SINUMERIK Systems 3/8

Measuring Cycles Part 1 (Measuring Cycles for Turning Machines)

Planning Guide

SINUMERIK

Edition 07.89

SINUMERIK®Documentation

Key to editions

The editions listed below have been published prior to the current edition.

The column headed "Amendments" lists the amended sections, at all times with reference to the previous edition.

Edition	Order No.	Amendments
12.86	E80210-T53-X-A7	4-1, 4-13, 4-84, 4-86
10.87	E80850-D045-X-A1	4-0, 4-27, 4-29, 4-30, 4-33, 4-34, 4-84, 4-100
07.89	6ZB5410-0CY02-0BA0	4-1, 4-11, 4-13, 4-18, 4-30, 4-32, 4-84

Other functions not described in this documentation might be executable in the control. This does not, however, represent an obligation to supply such functions with a new control or when servicing.

Subject to change without prior notice.

Contents

Preliminary Remarks

Measuring Cycles Part 0
Basic Operation and Commissioning Instructions
for Measuring Cycles

Measuring Cycles Part 2
Measuring Cycles for Milling Machines
and Machining Centres

4. Measuring cycles for turning machines

Part 1

of the Measuring Cycles Description only covers handling of the cycles for turning machines.
The measuring principle and the general preconditions are dealt with in Part 0.

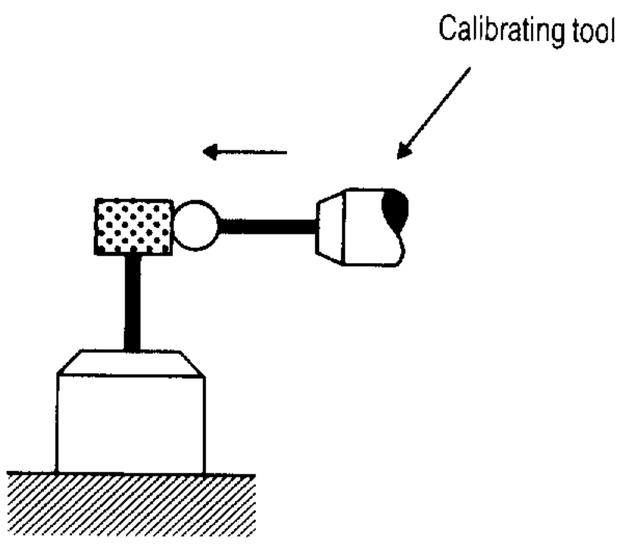
Explanation of header:

System 3		91	===>	Cycle number L91	for System 3
System 8	(F)	L972	===>	Cycle mumber L972	for System 8 ("Flying measurement")
System 8	(S)	L982	===>	Cycle number L982	for System 8 ("Loop measurement")

Measurement variants for turning machines

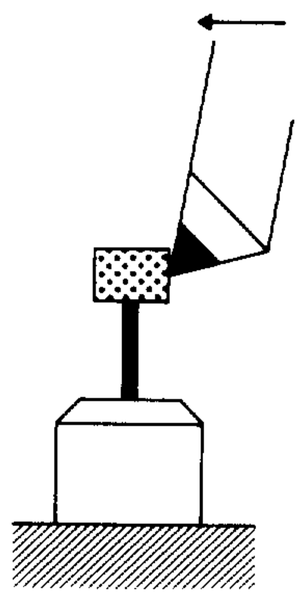
Tool measurement:

Calibrate tool probe



Result:
Probe switching point
relative to machine datum

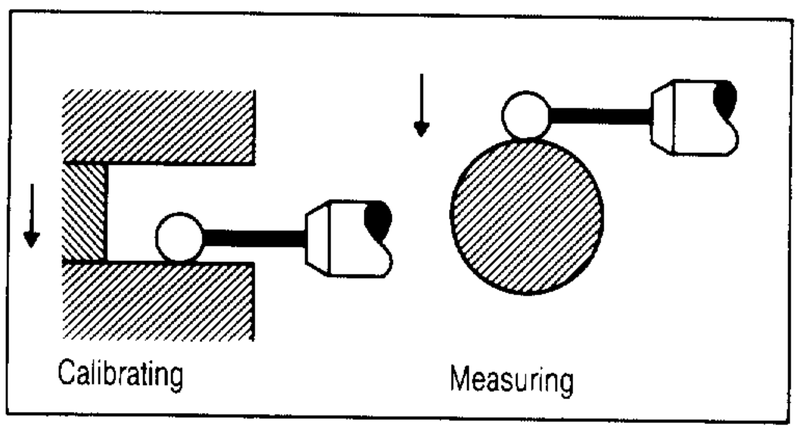
Measure tool



Result:
Tool length (X, Z)

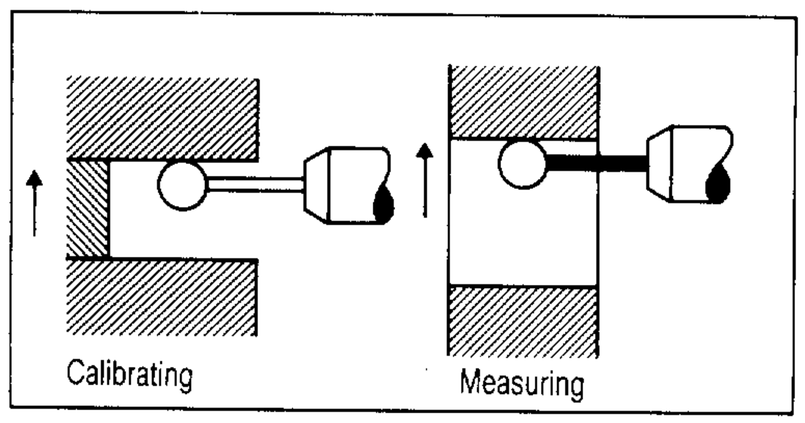
Workpiece measurement with calibration:

1-point external measurement



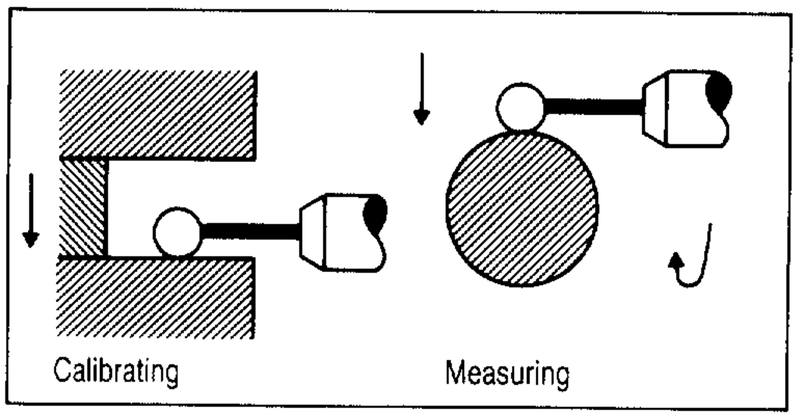
Result:
Actual dimension (diameter, length),
deviation,
tool offset,
zero offset (G59)

1-point internal measurement



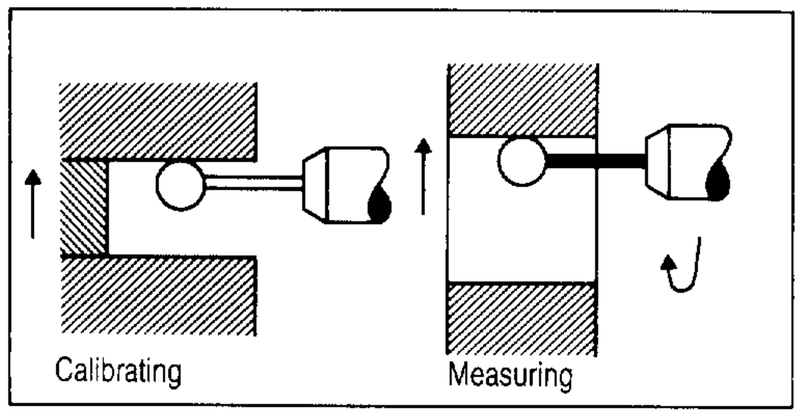
Result:
Actual dimension (diameter, length),
deviation,
tool offset,
zero offset (G59)

1-point external measurement with 180° rotation



Result:
Actual dimension (diameter),
deviation,
tool offset

1-point internal measurement with 180° rotation

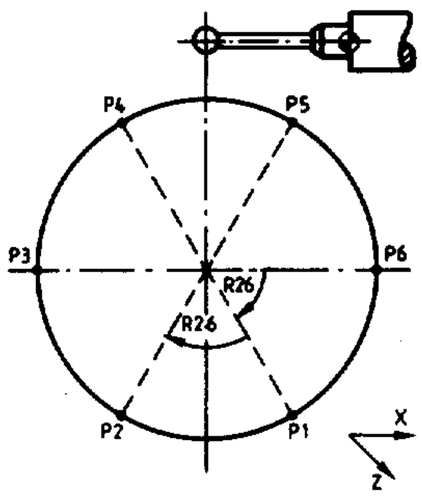


Result:
Actual dimension (diameter),
deviation,
tool offset

Measurement variants for turning machines

Workpiece measurement with calibration:

