

◇ ◇ **Help** The attempt to write to the file has failed. Be sure that the writing rights of both the file and directory are valid.

◇ **Error 46** File read error

◇ ◇ **Help** The attempt to read the file has failed. Be sure that the file is available and that the reading rights of both the file and directory are valid.

◇ **Error 47** An error occurred when saving active tooling-up

◇ **Error 48** Bit not found in tool change magazine

◇ ◇ **Help** The drill bit has not been found in the tool change magazine. Be sure that the tool has been declared in the magazine and that presence flag is 1.

◇ **Error 49** Incorrect operation in tool change magazine

◇ ◇ **Help** An attempt has been made to either retrieve from the tool change magazine a drill bit which is not available or to erroneously place a drill bit in the magazine.

◇ **Error 50** Incorrect work mode (runtime, interpreted, ...)

◇ ◇ **Help** The working mode is not among those managed by the machine: runtime, interpreted, etc.

◇ **Error 51** Tool cycle not found

◇ ◇ **Help** The researched tool cycle has not been found in the available tool cycle table.

◇ **Error 52** Tool change disabled (tooled manually)

◇ ◇ **Help** The tool was installed in the manual mode; therefore, the automatic tooling mode has been disabled. Remove the tool manually until automatic mode is restored.

◇ **Error 53** No free positions in tool change

◇ ◇ **Help** There are no more empty spaces in the magazine to accomodate the tool to be deposited. Check for and free up, if possible, a space in the magazine to continue with the operation.

◇ **Error 54** Work stopped

◇ ◇ **Help** The requested operation cannot be carried out because the machine data server is temporarily busy working on other requests (for example, when copying some data files from a diskette to hard disk using the DSK process). Wait and try again when the operation is finished.

◇ **Error 55** Machine data being re-loaded

◇ ◇ **Help** The machine data server is busy reloading machine data (for example, when copying some data files from a diskette to hard disk using the DSK process). Wait and try again when the operation is finished..

◇ **Error 56** No data to display

◇ ◇ **Help** An attempt is being made to open an object which does not have any data to be visualized.

◇ **Error 57** Edit field too long

◇ ◇ **Help** Too many characters have been edited with respect to the memorization capacity. Eliminate the excess characters and try again.

◇ **Error 58** Edit size at 0 for a group of data

◇ ◇ **Help** None of the characters is acceptable. Check the data structure of the configuration file.

◇ **Error 59** Description too long

◇ **Error 60** Tool type set not compatible with installed tool

◇ **Error 61** Password level too low to edit required data

◇ ◇ **Help** The active password level does not allow for editing the requested data. Change the active password level and try again.

◇ **Error 62** Incorrect password

◇ ◇ **Help** The attempt to set a new password has failed due either to a rewriting error or to the fact that it already exists.

◇ **Error 63** Invalid category

◇ **Error 64** No axis

◇ **Error 65** Axis display number error

◇ ◇ **Help** The axis visualization number is either less than 0 or is greater than the maximum number of machine axes. Check the number in the axis user table.

◇ **Error 66** No axis configuration data

◇ **Error 67** No axis type

◇ **Error 68** No axis type configuration data

◇ **Error 69** Spindle type error

◇ ◇ **Help** The type of spindle is not among the manageable spindle types: vertical, horizontal, router or special. Check the type in the spindle user table.

◇ **Error 70** No vertical spindles

◇ ◇ **Help** There is no vertical spindle in the selected center.

◇ **Error 71** No horizontal spindles

◇ ◇ **Help** There is no horizontal spindle in the selected center.

◇ **Error 72** No router spindles

◇ ◇ **Help** There is no router-type spindle in the selected center.

◇ **Error 73** No special spindles

◇ ◇ **Help** There is no special-type spindle in the selected center.

◇ **Error 74** Vertical spindle number error (>n)

◇ ◇ **Help** The number of vertical spindles is greater than the number of center spindles.

◇ **Error 75** Horizontal spindle number error (>n)

◇ ◇ **Help** The number of horizontal spindles is greater than the number of center spindles.

◇ **Error 76** Router spindle number error (>n)

◇ ◇ **Help** The number of router spindles is greater than the number of center spindles.

◇ **Error 77** Special spindle number error (>n)

◇ ◇ **Help** The number of special spindles is greater than the number of center spindles.

◇ **Error 78** No spindles

◇ ◇ **Help** There are no spindles in the selected center.

◇ **Error 79** No spindle types

◇ **Error 80** Spindle number too large

◇ **Error 81** No spindle type configuration data

◇ **Error 82** No heads

◇ ◇ **Help** There are no heads in the selected center.

◇ **Error 83** Head number error (>n)

◇ **Error 84** No head configuration data

◇ **Error 85** No wear

◇ **Error 86** Wear number error (>n)

◇ **Error 87** No wear configuration data

◇ **Error 88** No origin

◇ ◇ **Help** There are no origins in the machine.

◇ **Error 89** No origin configuration data

◇ **Error 90** Directory error (non existent or wrong rights)

◇ ◇ **Help** The management of the directory has failed. Check the existence of the directory or the directory which contains it, as well as the reading/ writing rights.

◇ **Error 91** Error in work directory of programs / subprograms / ...

◇ **Error 92** Directory deletion failed

◇ ◇ **Help** The deletion of the directory has failed. Check the existence of the directory or the directory which contains it, as well as the reading/ writing rights.

◇ **Error 93** Directory creation failed

◇ ◇ **Help** The creation of the directory has failed. Check whether or not it already exists and the reading/writing rights of the directory which should contain it.

◇ **Error 94** File deletion failed

◇ ◇ **Help** The deletion of the file has failed. Check the existence of the file or the directory which should contain it, as well as the reading/writing rights.

◇ **Error 95** Too many files open

◇ **Error 96** File section name error

◇ **Error 97** Error in requested section (not found on file)

◇ ◇ **Help** The requested section has not been found in the file. The section will continue to be empty until the file has been saved.

◇ **Error 98** Filename not set error

◇ **Error 99** File open error

◇ ◇ **Help** The opening of the file has failed. Be sure that the file is available, and that the reading/writing rights of both the file and directory which should contain the file are valid.

◇ **Error 100** File error

◇ **Error 101** File write error

◇ ◇ **Help** The attempt to write to the file has failed. Be sure that the writing rights of both the file and the directory are valid.

◇ **Error 102** File does not appear to be of declared type

◇ ◇ **Help** The file has not been recognized as the declared type. Be sure that the file is in the correct directory and that its extension corresponds with its content.

◇ **Error 103** File read error

◇ ◇ **Help** The reading of the file has failed. Be sure that the file is available and that the reading rights of both the file and the directory are valid.

◇ **Error 104** Non recognised instruction error

◇ ◇ **Help** The instruction is not managed by the running processing version. Check the congruence between the processing version and the instruction.

◇ **Error 105** Parameters string too long

◇ **Error 106** Line cannot be modified (empty or without N).

◇ ◇ **Help** The line is either empty or it does not begin with the N command; therefore, it may not be modified. Change lines with the editor cursor and try again.

◇ **Error 107** Unrecognised data type

◇ **Error 108** File in execution

◇ ◇ **Help** The machine is executing the file; therefore, it may not be modified. Wait until the execution is finished and try the operation again.

◇ **Error 109** Cannot insert a new line.

◇ ◇ **Help** It is not possible to insert a line in this particular cursor position. More than likely it is either in the middle of a geometric triad or it divides a line which was begun on a preceding line. Change lines with the editor cursor and try again.

