Electric Drives and Controls | Hydraulics | Linear Motion and Assembly Technologies | Pneumatics | Service

Rexroth Bosch Group

Rexroth IndraMotion MTX 09VRS Standard NC Cycles

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1.1 Appropriate Use

1.1.1 Introduction

Bosch Rexroth products represent state-of-the-art developments and manufacturing. They are tested prior to delivery to ensure operating safety and reliability.

The products may only be used in the manner that is defined as appropriate. If they are used in an inappropriate manner, then situations can develop that may lead to property damage or injury of personnel.

☞ Bosch Rexroth, as manufacturer, is not liable for any damages resulting from inappropriate use. In such cases, the guarantee and the right to payment of damages resulting from inappropriate use are forefeited. The user alone carries all responsibility of the risks.

Before using Bosch Rexroth products, make sure that all the pre-requisites for appropriate use of the products are satisfied:

- Personnel that in a way, shape or form uses our products must first read and understand the relevant safety instructions and be familiar with appropriate use.
- If the product takes the form of hardware, then they must remain in the original state, in other words, no structural changes are permitted. It its not permitted to decompile software products or alter source codes.
- Do not mount damaged or faulty products or use them in operation.
- Make sure that the products have been installed in the manner described in the relevant documentation.

1.1.2 Areas of Use and Application

The Rexroth IndraMotion MTX control is used to

- Programming contour and machining technology (feedrate, spindle speed, tool change) or a workpiece.
- Guiding a machining tool along a programmed bath.

Feed drives, spindles and auxiliary axes of a machine tool are activated via SERCOS interface.

☞ This additionally requires I/O components for the integrated PLC which, in combination with the actual CNC, controls the machining process as a whole and also monitors this process with regard to technical safety.

The unit may be operated only with the explicitly specified hardware component configurations and combinations and only with the software and firmware specified in the appropriate documentations and functional descriptions.

The Rexroth IndraMotion MTX has been developed for control tasks in multi-axis installations.

Typical applications are:

- lathes
- milling machines

- machining centers

1.2 Inappropriate Use

Using the Rexroth IndraMotion MTX outside of the above-referenced areas of application or under operating conditions other than described in the document and the technical data specified is defined as "inappropriate use".

The Rexroth IndraMotion MTX may not be used if ...

- they are subject to operating conditions that do not meet the above specified ambient conditions. This includes, for example, operation under water, in the case of extreme temperature fluctuations or extreme maximum temperatures or if
- Bosch Rexroth has not specifically released Rexroth IndraMotion MTX for that intended purpose. Please note the specifications outlined in the general safety instructions!

2 Safety Instructions for Electric Drives and Controls

2.1 Safety Instructions - General Information

2.1.1 Using the Safety Instructions and Passing them on to Others

Do not attempt to install or commission this device without first reading all documentation provided with the product. Read and understand these safety instructions and all user documentation prior to working with the device. If you do not have the user documentation for the device, contact your responsible Bosch Rexroth sales representative. Ask for these documents to be sent immediately to the person or persons responsible for the safe operation of the device.

If the device is resold, rented and/or passed on to others in any other form, these safety instructions must be delivered with the device in the official language of the user's country.

WARNING

Improper use of these devices, failure to follow the safety instructions in this document or tampering with the product, including disabling of safety devices, may result in material damage, bodily harm, electric shock or even death!

Observe the safety instructions!

2.1.2 How to Employ the Safety Instructions

Read these instructions before initial commissioning of the equipment in order to eliminate the risk of bodily harm and/or material damage. Follow these safety instructions at all times.

- Bosch Rexroth AG is not liable for damages resulting from failure to observe the warnings provided in this documentation.
- Read the operating, maintenance and safety instructions in your language before commissioning the machine. If you find that you cannot completely understand the documentation for your product, please ask your supplier to clarify.
- Proper and correct transport, storage, assembly and installation, as well as care in operation and maintenance, are prerequisites for optimal and safe operation of this device.
- Only assign trained and qualified persons to work with electrical installations:
  - Only persons who are trained and qualified for the use and operation of the device may work on this device or within its proximity. The persons are qualified if they have sufficient knowledge of the assembly, installation and operation of the product, as well as an understanding of all warnings and precautionary measures noted in these instructions.
  - Furthermore, they must be trained, instructed and qualified to switch electrical circuits and devices on and off in accordance with technical safety regulations, to ground them and to mark them according to the requirements of safe work practices. They must have adequate safety equipment and be trained in first aid.
- Only use spare parts and accessories approved by the manufacturer.

- Follow all safety regulations and requirements for the specific application as practiced in the country of use.
- The devices have been designed for installation in industrial machinery.
- The ambient conditions given in the product documentation must be observed.
- Only use safety-relevant applications that are clearly and explicitly approved in the Project Planning Manual. If this is not the case, they are excluded. Safety-relevant are all such applications which can cause danger to persons and material damage.
- The information given in the documentation of the product with regard to the use of the delivered components contains only examples of applications and suggestions.

  The machine and installation manufacturer must

  – make sure that the delivered components are suited for his individual application and check the information given in this documentation with regard to the use of the components,
  – make sure that his application complies with the applicable safety regulations and standards and carry out the required measures, modifications and complements.
- Commissioning of the delivered components is only permitted once it is sure that the machine or installation in which they are installed complies with the national regulations, safety specifications and standards of the application.
- Operation is only permitted if the national EMC regulations for the application are met.
- The instructions for installation in accordance with EMC requirements can be found in the section on EMC in the respective documentation (Project Planning Manuals of components and system).

  The machine or installation manufacturer is responsible for compliance with the limiting values as prescribed in the national regulations.
- Technical data, connection and installation conditions are specified in the product documentation and must be followed at all times.

National regulations which the user must take into account

- European countries: according to European EN standards
- United States of America (USA):
  – National Electrical Code (NEC)
  – National Electrical Manufacturers Association (NEMA), as well as local engineering regulations
  – regulations of the National Fire Protection Association (NFPA)
- Canada: Canadian Standards Association (CSA)
- Other countries:
  – International Organization for Standardization (ISO)
  – International Electrotechnical Commission (IEC)

2.1.3 Explanation of Warning Symbols and Degrees of Hazard Seriousness

The safety instructions describe the following degrees of hazard seriousness. The degree of hazard seriousness informs about the consequences resulting from non-compliance with the safety instructions:

Warning symbol	Signal word	Degree of hazard seriousness acc. to ANSI Z 535.4-2002
	Danger	Death or severe bodily harm will occur.
	Warning	Death or severe bodily harm may occur.
	Caution	Minor or moderate bodily harm or material damage may occur.

Fig.2-1: Hazard classification (according to ANSI Z 535)

2.1.4 Hazards by Improper Use

DANGER

High electric voltage and high working current! Risk of death or severe bodily injury by electric shock!

Observe the safety instructions!

DANGER

Dangerous movements! Danger to life, severe bodily harm or material damage by unintentional motor movements!

Observe the safety instructions!

WARNING

High electric voltage because of incorrect connection! Risk of death or bodily injury by electric shock!

Observe the safety instructions!

WARNING

Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electrical equipment!

Observe the safety instructions!

CAUTION

Hot surfaces on device housing! Danger of injury! Danger of burns!

Observe the safety instructions!

CAUTION

Risk of injury by improper handling! Risk of bodily injury by bruising, shearing, cutting, hitting or improper handling of pressurized lines!

Observe the safety instructions!

CAUTION

Risk of injury by improper handling of batteries!

Observe the safety instructions!

2.2 Instructions with Regard to Specific Dangers

2.2.1 Protection Against Contact with Electrical Parts and Housings

☞ This section concerns devices and drive components with voltages of **more than 50 Volt**.

Contact with parts conducting voltages above 50 Volts can cause personal danger and electric shock. When operating electrical equipment, it is unavoidable that some parts of the devices conduct dangerous voltage.

DANGER

High electrical voltage! Danger to life, electric shock and severe bodily injury!

- Only those trained and qualified to work with or on electrical equipment are permitted to operate, maintain and repair this equipment.
- Follow general construction and safety regulations when working on power installations.
- Before switching on the device, the equipment grounding conductor must have been non-detachably connected to all electrical equipment in accordance with the connection diagram.
- Do not operate electrical equipment at any time, even for brief measurements or tests, if the equipment grounding conductor is not permanently connected to the mounting points of the components provided for this purpose.
- Before working with electrical parts with voltage potentials higher than 50 V, the device must be disconnected from the mains voltage or power supply unit. Provide a safeguard to prevent reconnection.
- With electrical drive and filter components, observe the following:

  Wait **30 minutes** after switching off power to allow capacitors to discharge before beginning to work. Measure the electric voltage on the capacitors before beginning to work to make sure that the equipment is safe to touch.
- Never touch the electrical connection points of a component while power is turned on. Do not remove or plug in connectors when the component has been powered.
- Install the covers and guards provided with the equipment properly before switching the device on. Before switching the equipment on, cover and safeguard live parts safely to prevent contact with those parts.
- A residual-current-operated circuit-breaker or r.c.d. cannot be used for electric drives! Indirect contact must be prevented by other means, for example, by an overcurrent protective device according to the relevant standards.
- Secure built-in devices from direct touching of electrical parts by providing an external housing, for example a control cabinet.

For electrical drive and filter components with voltages of **more than 50 volts**, observe the following additional safety instructions.

DANGER

High housing voltage and high leakage current! Risk of death or bodily injury by electric shock!

- Before switching on, the housings of all electrical equipment and motors must be connected or grounded with the equipment grounding conductor to the grounding points. This is also applicable before short tests.
- The equipment grounding conductor of the electrical equipment and the devices must be non-detachably and permanently connected to the power supply unit at all times. The leakage current is greater than 3.5 mA.
- Over the total length, use copper wire of a cross section of a minimum of 10 mm^2 for this equipment grounding connection!
- Before commissioning, also in trial runs, always attach the equipment grounding conductor or connect to the ground wire. Otherwise, high voltages may occur at the housing causing electric shock.

2.2.2 Protection Against Electric Shock by Protective Extra-Low Voltage

Protective extra-low voltage is used to allow connecting devices with basic insulation to extra-low voltage circuits.

All connections and terminals with voltages between 5 and 50 volts at Rexroth products are PELV systems. [1] It is therefore allowed to connect devices equipped with basic insulation (such as programming devices, PCs, notebooks, display units) to these connections and terminals.

WARNING

High electric voltage by incorrect connection! Risk of death or bodily injury by electric shock!

If extra-low voltage circuits of devices containing voltages and circuits of more than 50 volts (e.g. the mains connection) are connected to Rexroth products, the connected extra-low voltage circuits must comply with the requirements for PELV. [2]

2.2.3 Protection Against Dangerous Movements

Dangerous movements can be caused by faulty control of connected motors. Some common examples are:

- improper or wrong wiring of cable connections
- incorrect operation of the equipment components
- wrong input of parameters before operation
- malfunction of sensors, encoders and monitoring devices
- defective components
- software or firmware errors

Dangerous movements can occur immediately after equipment is switched on or even after an unspecified time of trouble-free operation.

1) *"Protective Extra-Low Voltage"*

2) *"Protective Extra-Low Voltage"*

The monitoring in the drive components will normally be sufficient to avoid faulty operation in the connected drives. Regarding personal safety, especially the danger of bodily harm and material damage, this alone cannot be relied upon to ensure complete safety. Until the integrated monitoring functions become effective, it must be assumed in any case that faulty drive movements will occur. The extent of faulty drive movements depends upon the type of control and the state of operation.

DANGER

Dangerous movements! Danger to life, risk of injury, severe bodily harm or material damage!

- Ensure personal safety by means of qualified and tested higher-level monitoring devices or measures integrated in the installation.

  These measures have to be provided for by the user according to the specific conditions within the installation and a hazard and fault analysis. The safety regulations applicable for the installation have to be taken into consideration. Unintended machine motion or other malfunction is possible if safety devices are disabled, bypassed or not activated.

To avoid accidents, bodily harm and/or material damage:

- Keep free and clear of the machine's range of motion and moving parts. Possible measures to prevent people from accidentally entering the machine's range of motion:
  - use safety fences
  - use safety guards
  - use protective coverings
  - install light curtains or light barriers
- Fences and coverings must be strong enough to resist maximum possible momentum.
- Mount the emergency stop switch in the immediate reach of the operator. Verify that the emergency stop works before startup. Don't operate the device if the emergency stop is not working.
- Isolate the drive power connection by means of an emergency stop circuit or use a safety related starting lockout to prevent unintentional start.
- Make sure that the drives are brought to a safe standstill before accessing or entering the danger zone.
- Additionally secure vertical axes against falling or dropping after switching off the motor power by, for example:
  - mechanically securing the vertical axes,
  - adding an external braking/ arrester/ clamping mechanism or
  - ensuring sufficient equilibration of the vertical axes.
- The standard equipment motor brake or an external brake controlled directly by the drive controller are **not sufficient to guarantee personal safety**!
- Disconnect electrical power to the equipment using a master switch and secure the switch against reconnection for:
  - maintenance and repair work
  - cleaning of equipment
  - long periods of discontinued equipment use
- Prevent the operation of high-frequency, remote control and radio equipment near electronics circuits and supply leads. If the use of such devices cannot be avoided, verify the system and the installation for possible malfunctions in all possible positions of normal use before initial startup. If necessary, perform a special electromagnetic compatibility (EMC) test on the installation.

2.2.4 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting

Magnetic and electromagnetic fields generated by current-carrying conductors and permanent magnets in motors represent a serious personal danger to those with heart pacemakers, metal implants and hearing aids.

WARNING

Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electrical equipment!

- Persons with heart pacemakers and metal implants are not permitted to enter following areas:
  - Areas in which electrical equipment and parts are mounted, being operated or commissioned.
  - Areas in which parts of motors with permanent magnets are being stored, repaired or mounted.
- If it is necessary for somebody with a pacemaker to enter such an area, a doctor must be consulted prior to doing so. The noise immunity of present or future implanted heart pacemakers differs greatly so that no general rules can be given.
- Those with metal implants or metal pieces, as well as with hearing aids, must consult a doctor before they enter the areas described above. Otherwise health hazards may occur.

2.2.5 Protection Against Contact with Hot Parts

CAUTION

Hot surfaces at motor housings, on drive controllers or chokes! Danger of injury! Danger of burns!

- Do not touch surfaces of device housings and chokes in the proximity of heat sources! Danger of burns!
- Do not touch housing surfaces of motors! Danger of burns!
- According to the operating conditions, temperatures can be **higher than 60 °C**, 140°F during or after operation.
- Before accessing motors after having switched them off, let them cool down for a sufficiently long time. Cooling down can require **up to 140 minutes**! Roughly estimated, the time required for cooling down is five times the thermal time constant specified in the Technical Data.
- After switching drive controllers or chokes off, wait 15 minutes to allow them to cool down before touching them.
- Wear safety gloves or do not work at hot surfaces.
- For certain applications, the manufacturer of the end product, machine or installation, according to the respective safety regulations, has to take measures to avoid injuries caused by burns in the end application. These measures can be, for example: warnings, guards (shielding or barrier), technical documentation.

2.2.6 Protection During Handling and Mounting

In unfavorable conditions, handling and mounting certain parts and components in an improper way can cause injuries.

CAUTION

Risk of injury by improper handling! Bodily injury by bruising, shearing, cutting, hitting!

- Observe the general construction and safety regulations on handling and mounting.
- Use suitable devices for mounting and transport.
- Avoid jamming and bruising by appropriate measures.
- Always use suitable tools. Use special tools if specified.
- Use lifting equipment and tools in the correct manner.
- If necessary, use suitable protective equipment (for example safety goggles, safety shoes, safety gloves).
- Do not stand under hanging loads.
- Immediately clean up any spilled liquids because of the danger of skidding.

2.2.7 Battery Safety

Batteries consist of active chemicals enclosed in a solid housing. Therefore, improper handling can cause injury or material damage.

CAUTION

Risk of injury by improper handling!

- Do not attempt to reactivate low batteries by heating or other methods (risk of explosion and cauterization).
- Do not recharge the batteries as this may cause leakage or explosion.
- Do not throw batteries into open flames.
- Do not dismantle batteries.
- When replacing the battery/batteries do not damage electrical parts installed in the devices.
- Only use the battery types specified by the manufacturer.

☞ Environmental protection and disposal! The batteries contained in the product are considered dangerous goods during land, air, and sea transport (risk of explosion) in the sense of the legal regulations. Dispose of used batteries separate from other waste. Observe the local regulations in the country of assembly.

2.2.8 Protection Against Pressurized Systems

According to the information given in the Project Planning Manuals, motors cooled with liquid and compressed air, as well as drive controllers, can be partially supplied with externally fed, pressurized media, such as compressed air, hydraulics oil, cooling liquids and cooling lubricating agents. Improper handling of the connected supply systems, supply lines or connections can cause injuries or material damage.

CAUTION

Risk of injury by improper handling of pressurized lines!

- Do not attempt to disconnect, open or cut pressurized lines (risk of explosion).
- Observe the respective manufacturer's operating instructions.
- Before dismounting lines, relieve pressure and empty medium.
- Use suitable protective equipment (for example safety goggles, safety shoes, safety gloves).
- Immediately clean up any spilled liquids from the floor.

☞ Environmental protection and disposal! The agents used to operate the product might not be economically friendly. Dispose of ecologically harmful agents separately from other waste. Observe the local regulations in the country of assembly.

3 General

3.1 Introduction

NC Cycles are an effective tool for NC work piece programming. They enable the user to program selected geometric elements and technological sequences simply using cycle requests and specified parameters.

The standard cycles are a constituent of the firmware. It is not possible to modify them. It is possible to overwrite standard cycles but this should be avoided. Standard cycles can be modified with a new release / version in order to eliminate errors or make useful extensions to the functions.

3.2 Assignment of the G-Codes

Pre-assigned G-code ranges for cycles

Cycle groups	G-code range	Note
Drilling cycles (part 1)	G80 - G89	
Bore patterns	G110 - G129	
Reserved by the controller	G130 - G159	Partially assigned by controller commands (3D radius correction, placements)
Turning cycles	G160 - G179	
Drilling cycles (part 2)	G180 - G199	reserved
Engraving cycles	G200 - G209	
Reserved by the controller	G210 - G259	for future extensions
Milling cycles	G260 - G299	
Measuring cycles	G300 - G349	reserved for future extensions
Fixed user cycles, local	G350 - G368	Can be used by the machine-operator
Fixed user cycles, modal	G370 - G388	Can be used by the machine-operator
OEM user cycles	G390 - G449	Range for OEM cycles
USER user cycles	G450 - G499	User range

Fig.3-1: Pre-assignment of G-codes for cycles

The ranges G390 to G499 are available for assignment of proprietary G-codes.

The above G-code ranges are reserved in the MTX for relevant cycles. Additional cycles can also be added with a new version/ release. OEMs and users should only use cycles in the G-code ranges reserved for them.

Should the OEM or user use arbitrary names for their cycles, then they must accept responsibility for ensuring that there is no double use of the existing key CNC terms.

3.3 General Rules for Modal Cycle Requests

A modal cycle will be executed at the position programmed in the same NC block N110. In the next NC block N120 only the position will be programmed. It will firstly be positioned and then the cycle will be executed. This will continue until the modal request is deleted with G80.

Example: *Program:*

```
N100 G0 X0 Y0 Z100 S2500 M3
N110 X0 G81(IX Z,SL2,DT-5,RL2) F250 ; Parameter setting and 1st request
N120 X10                                  ; 2nd request
N120 X20                                  ; 3rd request
N130 G80 Z100 M5                          ; Delete Leaving modal request
```

If no position is programmed in the NC block N110, then a modal cycle will only be executed in the next NC block N120, in which a position has been programmed.

Program:

```
N100 G0 X0 Y0 Z100 S2500 M3
N110 G81(IX Z,SL2,DT-5,RL2) F250    ; Parameters setting
N120 X10                            ; 1st request
N120 X20                            ; 2nd request
N130 G80 Z100 M5                    ; Delete leaving modal request
```

Individual parameters cannot be modified with this type of programming. The setting of the parameters would then have to be completely reprogrammed. It is not necessary to delete the modal function between the individual bores with G80.

Program:

```
N100 G0 X0 Y0 Z100 S2500 M3
N110 X0 G81(IX Z,SL2,DT-5,RL2) F250 ; Parameter setting and
                                      1. Depth request -5  Retract height 2
N120 X10 G81(IX Z,SL2,DT-10,RL30)   ; 2nd Depth request -10  Retract height 30
N120 X20 G81(IX Z,SL2,DT-5,RL2)   ; 3rd Depth request -5  Retract height 2
N130 X30                            ; 4th Depth request -5   Retract height 2
N140 G80 Z100 M5                    ; Delete leaving modal request
```

If no parameters are specified in the cycle request, then the SD parameters will be used. In this way individual parameters can also be modified. SD parameters are permanent and channel-specific.

Program:

```
N100 G0 X0 Y0 Z100 S2500 M3
1 SD.SysCyc.SL=2 : SD.SysCyc.DT=-5 : SD.SysCyc.RL=2 : REM Parameter setting
N110 X0 G81 F250                    ; 1st Depth request -5  Retract height 2
2 SD.SysCyc.DT=-10 : SD.SysCyc.RL=30
N120 X10                            ; 2nd Depth request -10   Retract height 30
3 SD.SysCyc.DT=-5 : SD.SysCyc.RL=2
N120 X20                            ; 3rd Depth request -5   Retract height 2
N130 X30                            ; 4th Depth request -5   Retract height 2
N140 G80 Z100 M5                    ; Delete leaving modal request
```

3.4 User Cycles

Both the machinery manufacturer (OEM) and the end user have the option to create their own proprietary cycles. The following rules should be observed in order to be able to use MTX cycle functions (e.g. Export cycles).

Reserved directories on the controller

The machine manufacturer's cycles should be saved in the controller's data structure at ...\usr\mtb\Cycles.

The end user's cycles should be saved in the controller's data structure at ... \usr\user\Cycles.

Reserved directories on the PC or operating unit

The machine manufacturer's cycle headers, input images and texts should be filed in the project under ...\"Visualization unit" e.g. VPP40\OEM-Data\Cycles.

The end user's cycle headers, input images and texts should be filed in the project under ...\"Visualization unit" e.g. VPP40\user\Cycles.

There are various options when creating user cycles. The manual "Creating user cycles" should be followed to create user cycles and cycle headers.

Cycles with addressed parameters:

The user has the option to copy existing standard cycles, adapt them and use them as user cycles. The addressed parameters, permitted in the cycle, should be used for this (possibly additional user parameters). If a user cycle with the same name is created, then the standard cycle with the same name is no longer active.

☞ The cycle used is determined by the search path. Standard cycles should only be overwritten in exceptional cases.

G-commands from the listed groups, which have not yet been implemented, should not be used as these are reserved for future extensions of the standard cycles.

Cycles with position parameters:

The user can also create proprietary cycles G390 to G499 or using his own name without a G-command. In this event, the parameters are regarded as unaddressed position parameters (P1 to Pn).

3.5 Rigid Machine-Operator Cycles

A series of cycles are defined as rigid for the machine-operator. He can create cycles himself in program code without having to make changes to the controller's configuration data. The following rules should be adhered to in this regard:

Rules for rigid machine-operator cycles

G-codes G370 - G388 are reserved for modal cycles

G-codes G350 - G368 are reserved for local cycles

A rigid machine-operator cycle has up to 10 transfer parameters. It is up to the operator whether he wishes to use all of the parameters.

There are no standard input masks for rigid machine-operator cycles. Should masks have to be defined for these cycles, then they have to be described in the corresponding cycle header definition file.

The NC program name of the cycle is **USRCYCxxx**.

xxx is the respective number of the G-code (thus G382 has the NC program name USRCYC382).