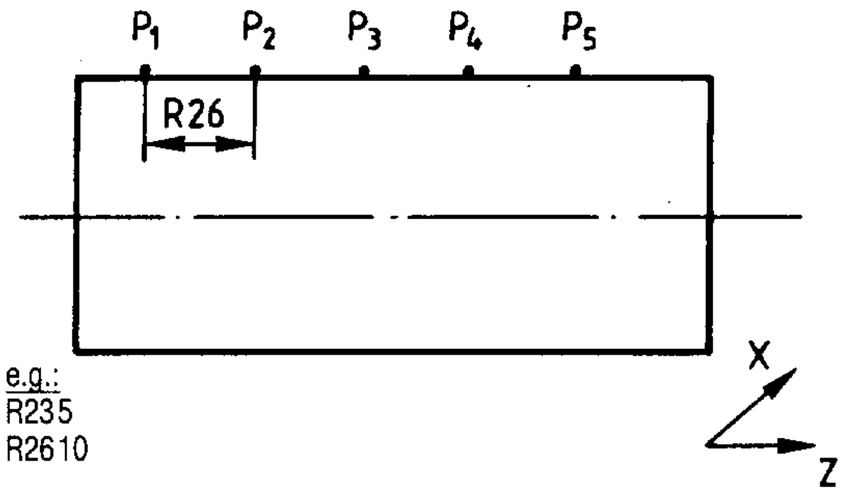
Multi-point measurement on circumference



e.g.:
R236
R2660

Result:
Actual dimension (diameter),
deviation
tool offset

Multi-point measurement on cylinder

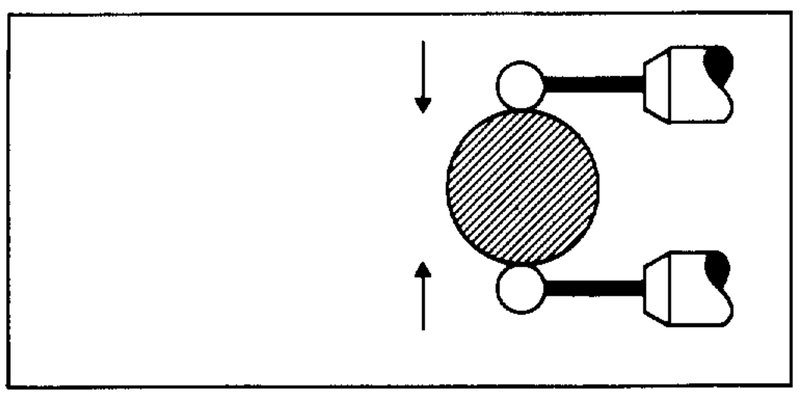


e.g.:
R235
R2610

Result:
Actual dimension (diameter),
deviation
tool offset

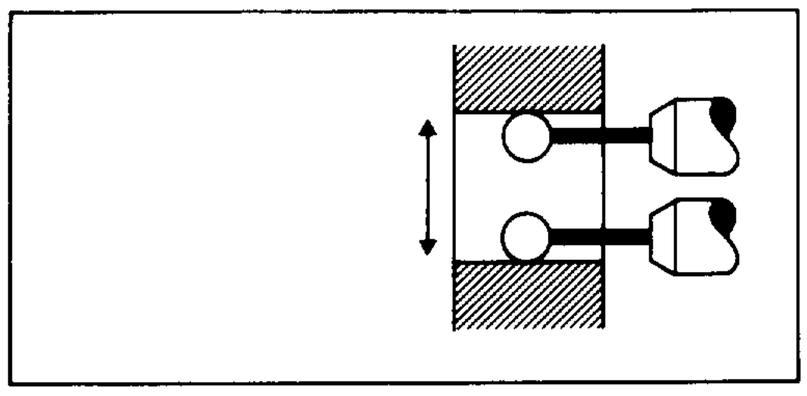
Workpiece measurement without calibration:

2-point measurement across outside diameter



Result:
Actual dimension (diameter),
deviation
tool offset

2-point measurement across inside diameter



Result:
Actual dimension (diameter),
deviation
tool offset

4.1 General preconditions for turning machines

4.1.1 REQUIRED PLC PROGRAMS

a) Loop measurement:

FB237 in Package 1 "Function blocks" for SINUMERIK System 8.

b) Flying measurement, System 8T:

The following commands are to be stored in the PLC:

```
PB...
ON F 31.1    Change signal T
ON F22.5     End of program MO1/M30
R  F 1.1     Flying measurement inactive
A  F ....    Flag for "Probe active" M function
S  F 1.1     Flying measurement active
BE
```

c) Flying measurement, System 3T - basic version 3:

The following commands are to be stored in the PLC:

```
PB...
O  F 12.5    Change signal T
O  F 13.1    End of program MO2/M30
R  F 3.4     Flying measurement inactive
A  F.....    Flag for "Probe active" M function
S  F 3.4     Flying measurement active
BE
```

d) Flying measurement System 3T - basic version 4:
Example for NC1 (corresponding to data block 21)
(see also Interface Description System 3 - Part 2)

The following commands are to be stored in the PLC:

```
PB...
C  DB21
L  DW1
T  FB100     Unassigned flag byte
O  F100.5    Change signal T
O  I 67.6    End of program MO2/M30
R  Q 68.2    Flying measurement inactive
A  F.....    Flag for "Probe active" M function
S  Q 68.2    Flying measurement active
BE
```

Note:

TOO must not be evaluated by the PLC program.