◇ **Error 110** Assisted box without title

◇ ◇ **Help** The help box is without /I instruction and is, therefore, unmanaged. Edit the corresponding file in the box and be sure that the instruction has been correctly inserted.

◇ **Error 111** Syntax error

◇ ◇ **Help** A syntax error has been detected. Follow the instructions in the specific manual.

◇ **Error 112** Assisted box without ID string

◇ ◇ **Help** The help box is without /R instruction and is, therefore, unmanaged. Edit the corresponding file in the box and be sure that the instruction has been correctly inserted.

◇ **Error 113** Useless instruction: Overwritten or not used

◇ ◇ **Help** The instruction is useless because it has been overwritten by another instruction of either the same type or its equivalent.

◇ **Error 114** Assisted box without lines

◇ ◇ **Help** The help box has no line to be visualized. Edit the corresponding file in the box and be sure that the commands have been correctly set.

◇ **Error 115** Boring representation error (out of panel)

◇ ◇ **Help** The boring has been set outside the panel. Review the set coordinates.

◇ **Error 116** Incorrect panel corner

◇ ◇ **Help** An erroneous reference edge has been set. The allowed values are 1, 2, 3 and 4.

◇ **Error 117** Incorrect panel side

◇ ◇ **Help** An erroneous reference side has been set. The allowed values are 1, 2, 3, 4 and 5.

◇ **Error 118** Operation not allowed

◇ **Error 119** The program is not the same in start.

◇ **Error 120** No unit-of-measurement configuration data

◇ **Error 121** No aggregates

◇ ◇ **Help** There is no aggregate to be visualized for the machine.

◇ **Error 122** No aggregate configuration data

◇ **Error 123** No screw configuration data

◇ **Error 124** No tool change

◇ ◇ **Help** There is no tool change magazine to be visualized in the selected center.

◇ **Error 125** No tool change configuration data

◇ **Error 126** No tool up configuration data

◇ **Error 127** No general data

◇ ◇ **Help** The machine does not manage any general data.

◇ **Error 128** No general data configuration data

◇ **Error 129** No bits

◇ ◇ **Help** The machine has no drill bit to be visualized.

◇ **Error 130** No bit configuration data

◇ **Error 131** Message queue destruction error

◇ ◇ **Help** The destruction of the queue has failed.

◇ **Error 132** Message reception error

◇ ◇ **Help** The reception of a message from the queue has failed.

◇ **Error 133** Shared memory destruction error

◇ ◇ **Help** The destruction of the shared memory has failed.

◇ **Error 134** Error in getting shared memory information

◇ ◇ **Help** It has not been possible to obtain information on the shared memory.

◇ **Error 135** Error in releasing shared memory

◇ **Error 136** Syntax error in Program. Incorrect line beginning.

◇ ◇ **Help** Each line can only begin with one of the following characters: "N", "%". Correct the program line.

◇ **Error 137** Cannot execute Program Line. Incorrect subspindle programmed.

◇ ◇ **Help** The programmed sub-spindle number does not exist. Correct the program or define the programmed sub-spindle in the sub- spindles table.

◇ **Error 138** Cannot execute Program Line. Too many data instructions to the PLC.

◇ ◇ **Help** Too many instruction of the types T, TH, TP, M, S, KA, WBT, WBY, WW, WL, WF in the same program line. Divide it into several lines.

◇ **Error 139** Cannot execute Program Line. Tool rotation direction mismatch.

◇ ◇ **Help** This error is generated after a KB=1 instruction or the activation of a subspindle, for example TP2:3. In both cases check that the direction of rotation of tool, spindle and sub-spindle in the relevant tables match.

◇ **Error 140** Cannot execute Program line. Tool rotation speed out of permissible range.

◇ ◇ **Help** This error is generated following a KB=1 instruction or following the activation of a subspindle, for instance TP2:3. In both cases, check that the rotation speed of the tool falls within the minimum and maximum speed range associated to it. Check also that the speed does not exceed the limits defined for the spindle and/or subspindle on which the tool is mounted.

◇ **Error 141** Cannot execute Program line. Tool change instruction error.

◇ ◇ **Help** The program contains a KB instruction associated to a spindle not allowing tool changes.

◇ **Error 142** Cannot execute Program line. No tool on spindle.

◇ ◇ **Help** The program contains an instruction like T=1,2,3,..., TH=1,2,3,..., TP=1,2,3,..., in which the first spindle in the list following the instruction (in this case 1) has no tool mounted on it. Correct the program, or change the tool- up data of the spindle.

◇ **Error 143** Cannot execute Program line. Non existing spindle.

◇ ◇ **Help** The program contains an instruction like T=1,2,3,..., TH=1,2,3,..., TP=1,2,3,..., in which the first spindle in the list following the instruction (in this case 1) does not exist. Correct the program, or define the spindle.

◇ **Error 144** Cannot execute Program line. Programmed tool rotation speed out of permitted range.

◇ ◇ **Help** The program contains an S instruction whose operand, which assigns the tool rotation speed, exceeds the permitted range. Check that the programmed rotation speed of the tool falls within the minimum and maximum speed range associated to the tool, and the spindle or subspindle on which the tool is mounted. If the error is generated by a line of the type: TP=1,2,3,... S=1000, check the speed for every spindle activated.

◇ **Error 145** Cannot execute program; Panel size out of permitted range.

◇ ◇ **Help** Instructions of the type LX=0, LY=0, LZ=0 have been programmed. Panel sizes must always be greater than 0 (zero). Check the "Parameters" section in the program.

◇ **Error 146** Cannot execute Program line. Circle interpolation with incorrect radius.

◇ ◇ **Help** The program contains a circular interpolation instruction with a radius which is less than half of the distance between beginning point and end point. Correct the program.

◇ **Error 147** Cannot execute Program line. Interference in spatial direction X.

◇ ◇ **Help** The same program line contains positioning instructions for two axes for which interference control is active (see Overall Dimensions in Heads Table). The execution of the program was stopped to prevent the collision of the heads. Correct the Dimension data for the heads or the positioning values of the axes.

◇ **Error 148** Cannot execute Program line. Interference in spatial direction Y.

◇ ◇ **Help** The same program line contains positioning instructions for two axes for which interference control is active (see Overall Dimensions in Heads Table). The execution of the program was stopped to prevent the collision of the heads. Correct the Dimension data for the heads or the positioning values of the axes.

◇ **Error 149** Cannot execute Program line. Interference in spatial direction Z.

◇ ◇ **Help** The same program line contains positioning instructions for two axes for which interference control is active (see Overall Dimensions in Heads Table). The execution of the program was stopped to prevent the collision of the heads. Correct the Dimension data for the heads or the positioning values of the axes.

◇ **Error 150** Program, subprogram, or fixed cycle not found.

◇ ◇ **Help** The program, subprogram or fixed cycle to be executed could not be found.

◇ **Error 151** Cannot execute work list line. Error in interpreting comment string.

◇ ◇ **Help** A syntax error was found in the parameter assignment instructions in the Comment field of the Work List line. Check the syntax.

◇ **Error 152** Cannot execute program. Requested jump to non-existing label.

◇ ◇ **Help** JP or JM instructions have been found transferring the execution of the program to a non-existent label. Correct the program.

◇ **Error 153** Incorrect origin number.

◇ ◇ **Help** The number corresponding to the selected origin (supplied by the PLC) against which the program is to be executed, does not exist. Check that the number is in the 1 to 16 range.

◇ **Error 154** Cannot execute Program line. Non-recognised G instruction.