☞ The content of the cycle depends on the machine-operator. The cycle is not protected against modifications.

The NC program has to be saved within the search path.

4 Drilling Cycles

4.1 General

The drilling cycles described in the following are modal and are thus also suitable for use with dot patterns. If the cycles are given without specification of the parameters, then the parameters from the assigned system variables will be used.

4.2 G81 Drilling

The modal cycle G81 is suitable, for example for drilling with NC spot drills or for drilling where swarf crushing and swarf removal are guaranteed.

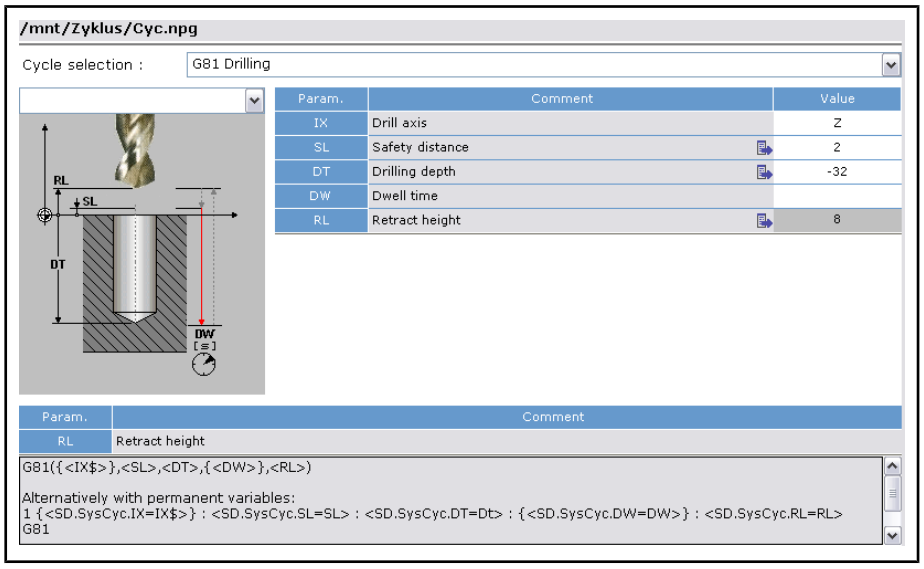

Fig.4-1: G81 Drilling

G81		Drilling	G81(IX,SL,DT,DW,RL)		
IX	SD.SysCyc.IX	Drill axis	string	optional	
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Drilling depth	real	obligatory	absolute
DW	SD.SysCyc.DW	Dwell time	real	optional	seconds
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute

Sequence diagram Sequence:

From the last programmed position of the drill axis, it is positioned in rapid traverse at the safety distance. From this point it travels with feed to the drilling depth. The feedrate value has to be programmed before or at the latest in the NC block of the cycle request. It is possible to work with G94 Feeds per min. or even, if the reference spindle rotates to the right or left, with G95 Feeds per revolution. If a dwell time (option) is specified, this runs in seconds once the drilling depth has been reached. Finally it travels in rapid traverse to the retract height position.

Example:

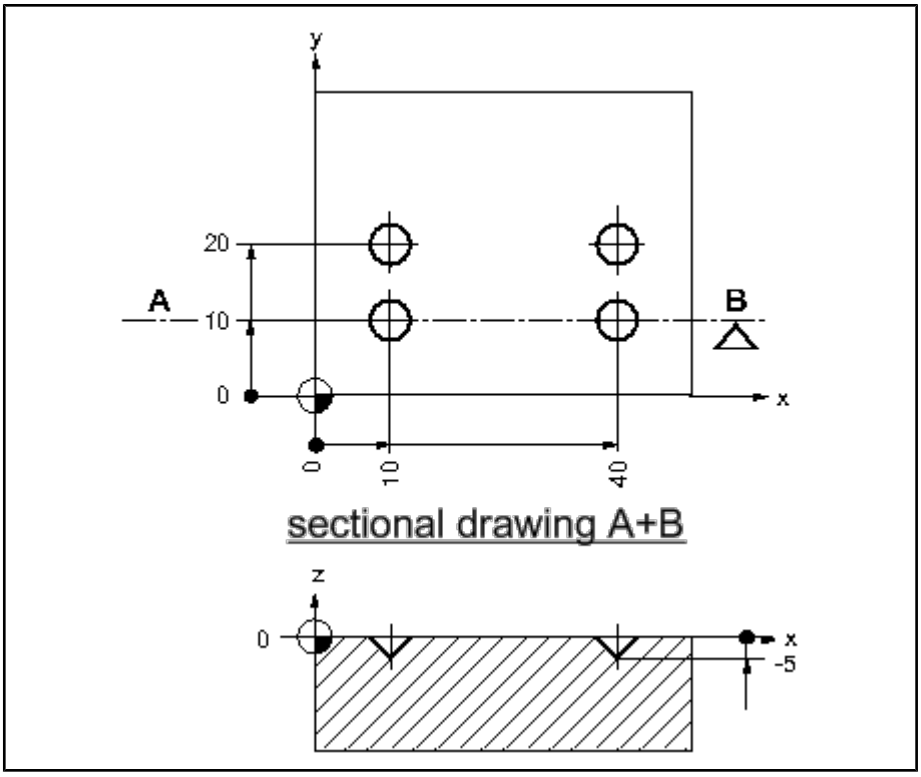

Fig.4-2: Example of G81 Drilling

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X10 Y10 Z100 S2500 M3       ; Pre-position
N30 G81(IX=Z,SL2,DT-5,DW1,RL10) F300   ; Cycle definition + Feed
N40 X10 Y10                            ; 1st Cycle request
N50 X10 Y20                            ; 2nd Cycle request
N60 X40 Y20                            ; 3rd Cycle request
N70 X40 Y10                            ; 4t Cycle request
N80 G80 Z100 M5                        ; Delete leaving modal request
```

4.3 G82 Countersinking

The modal cycle G82 is suitable for centering or drilling with double-edged centering or step drills.

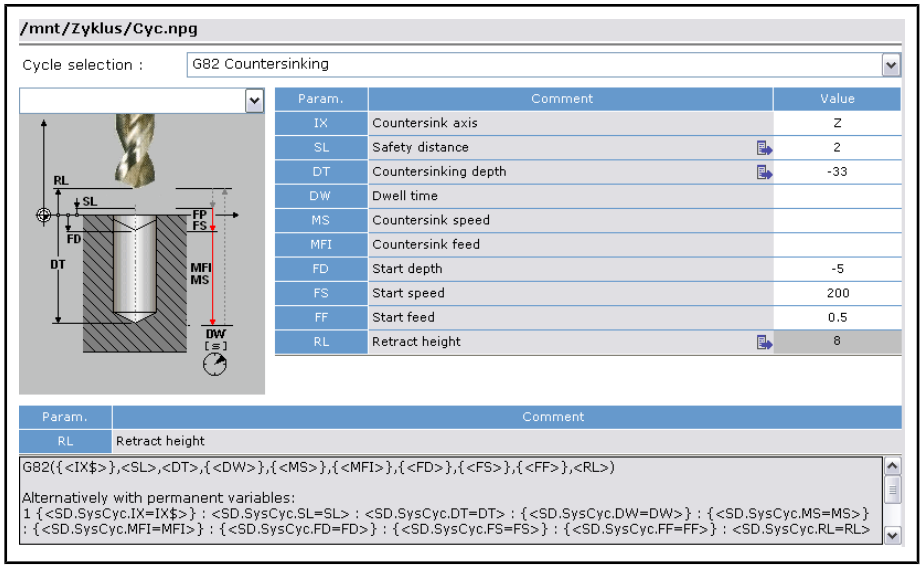

Fig.4-3: G82 Countersinking

G82		**Countersinking**	**G82(IX,SL,DT,DW,MS,MFI,FD,FS,FF,RL)**		
IX	SD.SysCyc.IX	Countersink axis	string	optional	
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Countersink depth	real	obligatory	absolute
DW	SD.SysCyc.DW	Dwell time	real	optional	seconds
MS	SD.SysCyc.MS	Countersink speed	real	optional	
MFI	SD.SysCyc.MFI	Countersink feed	real	optional	
FD	SD.SysCyc.FD	Start depth	real	optional	absolute
FS	SD.SysCyc.FS	Start speed	real	optional	
FF	SD.SysCyc.FF	Start feed	real	optional	
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute

Sequence diagram Sequence:

From the last programmed position of the countersink axis, it is positioned in rapid traverse at the safety distance. From this point it travels with the start feed and start speed to the start depth. This step cannot take place without specification of the start depth. It then travels with countersink feed and at countersink speed to the countersink depth. If no countersink feed is transferred in the cycle request, then a feedrate value has to be programmed beforehand or at the latest in the NC block of the cycle request. It is possible to work with G94 Feeds per min. or even, if the reference spindle rotates to the right or left, with G95 Feeds per revolution. If a dwell time (option) is specified, this runs in seconds once the countersink depth has been reached. Finally it travels in rapid traverse to the retract height position.

Example:

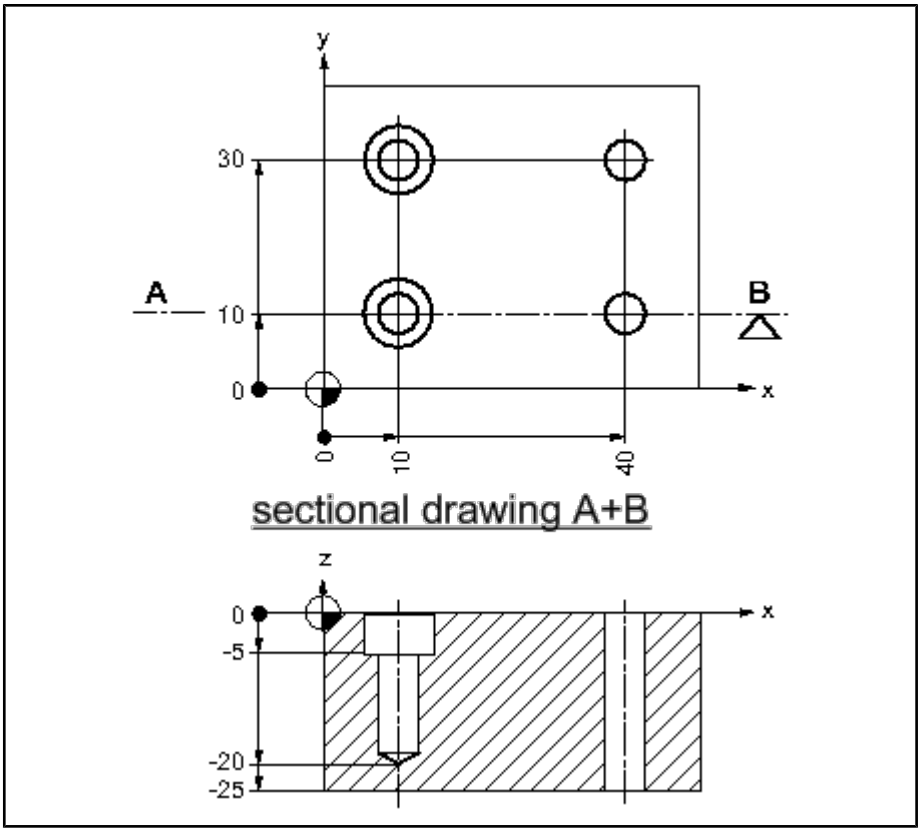

Fig.4-4: Example G82 Countersinking

Program:

```
N10 T1 M6                                ; Took change (Step drill)
N20 G17 G0 X10 Y10 Z100 M3               ; Pre-position
N30 G82(IX=Z,SL2,DT-20,DW1,MS1500,MFI250,FD-15,FS1000,FF150,RL10)
                                         ; Cycle definition
N40 X10 Y10                              ; 1st Cycle request
N60 X10 Y30                              ; 2nd Cycle request
N80 G80 Z100 M5                          ; Delete leaving modal request
```

4.4 G83 Deep Hole Drilling

The modal cycle G83 is suitable for the drilling of bores where swarf crushing and swarf removal has to be ensured.

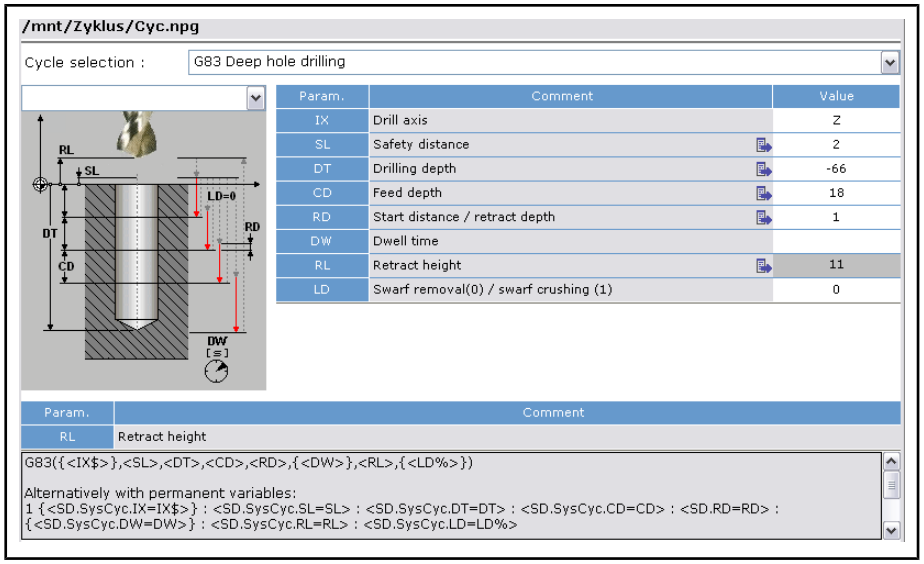

Fig.4-5: G83 Deep hole drilling

G83		**Deep hole drilling**	**G83(IX,SL,DT,CD,RD,DW,RL,LD)**		
IX	SD.SysCyc.IX	Drill axis	string	optional	
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Drilling depth	real	obligatory	absolute
CD	SD.SysCyc.CD	Feed depth	real	obligatory	incremental
RD	SD.SysCyc.RD	Start distance / retract depth	real	obligatory	incremental
DW	SD.SysCyc.DW	Dwell time	real	optional	seconds
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute
LD	SD.SysCyc.LD	Swarf crushing	integer	optional	Swarf removal (0) is pre-assigned Swarf removal (0) / Swarf crushing (1)

Sequence diagram Sequence:

From the last programmed position of the drill axis, it is positioned in rapid traverse at the safety distance. From from this point it drills with feed the value of the feed depth. Now, if swarf removal (0) has been programmed in LD, it is positioned in rapid traverse at the safety distance. Then it travels in rapid traverse to the respective feed depth, reduced by the start distance. If swarf crushing has been pre-selected in LD, it is raised by the retract height value. This process repeats itself until the drilling depth has been reached. The feedrate value has to be programmed before or at the latest in the NC block of the cycle request. It is possible to work with G94 Feeds per min. or even, if the reference spindle rotates to the right or left, with G95 Feeds per revolution. If a dwell time (option) is specified, this runs in seconds once the drilling depth has been reached. Finally it travels in rapid traverse to the retract height position.

Example:

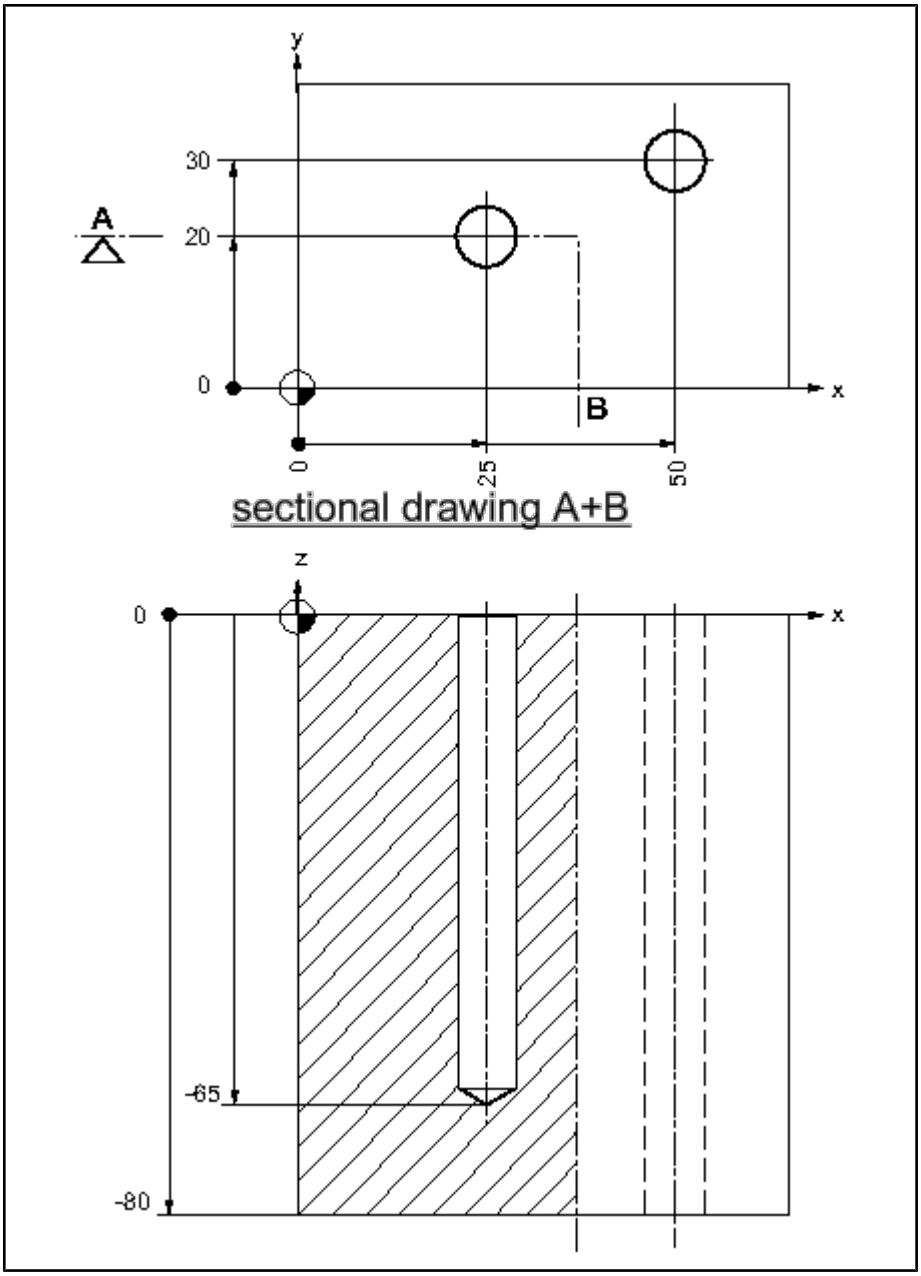

Fig.4-6: Example G83 Deep hole drilling

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X25 Y20 Z100 S2500 M3       ; Pre-position
N30 G83(IX=Z,SL2,DT-65,CD15,RD1,DW1,RL10,LD0) F300
                                       ; Cycle definition + Feed
N40 X25 Y20                            ; 1st Cycle request
N50 G83(IX=Z,SL2,DT-85,CD15,RD1,DW1,RL10,LD0)
                                       ; Cycle definition + Feed
N60 X50 Y30                            ; 2nd Cycle request
N70 G80 Z100 M5                        ; Delete leaving modal request
```

4.5 G84 Tapping

The modal cycle G84 is suitable for the making of tappings, where swarf crushing and swarf removal are ensured.

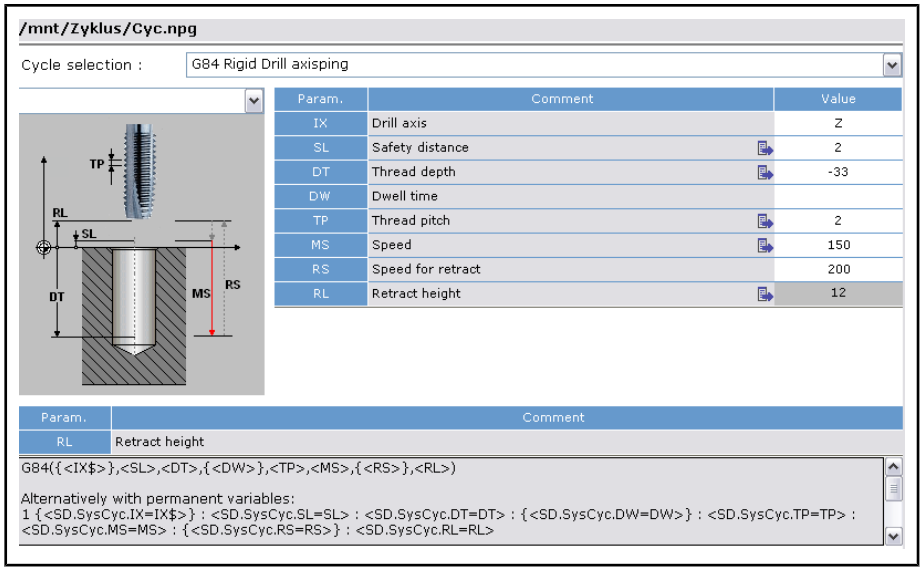

Fig.4-7: G84 Tapping without compensating chuck

G84		**Tapping without compensating chuck**	**G84(IX,SL,DT,DW,TP,MS,RS,RL)**		
IX	SD.SysCyc.IX	Drill axis	string	optional	
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Thread height	real	obligatory	absolute
DW	SD.SysCyc.DW	Dwell time	real	optional	seconds
TP	SD.SysCyc.TP	Thread pitch	real	obligatory	
MS	SD.SysCyc.MS	Speed	real	obligatory	revolutions
RS	SD.SysCyc.RS	Speed for retract	real	optional	revolutions
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute

Sequence diagram Sequence:

From the last programmed position of the drill axis, it is positioned in rapid traverse at the safety distance. From this point, it travels with the last programmed speed and the specified thread pitch to the thread height. The reference spindle should be programmed before the cycle request with TSP. A left-hand thread can be produced by the specification of a negative pitch and a right-hand thread by the specification of a positive pitch. If a dwell time (optional) is specified in seconds, this runs once the thread depth has been reached. It then returns in a counter direction at the same speed or, if specified, at the speed for retract to the safety distance. Finally there is travel in rapid traverse to the retract height position.