Measurement function diagram

Loop measurement System 8T/Sprint 8T

See also FB237 description

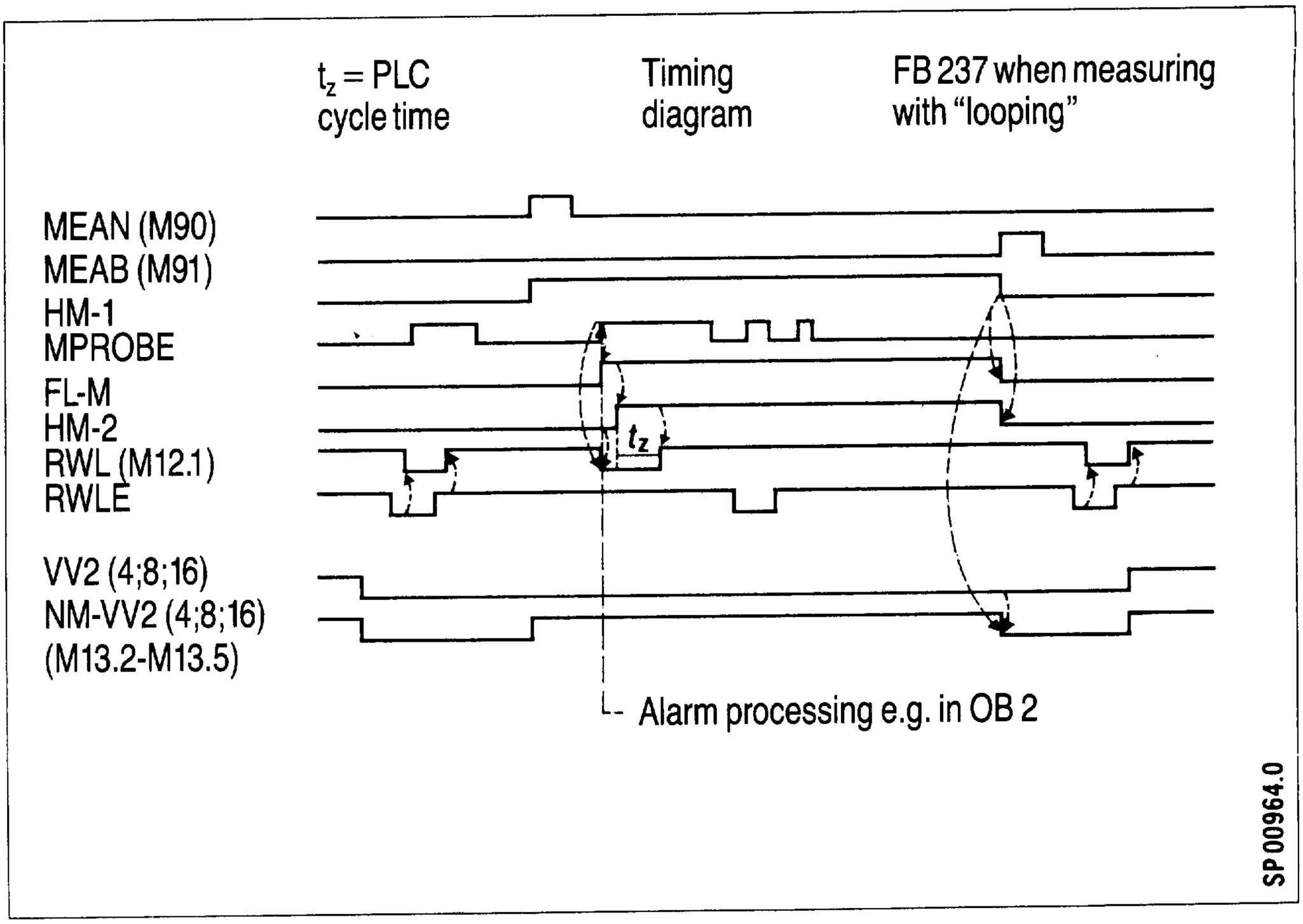


Fig. 1

Flying measurement System 8T/Sprint 8T

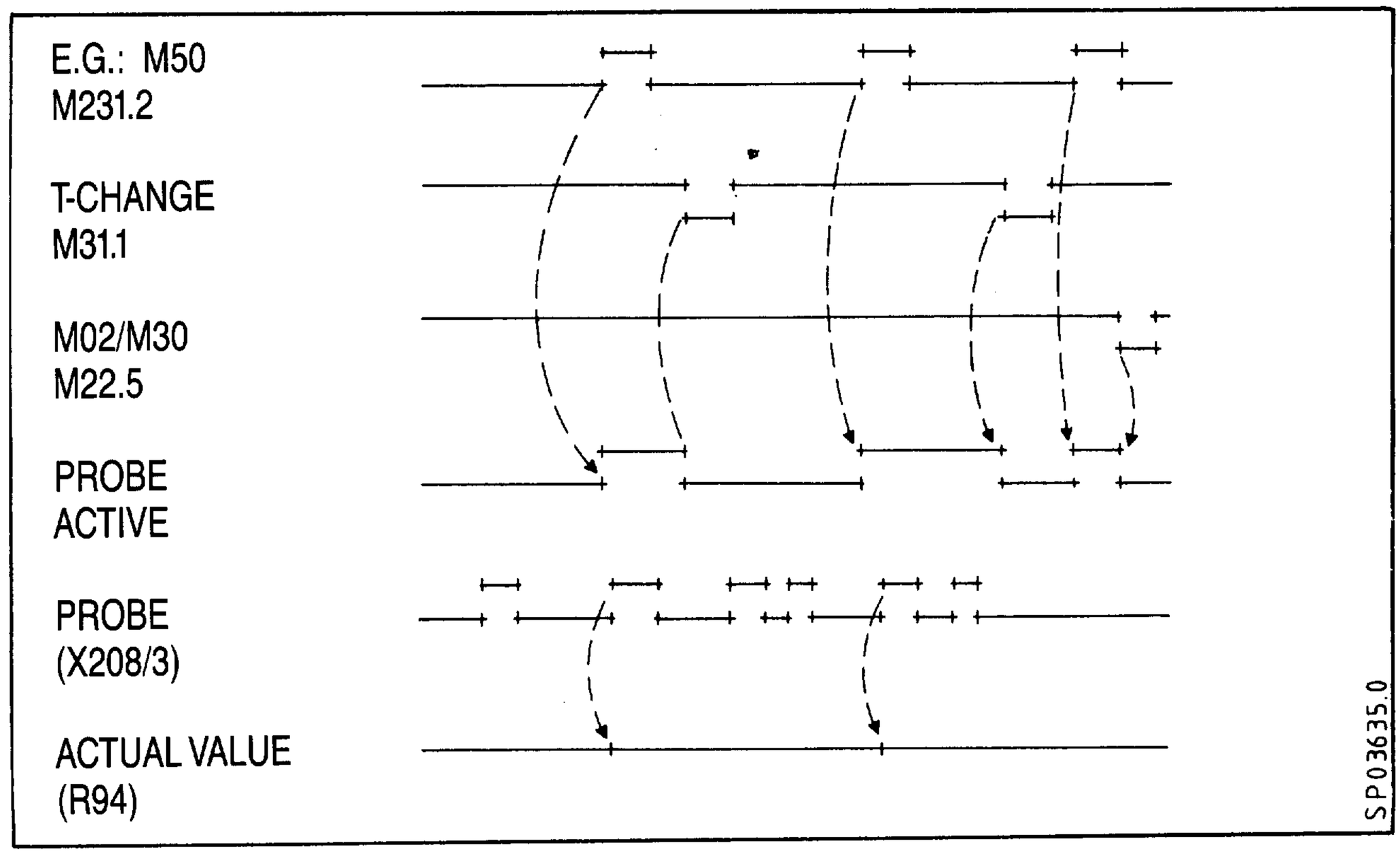


Fig. 2

Flying measurement System 3T - basic version 3

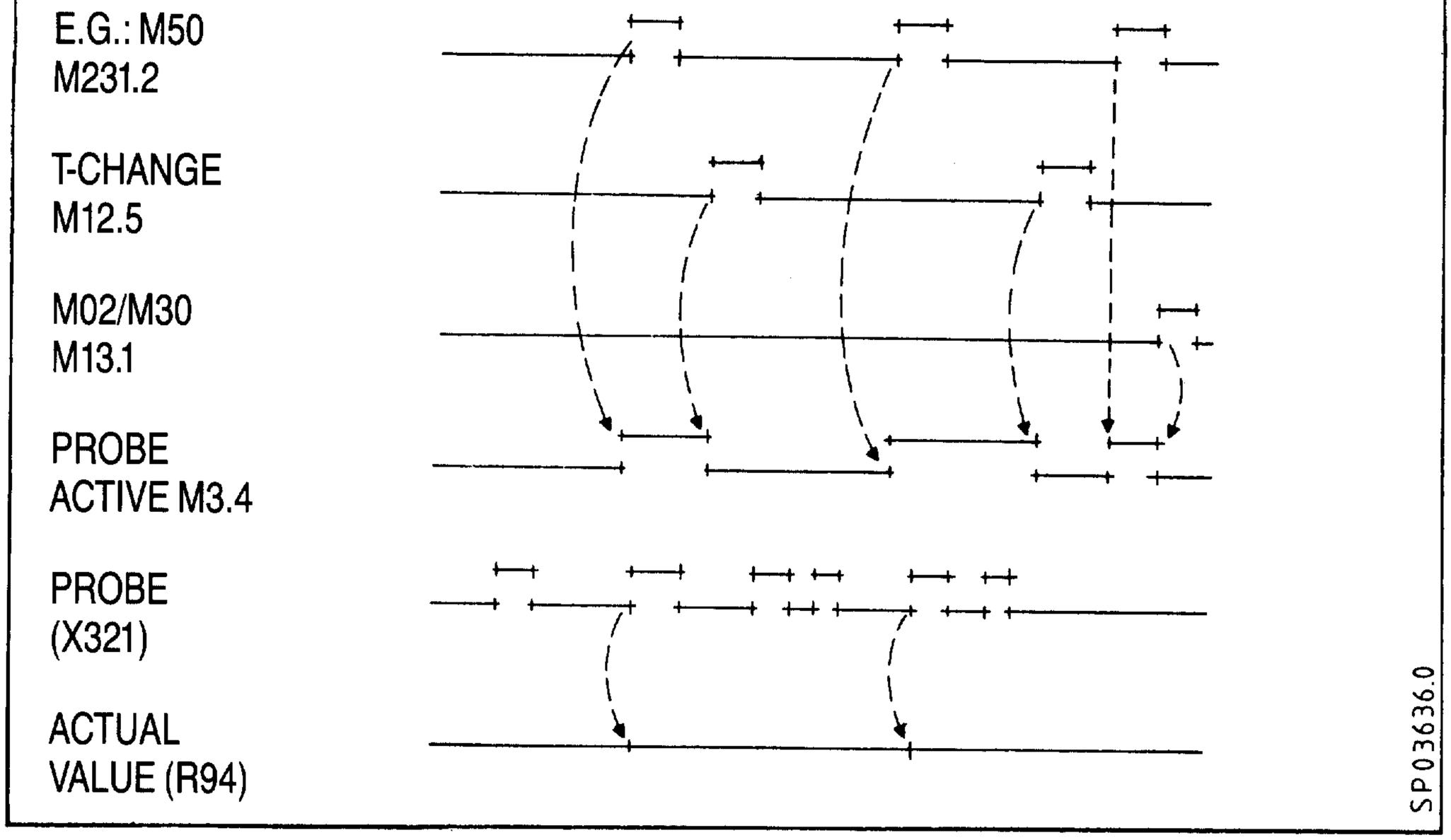


Fig. 3

Flying measurement System 3T - basic version 4

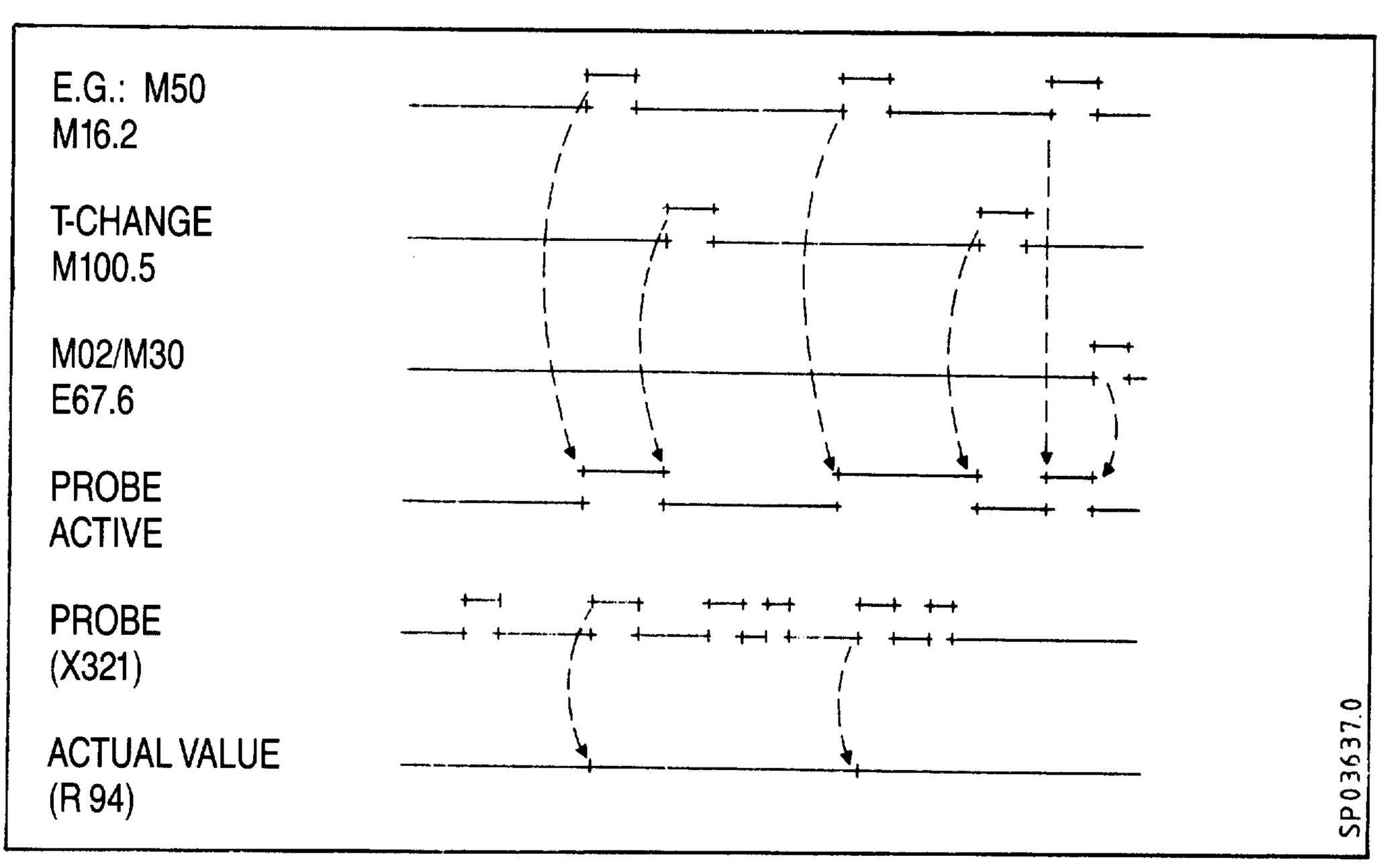


Fig. 4

4.1.2 Overview of measuring cycle programs System 3T

L no.	F U N C T I O N
L70	Read out random background memory number
L71	Additive input in background memory
L72	Background memory erase program
L73	Load contents of TO memory in background memory
L74	Load background memory in TO memory
L75	Calculation of R32 and R35 from R40, R41 and R42
L78	Background memory loading program
L79	Measuring cycles alarm texts English
L79	Measuring cycles alarm texts German
L79	Measuring cycles alarm texts French
L79	Measuring cycles alarm texts Italian
L79	Measuring cycles alarm texts Norwegian
L90	Tool measurement autom. positioning depending on tool nose vector
L91	Tool measurement calibrating/measuring
L92	Workpiece measurement calibrate probe
L93	Workpiece measurement

4.1.3 Overview of measuring cycle programs System 8T/Sprint 8T

L no.	F U N C T I O N	
L898	Background memory loading program	
L899	Measuring cycles alarm texts English	
[899	Measuring cycles alarm texts German	
L899	Measuring cycles alarm texts French	
L899	Measuring cycles alarm texts Italian	
L899	Measuring cycles alarm texts Norwegian	
*L910	TO data transfer between NC <--> PLC	
*L911	Decision program: measure tool?	
L960	Read out random background memory number	
L961	Additive input in background memory	
L962	Background memory erase program	
L963	Load contents of TO memory in background memory	
L964	Load background memory in TO memory	
L965	Calculation of R32 and R35 from R40, R41 and R42	
**L966	Search cycle	Flying
*L967	Utility routine: Calibrate workpiece probe on calibration surfaces	
L971	Tool measurement autom. positioning depending on tool nose vector	Flying
L972	Tool measurement calibrating/measuring	Flying
L973	Tool measurement calibrate probe	Flying
L974	Tool measurement	Flying
L981	Tool measurement autom. positioning depending on tool nose vector	Loop
L982	Tool measurement calibrating/measuring	Loop
L983	Tool measurement calibrate probe	Loop
L984	Tool measurement	Loop

* Special cycle