◇ ◇ **Help** The program contains a G instruction that does not exist. Correct the program.

◇ **Error 155** Cannot execute Program line. Cannot call subprogram or fixed cycle.

◇ ◇ **Help** The nesting level of the called subprogram or fixed cycle is deeper than the maximum allowed level. The maximum nesting level allowed is 4. Correct the program.

◇ **Error 156** Cannot execute Program line. Incorrect operand of JP instruction.

◇ ◇ **Help** The operand of the JP instruction must be of the type: nn,bb where nn is a number in the range 0 to 63, and bb a number in the range 0 to 31. Correct the instruction.

◇ **Error 157** Cannot execute Program line. Incorrect operand of WBT, WBY, WW, WL, WF instructions.

◇ ◇ **Help** The operand of the WBT instruction must be of the type: nn,bb, where nn is number in the range 0 to 255, bb a number in the range 0 to 7. The operand of the WBY instruction must be of the type: nn, where nn is a number in the range 0 to 255. The operand of the WW instruction must be of the type: nn where nn is a number in the range 0 to 127. The operand of the instruction WL must be of the type: nn where nn is a number in the range 0 to 63. The operand of the instruction WF must be of the type: nn where nn is a number in the range 0 to 63. Correct the instruction.

◇ **Error 158** Incorrect configuration number defined in instruction HC.

◇ ◇ **Help** The operand of instruction HC is a number other than that identifying the active configuration of the machine.

◇ **Error 159** Cannot execute program. Too many labels in file.

◇ ◇ **Help** A "non CNI standard" program is being executed, that is program without routing, boring sections, etc. This type of program can contain up to a maximum of 100 labels. Correct the program.

◇ **Error 160** Cannot execute Program line. Tool change parameters not preset.

◇ ◇ **Help** Before programming an instruction of the type KB=1 (tool change), it is always necessary to program an instruction of the type TP=n:<"tool_name", where n is the spindle on which the tool change is to be performed and "tool_name" is the character string identifying the tool to collect. This instruction sets a series of parameters required by the NC. Correct the program.

◇ **Error 161** Error in tool change parameters preset instruction.

◇ ◇ **Help** An error was found in the tool change parameters preset instruction. Check if the programmed spindle accepts tool changes.

◇ **Error 162** Tool change: cannot unload tool.

◇ **Error 163** Tool change: cannot pick up tool.

◇ **Error 164** Cannot execute Program line. G60 programmed without G61.

◇ ◇ **Help** To be able to program the positioning of an axis moving in G60 mode it is necessary to first program a line containing the instruction G61.

◇ **Error 165** Cannot execute Program line. G60 instruction programming error.

◇ ◇ **Help** One of the following error cases was detected: 1) Instructions G60 and G61 are present in the same program line. 2) A line containing the instruction G60 contains also instructions of the type M, KA, S, WBT, WBY, WW, WL, WF.

◇ **Error 166** Cannot execute Program line. KL instruction with incorrect operand.

◇ ◇ **Help** The operand of the KL instruction programmed, that defines the "CAR" program step number must be in the range 1 to 16. Correct the program.

◇ **Error 167** Cannot execute Program line. Centre co-ordinates missing.

◇ ◇ **Help** A circular interpolation instruction given the centre has the following syntax: G2 X=n1 Y=n2 I=n3 J=n4 (or G3) where n1, n2 are the co-ordinates of the end point and n3, n4 the co-ordinates of the centre. For some types of operation it may be convenient to program only the end point, since the co-ordinates of the centre remain the same. However, I and J are required and must be assigned in the first G2 instruction. The same rule applies also to spherical interpolation.

◇ **Error 168** Cannot execute Program line. Radius length missing.

◇ ◇ **Help** A circular interpolation instruction given the radius has the following syntax: G4 X=n1 Y=n2 R=n3 (or G5) where n1, n2 are the co-ordinates of the end point and n3 the length of the radius. For some types of operation it may be convenient to program only the end point, since the length of the radius remains the same. However, R is required and must be assigned in the first G4 instruction. The same rule applies also to elliptical interpolation.

◇ **Error 169** The program requires a tool not loaded in the magazine

◇ ◇ **Help** The tool magazine must be tooled up appropriately to execute the program

◇ **Error 170** Non-existing tool associated to spindle.

◇ ◇ **Help** The message displayed in the Errors windows shows the number of a spindle to which a non-existing tool was assigned. This error may have been generated following a variation of machine data, the execution of a tool change instruction, or the interpretation of a subspindle activation instruction.

◇ **Error 171** Incorrect Correction Type Data (Tools Table).

◇ ◇ **Help** The Correction Type data in the Tools Table can only take the values 0, 1, 2, 14. This error may have been generated following a variation of machine data, the execution of a tool change instruction, or the interpretation of a subspindle activation instruction.

◇ **Error 172** Direction of rotation of Spindle and Subspindle mismatch.

◇ ◇ **Help** A subspindle was associated to a spindle but its direction of rotation is not compatible with the spindle's.

◇ **Error 173** Cannot execute Program line. Axis cannot be positioned at this time.

◇ ◇ **Help** The programmed movement of the axis cannot be performed because the axis is performing another type of positioning not related with the execution of the program. The program execution procedure must be repeated (STOP RESET).

◇ **Error 174** Generic error in Technical Data Table.

◇ ◇ **Help** This error signals a mismatch of the data contained in the Technical Data Tables. To remove the cause of the error, it is necessary to eliminate the errors identified by the GMM code displayed with it.

◇ **Error 175** Bad line start

◇ **Error 176** Cannot execute Program line. Non-existing instruction.

◇ **Error 177** Cannot execute Program line. Bad instruction beginning.

◇ **Error 178** Cannot execute Program line. Equal sign (=) missing.

◇ **Error 179** Cannot execute Program line. Tool number not permitted.

◇ **Error 180** Cannot execute Program line. Delimiter not permitted.

◇ **Error 181** Cannot execute Program line. Incorrect data.

◇ **Error 182** Cannot execute Program line. Incorrect label.

◇ **Error 183** Cannot execute Program line. Open parenthesis missing.

◇ **Error 184** Cannot execute Program line. Closed parenthesis missing.

◇ **Error 185** Cannot execute Program line. Bit to test missing.

◇ **Error 186** Cannot execute Program line. Incorrect bit number.

◇ **Error 187** Cannot execute Program line. Name too long.

◇ **Error 188** Cannot execute Program line. No more space for symbols.

◇ **Error 189** Cannot execute Program line. Colon (":") missing.

◇ **Error 190** Cannot execute Program line. Illegal characters in literal entity.

◇ **Error 191** Cannot execute Program line. Undefined parameter.

◇ **Error 192** Cannot execute Program line. Cannot execute instruction.

◇ **Error 193** Cannot execute Program line. Other instructions in label line.

◇ **Error 194** Cannot execute Program line. Other instructions in end line.

◇ **Error 195** Cannot execute Program line. Message too long.

◇ **Error 196** Cannot execute Program line. Incomplete definition of plane.

◇ **Error 197** Cannot execute Program line. Incorrect definition of three points.

◇ **Error 198** Three points defined with non-existing axis.

◇ **Error 199** Cannot execute Program line. Too many subroutine levels.

◇ **Error 200** Cannot execute Program line. Instruction not permitted with current geometrical calculation.

◇ **Error 201** Cannot execute Program line. Increment instruction on initial unknown value.

◇ **Error 202** Cannot execute Program line. Instruction not permitted with mode G53 enabled.