Drilling Cycles

Example:

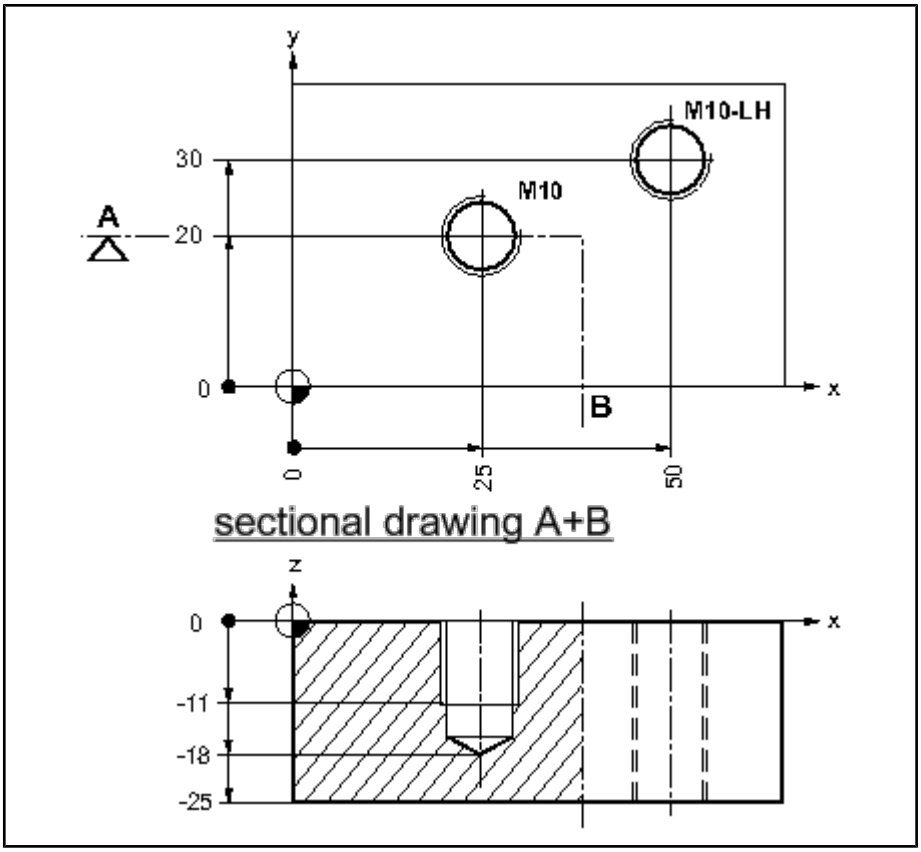

Fig.4-8: Motion sequence G84 Tapping

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X25 Y20 Z100 M35           ; Pre-position
N30 TSP(CAX3)                          ; Reference spindle 3
N40 G84(IX=Z,SL2,DT-11,TP1.5,MS300,RS600,RL10)
                                       ; Cycle definition
N50 X25 Y20                            ; 1st Cycle request
N60 G84(IX=Z,SL2,DT-30,TP-1.5,MS300,RS600,RL10)
                                       ; Cycle definition
N70 X50 Y30                            ; 2nd Cycle request
N80 G80 Z100 M5                        ; Delete leaving modal request
```

4.6 G85 Reaming

The modal cycle G85 is suitable for making finely-tolerated bores with a reamer.

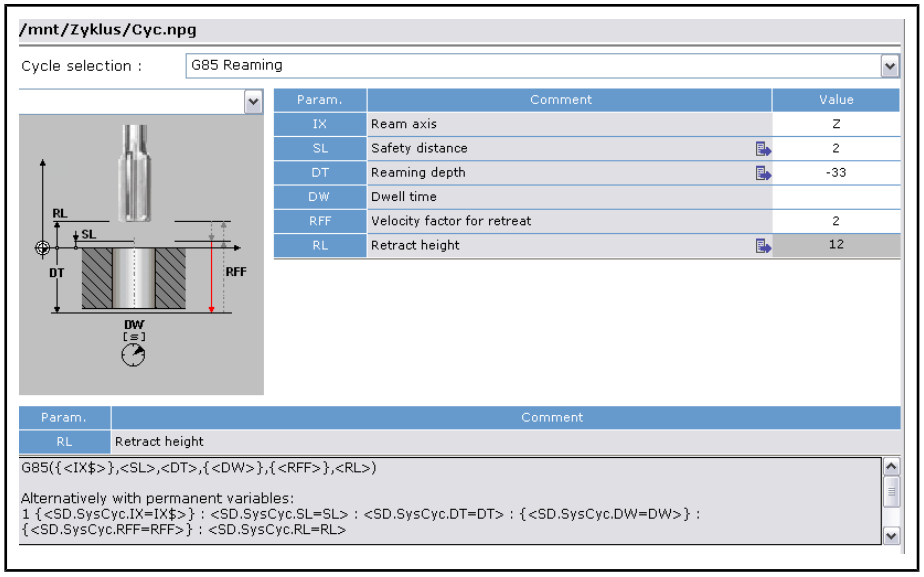

Fig.4-9: G85 Drilling

G85		Reaming	G85(IX,SL,DT,DW,RFF,RL)		
IX	SD.SysCyc.IX	Ream axis	string	optional	
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Reaming depth	real	obligatory	absolute
DW	SD.SysCyc.DW	Dwell time	real	optional	seconds
RFF	SD.SysCyc.RFF	Velocity factor for retract	real	optional	
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute

Sequence diagram Sequence:

From the last programmed position of the ream axis, it is positioned in a rapid traverse at the safety distance. From this point it travels with feed to the reaming depth. The feedrate value has to be programmed before or at the latest in the NC block of the cycle request. It is possible to work with G94 Feeds per min. or even, if the reference spindle rotates to the right or left, with G95 Feeds per revolution. If a dwell time (optional) is specified in seconds, this runs once the reaming depth has been reached. Then it travels to the position safety distance at the same feed or, if a velocity factor for retract has been specified, with increased feed and then travels the retract height with rapid traverse.

Drilling Cycles

Example:

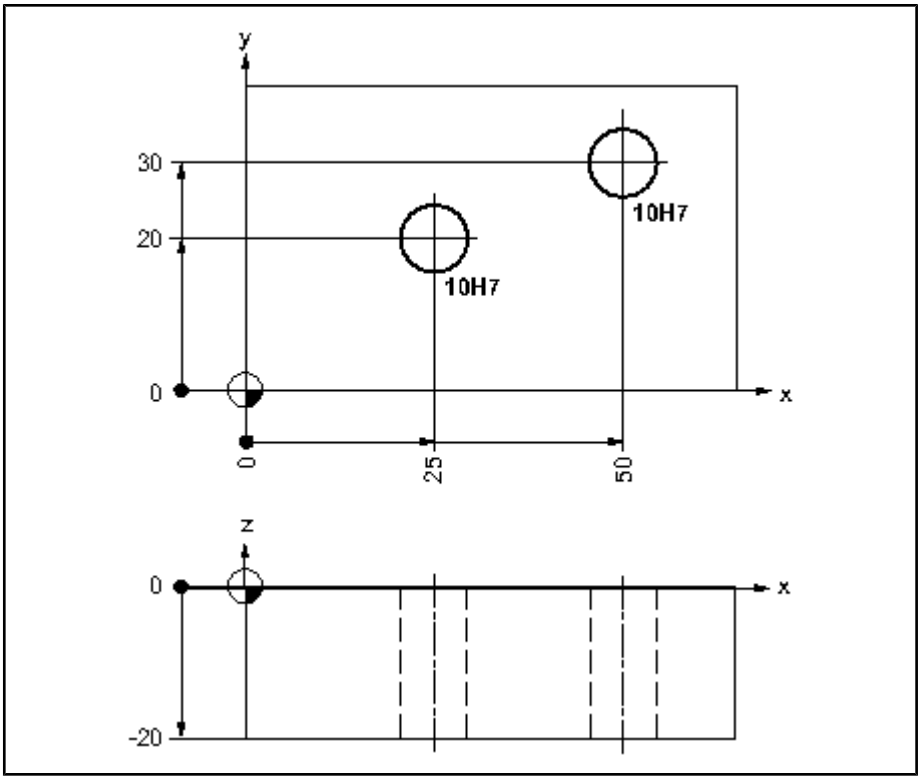

Fig.4-10: Example G85 Reaming

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X25 Y20 Z100 S1000 M3       ; Pre-position
N30 G85(IX=Z,SL2,DT-25,DW1,RFF20,RL10) F150
                                       ; Cycle definition
N40 X25 Y20                            ; 1st Cycle request
N50 X50 Y30                            ; 2nd Cycle request
N60 G80 Z100 M5                        ; Delete leaving modal request
```

4.7 G86 Boring

The modal cycle G86 is suitable for boring finely-tolerated bores with a finishing tool.

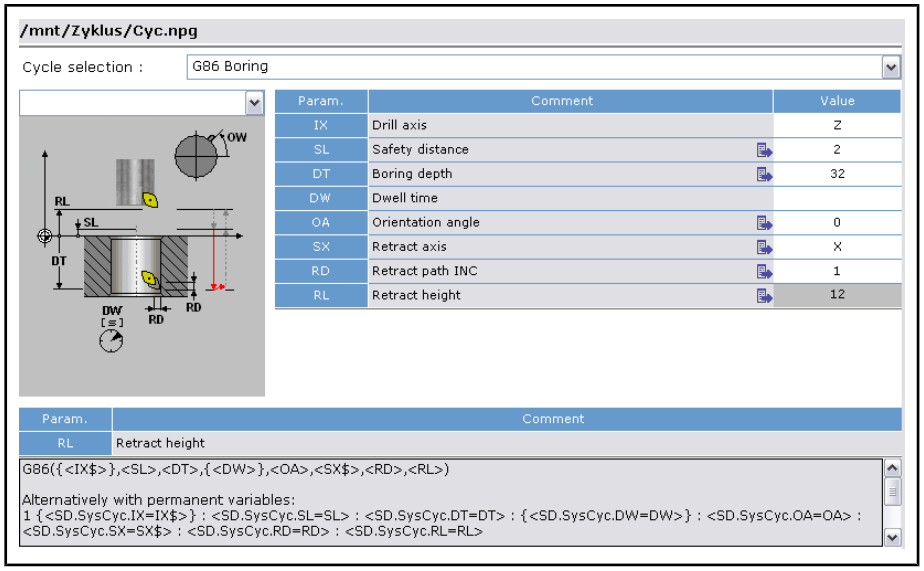

Fig.4-11: G86 Boring

G86		Boring	G86(IX,SL,DT,DW,OA,SX,RD,RL)		
IX	SD.SysCyc.IX	Drill axis	string	optional	
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Boring depth	real	obligatory	absolute
DW	SD.SysCyc.DW	Dwell time	real	optional	seconds
OA	SD.SysCyc.OA	Orientation angle	real	obligatory	absolute
SX	SD.SysCyc.SX	Retract axis	string	obligatory	
RD	SD.SysCyc.RD	Retract path	real	obligatory	incremental
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute

Sequence diagram Sequence:

From the last programmed position of the drill axis, it is positioned in rapid traverse at the safety distance. From this point it travels with feed to the drilling depth. The feedrate value has to be programmed before or at the latest in the NC block of the cycle request. It is possible to work with G94 Feeds per min. or, if the reference spindle rotates to the right or left, with G95 Feeds per revolution. If a dwell time (option) is specified in seconds, this runs once the drilling depth has been reached. Now the spindle is stopped at the orientation angle and returns along the retract path in the programmed retract axis and the drilling axis in order to clear the edge with an angle of 45°. Finally it travels in rapid traverse to the retract height position. The positioning and reactivation of the spindle over the center of the bore end the cycle.

Example:

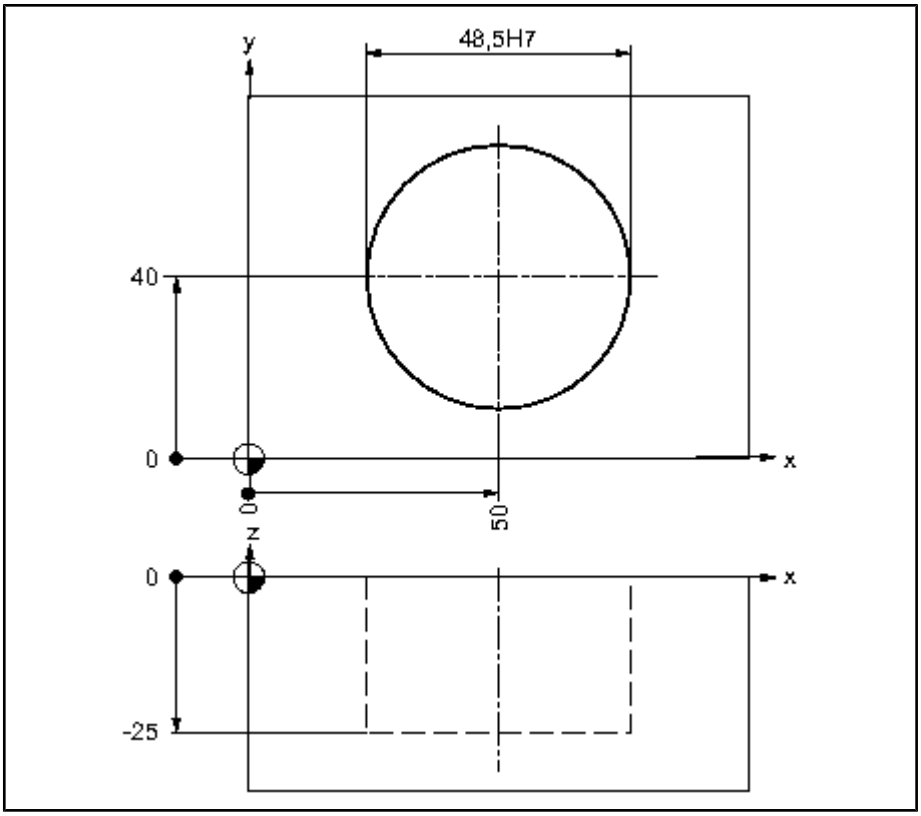

Fig.4-12: Example G86 Boring

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X25 Y40 Z100 S2500 M3       ; Pre-position
N30 G86(IX=Z,SL2,DT-25,DW1,OA0,SX=X,RD1,RL10) F300
                                       ; Cycle definition + Feed
N40 X50 Y10                            ; 1st Cycle request
N50 G80 Z100 M5                        ; Delete leaving modal request
```

4.8 G87 Back Boring

The modal cycle G87 is suitable for back boring finely-tolerated bores with a back boring tool.

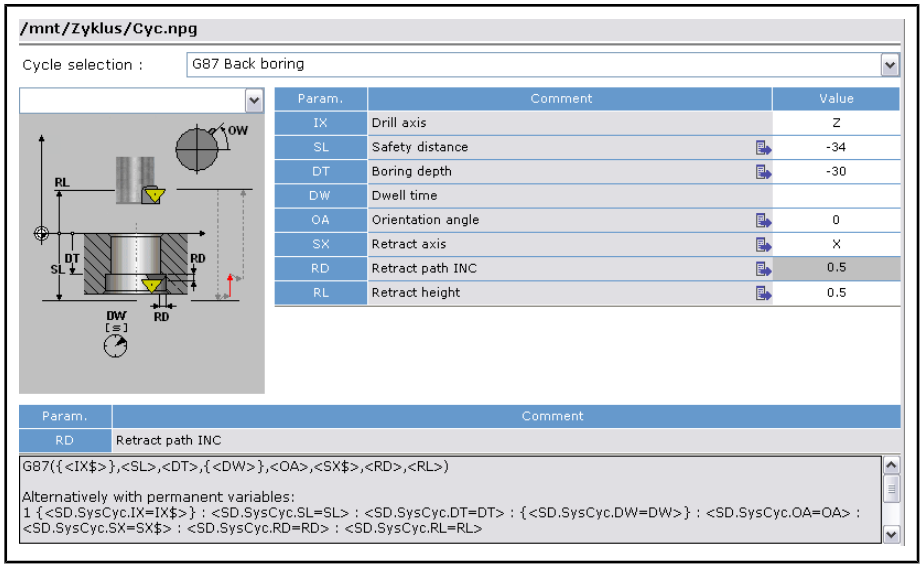

Fig.4-13: G87 Back boring

G87		**Back boring**	**G87(IX,SL,DT,DW,OA,SX,RD,RL)**		
IX	SD.SysCyc.IX	Drill axis	string	optional	
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Back boring depth	real	obligatory	absolute
DW	SD.SysCyc.DW	Dwell time	real	optional	seconds
OA	SD.SysCyc.OA	Orientation angle	real	obligatory	absolute
SX	SD.SysCyc.SX	Retract axis	string	obligatory	
RD	SD.SysCyc.RD	Retract path	real	obligatory	incremental
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute

Sequence diagram Sequence:

From the last programmed position of the drill axis, the spindle is stopped at the orientation angle and returns the retract path in the programmed retract axis. Now it is positioned in rapid traverse with the orientated spindle at the safety distance. Then it travels the retract path along the retract axis so that the spindle is now stationary in the center of the bore. From this point it travels with feed to the back boring depth. The feedrate value has to be programmed before or at the latest in the NC block of the cycle request. It is possible to work with G94 Feeds per min. or, if the reference spindle rotates to the right or left, with G95 Feeds per revolution. If a dwell time (optional) is specified in seconds, this runs once the back boring depth has been reached. Now the spindle is stopped at the orientation angle and returns along the retract path in the programmed retract axis and the drilling axis in order to clear the edge with an angle of 45°. Finally it travels in rapid traverse to the retract height position. The positioning and reactivation of the spindle over the center of the bore end the cycle.

Example:

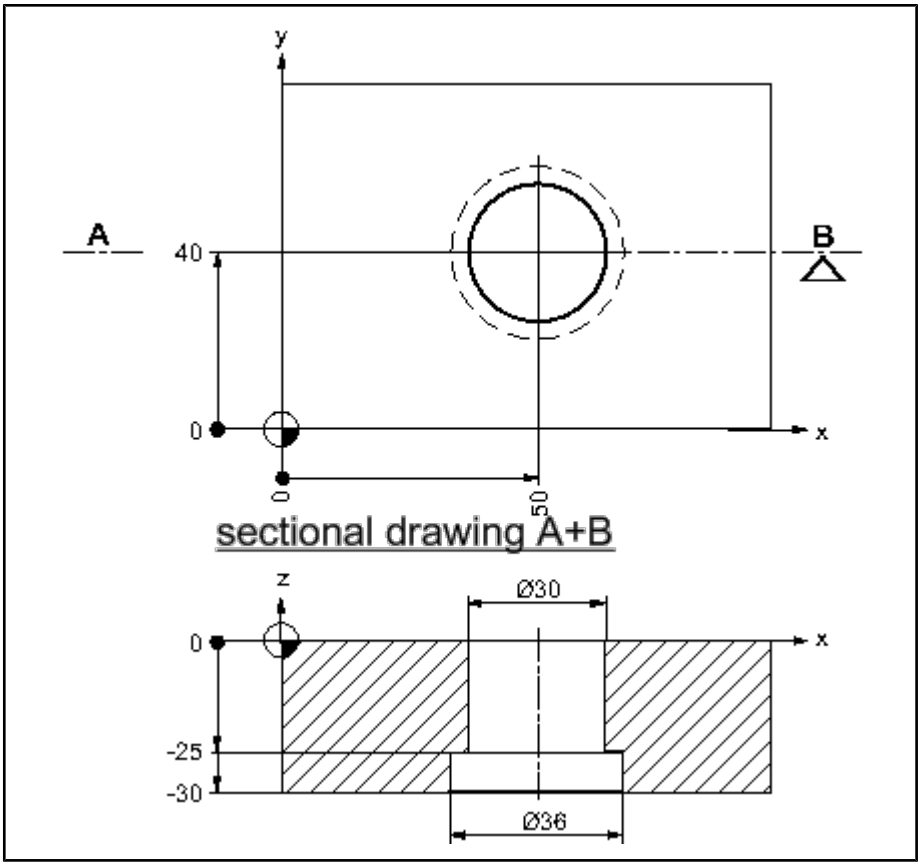

Fig.4-14: Example G87 Back boring

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X25 Y40 Z100 S2500 M3       ; Pre-position
N30 G87(IX=Z,SL-32,DT-25,DW1,OA0,SX=X,RD1,RL10) F300

N40 X50 Y10                            ; 1st Cycle request
N50 G80 Z100 M5                        ; Delete leaving modal request
```

4.9 G88 Spot Drilling

The modal cycle G88 is suitable for making deeper bores with deep hole drills with internal cooling.

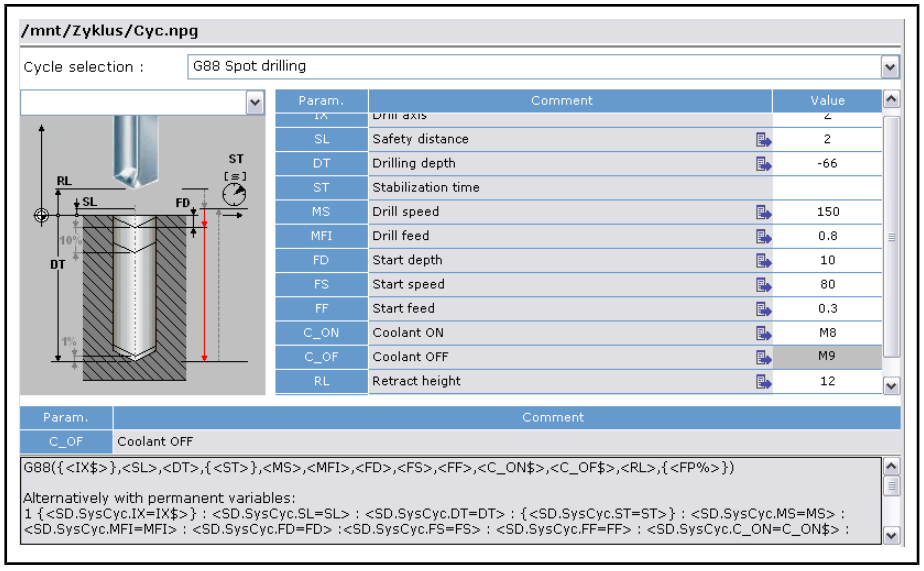

Fig.4-15: G88 Spot drilling

G88		**Spot drilling**	**G88(IX,SL,DT,ST,MS,MFI,FD,FS,FF, C_ON,C_OF,RL,FP)**		
IX	SD.SysCyc.IX	Drill axis	string	optional	
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Drilling depth	real	obligatory	absolute
ST	SD.SysCyc.ST	Stabilization time	real	optional	seconds
MS	SD.SysCyc.MS	Drill speed	real	obligatory	revolutions
MFI	SD.SysCyc.MFI	Drill feed	real	obligatory	mm/min
FD	SD.SysCyc.FD	Start depth	real	obligatory	absolute
FS	SD.SysCyc.FS	Start speed	real	obligatory	revolutions
FF	SD.SysCyc.FF	Start feed	real	obligatory	mm/U
C_ON	SD.SysCyc.C_ON	Coolant ON	string	obligatory	Auxiliary function
C_OF	SD.SysCyc.C_OF	Coolant OFF	string	obligatory	Auxiliary function
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute
FP	SD.SysCyc.FP	Start drill speed and drill feed in %	integer	optional	50%-100% pre-assigned with 100 Effective for the first 10 % of the drill path
The retract path until the spindle stops 1 % of the depth is calculated.					

Sequence diagram Sequence:

From the last programmed position of the drill axis, it is positioned in rapid traverse at the safety distance. If a stabilization time is specified, the drill is stabilized by switching on the coolant for this time with the spindle stationary and then the coolant is switched off again. The drill now travels in a counter direction with the start speed and start feed to the start depth of the pilot bore. The coolant is switched on there and the spindle starts in the cutting direction at the start drill speed given by FP. The start feed and start speed are now increased in a linear fashion during the first 10 % of the drilling depth up to the

drill speed and drill feed. From this point it travels with drill feed and drill speed to the drilling depth. It is only possible to work with G94 Feeds per min. Once the drilling depth has been reached, it is retracted in rapid traverse by 1% of the drilling depth, the coolant is switched off and, with the spindle stationary, it travels with rapid traverse to the retract height position.