** Special cycle (Option)

4.1.4 Background memory operator programs, auxiliary programs

These programs simplify the input, output and editing of values in the background memories. The "@" command (@29 ... 18 R..) need no longer be programmed.

Program number

System 8	3	
L898	L78	Background memory loading program Area 00-57 is erased. Variables can be entered in area 60-99.

Example of program structure:

```
L898
(Erase memories 00-57)
N58 R58 0
    R50 58  @29  25818 R50    (b/mem 58 loaded)
N59 R59 0
    R50 59  @29  25918 R50    (b/mem 59 loaded)
N60 R60 0
    R50 60  @29  26018 R50    (b/mem 60 loaded)
N61 R61 0
    R50 61  @29  26118 R50    (b/mem 61 loaded)
:
:
:
N99 R99 0
    R50 99  @29  29918 R50    (b/mem 99 loaded)
```

Procedure:
e.g. input value 50 in background memory no. 61 (M50 probe active)

- Call L78 in MDI part program
- Block search for N61
- In N61 change R61 0 to R61 50 (EDIT)
- Select MDA, L78 LF INPUT
- NC Start (without single block)

Background memories 58-99 are reloaded with the values from L78.

Original subroutine	Edited subroutine
.	.
.	.
N61 R61 0	N61 R61 50
R50 61 @29 26118 R50	R50 61 @29 26118 R50
.	.
.	.

Program number		
System 8	3	
L960	L70	Read out random background memory number R11 indicates the number of the background memory. The value is entered in R00. Procedure: e.g. read memory no. 61 - Select MDA mode - R11 61 L960 LF INPUT - NC Start (without single block) - Read R00 in TO memory
L961	L71	Additive input in background memory e.g. to input or edit empirical values R11: Number of background memory R12: Value (additive) Procedure as for L960/L70
L962	L72	Background memory erase program for 00-57 (empirical and average values) R40: Start address of erase area R41: End address of erase area Procedure as for L960/L70 Application: e.g. when changing part programs
L963	-	Load contents of TO memory (NT1 X ... to NT20 X ...) in background memory (01 to 20) This program complements L964/L74
-	L73	Load contents of TO memory in background memory TO memory: T1 X.. - T16.., T1 Z.. - T4 Z.. B/memory: 1 - 16 , 17 - 20 This program complements L74
L964	-	Load background memory (01 to 20) in tool offset memory (NT1 X... to NT20 X...). This auxiliary program is used to have empirical values from the background memory punched out for off-line storage via the TO memory. The TO memory is first completely erased. The background memory values are entered under X.