◇ **Error 203** Cannot execute Program line. Illegal use of PRK.

◇ **Error 204** Cannot execute Program line. Non-blank characters after character '?'.

◇ **Error 205** Cannot execute Program line. Machine data read error (incorrect setup of QM parameters).

◇ **Error 206** Cannot execute Program line. Machine data write error (incorrect setup of QM parameters).

◇ **Error 207** Cannot execute Program line. Subroutine name missing.

◇ **Error 208** Cannot execute Program line. Routine name does not begin with capital letter.

◇ **Error 209** Cannot execute Program line. Subroutine name with extra characters.

◇ **Error 210** Cannot execute Program line. Incorrect octal constant.

◇ **Error 211** Cannot execute Program line. Geometrical calculation cannot be performed. Mathematical co-processor missing.

◇ **Error 212** Cannot execute Program line. Interpolation impossible: different scale factors of axes.

◇ **Error 213** Cannot execute Program line. Incorrect allocation type.

◇ **Error 214** Cannot execute Program line. Incorrect octal address.

◇ **Error 215** Cannot execute Program line. Incorrect spindle activation instruction.

◇ **Error 216** Cannot execute Program line. Incorrect vector index number.

◇ **Error 217** Cannot execute Program line. Incorrect vector index range.

◇ **Error 218** Cannot execute Program line. Insufficient data space.

◇ **Error 219** Cannot execute Program line. Incorrect PLC<->NC area address.

◇ **Error 220** Cannot execute Program line. Speed or acceleration nil.

◇ **Error 221** Cannot execute Program line. Radius or half-axis nil.

◇ **Error 222** Cannot execute Program line. Incorrect G mode in geometry.

◇ **Error 223** Cannot execute Program line. Unsolved case.

◇ **Error 224** Cannot execute Program line. Impossible for tangent step.

◇ **Error 225** Cannot execute Program line. Not line segments.

◇ **Error 226** Cannot execute Program line. Line segment in rounding not possible.

◇ **Error 227** Cannot execute Program line. Rounding too long.

◇ **Error 228** Cannot execute Program line. Connection radius too long.

◇ **Error 229** Cannot execute Program line. Radius smaller than half distance.

◇ **Error 230** Cannot execute Program line. Arc longer than 2*pi.

◇ **Error 231** Cannot execute Program line. Length smaller than DX.

◇ **Error 232** Cannot execute Program line. Length smaller than DY.

◇ **Error 233** Cannot execute Program line. No intersection.

◇ **Error 234** Cannot execute Program line. Point on line.

◇ **Error 235** Cannot execute Program line. Point in opposite direction.

◇ **Error 236** Cannot execute Program line. Point internal to the circle.

◇ **Error 237** Cannot execute Program line. Point on circumference.

◇ **Error 238** Cannot execute Program line. Direction must agree.

◇ **Error 239** Cannot execute Program line. Contained circumference.

◇ **Error 240** Cannot execute Program line. Nil radius.

◇ **Error 241** Cannot execute Program line. Line parallel to X.

◇ **Error 242** Cannot execute Program line. Line parallel to Y.

◇ **Error 243** Cannot execute Program line. Not implemented.

◇ **Error 244** Cannot execute Program line. Syntax error.

◇ **Error 245** Cannot execute Program line. Operator or closed parenthesis missing.

◇ **Error 246** Cannot execute Program line. An operand is missing.

◇ **Error 247** Cannot execute Program line. Undefined function.

◇ **Error 248** Cannot execute Program line. Too many closed parenthesis.

◇ **Error 249** Cannot execute Program line. Too many suspended operations.

◇ **Error 250** Cannot execute Program line. Incorrect constant.

◇ **Error 251** Cannot execute Program line. Closed parenthesis missing.

◇ **Error 252** Cannot execute Program line. Division by zero.

◇ **Error 253** Cannot execute Program line. Negative value root.

◇ **Error 254** Cannot execute Program line. Open parenthesis required.

◇ **Error 255** Cannot execute Program line. String end missing.

◇ **Error 256** Cannot execute Program line. Run out of string space.

◇ **Error 257** Cannot execute Program line. String too long.

◇ **Error 258** Cannot execute Program line. Type mismatch.

◇ **Error 259** Cannot execute Program line. Incorrect number of parameters.

◇ **Error 260** Cannot execute Program line. Base zero and non-positive exponent.

◇ **Error 261** Cannot execute Program line. Base negative and non-integer exponent.

◇ **Error 262** Cannot execute Program line. Overflow during conversion.

◇ **Error 263** Cannot execute Program line. Illegal number of bytes.

◇ **Error 264** Cannot execute Program line. Cannot get symbolic value.

◇ **Error 265** Cannot execute Program line. Illegal ASCII code.

◇ **Error 266** Cannot execute Program line. Undefined angle.

◇ **Error 267** Cannot execute Program line. Illegal bit index.

◇ **Error 268** Cannot execute Program line. Illegal read mode.

◇ **Error 269** Tool rotation speed out of permitted range.

◇ ◇ **Help** Check that the tool rotation speed falls within the minimum and maximum speed range associated to it. Check also that this speed does not exceed the range defined for the spindle and/or subspindle on which the tool is mounted.

◇ **Error 270** Router Spindles Correctors Table. Wrong inverter number.

◇ ◇ **Help** The number of the inverter linked to the specified router spindle is not correct since it must be in the range 0 to n- 1 where n is the number of the inverters on the machine.

◇ **Error 271** Router Spindles Correctors Table; Inverter already assigned to another centre.

◇ ◇ **Help** Spindles belonging to different centres connected to the same inverter cannot be defined.

◇ **Error 272** Cannot execute Program line. Too many dynamic inverters programmed.

◇ ◇ **Help** It is not possible to program a router spindle list with over 5 spindles for which the associated inverter number is defined by the PLC "dynamically".

◇ **Error 273** Cannot supply the PLC with information on the next program to execute.

◇ ◇ **Help** The NC can supply to the PLC some data (for instance LX, LY, LZ, etc.) relative to the program that will be executed at the end of the program currently executed. This information is not available in the following cases: 1) The program being executed is the last in the work list and the number of times that it has been executed corresponds to the preset value. 2) The next program to be executed is a "non CNI standard" program and therefore it does not contain a parameter section. 3) The next program to be executed after the current program does not exist.

◇ **Error 274** The inverter on a spindle without tool was actuated.

◇ ◇ **Help** The PLC actuated a spindle without a tool mounted.

◇ **Error 275** NC in emergency.

◇ ◇ **Help** The NC detected the trigger of the Emergency signal belonging to the PLC-NC exchange signals.

◇ **Error 276** The PLC commanded a coincidence yet to be defined.

◇ ◇ **Help** Check the PLC program.

◇ **Error 277** Technical data. Direction of rotation of spindle and tool mismatch.

◇ ◇ **Help** When loading Technical Data, the NC detected that the direction of rotation of the tool associated to the spindle does not match with the direction of rotation of the spindle. Change the Machine Data as necessary.

◇ **Error 278** Technical Data. Non existing tool

◇ ◇ **Help** A non existing tool was associated to the spindle. Change the Spindles Configuration Table as necessary.

◇ **Error 279** Tools Table. Unrecognised correction type.

◇ ◇ **Help** At present 4 possible values are accepted: 0, 1, 2, 14. Correct the Correction Type data in the Tools Table.

◇ **Error 280** Technical Data. Direction of rotation of spindle and subspindle mismatch.