Example:

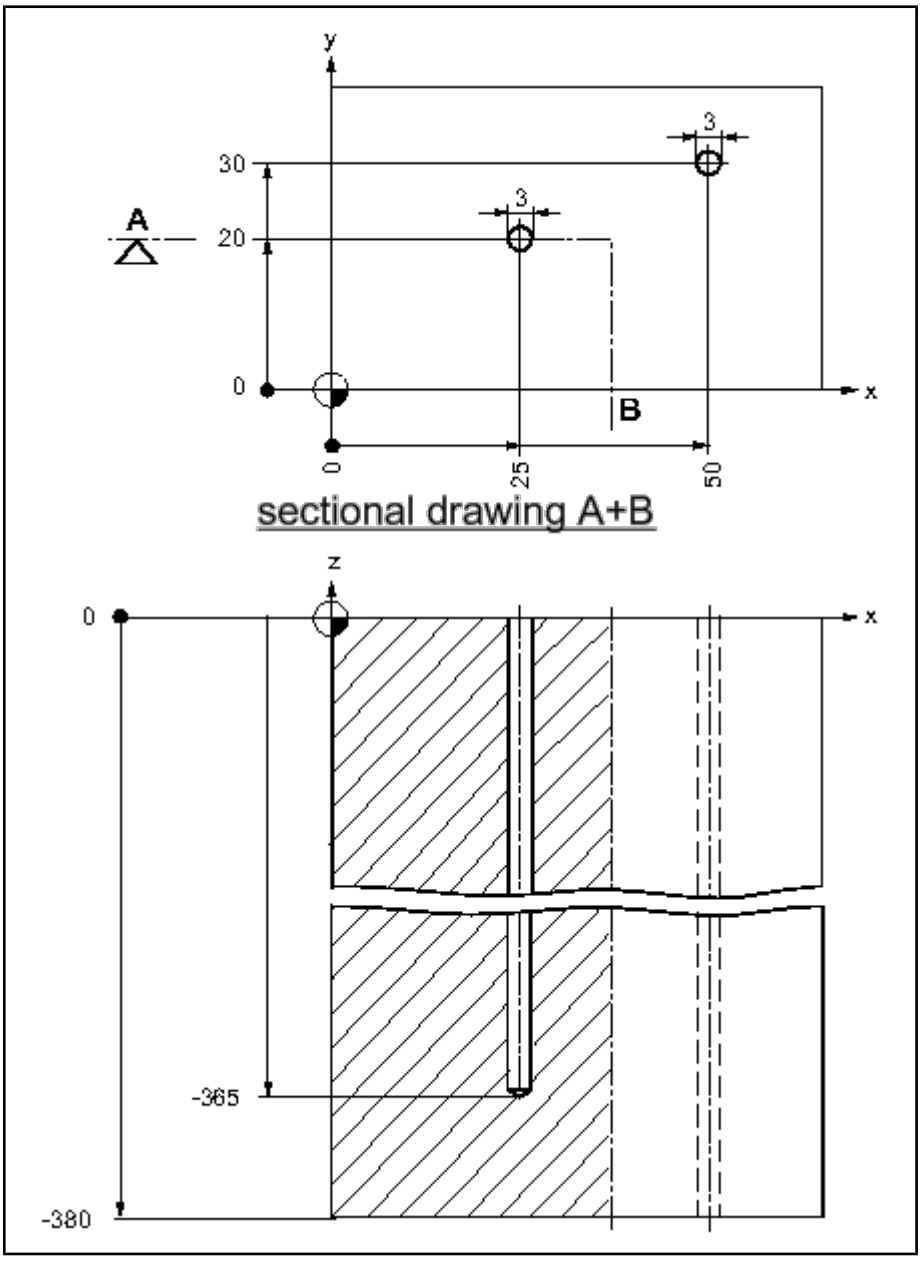

Fig.4-16: Example G88 Spot drilling

Program:

```
N10 T1 M6                           ; Took change (Step drill)
N20 G17 G0 X25 Y20 Z100 S0 M3                          ; Pre-position
N30 G88(IX=Z,SL2,DT-365,ST5,MS5000,MFI500,FD-15,FS50,FF250,C_ON=M8,
    C_OF=M9,RL10,FP80)
                                    ; Cycle definition
N40 X25 Y20                         ; 1st Cycle request
N60 X50 Y30                         ; 2nd Cycle request
N80 G80 Z100 M5                     ; Delete leaving modal request
```

4.10 G89 Tapping with Swarf Crushing

The modal cycle G89 is suitable for the making of tappings where swarf crushing and swarf removal have to be ensured.

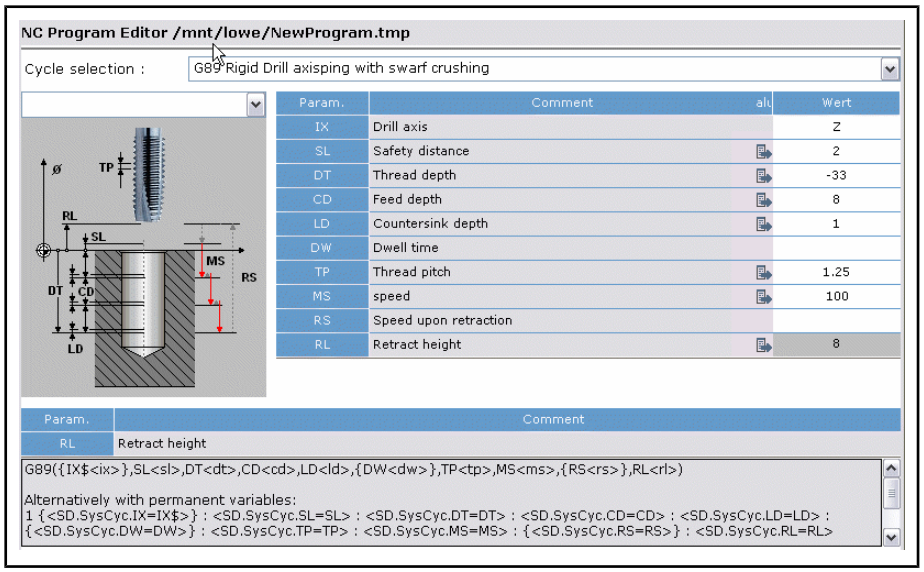

Fig.4-17: G89 Rigid tapping with swarf crushing

G89		**Tapping with swarf crushing**	**G89(IX,SL,DT,CD,LD,DW,TP,MS,RS,RL)**		
IX	SD.SysCyc.IX	Drill axis	string	optional	
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Thread height	real	obligatory	absolute
CD	SD.SysCyc.CD	Feed depth	real	obligatory	incremental
LD	SD.SysCyc.LD	Retract distance	real	obligatory	incremental
DW	SD.SysCyc.DW	Dwell time	real	optional	seconds
TP	SD.SysCyc.TP	Thread pitch	real	obligatory	
MS	SD.SysCyc.MS	Speed	real	obligatory	revolutions
RS	SD.SysCyc.RS	Speed for retract	real	optional	revolutions
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute

Sequence diagram Sequence:

From the last programmed position of the drill axis, it is positioned in rapid traverse at the safety distance. From this point, it travels at the last programmed speed and the specified thread pitch to the feed depth. Then, the retract distance is traveled incrementally at the speed for retract. This process repeats itself until the thread height has been reached. The reference spindle should be programmed before the cycle request with TSP. A left-hand thread can be produced by the specification of a negative pitch and a right-hand thread by the specification of a positive pitch. If a dwell time (optional) is specified in seconds, this runs once the thread depth has been reached. The spindle then returns in a counter direction at the same speed, or if specified, at the speed for retract, to the safety distance. Finally it travels in rapid traverse to the retract height position.

Drilling Cycles

Example:

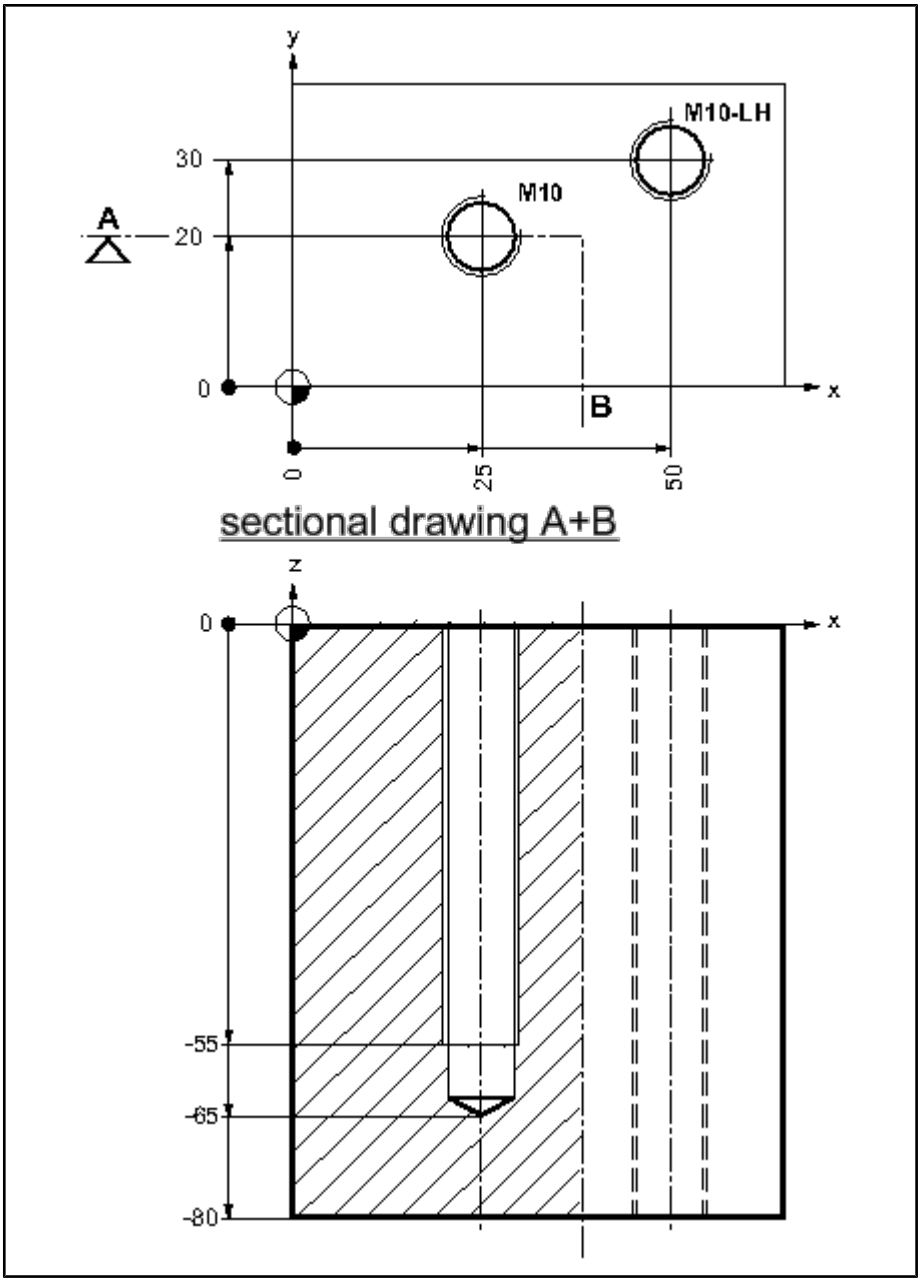

Fig.4-18: Example G89 Rigid tapping with swarf crushing

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X25 Y20 Z100 M35           ; Pre-position
N30 TSP(CAX3)                          ; Reference spindle 3
N40 G89(IX=Z,SL2,DT-55,CD15,LD1,TP1.5,MS300,RS600,RL10)
                                       ; Cycle definition
N50 X25 Y20                            ; 1st Cycle request
N60 G84(IX=Z,SL2,DT-85,CD15,LD1,TP-1.5,MS300,RS600,RL10)
                                       ; Cycle definition
N70 X50 Y30                            ; 2nd Cycle request
N80 G80 Z100 M5                        ; Delete leaving modal request
```

5 Bore Patterns

5.1 General

Modal cycles can be performed simply with the bore patterns described in the following.

5.2 G111 Bore Circle Rotary Axis

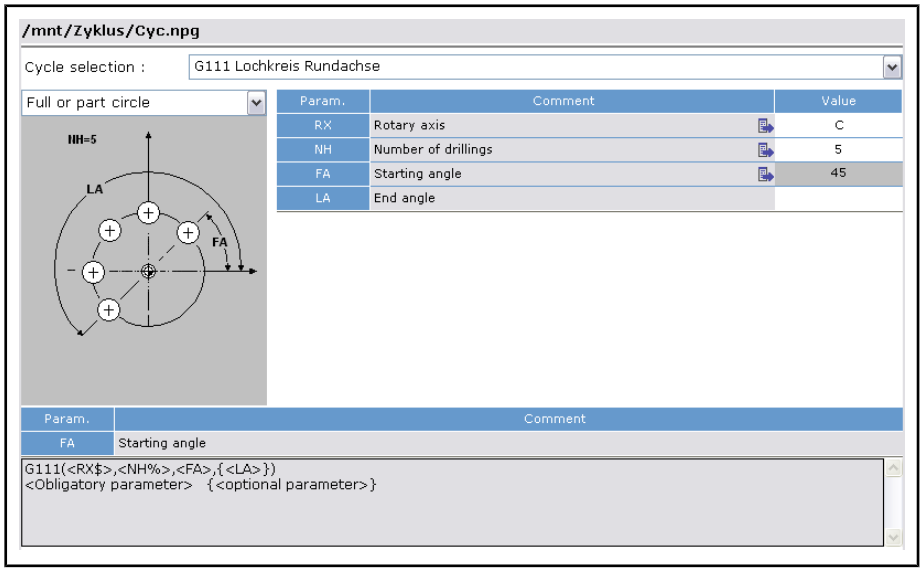

Fig.5-1: G111 Bore circle rotary axis

G111		Bore circle rotary axis	G111(RX,NH,FA,LA)		
RX	SD.SysG111.RX	Rotary Axis	string	obligatory	
NH	SD.SysG111.NH	Number of drillings	integer	obligatory	
FA	SD.SysG111.FA	Starting angle	real	obligatory	degrees
LA	SD.SysG111.LA	End angle	real	optional	degrees

Sequence: The modal drilling cycle programmed before the cycle request is performed at every position given by the starting parameters. If no end angle is specified, a full circle is assumed and it is always traveled in a positive direction. Only a part circle can be produced by inputting the end angle. If the start angle is larger than the end angle, then the travel is in a negative direction. Thus a bore circle can also be produced in a negative direction.

Sequence diagram:

Bore Patterns

Example 1:

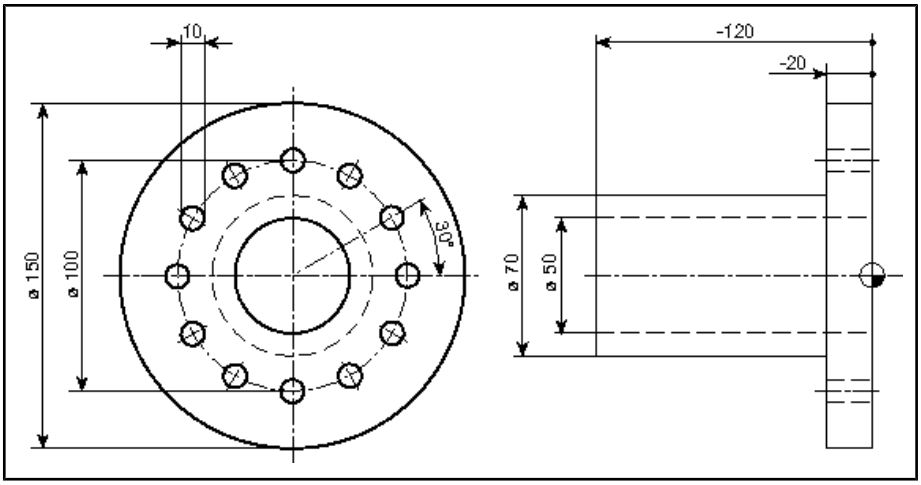

Fig.5-2: Example G111 Rotary axis (full circle)

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X50 Y50 Z100 S2500 M3       ; Pre-position
N30 G81(IX=Z,SL2,DT-22,DW1,RL10) F300  ; Cycle definition + Feed
N40 G111(RX=C,NH12,FA0,LA330)          ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

Example 2:

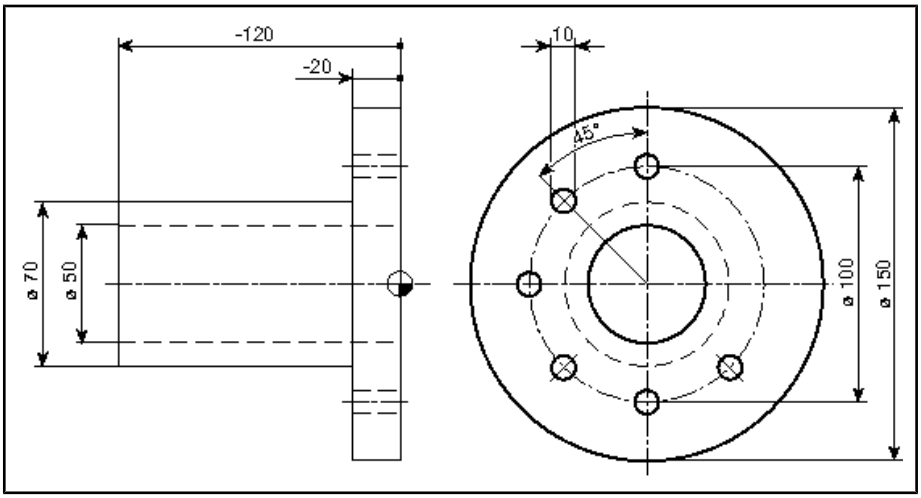

Fig.5-3: Example G111 Rotary axis (part circle)

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X50 Y50 Z100 S2500 M3       ; Pre-position
N30 G81(IX=Z,SL2,DT-22,DW1,RL10) F300  ; Cycle definition + Feed
N40 G111(RX=C,NH6,FA90,LA315)          ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

5.3 G112 Bore Circle Master Spindle

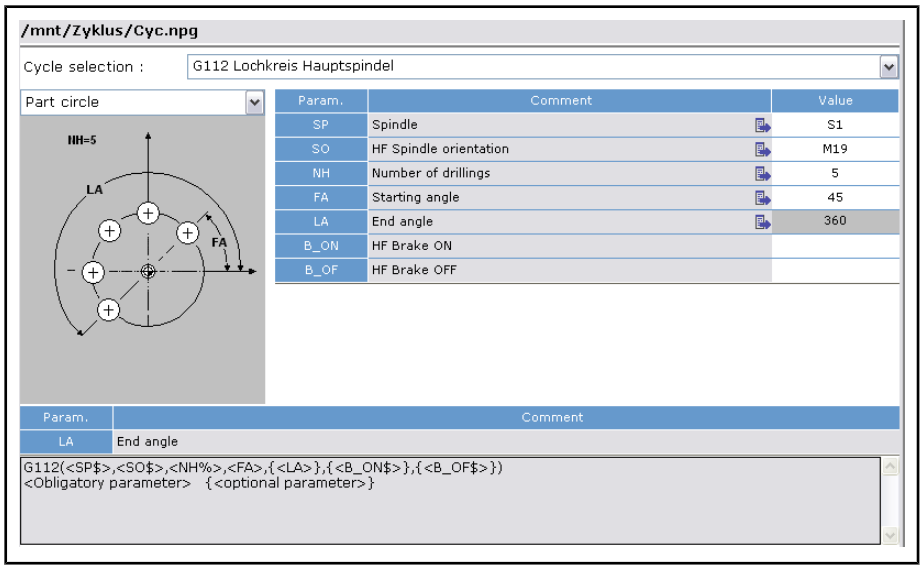

Fig.5-4: G112 Bore circle master spindle

G112		**Bore circle master spindle**	**G112(SP,SO, NH,FA,LA,B_ON,B_OF)**		
SP	SD.SysG112.SP	Spindle identifier	string	obligatory	
SO	SD.SysG112.SO	Spindle orientation	string	obligatory	auxiliary function
NH	SD.SysG112.NH	Number of drillings	integer	obligatory	
FA	SD.SysG112.FA	Starting angle	real	obligatory	degrees
LA	SD.SysG112.LA	End angle	real	optional	degrees
B_ON	SD.SysG112.B_ON	Spindle brake ON	string	optional	Auxiliary function
B_OF	SD.SysG112.B_OF	Spindle brake OFF	string	optional	Auxiliary function

Sequence: The modal drilling cycle programmed before the cycle request is performed at every spindle position given by the starting parameters. It is possible with the optional input of the auxiliary functions for the spindle brake to clamp the spindle during drilling. If no end angle is specified, a full circle is assumed and is always traveled in a positive direction. Only a part circle can be produced by inputting the end angle. If the start angle is larger than the end angle, then the travel is in a negative direction. Thus a bore circle can also be produced in a negative direction.

Bore Patterns

Example 1:

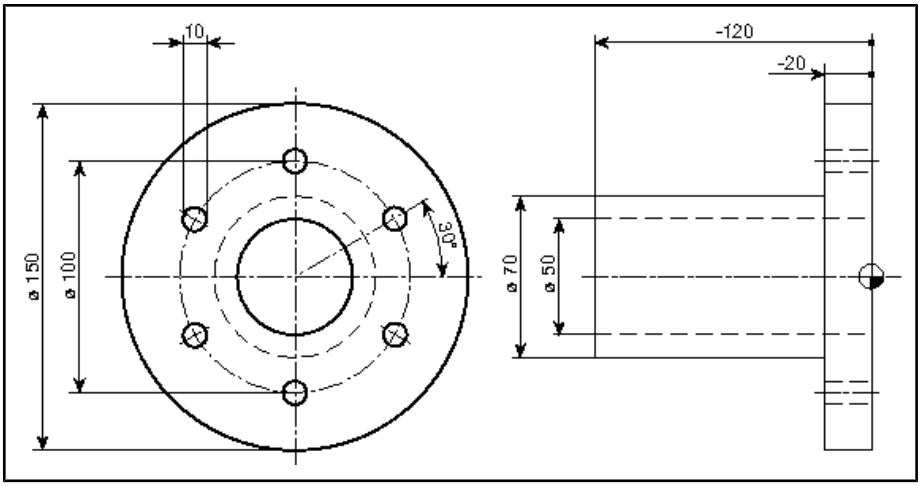

Fig.5-5: Example G112 Master spindle (full circle)

Program:

```
N10 T1 M6                              ; Took change
N20 G18 G0 X50 Y50 Z100 M5              ; Pre-position
N30 G81(IX=Z,SL2,DT-22,DW1,RL10) F300     ; Cycle definition + Feed
N40 G112(SP=S,SO=M19,NH6,FH30,LA330,B_ON=M10,B_OF=M11)
                                        ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

Example 1:

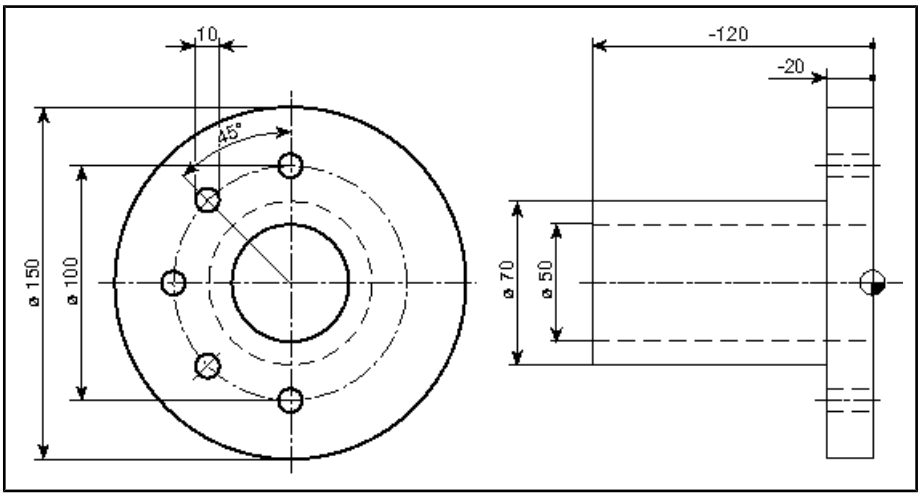

Fig.5-6: Example G112 Master spindle (part circle)