Program number	
System 8	3
-	L74
L965	L75

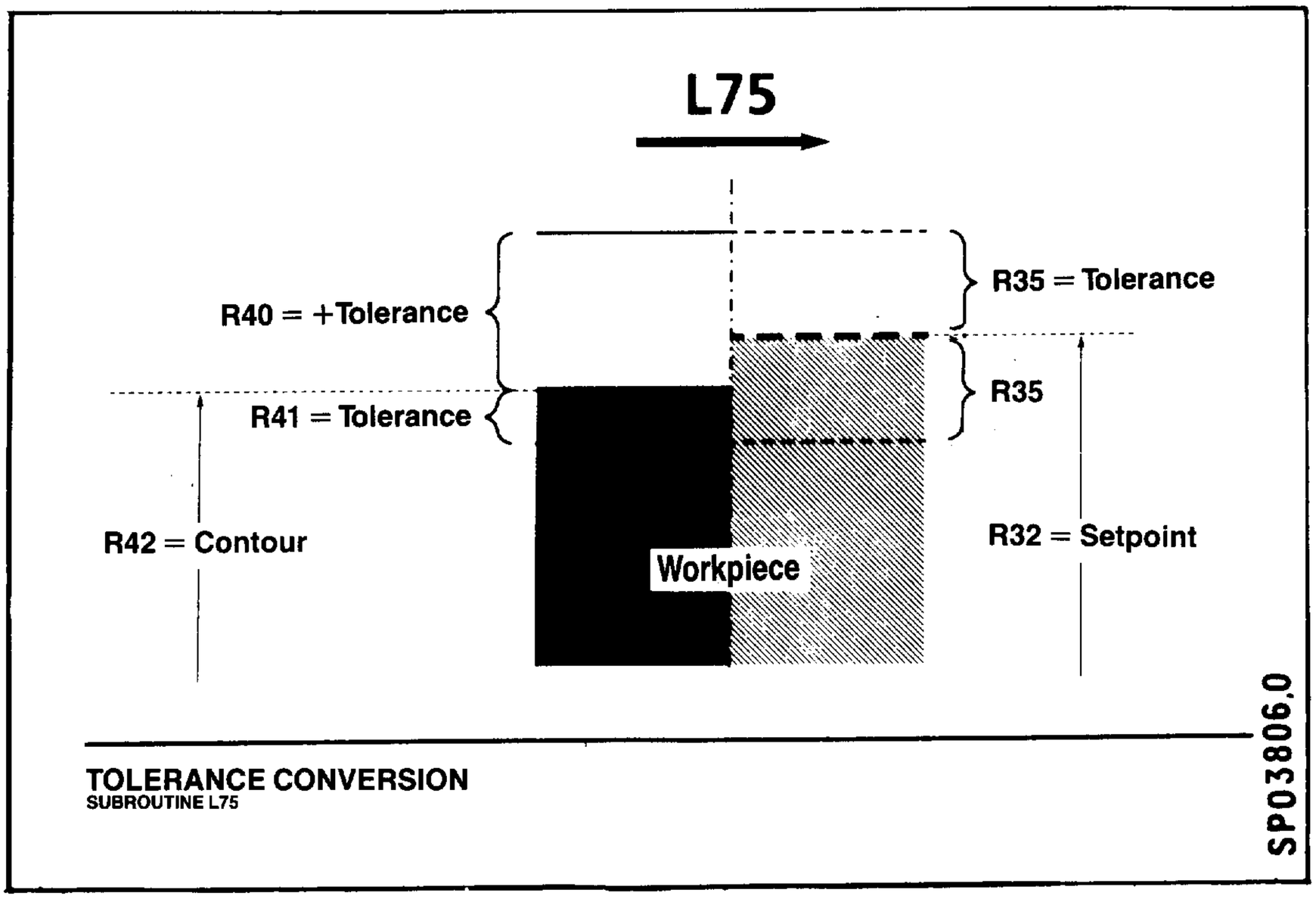
Load background memory from 01 - 20 in the TO memory T1 X - T16 X and T1 Z - T4 Z
Application as L964 of System 8

Auxiliary program for calculating R32 and R35 from R40, R41 and R42

The specified centre point and centre tolerance should be input in R32 and R35 respectively

e.g.: specified drawing dimension with asymmetrical tolerance $100^{+0.02}_{-0.01}$

Definition of R40 - R42:
R40 0.02
R41 -0.01
R42 100
Following execution of L965/75, parameters R32 and R35 have the following contents:
R32 100.005
R35 0.015



TOLERANCE CONVERSION
SUBROUTINE L75

4.2 Description of measuring cycles for turning machines

4.2.1 Tool measurement

4.2.1.1 Calibrate tool probe

Function and application

With the aid of the calibration tool, the cycle determines the current distances between machine data and probe trigger points and loads them automatically into the background memories 65-68.

Calculations are performed without empirical and mean values.

When calibration has been completed, the calibration tool is located away from the measuring surface by an amount R28.

Tool probes mirror-imaged in the X or Z axis can also be calibrated with this cycle (see Figs. 6-8).
An advantage of mirror imaging is that the probes can be fitted outside the work zone.
When calibrating, the calibration tool must be positioned in the turret rotated through 180 degrees, under PLC control. The identifications for mirror imaging must be input into background memory 99 (see Appendix, Table I-1).

Preconditions

- The side surfaces of the probe cube must be aligned parallel to the machining axes X and Z.

- The distances of the side surfaces of the probe cube with respect to machine datum must be input in mm in the background memories 65-68 (see Figs 5-8).

- The dimensions of the calibration tool must be input in mm in the background memories 62-64 (see Figs. 5-8).

  The dimensions must be given as tool vector 3,
  that means X-minus and Z-minus

- The calibrating axis must be programmed with G53 and TO No. 0 (T xx00).

- Start position in accordance with Fig. 9
  The measuring cycle calculates the start position automatically.