◇ ◇ **Help** When loading Technical Data, the NC detected that the direction of rotation of the subspindle does not match with the direction of rotation of the spindle. Change the Machine Data as necessary.

◇ **Error 281** Movement cannot be performed.

◇ ◇ **Help** The axis cannot perform the movement required because it is already being moved.

◇ **Error 282** Technical Data. The tool declared in the magazine does not exist.

◇ ◇ **Help** Non-existing bits (or aggregates) cannot be declared to a magazine position. Change the technical data as necessary.

◇ **Error 283** Inverter not ready.

◇ ◇ **Help** The spindle associated to the inverter did not reach its work speed within the preset time interval. This time interval is set in an XNC configuration file. Check the setup data of the inverted for what concerns to the programmed time interval.

◇ **Error 284** Speed out of safety range.

◇ ◇ **Help** Once the spindle has reached its correct work speed, the XNC monitors periodically that the speed of the spindle remains in the range WS +-0, 1WS, where WS is the work speed. If the speed is found to be out of this range, the inverter is stopped.

◇ **Error 285** Drive over temperature.

◇ **Error 286** Motor over temperature.

◇ **Error 287** Overload.

◇ **Error 288** Current pick trip.

◇ **Error 289** Power supply fail.

◇ **Error 290** Undervoltage trip.

◇ **Error 291** Overvoltage trip.

◇ **Error 292** Phase loss.

◇ **Error 293** Current loop loss.

◇ **Error 294** Error flag.

◇ **Error 295** Movement not possible. PLC not running.

◇ ◇ **Help** Check that the PLC is running.

◇ **Error 296** Movement not possible. Machine in emergency status.

◇ ◇ **Help** Remove the conditions causing the emergency status.

◇ **Error 297** Movement of machine not enabled.

◇ ◇ **Help** This error occurs only during remote servicing. Movements cannot be commanded from the remote NC.

◇ **Error 298** Movement not possible. Technical Data Table modified.

◇ ◇ **Help** An attempt was made to issue a movement command after changing at least one data of the Technical Data Tables, without saving or cancelling the changes. Save or cancel the changes.

◇ **Error 299** Movement not possible. Technical Data Table mismatch.

◇ ◇ **Help** Changes have been made to the Technical Data Tables that caused the data to mismatch or be incongruous. Correct the Technical Data Tables as necessary.

◇ **Error 300** Start command not permitted. Program contains an error.

◇ ◇ **Help** The execution of a program cannot be resumed after it was interrupted following the detection of an error. The execution of the program must be stopped (STOP and RESET) and the program modified to remove the error.

◇ **Error 301** Modified data. +/- sign not at the beginning or unexpected.

◇ ◇ **Help** Characters + and - can only appear at the beginning of the data. Enter the data correctly.

◇ **Error 302** Modified data. More than one '.' character.

◇ ◇ **Help** The character . is used to separate the whole from the fractional portion of the data. It can appear only once. Enter the data correctly.

◇ **Error 303** Modified data. Too many non-decimal digits.

◇ ◇ **Help** The permitted number of digits in the whole portion of the number was exceeded. Enter the data correctly.

◇ **Error 304** Modified data. Too many decimal digits.

◇ ◇ **Help** The permitted number of digits in the fractional portion of the number was exceeded. Enter the data correctly.

◇ **Error 305** Modified data. Unexpected character.

◇ ◇ **Help** A non-permitted type of character was entered. For instance, a alphabetic character was entered in a numeric field, or in a positive-only field the - character was entered.

◇ **Error 306** Impossible to move. Axis blocked by PLC.

◇ ◇ **Help** The PLC is blocking the axis. Remove the conditions causing the block of the axis.

◇ **Error 307** Impossible to move. Axis Homing.

◇ ◇ **Help** An attempt was made to move an axis while the same was homing. Wait for the homing procedure to end.

◇ **Error 308** Impossible to move. Axis jogging.

◇ ◇ **Help** An attempt was made to move an axis while the same was being moved manually (jog). Wait for the manual movement to end

◇ **Error 309** Impossible to move. Axis in preset movement.

◇ ◇ **Help** An attempt was made to move an axis while the same was executing a preset movement. Wait for the preset movement to end.

◇ **Error 310** Homing not enabled.

◇ ◇ **Help** An attempt was made to home an axis not enabled to this function.

◇ **Error 311** Impossible to move. Display-only axis.

◇ ◇ **Help** An attempt was made to move an axis not enabled to perform any movement.

◇ **Error 312** Impossible to move. Axis not calibrated.

◇ ◇ **Help** An attempt was made to move an axis that had not been homed. Home the axis and repeat the operation.

◇ **Error 313** Impossible to move. Execution of a single step.

◇ ◇ **Help** An attempt was made to move an axis while a "single step" movement was being executed. Press STOP to interrupt the "single step" movement, otherwise wait until its end.

◇ **Error 314** Impossible to move. Machine in start.

◇ **Error 315** Reset not permitted. Machine homing.

◇ ◇ **Help** The RESET button was pressed while a homing operation was being performed. To stop the homing, press STOP, otherwise wait until the homing operation ends.

◇ **Error 316** Reset not permitted; Machine jogging.

◇ ◇ **Help** RESET button has been pushed with a manual movement in progress. To interrupt manual movement, push STOP; otherwise, wait for it to finish.

◇ **Error 317** Reset not permitted; Machine in preset movement.

◇ ◇ **Help** The RESET button was pressed while a preset movement operation was being performed. To stop the preset movement, press STOP, otherwise wait until the homing operation ends.

◇ **Error 318** Reset not permitted; Machine in start.

◇ ◇ **Help** The RESET button was pressed during the execution of a program. To suspend the execution of the program, press STOP. To stop and cancel the execution of the program, press STOP and RESET.

◇ **Error 319** Homing not permitted. Machine already received a command.

◇ ◇ **Help** A homing command was issued during the movement of one or more axes. To stop the movement, press STOP, otherwise wait until this ends before issuing the homing command.

◇ **Error 320** Impossible to move. Execution of a program.

◇ ◇ **Help** A homing command was issued, or the execution of a program was attempted during the execution of a program. To suspend the execution of the program, press STOP. To stop and cancel the execution of the program, press STOP and RESET.

◇ **Error 321** Start with non-existent single step function.

◇ ◇ **Help** The "single step" function was activate without entering the program line to execute. Enter the program line before pressing START.

◇ **Error 322** Program name to start not specified or with illegal characters.

◇ ◇ **Help** An attempt was made to execute a program having an invalid name. For instance, the name contains an asterisk (*) or no name was specified.

◇ **Error 323** Incorrect spindle selected.

◇ ◇ **Help** A reference spindle was selected not connected to the axis actuated. Select one connected to the axis.

◇ **Error 324** Attempt to write to the active configuration with machine in start.

◇ ◇ **Help** It is not possible to change the active configuration during the execution of a program. To change the configuration, stop the execution of the program by pressing STOP and RESET.

◇ **Error 325** Incorrect break write. Type program step first.

◇ ◇ **Help** To insert a Break instruction in a program line enter the number of the line at which the execution is to stop, and if necessary, the name of subprogram or fixed cycle. Example: 10 G99 interrupts the execution at line 10 of fixed cycle G99.

◇ **Error 326** On-line help not available.

◇ ◇ **Help** A help description may not yet be available for some errors. Update the on-line Errors help to a newer version.

◇ **Error 327** Incorrect program name in work list line.

◇ ◇ **Help** The name of the program in the work list line contains the ’*’ character that cannot be accepted. Change the name of the program.

◇ **Error 328** Piece counter greater than or equal to amount to manufacture.