Program:

```
N10 T1 M6                              ; Took change
N20 G18 G0 X50 Y50 Z100 M5              ; Pre-position
N30 G81(IX=Z,SL2,DT-22,DW1,RL10) F300  ; Cycle definition + Feed
N40 G112(SP=S,SO=M19,NH5,FH90,LA270,B_ON=M10,B_OF=M11)
                                        ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

5.4 G113 Bore Circle Plane

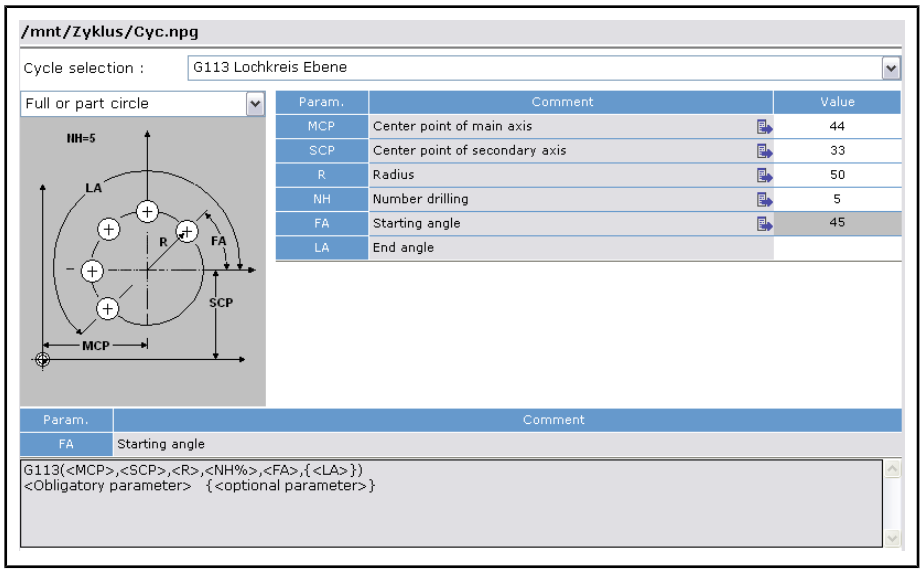

Fig.5-7: G113 Bore circle plane

G113		**Bore circle plane**	**G113(MCP,SCP,R,NH,FA,LA)**		
MCP	SD.SysG113.MCP	Center point of main axis	real	obligatory	
SCP	SD.SysG113.SCP	Center point of secondary axis	real	obligatory	
R	SD.SysG113.R	Radius	real	obligatory	
NH	SD.SysG113.NH	Number of drillings	integer	obligatory	
FA	SD.SysG113.FA	Starting angle	real	obligatory	degrees
LA	SD.SysG113.LA	End angle	real	optional	degrees

Sequence: The modal drilling cycle programmed before the cycle request is performed at every position given by the starting parameters. If no end angle is specified, a full circle is assumed and is always traveled in a positive direction. Only a part circle can be produced by inputting the end angle. If the start angle is larger than the end angle, then the travel is in a negative direction. Thus a bore circle can also be produced in a negative direction.

Bore Patterns

Example 1:

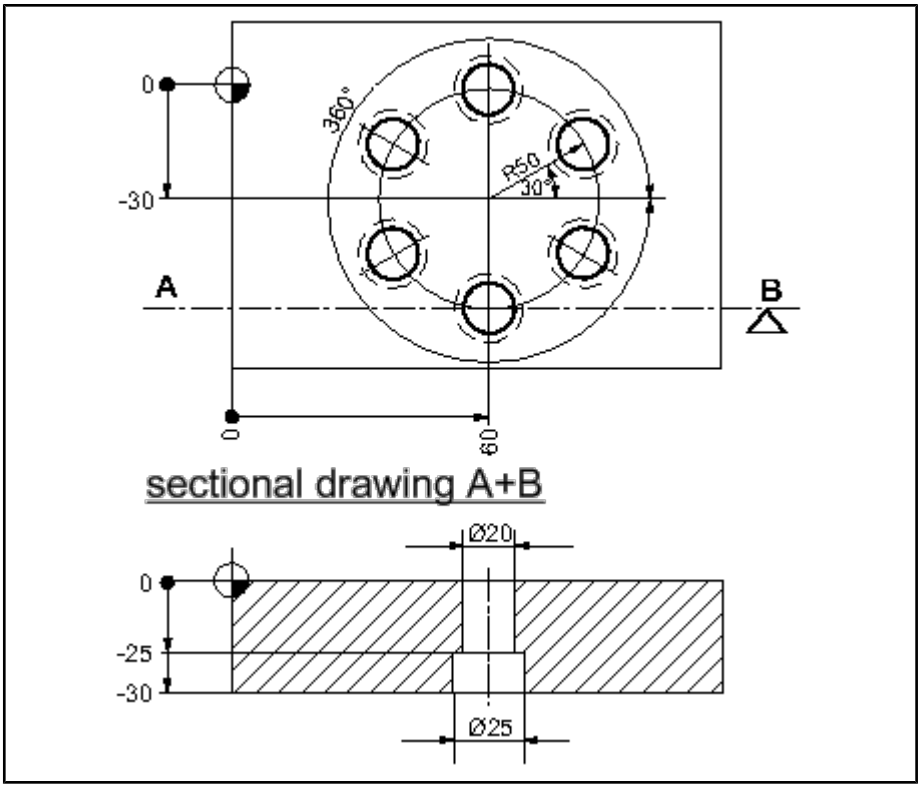

Fig.5-8: Example G113 Bore circle plane (full circle)

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X60 Y-30 Z100 S2500 M3       ; Pre-position
N30 G87(IX=Z,SL-32,DT-25,DW1,OA0,SX=X,RD1,RL10) F300
                                        ; Cycle definition + Feed
N40 G113(MCP60,SCP-30,R50,NH6,FA30,LA330)
                                        ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

Example 2:

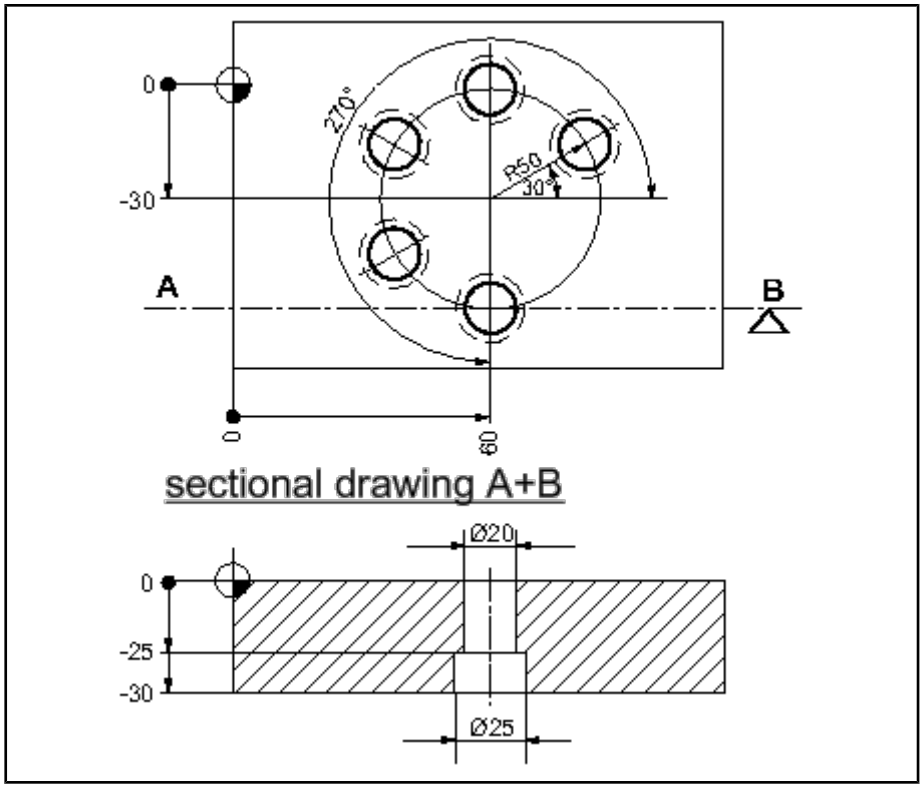

Fig.5-9: Example G113 Bore circle plane (part circle)

Program:

```
N10 T1 M6                                ; Took change
N20 G17 G0 X60 Y-30 Z100 S2500 M3        ; Pre-position
N30 G87(IX=Z,SL-32,DT-25,DW1,OA0,SX=X,RD1,RL10) F300
                                         ; Cycle definition + Feed
N40 G113 (MCP60,SCP-30,R50,NH5,FA30,LA270)
                                         ; Cycle definition
N50 G80 Z100 M5                         ; Delete leaving modal request
```

5.5 G114 Bore Pattern Line

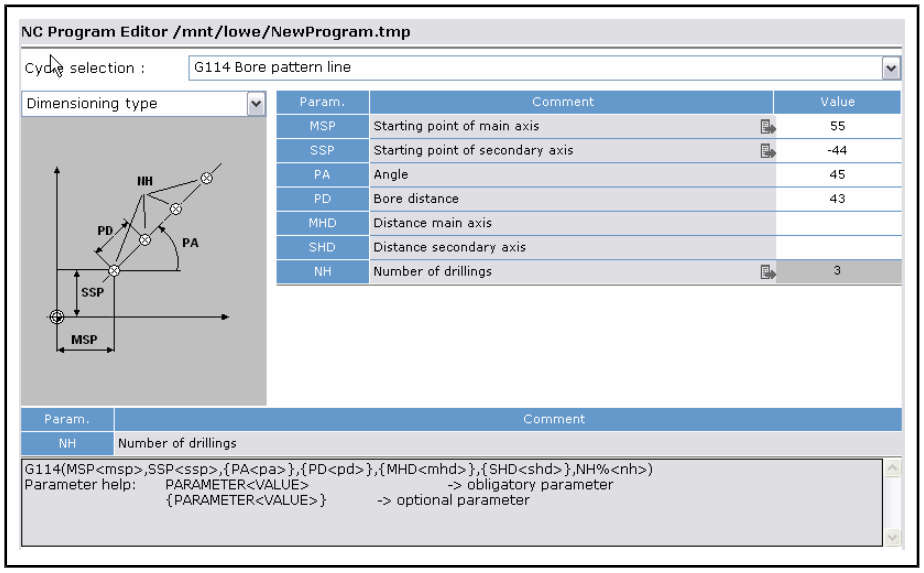

Fig.5-10: G114 Bore pattern line

Bore Patterns

G114		Bore pattern line	G114(MSP,SSP,PA,PD,MHD,SHD,NH)		
MSP	SD.SysG114.MSP	Starting point of main axis	real	obligatory	
SSP	SD.SysG114.SSP	Starting point of secondary axis	real	obligatory	
PA	SD.SysG114.PA	Angle	real	as an alternative	de-grees
PD	SD.SysG114.PD	Bore distance	real	as an alternative	
MHD	SD.SysG114.MHD	Distance main axis	real	as an alternative	
SHD	SD.SysG114.SHD	Distance secondary axis	real	as an alternative	
NH	SD.SysG114.NH	Number of drillings	integer	obligatory	

Sequence: The modal drilling cycle programmed before the cycle request is performed at every position given by the starting parameters. The cycle can be defined using the parameters angle (PA) and bore pattern (PD) or by the axis-specific distances (MHD and SHD). Should the working direction have to be changed, the last drilling position has to be given as the starting point (MSP and SSP) in both cases. With dimensioning type (PA and PD) the angle has to be increased by 180°. With dimensioning type MHD and SHD, the prefixes of the parameters Distance main axis and Distance secondary axis should be negated.

Example 1:

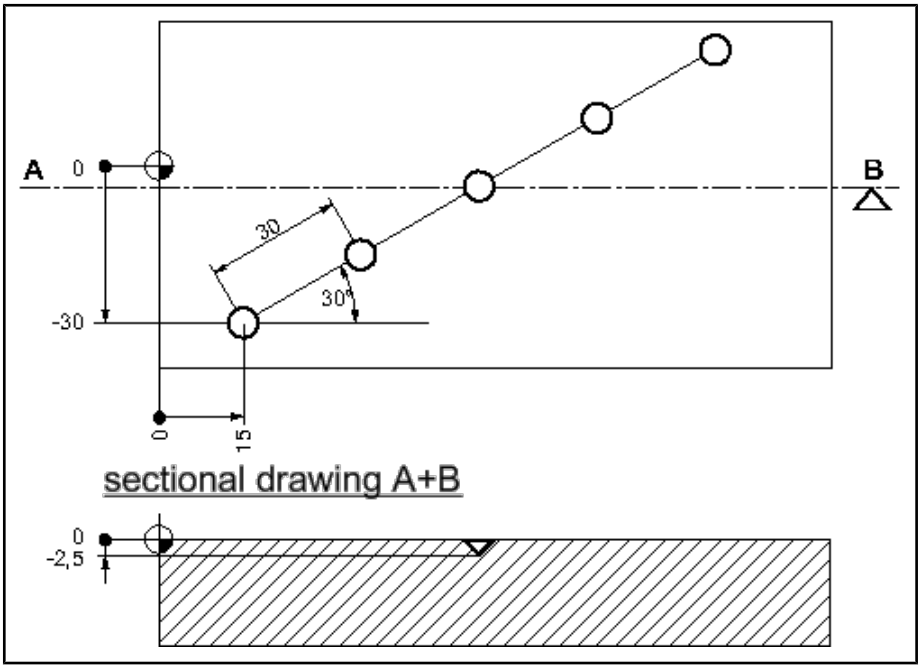

Fig.5-11: Example G114 Bore pattern line ("ANG")

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X15 Y-30 Z100 S2500 M3       ; Pre-position
N30 G81(IX=Z,SL2,DT-2.5,DW1,RL10) F300  ; Cycle definition + Feed
N40 G114 (MSP15,SSP-30,PA30,PD30,NH5)  ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

Example 2:

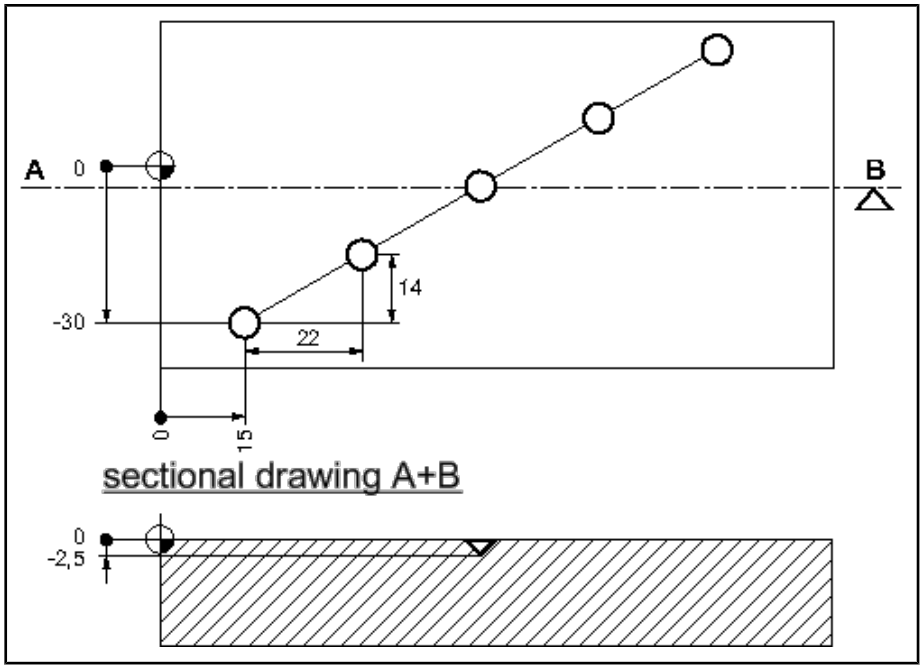

Fig.5-12: Example G114 Bore pattern line ("DIS")

Program:

```
N10 T1 M6                                ; Took change
N20 G17 G0 X15 Y-30 Z100 S2500 M3         ; Pre-position
N30 G81(IX=Z,SL2,DT-2.5,DW1,RL10) F300  ; Cycle definition + Feed
N40 G114(MSP15,SSP-30,MHD22,SHD14,NH5)  ; Cycle definition
N50 G80 Z100 M5                          ; Delete leaving modal request
```

5.6 G115 Bore Pattern Matrix

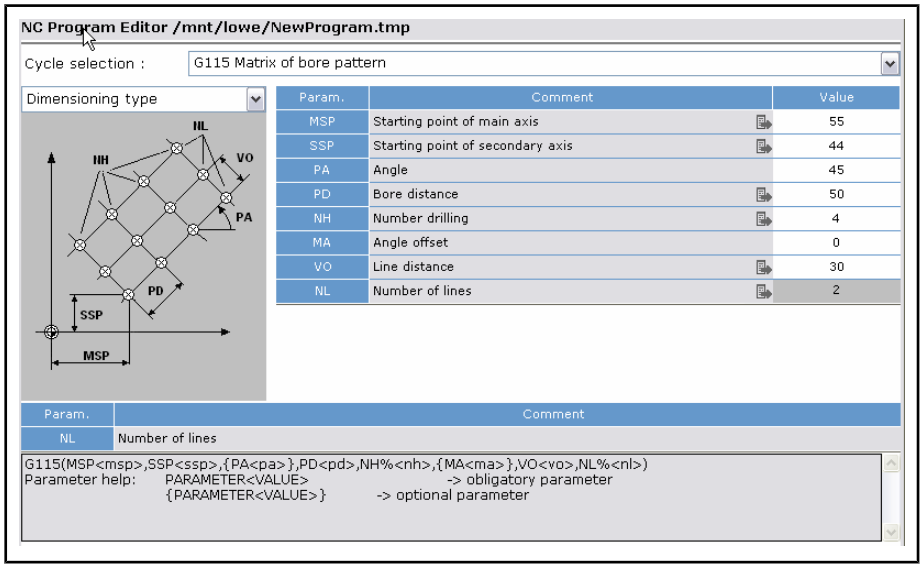

Fig.5-13: G115 Bore pattern matrix

Bore Patterns

G115		Bore pattern matrix	G115(MSP,SSP,PA,PD,MHD,SHD,NH,MA,VO,NL)		
MSP	SD.SysG115.MSP	Starting point of main axis	real	obligatory	
SSP	SD.SysG115.SSP	Starting point of secondary axis	real	obligatory	
PA	SD.SysG115.PA	Angle	real	as an alternative	de-grees
PD	SD.SysG115.PD	Bore distance	real	as an alternative	
MHD	SD.SysG115.MHD	Distance main axis	real	as an alternative	
SHD	SD.SysG115.SHD	Distance secondary axis	integer	as an alternative	
NH	SD.SysG115.NH	Number of drillings	integer	obligatory	
MA	SD.SysG115.MA	Angle offset	real	optional	de-grees
VO	SD.SysG115.VO	Line distance	real	obligatory	
NL	SD.SysG115.NL	Number of lines	integer	obligatory	

Sequence: The modal drilling cycle programmed before the cycle request is performed at every position given by the starting parameters. The cycle can be defined using the parameters Angle (PA) and Bore pattern (PD) or (probably from MTX10VRS) by the axis-specific distances (MHD and SHD). Should the working direction have to be changed, the last drilling position has to be given as the starting point (MSP and SSP) in both cases. With dimensioning type PA and PD, the angle (PA) has to be increased by 180°. With dimensioning type MHD and SHD, the prefixes of the parameters Distance main axis and Distance secondary axis should be negated.

The matrix can also be rotated by the optional specification of an angle of rotation.

Example 1:

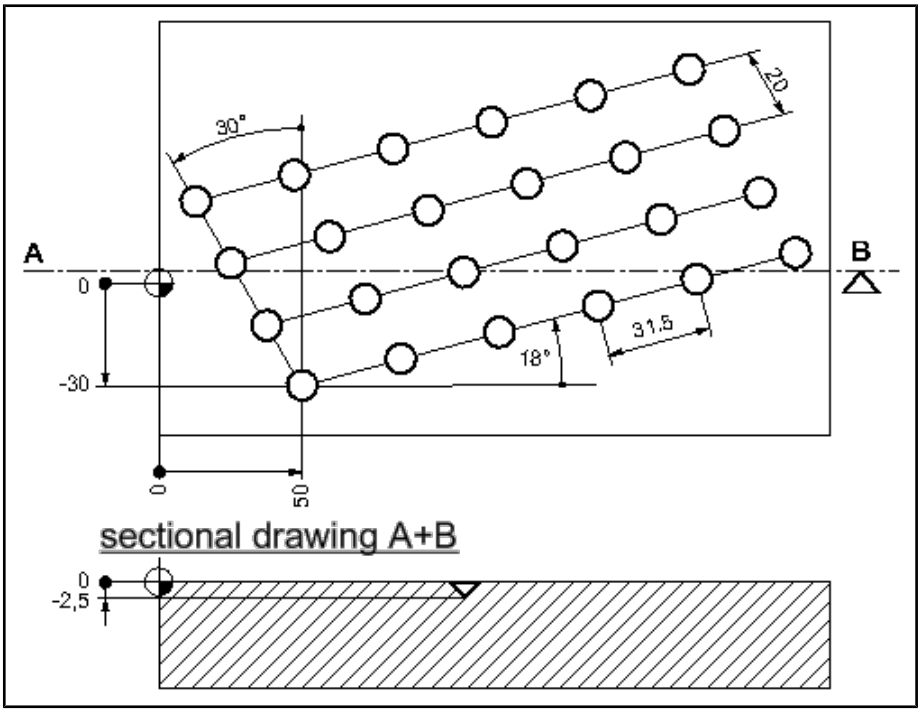

Fig.5-14: Example G115 Bore pattern matrix ("ANG")

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X50 Y-30 Z100 S2500 M3       ; Pre-position
N30 G81(IX=Z,SL2,DT-2.5,DW1,RL10) F300  ; Cycle definition + Feed
N40 G115(MSP50,SSP-30,PA18,PD31.5,NH6,MA30,VO20,NL4)
                                        ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

Example 2:

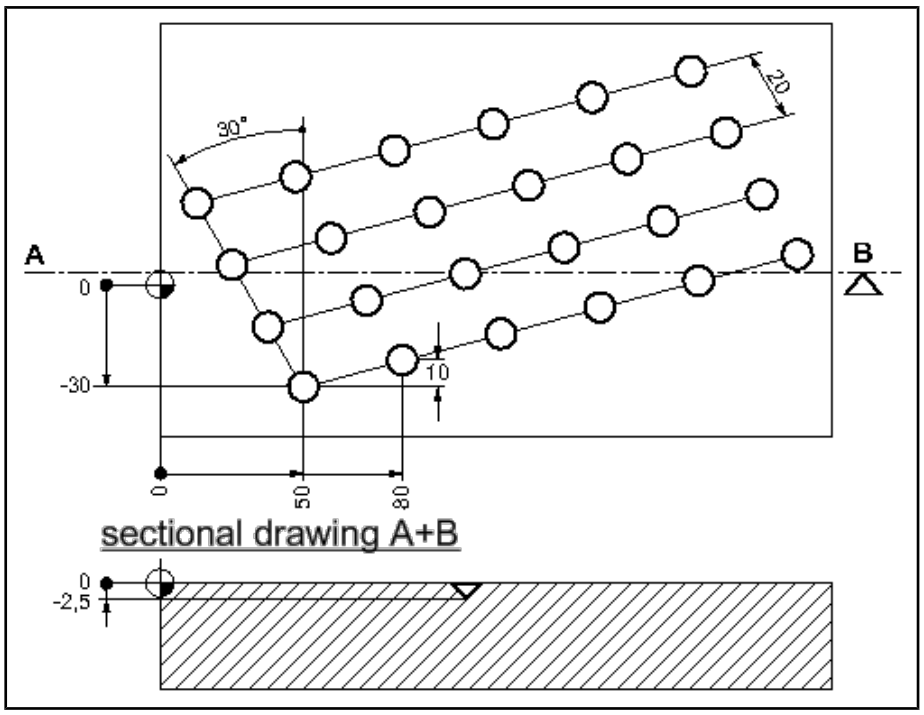

Fig.5-15: Example G115 Bore pattern matrix ("DIS")

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X50 Y-30 Z100 S2500 M3       ; Pre-position
N30 G81(IX=Z,SL2,DT-2.5,DW1,RL10) F300  ; Cycle definition + Feed
N40 G115(MSP50,SSP-30,MHD30,SHD10,NH6,MA30,VO20,NL4)
                                        ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

5.7 G116 Bore Pattern Frame

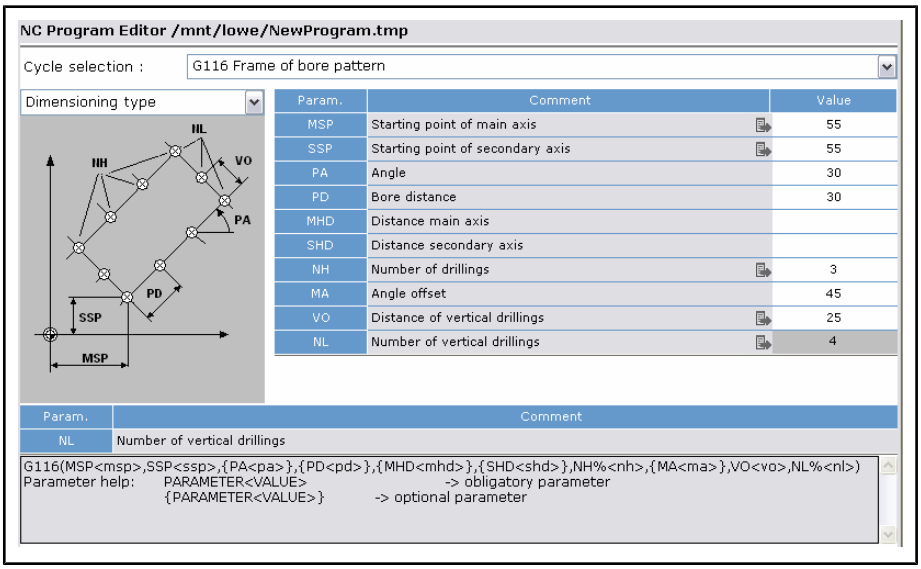

Fig.5-16: G116 Bore pattern frame

G116		**Bore pattern frame**	**G116(MSP,SSP,PA,PD,MHD,SHD,NH,MA, VO,NL)**		
MSP	SD.SysG116.MSP	Starting point of main axis	real	obligatory	
SSP	SD.SysG116.SSP	Starting point of secondary axis	real	obligatory	
PA	SD.SysG116.PA	Angle	real	as an alternative	
PD	SD.SysG116.PD	Bore distance	real	as an alternative	de-grees
MHD	SD.SysG116.MHD	Distance main axis	real	as an alternative	
SHD	SD.SysG116.SHD	Distance secondary axis	real	as an alternative	
NH	SD.SysG116.NH	Number of drillings	integer	obligatory	
MA	SD.SysG116.MA	Angle offset	real	optional	de-grees
VO	SD.SysG116.VO	Distance of vertical drillings	real	obligatory	
NL	SD.SysG116.NL	Number of drillings	integer	obligatory	

Sequence: The modal drilling cycle programmed before the cycle request is performed at every position given by the starting parameters. The cycle can be defined using the parameters Angle (PA) and Bore pattern (PD) or by the axis-specific distances (MHD and SHD). Should the working direction have to be changed, the last drilling position has to be given as the starting point (MSP and SSP) in both cases. With dimensioning type PA and PD, the angle (PA) has to be increased by 180°. With dimensioning type MHD and SHD, the prefixes of the parameters Distance main axis MHD) and Distance secondary axis (SHD) should be negated.

The frame can also be rotated by the optional specification of MA.

Example 1:

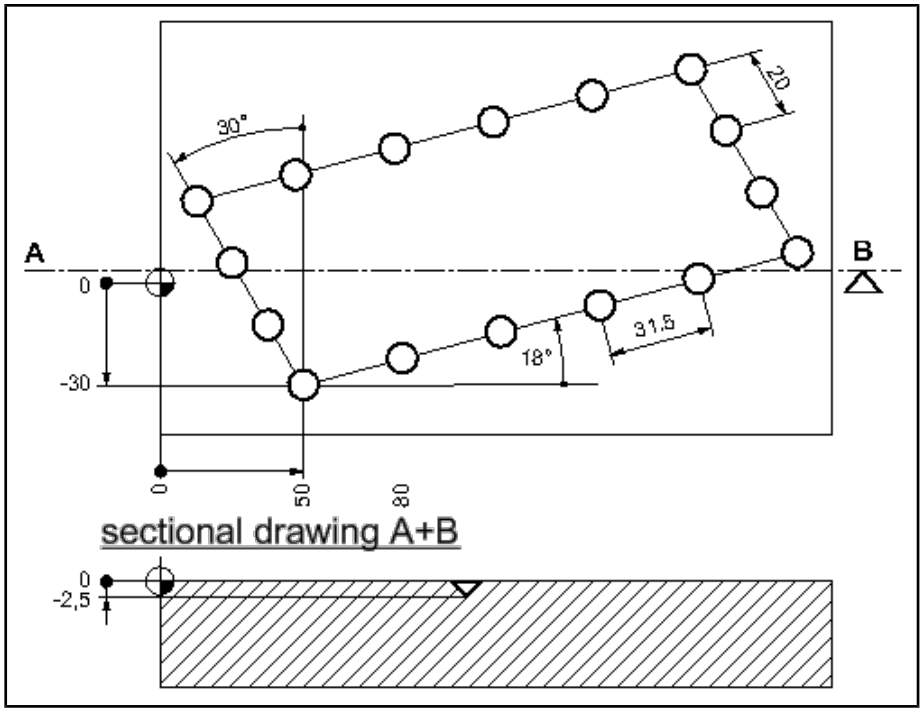

Fig.5-17: Example G116 Bore pattern matrix ("ANG")

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X50 Y-30 Z100 S2500 M3       ; Pre-position
N30 G81(IX=Z,SL2,DT-2.5,DW1,RL10) F300  ; Cycle definition + Feed
N40 G116(MSP50,SSP-30,PA18,PD31.5,NH6,MA30,VO20,NL4)
                                        ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

Example 2:

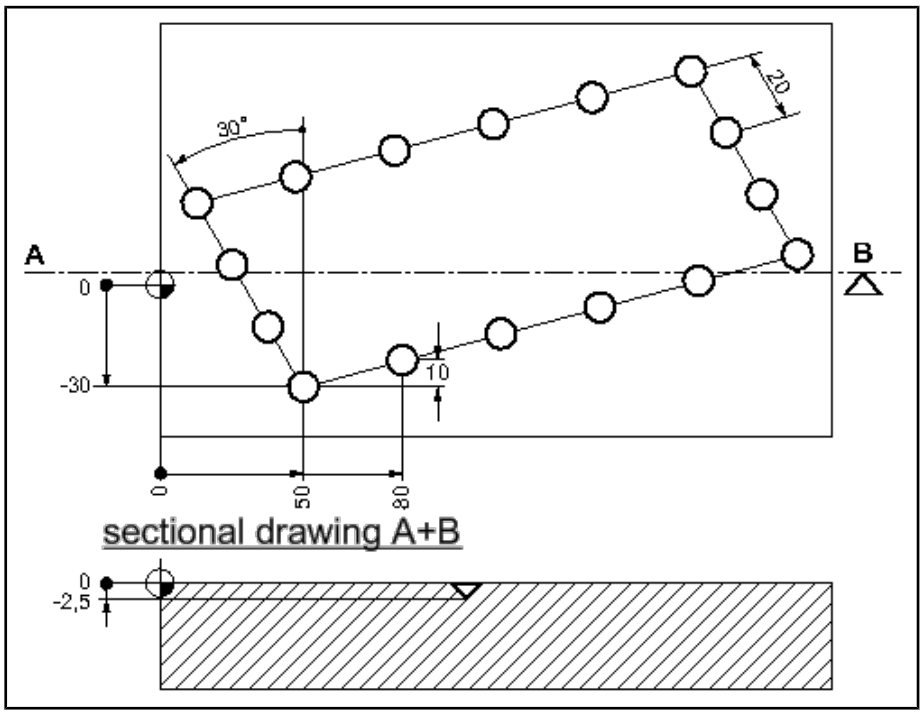

Fig.5-18: Example G116 Bore pattern matrix ("DIS")

Bore Patterns

Program:

```
N10 T1 M6                              ; Took change
N20 G17 G0 X50 Y-30 Z100 S2500 M3       ; Pre-position
N30 G81(IX=Z,SL2,DT-2.5,DW1,RL10) F300  ; Cycle definition + Feed
N40 G116(MSP50,SSP-30,MHD30,SHD10,NH6,MA30,VO20,NL4)
                                        ; Cycle definition
N50 G80 Z100 M5                        ; Delete leaving modal request
```

6 Milling Cycles

6.1 G261 Thread Milling

The cycle "Thread milling" (G261) serves to mill a thread using a thread milling cutter in an existing bore. Right-hand and left-hand threads can be produced in parallel feed and in counter direction.

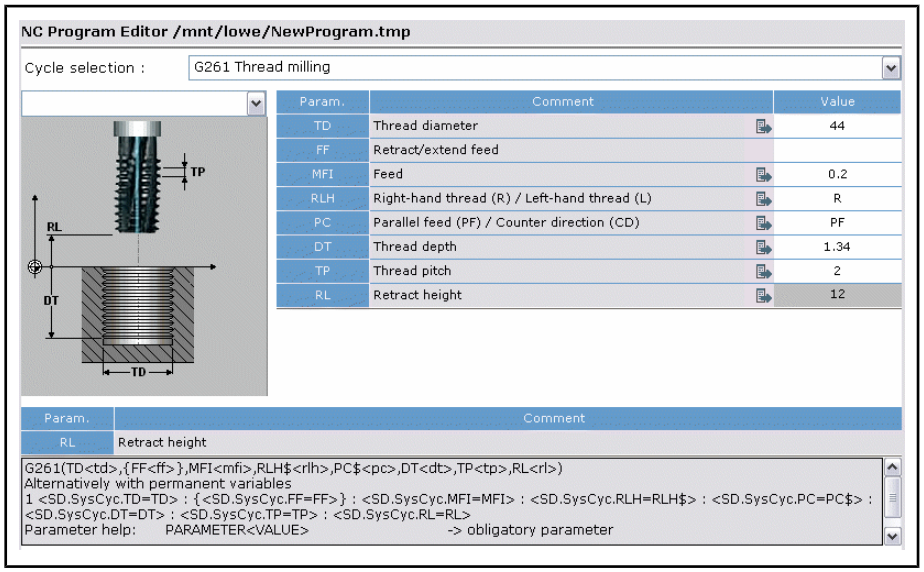

Fig.6-1: G261 Thread milling

G261		Thread milling	G261(TD,FF,MFI,RLH,PC,DT,TP,RL)		
TD	SD.SysCyc.TD	Thread diameter	real	obligatory	
FF	SD.SysCyc.FF	Start/retract feed	real	optional	
MFI	SD.SysCyc.MFI	Feed	real	obligatory	
RLH	SD.SysCyc.RLH	Right-hand thread (R) / Left-hand thread (L)	string	obligatory	SD.SysCyc.RLH=0 →"R" SD.SysCyc.RLH=1 →"L"
PC	SD.SysCyc.PC	Parallel feed (PF) / Counter direction (CD)	string	obligatory	SD.SysCyc.PC=0 →"PF" SD.SysCyc.PC=1 →"CD"
DT	SD.SysCyc.DT	Thread height	real	obligatory	
TP	SD.SysCyc.TP	Thread pitch	real	obligatory	
RL	SD.SysCyc.RL	Retract height	real	obligatory	

Milling Cycles

Sequence diagram:

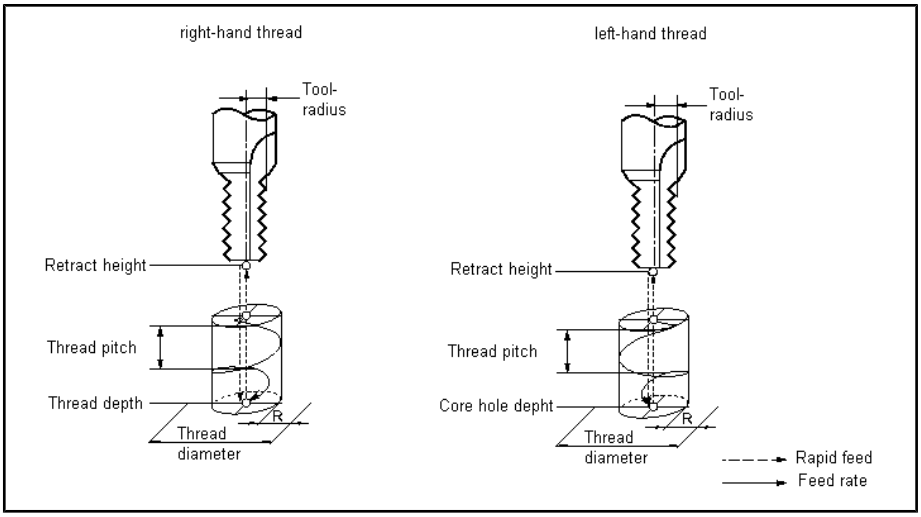

Fig.6-2: Motion sequence G261 Thread milling

Sequence: The cycle supports the planes G17, G18 and G19. The cycle automatically recognizes whether the thread is to be milled from the top or from the bottom thanks to the Depth parameter (P6), the Retract height parameter (P8) and the Parallel or Counter direction parameters (P5). From the position in the plane that has already been reached, the feed axis travels in rapid traverse to the calculated start position. From here it travels the start helix in a semi-circular motion in the plane and with ¼*pitch infeed. It then travels a full circle at the thread pitch. Now it travels the retract helix with a semi-circular motion in the plane and with ¼* pitch infeed to the thread height and the feed axis is positioned at the retract position.

Example:

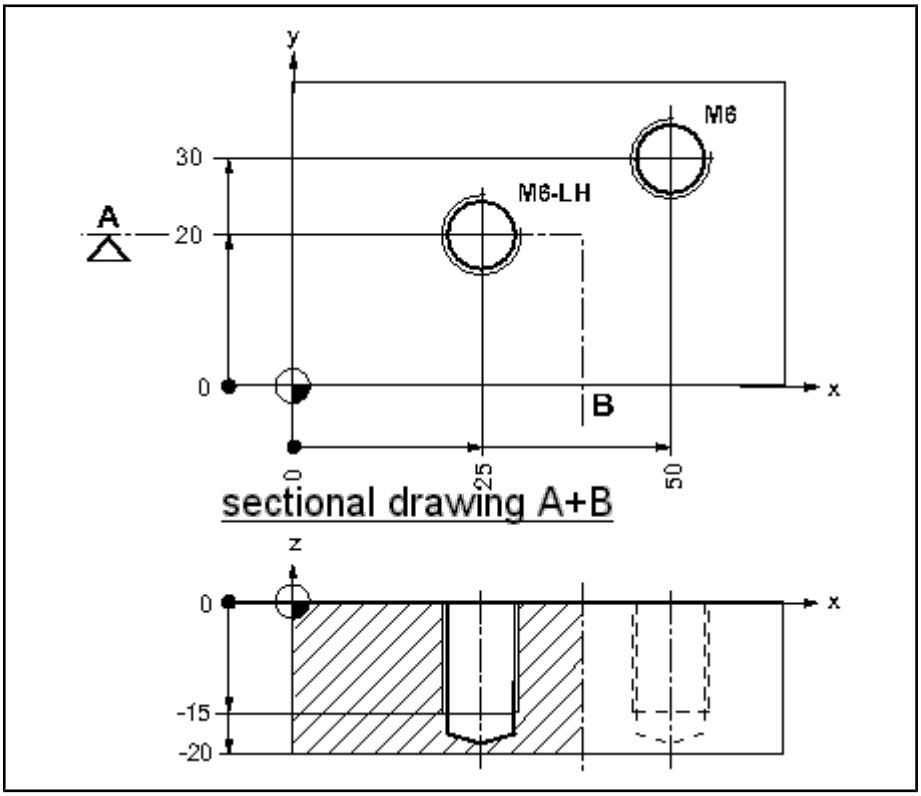

Fig.6-3: Example G261 Thread milling

Program:

```
N10 T1 M6                                ; Took change
N20 G17 G0 X25 Y20 Z100 S1500 M3         ; Pre-position
N30 G261(TD6,FF1000,MFI800,RLH=L,PC=CD,DT-15,TP1,RL10)
                                         ; Cycle definition
N40 X25 Y20                              ; 1st Cycle request
N30 G261(TD6,FF1000,MFT800,RLH=R,PC=PF,DT-15,TP1,RL10)
                                         ; Cycle definition
N40 X50 Y30                              ; 1st Cycle request
N80 G80 Z100 M5                          ; Delete leaving modal request
```

6.2 G262 Thread Drill Milling

The cycle "Thread drill milling" (G262) serves to produce a thread using a thread drill mill. With thread drill milling, the tap hole is made first of all then the thread is milled using the same tool. Right-hand and left-hand threads can be produced in parallel feed and in counter direction.

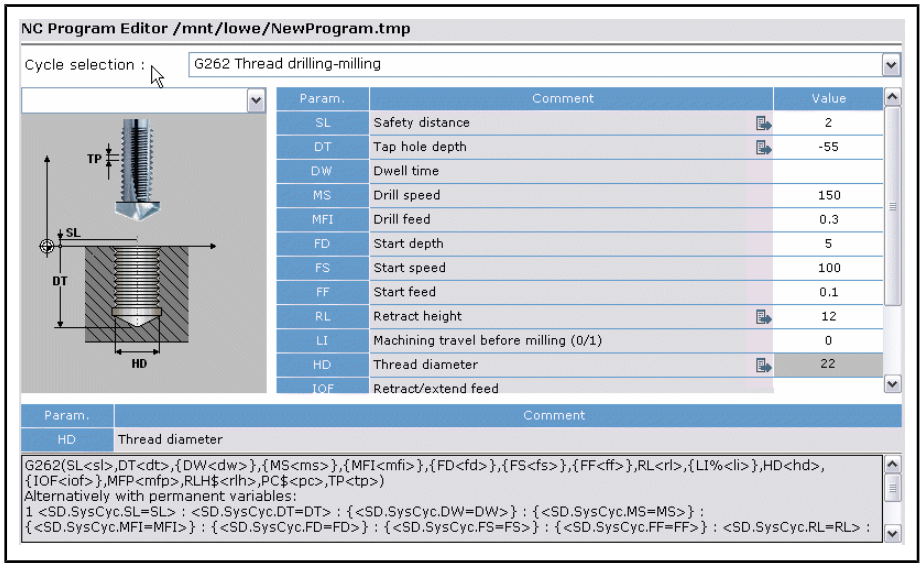

Fig.6-4: G262 Thread drill milling

G262	Thread drill milling		G262(SL,DT,DW,MS,MFI,FD,FS,FF,RL,LI,HD,IOF,MFP,RLH,PC,TP)		
SL	SD.SysCyc.SL	Safety distance	real	obligatory	absolute
DT	SD.SysCyc.DT	Tap hole depth	real	obligatory	absolute
DW	SD.SysCyc.DW	Dwell time	real	optional	seconds
MS	SD.SysCyc.MS	Drill speed	real	optional	
MFI	SD.SysCyc.MFI	Drill feed	real	optional	
FD	SD.SysCyc.FD	Start depth	real	optional	absolute
FS	SD.SysCyc.FS	Start speed	real	optional	
FF	SD.SysCyc.FF	Start feed	real	optional	
RL	SD.SysCyc.RL	Retract height	real	obligatory	absolute
LI%	SD.SysCyc.LI	Machining travel before milling (0/1)	integer	optional	
HD	SD.SysCyc.HD	Thread diameter	real	obligatory	
IOF	SD.SysCyc.IOF	Start/retract feed	real	optional	
MFP	SD.SysCyc.MFP	Circular feed	real	obligatory	

Milling Cycles

G262	Thread drill milling		G262(SL,DT,DW,MS,MFI,FD,FS,FF,RL,LI,HD,IOF,MFP,RLH,PC,TP)		
RLH	SD.SysCyc.RLH	Right-hand thread (R) / Left-hand thread (L)	string	obligatory	SD.SysCyc.RLH=0 →"R" SD.SysCyc.RLH=1 →"L"
PC	SD.SysCyc.PC	Parallel feed (PF) / Counter direction (CD)	string	obligatory	SD.SysCyc.PC=0 →"PF" SD.SysCyc.PC=1 →"CD"
TP	SD.SysCyc.TP	Thread pitch	real	obligatory	

Sequence diagram:

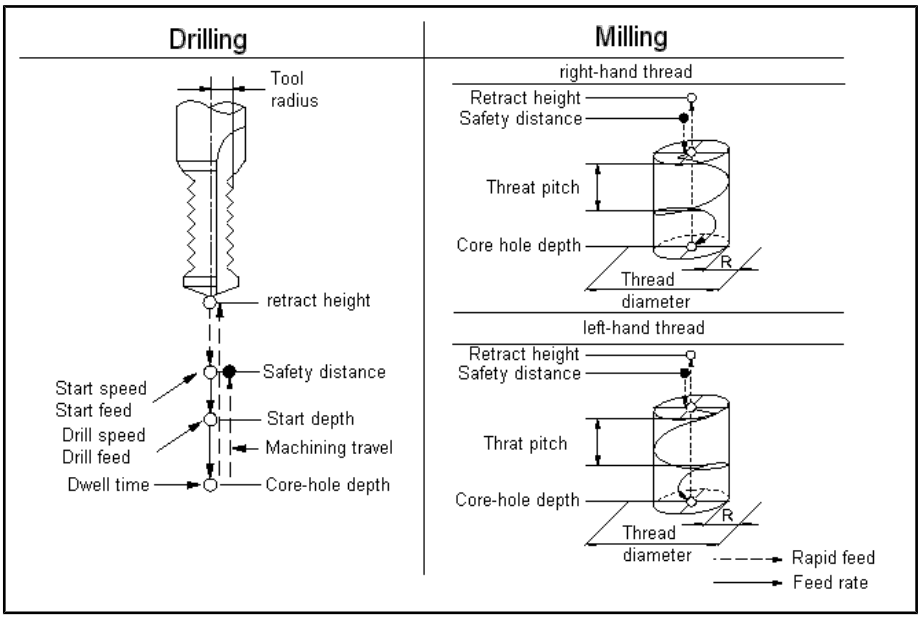

Fig.6-5: Motion sequence G262 Thread drill milling

Sequence: The cycle supports the planes G17, G18 and G19. From the last programmed position of the feed axis, there is a rapid traverse to the safety distance. From this point it travels with the start feed and start speed to the start depth. This step cannot take place without specification of the start depth. It then travels with drill feed and at drill speed to the tap hole depth. If no drill feed is transferred in the cycle request, then a feedrate value has to be programmed beforehand or at the latest in the NC block of the cycle request. It is possible to work with G94 Feeds per min. or even, if the reference spindle rotates to the right or left, with G95 Feeds per revolution. If a dwell time (option) is specified, this runs in seconds once the drilling depth has been reached. If the machining travel before milling (P10) is set to 1, it is positioned at the safety distance before thread milling and the dwell time is executed there. The cycle automatically recognizes whether the thread is to be milled from the top or from the bottom thanks to the Tap hole depth parameter (P2), the Retract height parameter (P9) and the Parallel or Counter direction parameters (P15). From the position in the plane that has already been reached, the feed axis travels in rapid traverse to the calculated start position. From here it travels the start helix in a semi-circular motion in the plane and with ¼*pitch infeed. It then travels a full circle at the thread pitch. Now it travels the retract helix with a semi-circular motion in the plane and with ¼* pitch infeed to the thread height and the feed axis is positioned at the retract height.

Example:

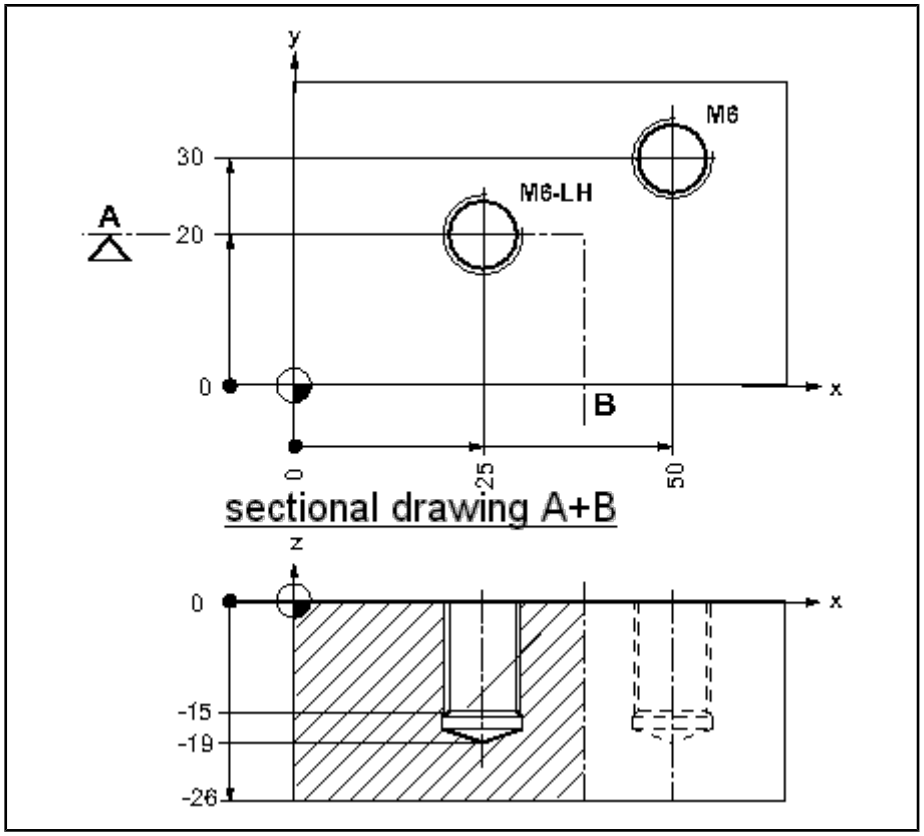

Fig.6-6: Example G262 Thread drill milling

Program:

```
N10 T1 M6                                ; Took change
N20 G17 G0 X25 Y20 Z100 S2000 M3         ; Pre-position
N30 G262(SL2,DT-19,DW1,MS2000,MFI300,FD-5,FS1000,FF250,RL10,LI0,HD6,IOF1000,MFP800,RLH=L,
 PC=CD,TP1)
                                         ; Cycle definition
N40 X25 Y20                              ; 1st Cycle request
N30 G262(SL2,DT-19,DW1,MS2000,MFT300,FD-5,FS1000,FF250,RL10,LI0,HD6,IOF1000,MFP800,RLH=R,
 PC=PF, TP1)
                                         ; Cycle definition
N40 X50 Y30                              ; 1st Cycle request
N60 G80 Z100 M5                          ; Delete leaving modal request
```

6.3 G263 Plunge Circular Milling

The cycle "Plunge circular milling" (G263) serves to mill a plunge or a circular pocket (finish). Milling can be performed in a clockwise or anti-clockwise direction.

Milling Cycles

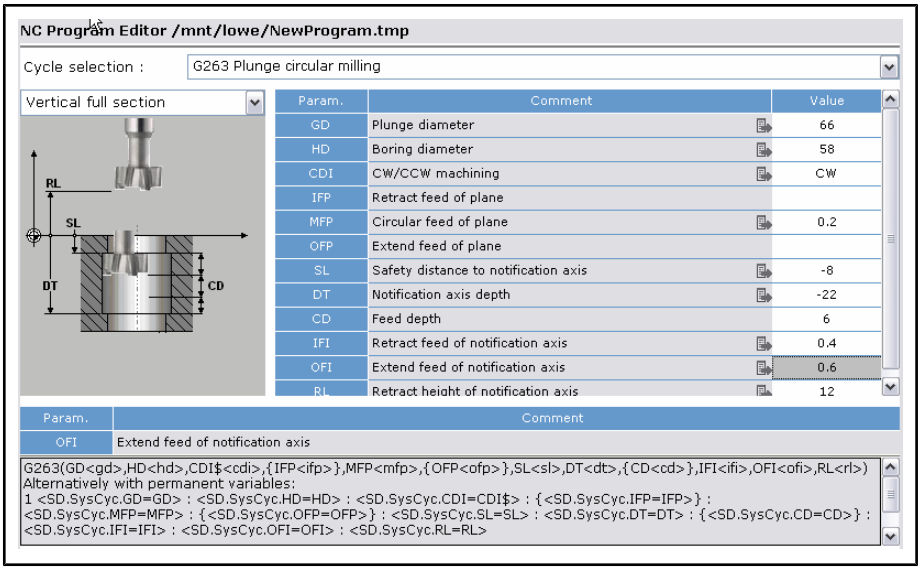

Fig.6-7: G263 Plunge circular milling

G263		**Plunge circular milling**	**G263(GD,HD,CDI,IFP,MFP,OFP,SL,DT,CD,IFI,OFI,RL)**		
GD	SSysCyc.GD	Plunge diameter	real	obligatory	
HD	SD.SysCyc.HD	Boring diameter	real	obligatory	
CDI	SD.SysCyc.CDI	CW / CCW machining	string	obligatory	SD.SysCyc.CDI=0 → “CW“ SD.SysCyc.CDI=1 → “CCW“
IFP	SD.SysCyc.IFP	Start feed of plane	real	optional	
MFP	SD.SysCyc.MFP	Circular feed of plane	real	obligatory	
OFP	SD.SysCyc.OFP	Retract feed of plane	real	optional	
SL	SD.SysCyc.SL	Safety distance to feed axis	real	obligatory	absolute
DT	SD.SysCyc.DT	Feed axis depth	real	obligatory	absolute
CD	SD.SysCyc.CD	Feed depth	real	optional	incremental
IFI	SD.SysCyc.IFI	Start feed of feed axis	real	optional	
OFI	SD.SysCyc.OFI	Retreat feed of feed axis	real	optional	
RL	SD.SysCyc.RL	Retract height of feed axis	real	optional	absolute

Sequence diagram:

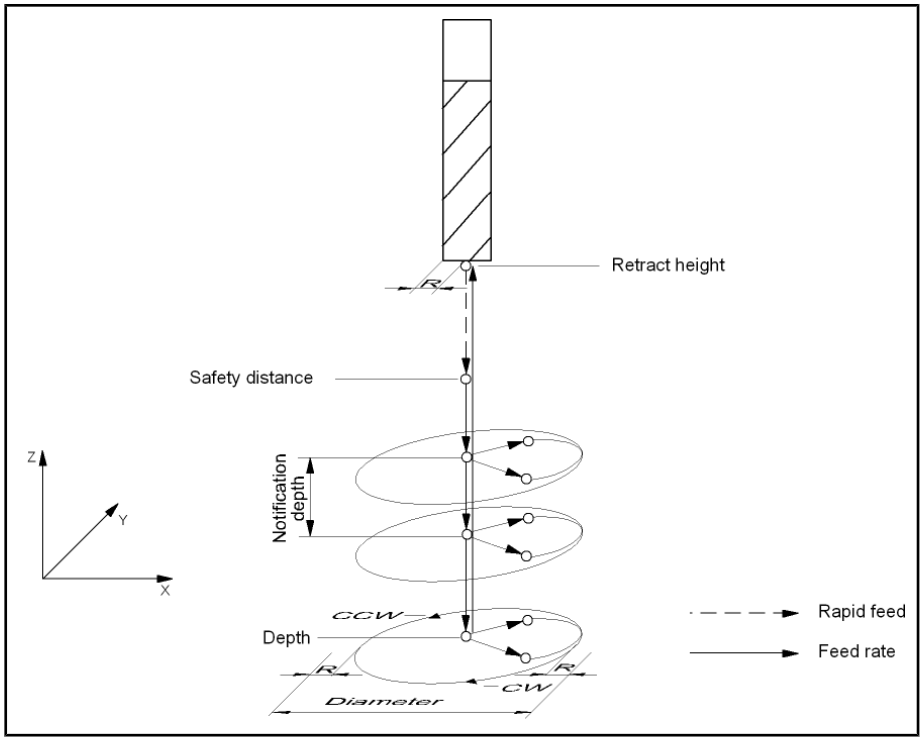

Fig.6-8: Motion sequence G263 Plunge circular milling (with feed)

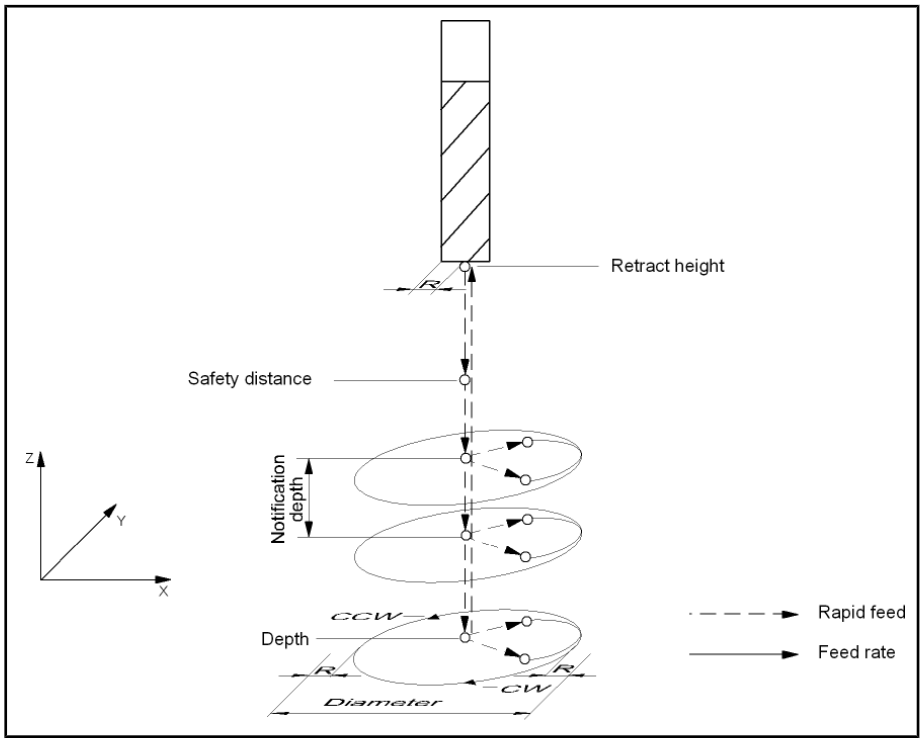

Fig.6-9: Motion sequence G263 Plunge circular milling (feed with rapid traverse)

Sequence: The cycle supports the planes G17, G18 and G19. From the last programmed position in the plane, the drill axis is positioned in rapid traverse at the safety distance. From this point it travels to the calculated feed depth. This is performed with feed (P10). If this is not specified, it will be positioned with rapid traverse.

Milling Cycles

Then it travels to the start position of the start circle. If there is no start feed specified for the plane in P4, it travels with rapid traverse and the radius correction is configured. From this point, it travels a ¼ start circle in start feed (P4) to the starting point of the full circle. Now a full circle is traveled with circular feed (P5) It is then positioned with retract feed (P6) and a 1/4 circle at the end point of the retract circle. If no start or retract feed is specified, then circular feed is used for starting and retracting. Then it travels to the cycle start position in the plane. If no value is specified in the feed plane (P6), it travels in rapid traverse. Now a check is made to ascertain whether another feed is required in the feed axis. If this is the case, it travels to the new depth and the complete circulation in the plane is repeated. This is performed until the depth (P9) has been reached. The positioning at the retract height (P12) ends the cycle. If no retract feed is specified for the feed axis (P11), this is performed with rapid traverse.

Example:

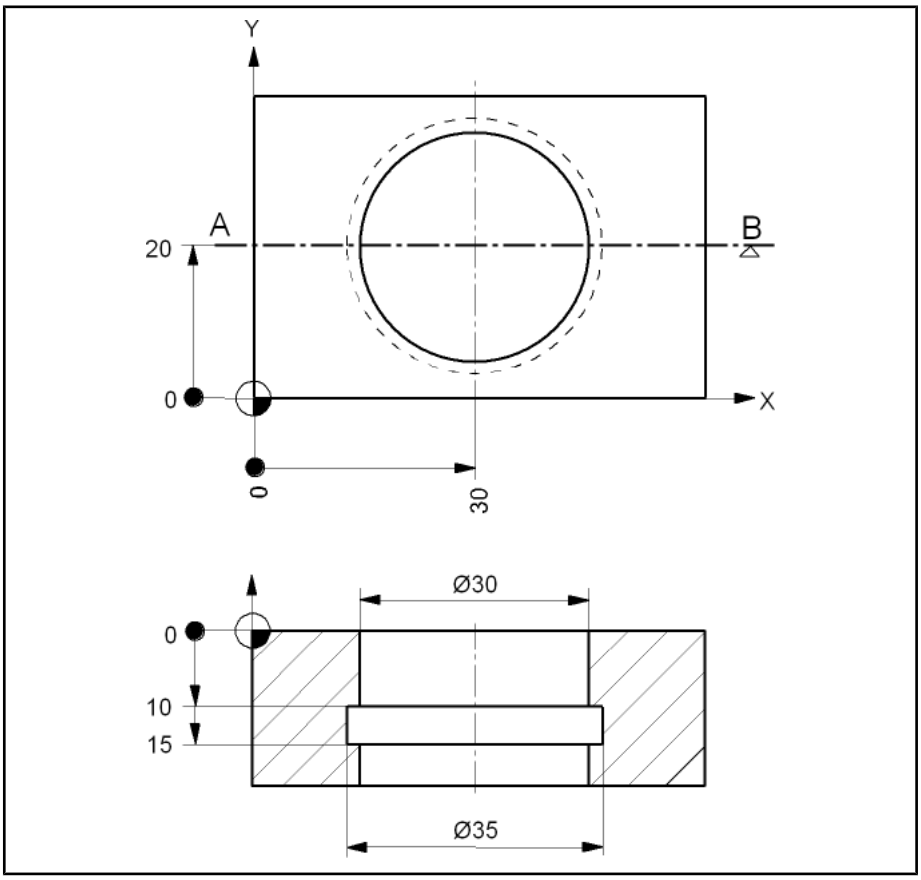

Fig.6-10: Example G263 Plunge circular milling

Program:

```
N10 T1 M6                                ; Took change (Step drill)
N20 G17 G0 X30 Y20 Z100 S0 M3               ; Pre-position
N30 G263(GD35,HD30,CDI=CCW,IFP2000,MFP1000,OFP2000,SL-12.5,DT-15,CD2.5,IFI2000,OFI5000,RL10)
                                            ; Cycle definition
N40 X30 Y20                                 ; Cycle request
N50 G80 Z100 M5                             ; Delete leaving modal request
```

7 Turning Cycles

7.1 G160 Longitudinal Turning

The cycle "Longitudinal turning" (G160) serves to work an axially parallel area with multiple cuts in a longitudinal direction on a turned part. Over and above the cut segmentation across the aforementioned area, a final finishing cut can be defined separately.

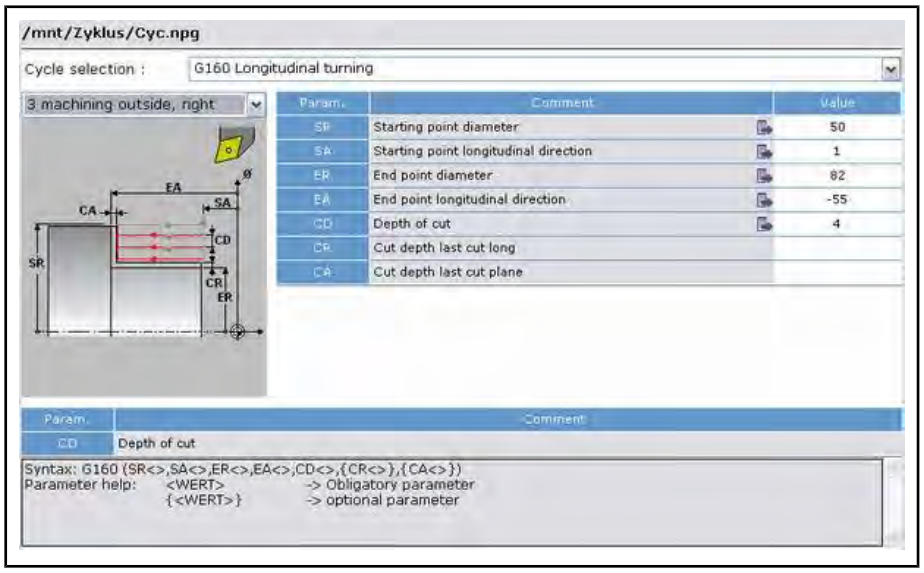

Fig.7-1: G160 Longitudinal turning

G160		Longitudinal turning	G160(SR,SA,ER,EA,CD,CR,CA)		
SR	SSysCyc.SR	Starting point diameter	real	obligatory	
SA	SD.SysCyc.SA	Starting point longitudinal direction	real	obligatory	
ER	SD.SysCyc.ER	End point diameter	real	obligatory	
EA	SD.SysCyc.EA	End point longitudinal direction	real	obligatory	
CD	SD.SysCyc.CD	Depth of cut	real	obligatory	
CR	SD.SysCyc.CR	Cut depth last cut long	real	optional	
CA	SD.SysCyc.CA	Cut depth last cut plane	real	optional	

Sequence: The cycle works in the G18 plane with a longitudinal and diameter axis. The cycle begins at the starting point (SR and SA). It must be possible to travel to the starting point straightforwardly from the last programmed position.

Where the last cut is specified, the cut segmentation is reduced by this last cut depth. The cut depth (CD) of the individual cuts in the cut segmentation is identical. The specified cut depth (CD) can optionally be reduced to the same depth.

The depth of the first cut in the direction of the diameter is traveled in rapid traverse. A possible start-up should be implemented via the starting point. The cuts are performed with the feed programmed prior to the cycle. After retraction, there is rapid traverse to the starting point in the longitudinal direction (SA). This sequence is repeated until the required cut depth has been reached. Once all of the cuts have been performed, the last cut is optionally performed.

7.2 G161 Face Turning

The cycle "Face turning" (G161) serves to work an axially parallel area with multiple cuts in a planar direction on a turned part. Over and above the cut segmentation across the area, a final finishing cut can be defined separately.

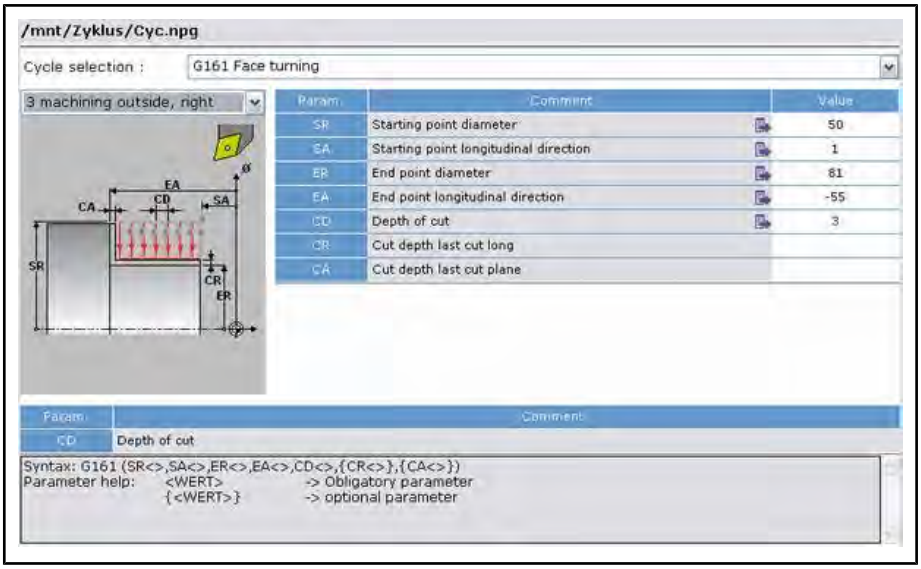

Fig.7-2: G161 Face turning

G161		Face turning	G161(SR,SA,ER,EA,CD,CR,CA)		
SR	SSysCyc.SR	Starting point diameter	real	obligatory	
SA	SD.SysCyc.SA	Starting point longitudinal direction	real	obligatory	
ER	SD.SysCyc.ER	End point diameter	real	obligatory	
EA	SD.SysCyc.EA	End point longitudinal direction	real	obligatory	
CD	SD.SysCyc.CD	Depth of cut	real	obligatory	
CR	SD.SysCyc.CR	Cut depth last cut long	real	optional	
CA	SD.SysCyc.CA	Cut depth last cut plane	real	optional	

Sequence: The cycle works in the G18 plane with a longitudinal and diameter axis. The cycle begins at the starting point (SR and SA). It must be possible to travel to the starting point straightforwardly from the last programmed position.

Where the last cut is specified, the cut segmentation is reduced by this last cut depth. The cut depth (CD) of the individual cuts in the cut segmentation is identical. The specified cut depth (CD) can optionally be reduced to the same depth.

The depth of the first cut in a longitudinal direction is traveled in rapid traverse. A possible start-up should be implemented via the starting point. The cuts are performed with the feed programmed prior to the cycle. After retraction, there is rapid traverse to the starting point in the direction of the diameter (SR). This sequence is repeated until the required cut depth has been reached. Once all of the cuts have been performed, the last cut is optionally performed.

7.3 G162 Taper Turning

The cycle "Taper turning" (G162) serves to work a tapered area with multiple cuts in a contour direction on a turned part. Over and above the cut segmentation across the area, a final finishing cut can be defined separately.

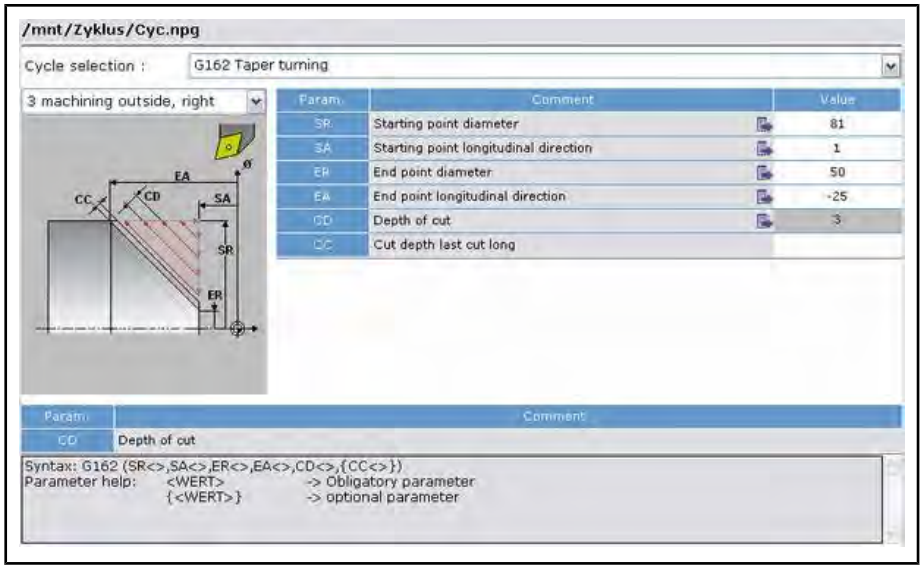

Fig.7-3: G162 Taper turning

G162		Taper turning	G162(SR,SA,ER,EA,CD,CC)		
SR	SSysCyc.SR	Starting point diameter	real	obligatory	
SA	SD.SysCyc.SA	Starting point longitudinal direction	real	obligatory	
ER	SD.SysCyc.ER	End point diameter	real	obligatory	
EA	SD.SysCyc.EA	End point longitudinal direction	real	obligatory	
CD	SD.SysCyc.CD	Depth of cut	real	obligatory	
CC	SD.SysCyc.CC	Cut depth last cut long	real	optional	

Sequence: The cycle works in the G18 plane with a longitudinal and diameter axis. The cycle begins at the starting point (SR and SA). It must be possible to travel to the starting point straightforwardly from the last programmed position.

Where the last cut is specified, the cut segmentation is reduced by this last cut depth. The cut depth (CD) of the individual cuts in the cut segmentation is identical. The specified cut depth (CD) can optionally be reduced to the same depth.

The depth of the first cut is traveled in rapid traverse. A possible start-up should be implemented via the starting point. The tool edge radius correction is switched on prior to each cut. The cuts are performed with the feed programmed prior to the cycle. The tool edge radius correction is switched off and there is travel in rapid traverse to the starting point (SR and SA). This sequence is repeated until the required cut depth has been reached. Once all of the cuts have been performed, the last cut is optionally performed.

7.4 G167 Cylindrical Thread Turning

The cycle "Cylindrical thread turning" (G167) serves to work a cylindrical thread on a turned part.

Turning Cycles

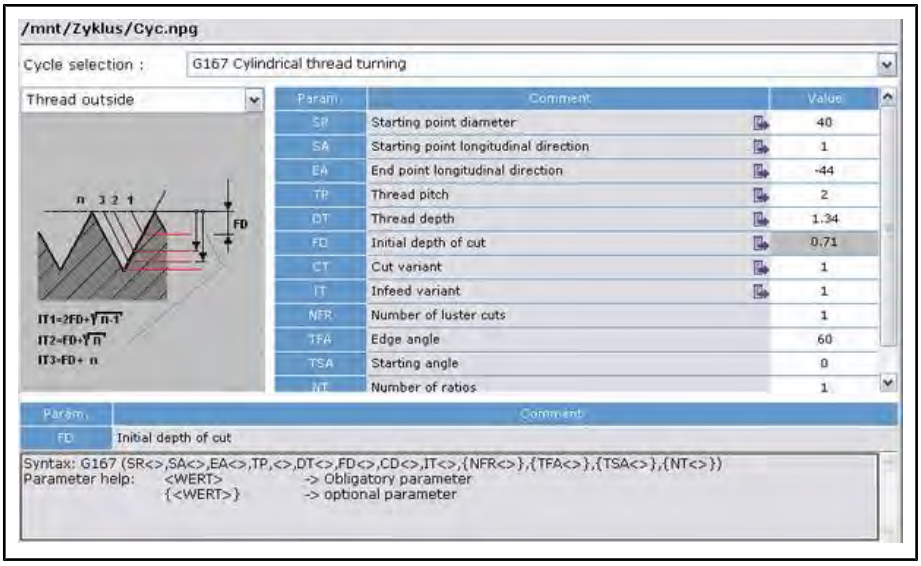

Fig.7-4: G167 Cylindrical thread turning

G167		**Cylindrical thread turning**	**G167(SR,SA,EA,TP,DT,FD,CT,IT,NFR,TFA,TSA,NT)**		
SR	SSysCyc.SR	Starting point diameter	real	obligatory	
SA	SD.SysCyc.SA	Starting point longitudinal direction	real	obligatory	
EA	SD.SysCyc.EA	End point longitudinal direction	real	obligatory	
TP	SD.SysCyc.TP	Thread pitch	real	obligatory	
DT	SD.SysCyc.DT	Thread height	real	obligatory	
FD	SD.SysCyc.FD	Initial depth of cut	real	optional	
CT	SD.SysCyc.CT	Cut variant	integer	optional	
IT	SD.SysCyc.IT	Feed variant	integer	optional	
NFR	SD.SysCyc.NFR	Number of luster cuts	integer	optional	
TFA	SD.SysCyc.TFA	Flank angle	real	optional	
TSA	SD.SysCyc.TSA	Starting angle	real	optional	
NT	SD.SysCyc.NT	Number of ratios	integer	optional	

Sequence: The cycle works in the G18 plane with a longitudinal and diameter axis. The cycle begins at the starting point (SR and SA). It must be possible to travel to the starting point straightforwardly from the last programmed position. An external thread is produced by a negative thread height. An internal thread is produced by a positive thread height.

The cycle can be adapted to the technological requirements by means of the feed variant and the cut variant.

The depth of the first cut is traveled in rapid traverse. A possible start-up should be implemented via the starting point. After retraction, there is rapid traverse to the starting point in the longitudinal direction (SA). This sequence is repeated until the required thread depth has been reached and during luster cuts.

8 Start-Up

8.1 Input Masks

8.1.1 General

All the data required for the standard cycle input masks has been installed.

The files provided should be copied into the project to start-up the machine manufacturer's (OEM) or end user's (User) input masks.

- The machine manufacturer's proprietary cycles are saved in the path ".../Visualizationdevice(e.g.B.VPP40)/OEM-Data/Cycles".
- The end user's proprietary cycles are saved in the path ".../Visualization-device(e.g.B.VPP40)/User/Config/Cycles".

The input masks require cycle header files, images and text. These should also be saved in the directories "OEM-Data\Cycles" or "\User\Config\Cycles".

- Cycle headers: These contain the input mask data and the links to images and text files. The cycle header files end with ".cyc". A cycle header file can contain multiple input masks for cycles. Multiple cycle header files can be located in the specified path. Example "Zyklus1.cyc".
- Images: These help to explain the input parameters. The images are 223x262 pixels in size. The following graphic formats are possible:
  - JPEG File interchange format (*.jpg)
  - Windows bitmap (*.bmp)
  - Graphics interchange format (*.gif)
  - Tagged image file format (*.tif)

  "gif" is recommended as the image format but other formats are also possible. Example "Zyklus1.cyc".
- Text: For language-specific texts, text files with a language identifier in the name e.g. "_de" and the ending "txt" are also possible. Example "Zyklus1_en.txt". Example of additional languages include:
  - de - German
  - en - English
  - fr - French
  - it - Italian
  - es - Spanish
  - ko - Korean
  - zh - Chinese

  A language should always be supported if the user interface can be switched to this language.

8.2 Parameter Settings for Cycle Requests

The non-modal standard cycles have already been inputted. Non-modal user cycles can be added here.

The modal standard cycles have already been inputted. Modal user cycles can be added here.

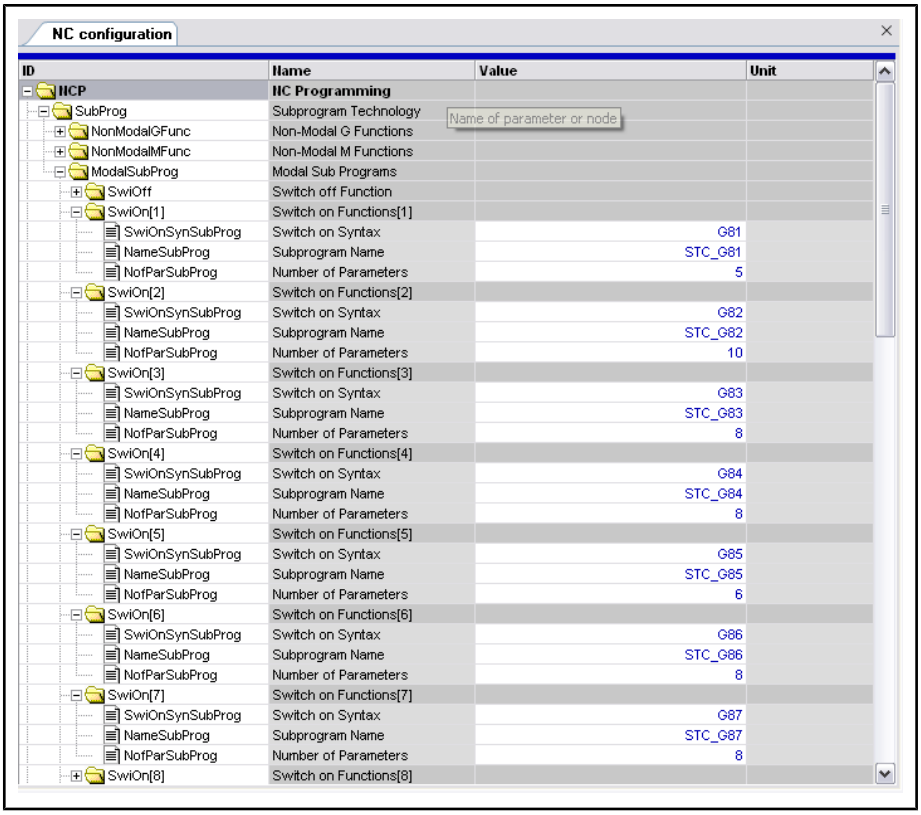

Fig.8-1: Editing IndraWorks Engineering parameters

8.3 Subprograms

The machine manufacturer's subprograms (cycles) are saved in the controller file system at "root\usr\mtb\cycles".

The end user's subprograms (cycles) are saved in the controller file system at "root\usr\user\cycles".

8.4 SD Variables

Some cycles can optionally work with permanent channel-dependent SD variables. The assignment is listed in the respective cycle description. The SD variables used for the standard cycles are available. Should user cycles be created and implemented in this way, the SD variables used for these have to be defined themselves.

8.5 Use of Existing Projects

This section relates only to projects which have been created with versions < MTX09V06.

There is not complete compatibility. The user therefore has to decide himself whether he wishes to continue using his existing projects in their "old" form or whether he wishes to work in future with standard cycles. **A combination of these two variants should not be used!**

The user of proprietary cycles from an old version does not require any further measures to be taken. However, it will then not be possible to access the installed standard cycles.

The following modifications are required to use the standard cycles in existing projects (Production version of the project >=MTC09V06):

- Adapt the search path for the cycles in the machinery parameters. "NC Optimization (NCO) -- FileOrg -- SrchPathSubProg". Add a new entry "/feprom/cycles" in front of the entry "/feprom".

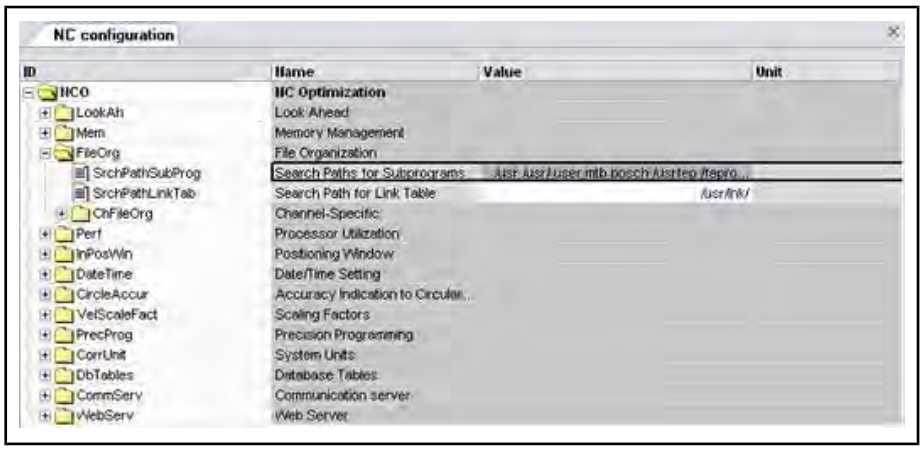

Fig.8-2: Extending the search path

- Make the standard cycle entries in the machine parameters. "NC Programming(NCP) -- SubProg -- ModalSubProg -- SwiOn[n]". Refer to chapter 8.2 "Parameter Settings for Cycle Requests" on page 61. The required entries can be taken from the default values.

If, after conversion to the standard cycles, the existing user cycles have also to be used, then these should either be adapted to the addressed notation or their names should be changed in such a way that they match the intended range for user cycles. In doing so, cycle subprograms, cycle headers and the definitions in the machine data also have to be adapted. It should also be noted that the cycle requests in the NC programs also have to be adapted to these changes.

9 Contour Drafts

9.1 General

Contour drafts can be used to work simple geometric elements with two or three lengths and transitions, such as chamfers or curve. A contour description can be created using these commands.

9.2 G0 Line with Chamfer or Curve

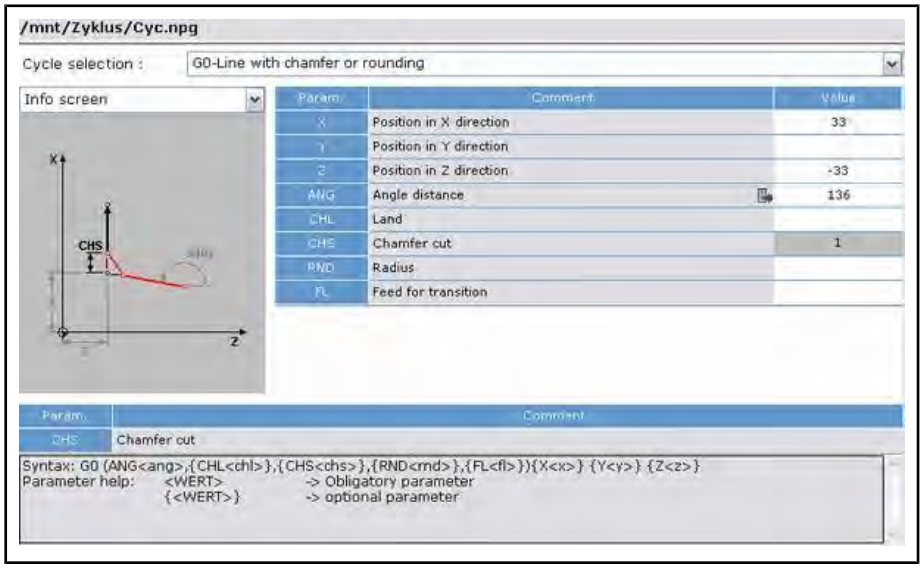

Fig.9-1:

G0 or G1	G0 line with chamfer or curve	G0(RND,CHL,CHS,FL) X Y Z G1(RND,CHL,CHS,FL) X Y Z		
X	Position in X direction	real	optional	
Y	Position in Y direction	real	optional	
Z	Position in Z direction	real	optional	
RND	Curve	real	optional	
CHL	Chamfer	real	optional	
CHS	Chamfer cut	real	optional	
FL	Feed for transition	real	optional	

Sequence: Using this contour draft, an additional transition element can be inserted at the transition of two lengths. From the last programmed position, a transition element is performed at the end point of the first length or at the starting point of the second length. A special feed can be specified for this transition element (curve or chamfer).

9.3 G1 Line with Chamfer or Curve

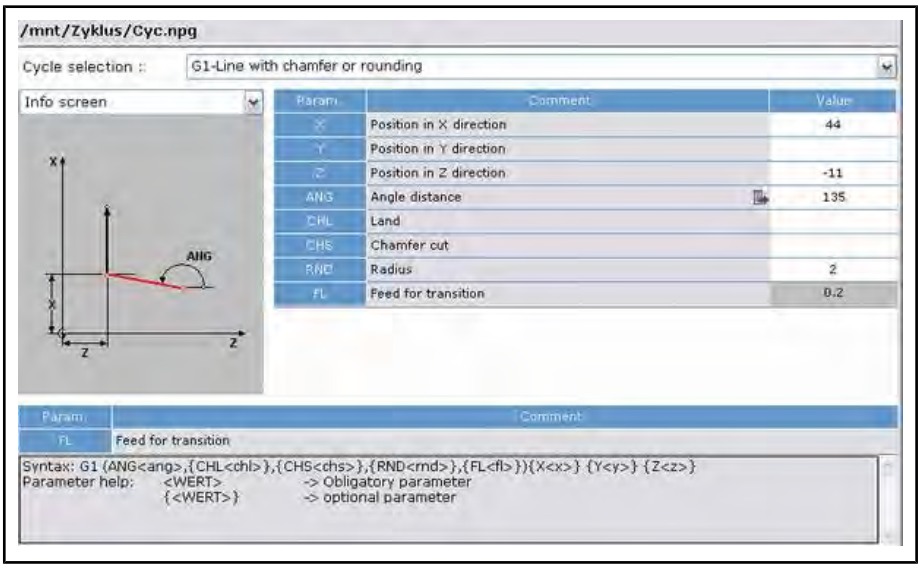

Fig.9-2:

G0 or G1	G1 line with chamfer or curve	G0(ANG,RND,CHL,CHS,FL) X Y Z G1(ANG,RND,CHL,CHS,FL) X Y Z		
X	Position in X direction	real	optional	
Y	Position in Y direction	real	optional	
Z	Position in Z direction	real	optional	
ANG		real	obligatory	degrees
RND	Curve	real	optional	
CHL	Chamfer	real	optional	
CHS	Chamfer cut	real	optional	
FL	Feed for transition	real	optional	

Sequence: Using this contour draft, an additional transition element can be inserted at the transition of two lengths. From the last programmed position, a transition element is worked at the end point of the first length or at the starting point of the second length, whereby the end point of the first length is produced by the angle of the lengths to each other. The coordinates of this point do not have to be known. A special feed can be specified for this transition element (curve or chamfer).

9.4 G1-Two-Line with up to Two Chamfers or Curves

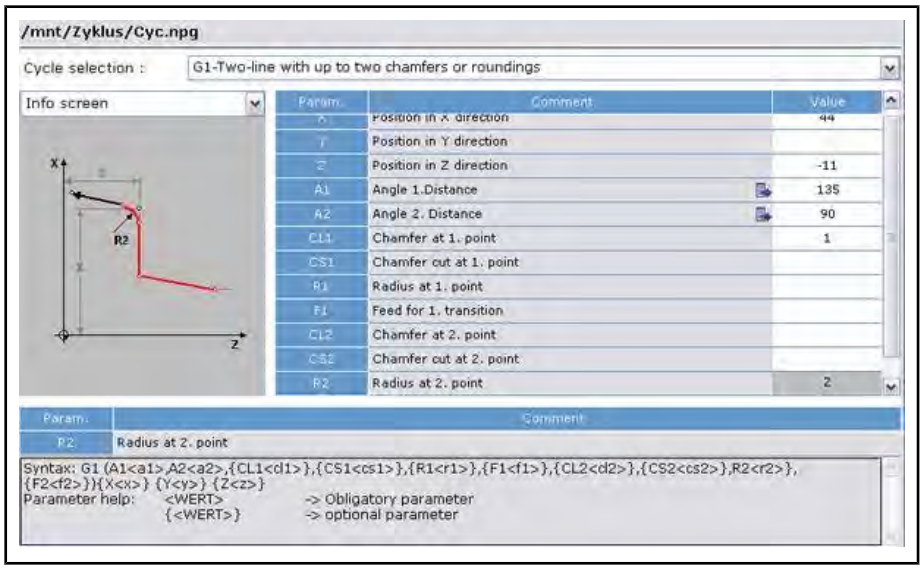

Fig.9-3:

G0 or G1	G0 line with chamfer or curve	G0(RND,CHL,CHS,FL) X Y Z G1(RND,CHL,CHS,FL) X Y Z		
X	Position in X direction	real	optional	
Y	Position in Y direction	real	optional	
Z	Position in Z direction	real	optional	
A1	Angle for 1st length	real	obligatory	degrees
A2	Angle for 2nd length	real	obligatory	degrees
CL1	Chamfer at 1st point	real	optional	
CS2	Chamfer cut at 1st point	real	optional	
R1	Curve at 1st point	real	optional	
F1	Feed for 1st transition	real	optional	
CL2	Chamfer at 2nd point	real	optional	
CS2	Chamfer cut at 2nd point	real	optional	
R2	Curve at 2nd point	real	optional	
F2	Feed for 2nd transition	real	optional	

Sequence: By means of this contour draft, a maximum of two additional transition elements can be simply inserted at the transitions of two lengths. From the last programmed position, the first transition element is worked at the end point of the first length or at the starting point of the second length, whereby the end point of the first length is produced by the angle of the lengths to each other. The coordinates of this point do not have to be known. The second transition element is worked at the end point of the second length or at the starting point of the third length. There too, the end point of the second length is formed by the angle of the lengths to each other. The coordinates of this point also do not have to be known. A special feed can be specified for these transition elements (curve or chamfer).

10 Tabular Overview of Standard NC Cycles

10.1 Defining the Modal G-Codes for Cycle Requests

A maximum of 64 modal cycles are available.

G-code	Designation	Standard UP name	No. of parameters
G80	Delete modal request		
G81	Drilling	STC_G81	5
G82	Countersinking	STC_G82	10
G83	Deep hole drilling	STC_G83	8
G84	Tapping without compensating chuck	STC_G84	8
G85	Reaming	STC_G85	6
G86	Boring	STC_G86	8
G87	Back boring	STC_G87	8
G88	Spot drilling	STC_G88	13
G89	Rigid tapping with swarf crushing	STC_G89	10
G261	Thread milling	STC_G261	8
G262	Thread drill milling	STC_G262	16
G263	Plunge circular milling	STC_G263	12

10.2 Defining the Non-Modal G-Codes for Cycle Requests

A maximum of 64 non-modal cycles are available.

G-code	Designation	Standard UP name	No. of parameters
G111	Bore circle rotary axis	STC_G111	4
G112	Bore circle master spindle	STC_G112	7
G113	Bore circle plane	STC_G113	6
G114	Bore pattern line	STC_G114	6
G115	Bore pattern matrix	STC_G115	9
G116	Bore pattern frame	STC_G116	9

11 Service and Support

Our service helpdesk at out headquarters in Lohr, Germany, will assist you with all kinds of enquiries. Out of helpdesk hours please contact our German service department directly.

	Helpdesk	Service Hotline Germany	Service Hotline Worldwide
Time [1]	Mo-Fr 7:00 am - 6:00 pm CET	Mo-Fr 6:00 pm - 7:00 am CET Sa-Su 0:00 am - 12:00 pm CET	Outwith Germany please contact our sales/service office in your area first. For hotline numbers refer to the sales office addresses on the Internet.
Phone	**+49 (0) 9352 40 50 60**	**+49 (0) 171 333 88 26** or **+49 (0) 172 660 04 06**	
Fax	**+49 (0) 9352 40 49 41**	–	
e-mail	service.svc@boschrexroth.de	–	
Internet	http://www.boschrexroth.com You will also find additional notes regarding service, maintenance (e.g. delivery addresses) and training.		

1) Central European Time (CET)

Preparing Information

For quick and efficient help please have the following information ready:

- detailed description of the fault and the circumstances
- information on the type plate of the affected products, especially type codes and serial numbers
- your phone, fax numbers and e-mail address so we can contact you in case of questions.

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Notes

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