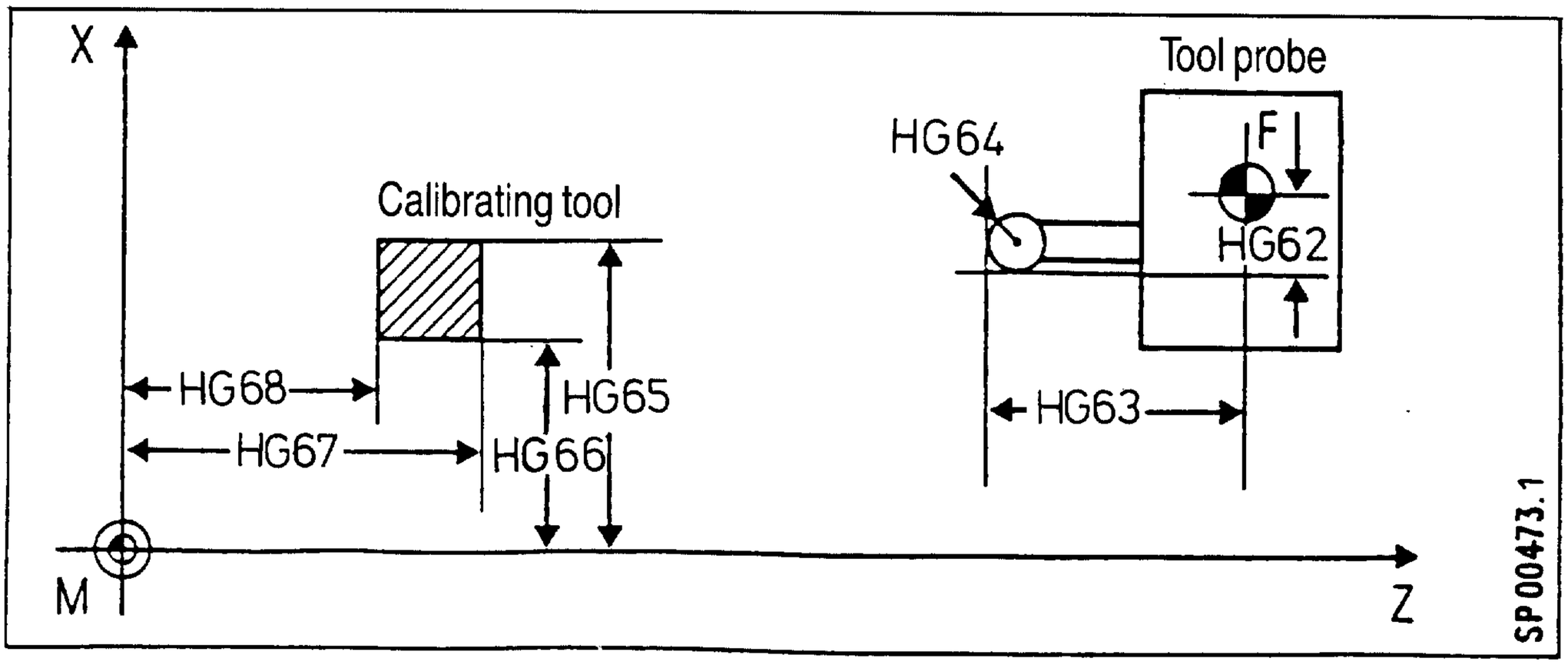


Fig. 5 Overview machine data: tool probe, calibrating tool

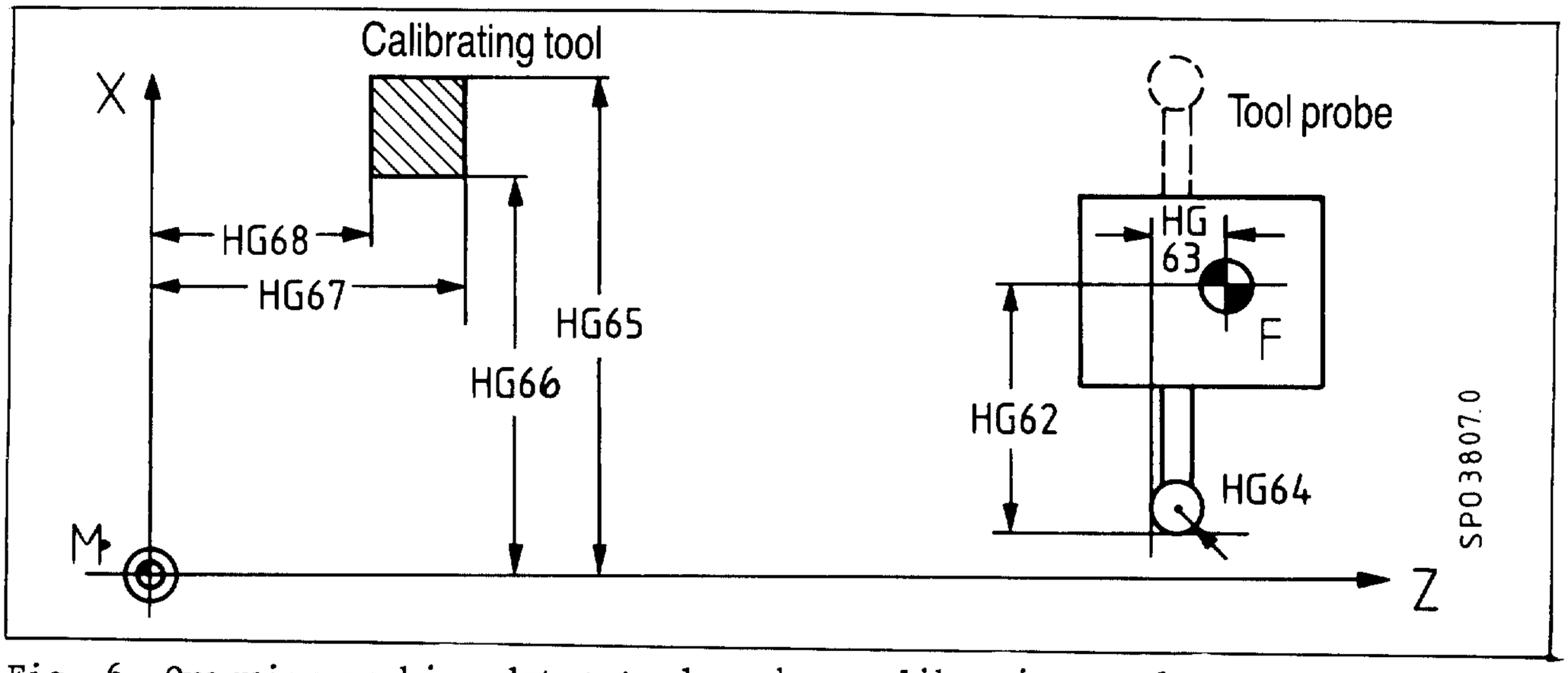


Fig. 6 Overview machine data: tool probe, calibrating tool
(X axis mirror-imaged)

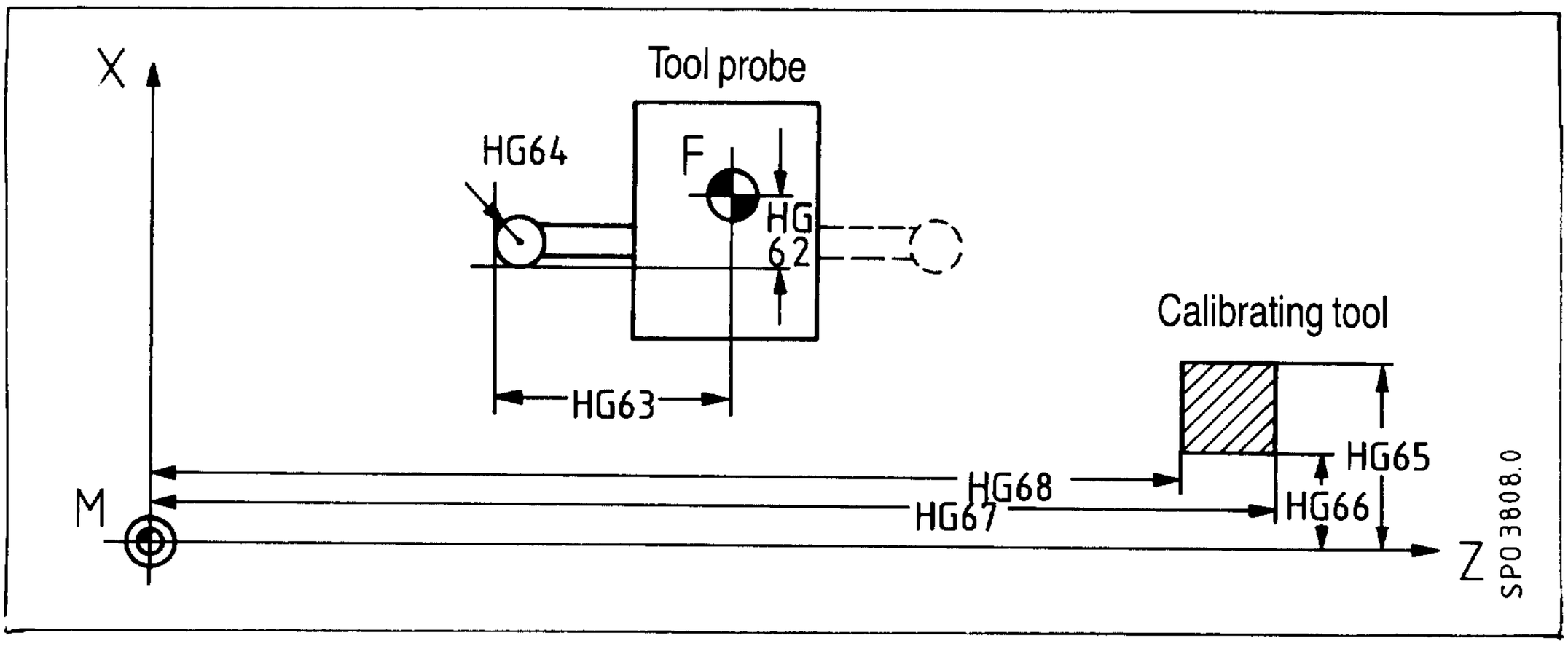


Fig. 7 Overview machine data: tool probe, calibrating tool
(Z axis mirror-imaged)