◇ ◇ **Help** The "AMOUNT" field on the work list cannot be set to value greater than that contained in the "PRESET" field. Change the value of one of the fields.

◇ **Error 329** Non-existent work list file.

◇ ◇ **Help** An attempt was made to access a work list file which does not exist or which is protected. Check that the file is correct.

◇ **Error 330** Attempt to read work list file failed.

◇ ◇ **Help** The attempt to read the work list file failed. The file contains meaningless data or is not a work list file. Check that the file is correct.

◇ **Error 331** Attempt to write work list file failed.

◇ ◇ **Help** The attempt to write the work list file failed. The file is protected or the data is meaningless. Check that the file is correct.

◇ **Error 332** Could not find label of JMP instruction.

◇ ◇ **Help** A jump (JMP) instruction was found pointing to a non existent label. Check that the label name is written correctly.

◇ **Error 333** Too many characters received from BARCODE serial line

◇ **Error 334** Null line received from BARCODE serial line.

◇ **Error 335** A line was received with unsuitable machine status.

◇ **Error 336** Axis at software end of range UP.

◇ ◇ **Help** Move the axis below the UP end of range value.

◇ **Error 337** Axis at software end of range DOWN.

◇ ◇ **Help** Move the axis above the DOWN end of range value.

◇ **Error 338** Follow up error for positive feedback.

◇ ◇ **Help** The inversion of the encoder phases or the analogue reference polarity is possible. The counting direction may be changed in the wiring or by changing the sign of machine data 4 (number of encoder impulses). The polarity of the reference can be inverted in the wiring or by changing the sign of machine data 14 (position loop gain).

◇ **Error 339** Axis not calibrated. Homing must be performed.

◇ ◇ **Help** Incremental encoders do not guarantee the position of the axis after a power off of the numerical control. Only manual movements (jog) are permitted.

◇ **Error 340** A null speed was set.

◇ ◇ **Help** Null speeds are not permitted in machine data. Movements using them will not be executed.

◇ **Error 341** Incorrect auxiliary voltage on RCX2 card (+/-12V).

◇ ◇ **Help** Check +12 and -12 voltages outputted by the power supply. If the voltage values are correct, it is possible that the axis card is malfunctioning.

◇ **Error 342** Follow up error. Insufficient speed.

◇ ◇ **Help** Check the correct setting of machine data 17 (maximum follow-up error), 8 (maximum speed), 20 (maximum positioning speed) as indicated in the machine data description.

◇ **Error 343** Insufficient interpretation time of interpolation block.

◇ ◇ **Help** Decrease the forward speed F of the program being executed.

◇ **Error 344** Insufficient interpretation time of positioning block.

◇ ◇ **Help** Decrease the forward speed of the indicated axis in program being executed.

◇ **Error 345** Incorrect tracing cycle. Step without cycle end.

◇ ◇ **Help** Insert instruction M254 in the program being executed at the end of the tracing cycle.

◇ **Error 346** Division by zero.

◇ ◇ **Help** Control PLC program logic.

◇ **Error 347** I/O device missing or incorrectly defined.

◇ ◇ **Help** Control name and existence of indicated device.

◇ **Error 348** Positioning not completed. Excessive offset tension.

◇ ◇ **Help** a) Check that machine data 15 (positioning end advance) is not nil. b) Check that a few seconds have passed from the trigger of the Drive OK signal to the first movement command, to allow automatic offset compensation. c) Check the drive offset calibration. d) Check that the NC is correctly wired to the drives.

◇ **Error 349** Interpolation not completed. Excessive offset tension.

◇ ◇ **Help** a) Check that machine data 16 (interp. end advance) is not nil. b) Check that a few seconds have passed from the trigger of the Drive OK signal to the first movement command, to allow automatic offset compensation. c) Check the drive offset calibration. d) Check that the NC is correctly wired to the drives.

◇ **Error 350** Circular interpolation (G4/G5). Radius too small.

◇ ◇ **Help** The value of the radius is less than half the distance between the beginning point and the end point of the arc.

◇ **Error 351** Positioning start not permitted. Drive signal not OK.

◇ ◇ **Help** A drive OK signal for the relevant axis must be supplied.

◇ **Error 352** Interpolation start not permitted. Drive signal not OK.

◇ ◇ **Help** A drive OK signal must be supplied for the axis to perform the interpolated movement.

◇ **Error 353** Positioning out of software range.

◇ ◇ **Help** The program being started requires the indicated axis to move to a position external to the permitted range.

◇ **Error 354** Circular interpolation (G2/G3). Final radius not correct.

◇ ◇ **Help** The difference between the beginning and the end radii is greater than the minimum permitted (general machine data 12).

◇ **Error 355** Hardware error on RCX2 card.

◇ ◇ **Help** Axis card RCX2 may be malfunctioning.

◇ **Error 356** Error on phase signals from the encoder.

◇ ◇ **Help** Check the correct connection of the encoder to the NC and the correct operation of the encoder.

◇ **Error 357** Programming error. Cycle end code with tool radius correction set.

◇ ◇ **Help** a) Check the presence of instruction G40 at the end of the working. b) Check that instructions G41 or G42 are not followed by instructions T, TP, M, S (instruction causing a cycle end).

◇ **Error 358** Ellipsis (G7/G8); Beginning point not on curve.

◇ ◇ **Help** Programming error at the beginning point of the ellipsis.

◇ **Error 359** Ellipsis (G7/G8); End point not on curve.

◇ ◇ **Help** Programming error at the end point of the ellipsis.

◇ **Error 360** Ellipsis (G7/G8); Intersection with non tangent ellipsis or circle.

◇ ◇ **Help** In tool radius correction, the intersection of an ellipsis with other non-tangent steps.

◇ **Error 361** Radius of tool greater than radius of circle or ellipsis.

◇ ◇ **Help** This step cannot be performed with the selected tool: working radius too small.

◇ **Error 362** Variable does not exist.

◇ ◇ **Help** The variable entered was not found in the exchange signals or in the global variables of the dynamically-loaded PLC program. Check that the variable name is written correctly.

◇ **Error 363** Dynamic loading of PLC program not possible.

◇ ◇ **Help** It is not possible to load a PLC program while another PLC program is being executed. Stop the PLC program before loading.

◇ **Error 364** Failed attempt to save PLC variables file.

◇ ◇ **Help** The file with the global or exchange variables of the PLC could not be saved.

◇ **Error 365** Saving of PLC variables file incomplete.

◇ ◇ **Help** A part of the file containing the global or exchange variable of the PLC program could not be saved. Retry.

◇ **Error 366** Failed attempt to read PLC variables file.

◇ ◇ **Help** The file with the global or exchange variables of the PLC program could not be read.

◇ **Error 367** Reading of PLC variables file incomplete.

◇ ◇ **Help** A part of the file containing the global or exchange variable of the PLC program could not be read. Retry.

◇ **Error 368** Trace cannot be enabled. Press the stop button.

◇ ◇ **Help** To start the trace option, disable the debugger by clicking on the stop button with the mouse.

◇ **Error 369** Not a Boolean variable.

◇ ◇ **Help** The variable edited exists but is not a Boolean variable. Tracing can be triggered only with Boolean variables.

◇ **Error 370** Machine in start.

◇ ◇ **Help** An attempt was made to HALT the PLC with the machine moving. To HALT the PLC, press sequentially the STOP and RESET keys.

◇ **Error 371** PLC not yet initialised.

◇ ◇ **Help** An attempt was made to set the PLC to GO even if isaker was not yet initialised. Check if the isaker process has been launched.

◇ **Error 372** HALT

◇ ◇ **Help** Start the PLC before resuming work.

◇ **Error 373** PLC cycle too long.

◇ ◇ **Help** Check the PLC program. Notify CNI if this error occurs frequently.

◇ **Error 374** Device not found.

◇ ◇ **Help** Hardware problem or incorrect machine configuration.

◇ **Error 375** Time-out during communication with a device

◇ ◇ **Help** Possible hardware problem.

◇ **Error 376** Operation failed

◇ ◇ **Help** Refer to the following messages.

◇ **Error 377** Operation permitted only with PLC in HALT

◇ ◇ **Help** HALT the PLC.

◇ **Error 378** Program load failed

◇ ◇ **Help** Check the name of the PLC program set.

◇ **Error 379** Not enough memory for the PLC program.

◇ ◇ **Help** Notify CNI.

◇ **Error 380** Tool change not possible. The spindle was tooled manually.

◇ ◇ **Help** The spindle must be re-defined with a tool change.

◇ **Error 381** Start on non-existing intermediate step.

◇ ◇ **Help** The intermediate start step number must exist in the selected section.

◇ **Error 382** Generic error.

◇ **Error 383** Edit does not meet set conditions.

◇ **Error 384** Incorrect file name.

◇ **Error 385** Duplicate label.

◇ **Error 386** Erroneous definition of the right and left limits of the critical zone.

◇ ◇ **Help** The left limit of the critical zone must be less than the right limit. Edit the data in the GENERAL section of the Technical Data.

◇ **Error 387** Irreversible HALT.

◇ ◇ **Help** Turn machine off and then on.

◇ **Error 388** PLC cycle greater than nominal period.

◇ ◇ **Help** Check the PLC program. Notify CNI if this error occurs frequently.

◇ **Error 389** Erroneous G66 programming

◇ ◇ **Help** The axes programmed in a step in which the G66 is present must belong to the same line.

◇ **Error 390** No non-volatile memory available.

◇ ◇ **Help** Possible hardware problem.

◇ **Error 391** I/O configuration not set.

◇ ◇ **Help** Set the I/O configuration.

◇ **Error 392** IOS card missing or incomplete.

◇ ◇ **Help** Hardware problem or incorrect machine configuration.

◇ **Error 393** I/O module missing.

◇ ◇ **Help** Hardware problem or incorrect machine configuration.

◇ **Error 394** An instruction LX,LY,LZ is missing.

◇ ◇ **Help** The first step is missing one of the definition instructions LX= LY= or LZ= of the dimensions of the panel. Correct the program.

◇ **Error 395** The inverter did not receive the command sent; try the transmission again.

◇ ◇ **Help** Check the hardware related to the serial connection with the inverter. Check the serial communication parameters set on the inverter. Check the address of the inverter.

◇ **Error 396** Failed dialogue with the inverter.

◇ ◇ **Help** Check the hardware related to the serial connection with the inverter. Check the serial communication parameters set on the inverter. Check the address of the inverter.

◇ **Error 397** Initial direction of unknown value. Geometric error.

◇ **Error 398** Different initial and final radiuses.

◇ **Error 399** The programmed point does not belong to the ellipse.

◇ **Error 400** The ellipse cannot be rotated.

◇ **Error 401** Program end with open geometric sequence.

◇ **Error 402** Program end with active tool correction.

◇ **Error 403** An incremental axis was used in the triad definition.

◇ **Error 404** The xy plane was not defined.

◇ **Error 405** No step to apply the correction to the radius tool.

◇ **Error 406** Positioning during the correction of the radius tool.

◇ **Error 407** E 1 : The object has not a valid solution (SOLMNG)

◇ **Error 408** W 1 : Mirror spindle not specified or not found (READDM)

◇ **Error 409** W 1 : Two equal point found at the same quote, one point will be deleted (Point optimizer module)

◇ **Error 410** Problems starting connection with remote host.

◇ ◇ **Help** Connection with the remote host failed. Verify that cables are still in good conditions and connectors are still at their place. Verify also that login and password are the correct ones.

◇ **Error 411** Problems sending file to the remote host.

◇ ◇ **Help** It is impossible to send the file to the remote host. Verify that cables are still in good conditions and connectors are still at their place. Verify also write permissions on the remote host.

◇ **Error 412** Problems receiving file from the remote host.

◇ ◇ **Help** It is impossible to receive the file from the remote host. Verify that cables are still in good conditions and connectors are still at their place. Verify also read permissions and the file existence on the remote host.

◇ **Error 413** Problems deleting remote file.

◇ ◇ **Help** It is impossible to delete the file from the remote host. Verify that cables are still in good conditions and connectors are still at their place. Verify also write permissions and the file existence on the remote host.

◇ **Error 414** Problems reading remote directory.

◇ ◇ **Help** It is impossible to receive the directory list from the remote host. Verify that cables are still in good conditions and connectors are still at their place. Verify also the directory existence on the remote host.

◇ **Error 415** Problems creating remote directory.

◇ ◇ **Help** It is impossible to create the directory on the remote host. Verify that cables are still in good conditions and connectors are still at their place. Verify also write permissions on the remote host.

◇ **Error 416** Problems deleting remote directory.

◇ ◇ **Help** It is impossible to delete the directory on the remote host. Verify that cables are still in good conditions and connectors are still at their place. Verify also write permissions on the remote host.

◇ **Error 417** Problems closing connection with the remote host.

◇ ◇ **Help** Disconnection with the remote host failed. Verify that cables are still in good conditions and connectors are still at their place.

◇ **Error 418** Cannot execute Operation because drawing program.

◇ ◇ **Help** Cannot execute Operation because drawing program. Repeat the Operation.

◇ **Error 419** E 1 : Spindles with the same offsets (READDM)

◇ ◇ **Help** There are one or more spindles with coinciding x y and z offsets.

◇ **Error 420** F 1 : Machine Data Server has returned error (READDM)

◇ ◇ **Help** An error has occurred in the reading of the machine data.

◇ **Error 421** F 6 : Invalid axes number (READDM)

◇ ◇ **Help** An axis not present in the machine is connected to the spindle head.

◇ **Error 422** Interpolation disabled

◇ ◇ **Help** To allow interpolation, first define the default interpolating axis set (tables - AXIS system)

◇ **Error 423** AX= instruction error

◇ ◇ **Help** To allow programming of the AX= instruction, interpolation must be enabled and the stated axes must be interpolating

◇ **Error 424** Hold on both X axes (2 heads)

◇ ◇ **Help** Both X axes are placed in hold for 2 head type interference

◇ **Error 425** Hold on one X axis (2 heads)

◇ ◇ **Help** One of the 2 X axes is placed in hold for 2 head type interference

◇ **Error 426** Interference on both X axes (2 heads)

◇ ◇ **Help** Interference on both X axes (2 heads): BITINT bit supplied to PLC

◇ **Error 427** Instantaneous wear correction impossible

◇ ◇ **Help** PLC can command an instantaneous wear change only if the PIC signal is at 1 and if a drill bit is fit on the reference spindle.

◇ **Error 428** Program file in editor.

◇ ◇ **Help** The file or directory you are attempting to copy or delete is now loaded in program editor and a different version could be saved. To copy or delete it, change the file in editor.

◇ **Error 429** Work list file being edited or executed.

◇ ◇ **Help** The file or directory you are attempting to copy or delete is now loaded in the work list editor. To copy or delete it, you must first close the work list editor, or load a different file in it.