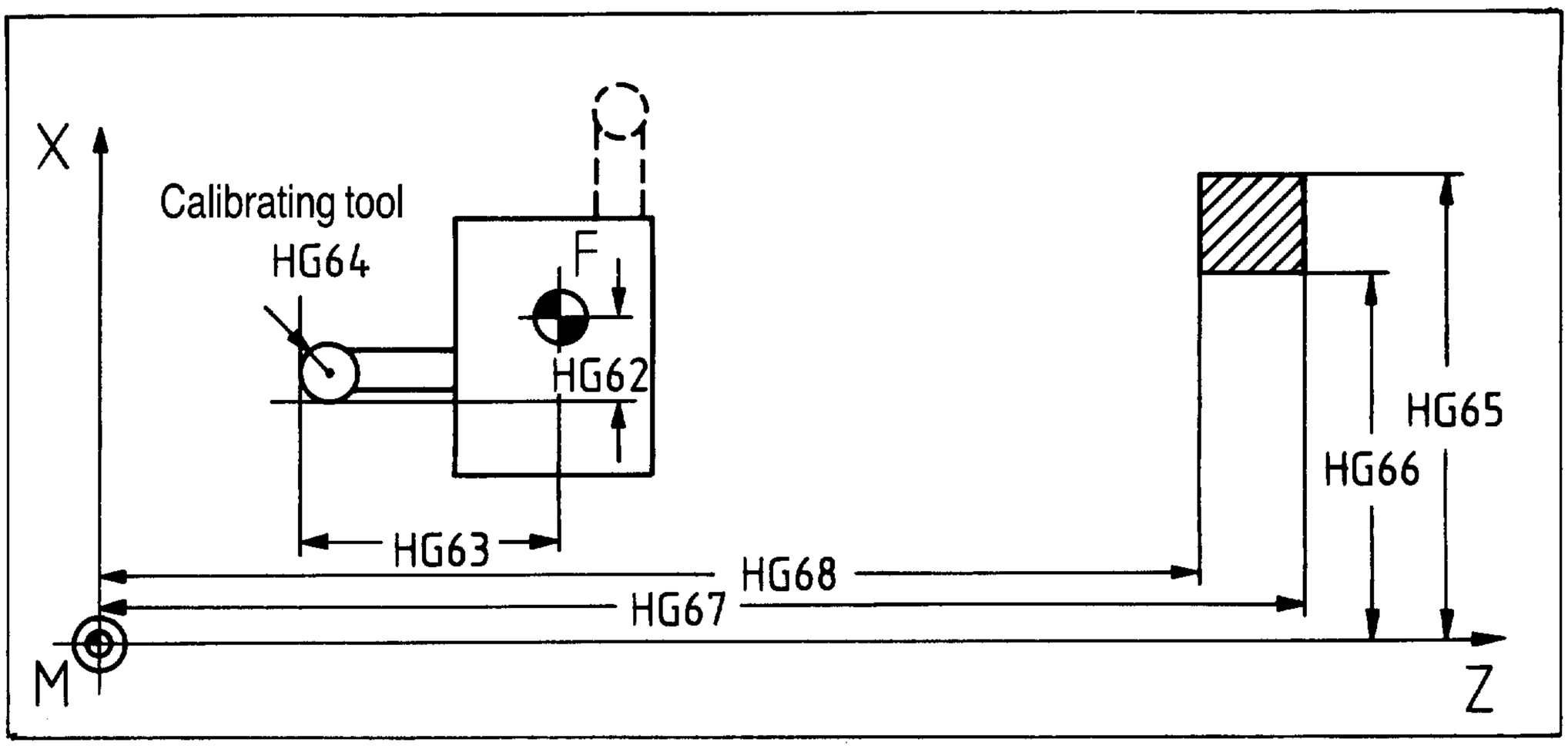
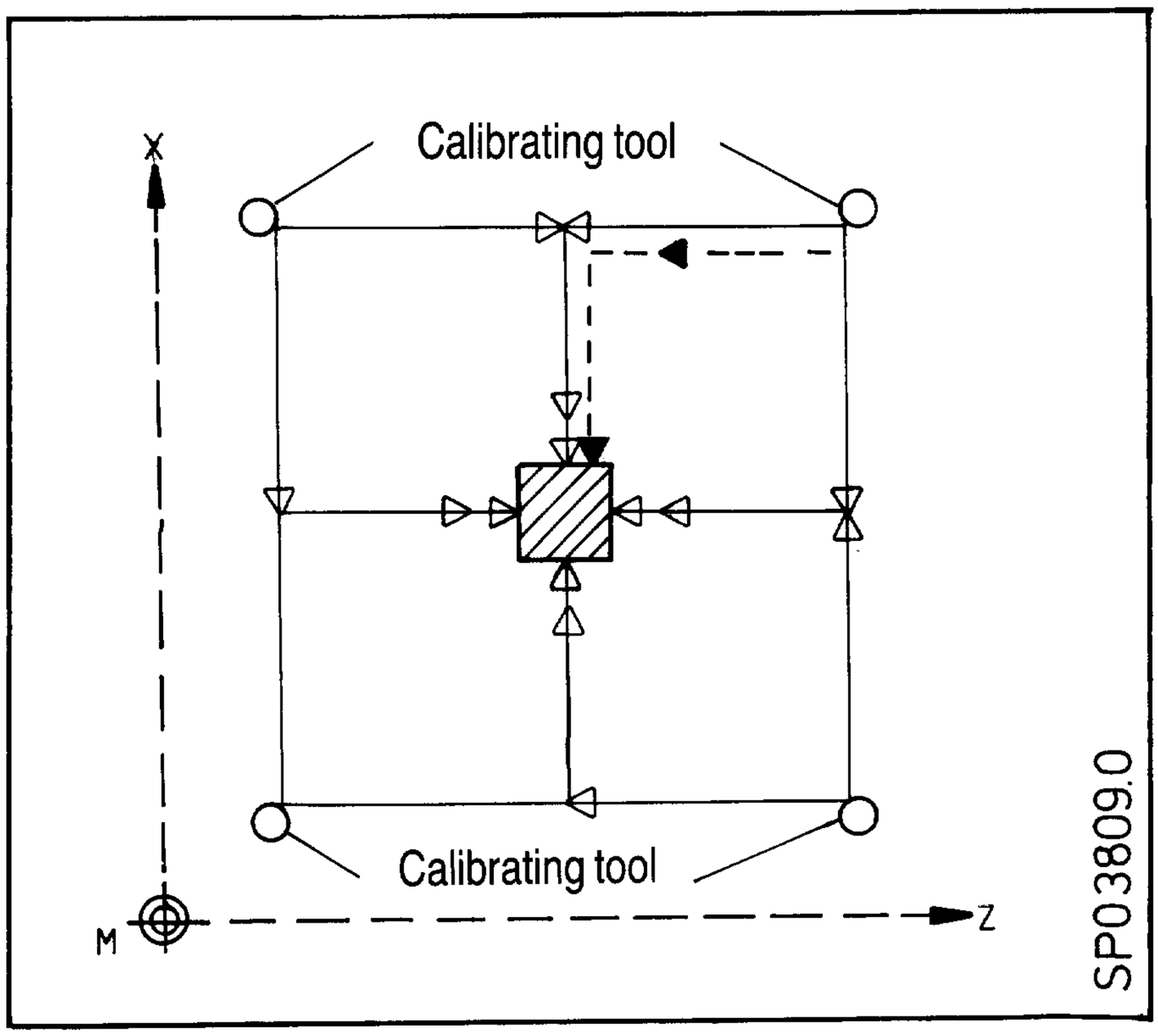


Fig. 8 Overview machine data: tool probe calibrating tool
(X and Z axis mirror-imaged)



Example: --
Positioning when calibrating in minus X direction

Fig. 9 Start positions for "Calibrate tool probe"

The calibrating tool must be prepositioned at these positions before the calibration cycle is called (start position).

Tool measurement	System 3 L91 System 8 (F) L972
Calibrate tool probe	System 8 (S) L982

Definition

The following parameters must be defined prior to call:

R20 1 Calibrate tool probe

R27 1 - 10 Number of measurements at same location (see Part 0 2.5)

R28 1 - 10 Multiplication factor for measurement path "2a"

R30 Number of measuring axis
1 X axis
2 Z axis

R33 Zero offset range (see Part 0 2.3.1)

R36 Safe area (see Part 0 2.3.1)

The following values are available in R parameters on completion of the cycle:

R42 Old tool probe length
R43 New tool probe length
R44 Difference set/actual D
R47 Background memory no., tool probe

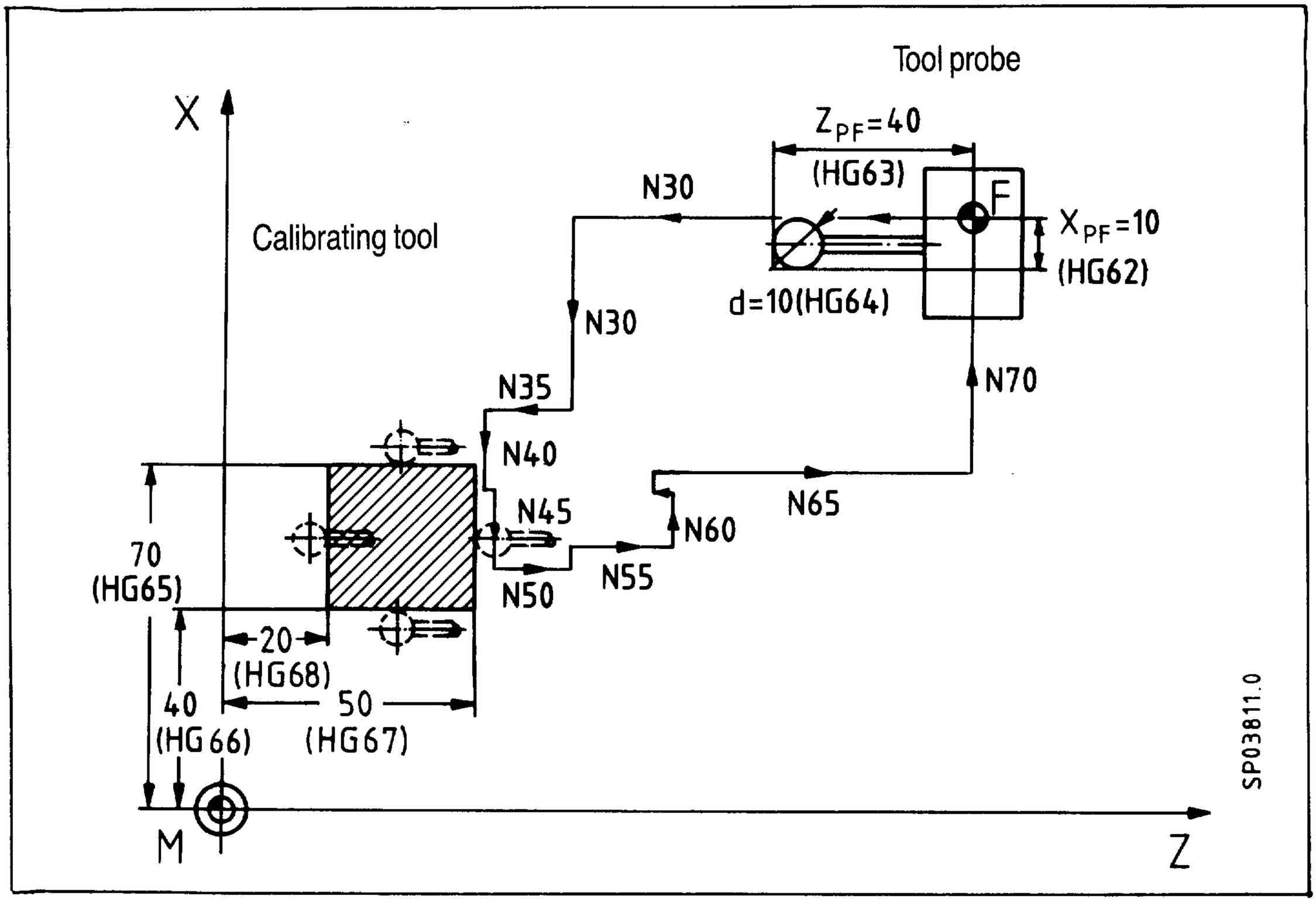


Fig. 10 Calibrate tool probe

The tool probe is stationary, but supplies switching signal.
The calibration tool is positioned with the turret.