◇ **Error 430** All units for manual movement occupied. Movement cannot be performed.

◇ ◇ **Help** A non-program movement has been commanded (ex. JOG/MDI...); or a program movement has been commanded in G66 mode but there are no free units. Movement not possible. Reduce number of simultaneous movements ordered.

◇ **Error 431** You cannot program more than 3 axes in G66 mode.

◇ ◇ **Help** A maximum of 3 axes may be commanded in G66 mode. Modify the program.

◇ **Error 432** Peripheral device not working.

◇ ◇ **Help** Possible electrical problem.

◇ **Error 433** Data in non-volatile storage do not conform to PLC program.

◇ ◇ **Help** Hardware problem, or new program has been installed.

◇ **Error 434** Column pointer indication missing.

◇ ◇ **Help** To debug a matrix element, you have to specify the column number in the edit field of the "Variable Type" window.

◇ **Error 435** Center section missing from program file (subroutine, fixed cycle).

◇ ◇ **Help** You are probably executing a program that is incompatible with the number of centers for the machine in use.

◇ **Error 436** Program file (subroutine, fixed cycle) contains center section inappropriate to machine

◇ ◇ **Help** You are probably executing a program that is incompatible with the number of centers for the machine in use.

◇ **Error 437** Operation not permitted.

◇ ◇ **Help** Compressed file copy or total backup are permitted only with UNIX disks and not with DOS disks.

◇ **Error 438** File copy not permitted.

◇ ◇ **Help** You cannot copy machine data from a remote unit when the local machine is in start. The local machine must be set to stop before the copy operation can take place.

◇ **Error 439** Write-protected File.

◇ ◇ **Help** The file you are attempting to copy in remote unit is in execution or loaded in program editor or loaded in the work list editor.

◇ **Error 440** Error reading configuration file.

◇ **Error 441** Error making data area.

◇ **Error 442** Error memory allocation

◇ **Error 443** Error reading file.

◇ **Error 444** Tooling not loaded

◇ **Error 445** Problem in object replacing

◇ **Error 446** Error in left configuration reading

◇ **Error 447** Error in right configuration reading

◇ **Error 448** No space to locate left configuration

◇ **Error 449** No space to locate right configuration

◇ **Error 450** Different file version

◇ **Error 451** Tooling file read error

◇ **Error 452** File saving error

◇ **Error 453** Panel graphics error

◇ **Error 454** Temporary file opening error

◇ **Error 455** Paragraph write error

◇ **Error 456** DXF file read error

◇ **Error 457** File label management error

◇ ◇ **Help** The graphics process of a program is unable to correctly load the label structures for possible cause jumps (empty or damaged file). Try to edit with editor and then save?

◇ **Error 458** Probable division by 0

◇ ◇ **Help** Division by 0 has occurred during calculation due to truncation or incorrect input data.

◇ **Error 459** One or more holes coincide

◇ ◇ **Help** You are trying to insert one or more holes having the same characteristics as existing holes.

◇ **Error 460** Incompatible version of machine data server

◇ ◇ **Help** Active version of machine data server is incompatible with the process. Some edit or save operations may be unsuccessful. Contact CNI.

◇ **Error 461** Time out in dialog with machine data server

◇ ◇ **Help** The machine data server does not respond to request. Version may be incompatible or server is no longer active.

◇ **Error 462** Machine data server is in read only mode

◇ ◇ **Help** Data cannot be written because they are blocked by another process or because machine is in start.

◇ **Error 463** Aggregate has no subspindles

◇ ◇ **Help** The aggregate selected has no subspindles to display.

◇ **Error 464** No subspindle configuration data

◇ ◇ **Help** The subspindle tables have no data to display because the active password does not permit editing.

◇ **Error 465** No tool cycle found

◇ ◇ **Help** There are no tool cycles to display.

◇ **Error 466** No tool cycle configuration data

◇ ◇ **Help** The tool cycles table has no data to display because the active password does not permit editing.

◇ **Error 467** Nvram init. error

◇ ◇ **Help** Novram not available: update hardware

◇ **Error 468** Read error from config. file such as homing with resolver

◇ ◇ **Help** Update machine configuration file

◇ **Error 469** Axis not enabled for homing

◇ ◇ **Help** Modify PLC program

◇ **Error 470** Impossible to define an MDI from PLC in a group with axes in positioning and axes in homing condition

◇ ◇ **Help** Modify PLC program

◇ **Error 471** Cannot open file: already used for other processes.

◇ ◇ **Help** Wait for file to be closed by current user.

◇ **Error 472** Cannot execute a save-as operation with files of different type.

◇ ◇ **Help** You are probably trying to save an ASCII file as a program (operation not allowed).

◇ **Error 473** Move not allowed in tool radius correction.

◇ **Error 474** Axis already programmed.

◇ **Error 475** Can’t find the new reference system.

◇ **Error 476** Points are on the same line.

◇ **Error 477** Trihedral xyz is undefined.

◇ **Error 478** Interpolation mode not allowed for incremental axis.

◇ **Error 479** No. of steps pre-interpreted by axes line is too large.

◇ ◇ **Help** Control data for interpreter levels no. and preinterpreted steps no. on line system table.

◇ **Error 480** Wrong connected head number.

◇ ◇ **Help** Control spindle technical data (connected head).

◇ **Error 481** Read problem in tooling section of current program.

◇ ◇ **Help** Re-edit information on mobile tables and suction cups

◇ **Error 482** Display module problem (mobile tables and suction cups).

◇ ◇ **Help** Control that display module address corresponds to that on DISPLAY system table. Control serial connection if necessary.

◇ **Error 483** Tooling file print error.

◇ **Error 484** Operation not allowed because file has been changed.

◇ **Error 485** Stop not associated with an origin.

◇ ◇ **Help** It is not possible to automatically reposition a stop which is not associated with an origin.

◇ **Error 486** Error in the creation of associated tooling.

◇ ◇ **Help** Check Origin Data (Origin Table) and Panel Dimensions (System table Translation Data).

◇ **Error 487** Error in calculation of active origin.

◇ ◇ **Help** Select as active origin the one relative to the loaded panel.

◇ **Error 488** No panel installed on active origin.

◇ ◇ **Help** Load a panel on the active origin.

◇ **Error 489** Error in calculation of origin relative to associated tooling.

◇ ◇ **Help** Check Origin Data (Origin Table) relative to active origin.

◇ **Error 490** Error in calculation of first working table relative to active tooling.

◇ ◇ **Help** Be sure that a working table with a stop associated with the active origin is available.

◇ **Error 491** Error in calculation of first working table relative to associated tooling.

◇ ◇ **Help** Be sure that a working table with a stop associated with the origin relative to the associated tooling is available.

◇ **Error 492** Problem of inconsistency between origin relative to active tooling and origin relative to associated tooling.

◇ ◇ **Help** Check Origin Data (Origin Table) relative both to active and associated origin.

◇ **Error 493** Number of interpreter levels is insufficient.

◇ **Error 494** Interfering axes interblock gap.

◇ **Error 495** Failure writing to HD.

◇ ◇ **Help** It is impossible to open the file during a writing operation. Be sure that the file is not being edited.

◇ **Error 496** Failure formatting diskette.

◇ ◇ **Help** The diskette may be defective. Substitute it.

◇ **Error 497** File not copied on HD.

◇ **Error 498** Attention! File dimensions greater than 64 Kb.

◇ ◇ **Help** The copy will be interrupted because of a deposit buffer which is too small for what is to be deposited.