Tool measurement	System 3 L91 System 8 (F) L972
Calibrate tool probe	System 8 (S) L982

Recommendation: Creation of a machine-specific calibration subroutine using the cycles L91/L972/L982.
This program can be used when required, either before each tool measurement using the main program or by means of MDA (once per day).

Example: Machine-specific calibration subroutine (details as in Fig. 10)

Values in the background memories:

```
62      10
63      40
64       5

65      70
66      40
67      50
68      20
```

```
%SP
L1000
N5 G00 G53 G94 X240                          /Approach any change position
N10 G53 Z300                                 /Any change position
N15 T1000                                    /Calibrating tool
N20 M71                                      /Tool probe (e.g. swing in)
N25 R20 1 R27 1 R28 1 R30 1 R36 2 R33  0 /Define parameters for cali-
                                              bration cycle
N30 L91                                      /Calibrate in minus X direction
N35 G00 G53 Z52                              /Approach new start position
N40 R30 2 L91                                /Calibrate in plus Z direction
N45 G00 G53 X94                              /Approach new start position
N50 R30 1 L91                                /Calibrate in plus X direction
N55 G00 G53 Z93                              /Approach new start position
N60 R30 2 L91                                /Calibrate in minus Z direction
N65 G00 G53 Z300                             /Approach any change position
N70 G53 X240                                 /Approach any change position
N75 M17
```

Tool measurement	System 3 L91 System 8 (F) L972
Calibrate tool probe	System 8 (S) L982

4.2.1.2 Determine dimensions of calibrating tool

1. Input background memories 62-68 with L78 (L898)

2. Measure turning tool at presetting station

3. Input tool data in TO memory (e.g. X60) and fit tool in turret

4. Machine test part (turn X dimension)

   Set diameter: 200.000 mm
   Actual diameter: 200.100 mm

5. Correct TO memory (X59.95)

6. Turn test part again

   Set diameter: 195.000 mm
   Actual diamter: 195.000 mm

7. Calibrate tool sensor, e.g. with L10 (see 4.2.1.1)

8. Measure tool (L91, L972, L982)

   TO memory: X59; the value 59.95 should be obtained (see point 5)

9. Modify background memory 62 (calibrating tool X axis)

   Background memory 62 = 40, change to 40.95 by means of L78 (898)
   N62 R62 40.95

   Start L78 (L898) in MDA

10. Calibrate tool probe as under 7.

11. Measure tool (L91, L972, L982)

    TO memory: X59.95 <=== value o.k.
    value of calibrating tool X is o.k.

Tool measurement	System 3 L91 System 8 (F) L972
Measure tool	System 8 (S) L982

4.2.1.3 Measure tool

Function and application

The cycle calculates the new tool length and checks whether the difference, after any necessary compensation by an empirical value, exceeds an amount defined in R36 as compared with the old length. If this is not the case, the new tool length is loaded under geometry in TO memory, otherwise an alarm is triggered.
In addition, compensation is performed when the deviation exceeds a lower limit specified in R33. Should this not be the case, the old tool length is not modified. Such action serves to suppress accidental measuring errors.

The tools can also be measured mirror-imaged in X or Z axis with this cycle (see also 4.2.1.1).

Averaging is not performed.

On completion of the cycle, the tool tip is now separated from the measuring surface by the amount R28.

Preconditions

- The tool probe must have been calibrated
- Tool geometry data has been input in the TO memory with tool nose radius and location

  Example: T3 X 50. Z - 25.
  B 1. A 3

- The measuring axis must be programmed with G53 (cancel zero offset) and the relevant tool offset number.

- Start position in accordance with Fig. 12. The cycle calculates the approach position automatically.

Note: In System 8, the appropriate tool wear memory is set to zero on completion of the cycle as the absolute length of the tool has been re-determined.

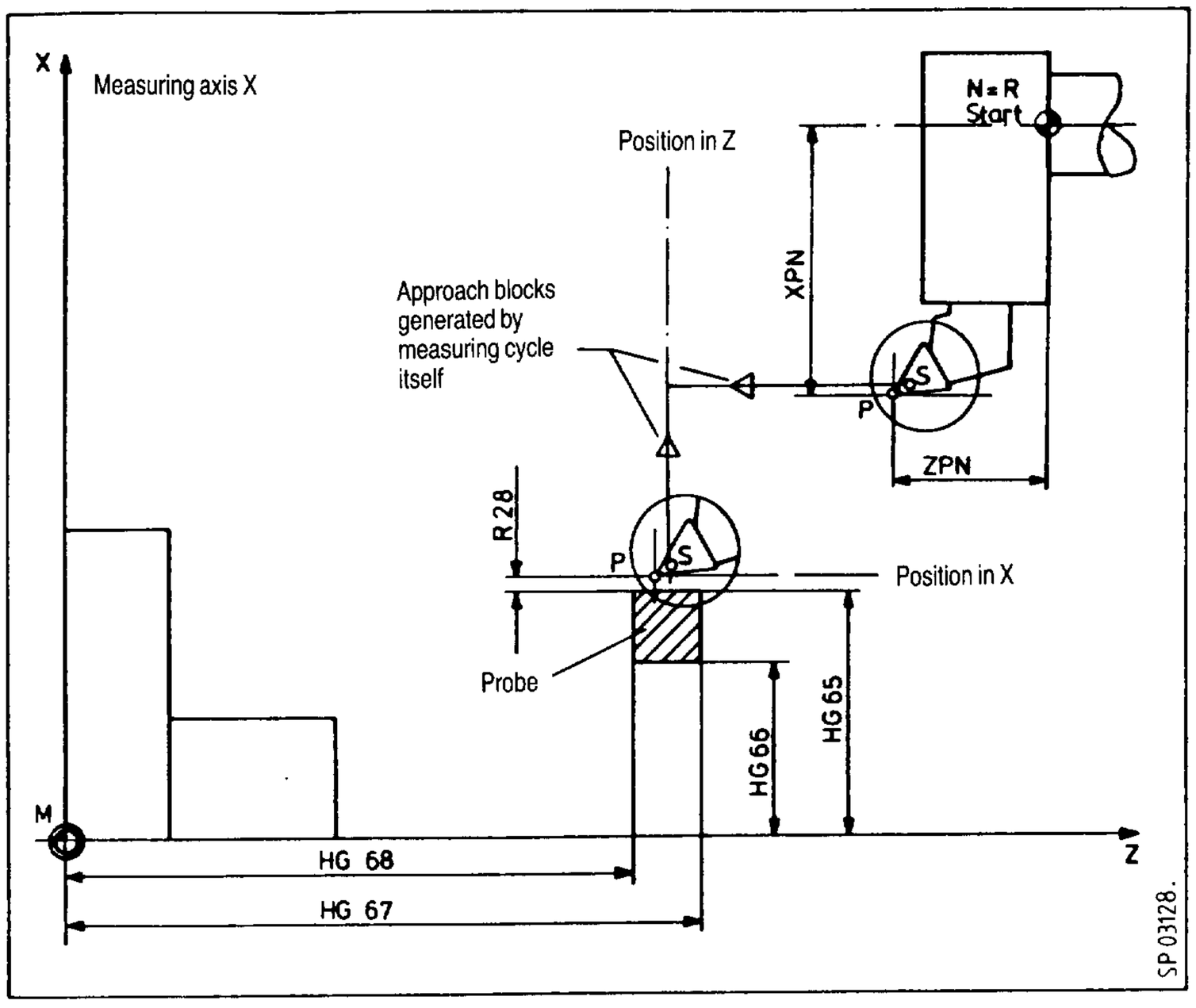
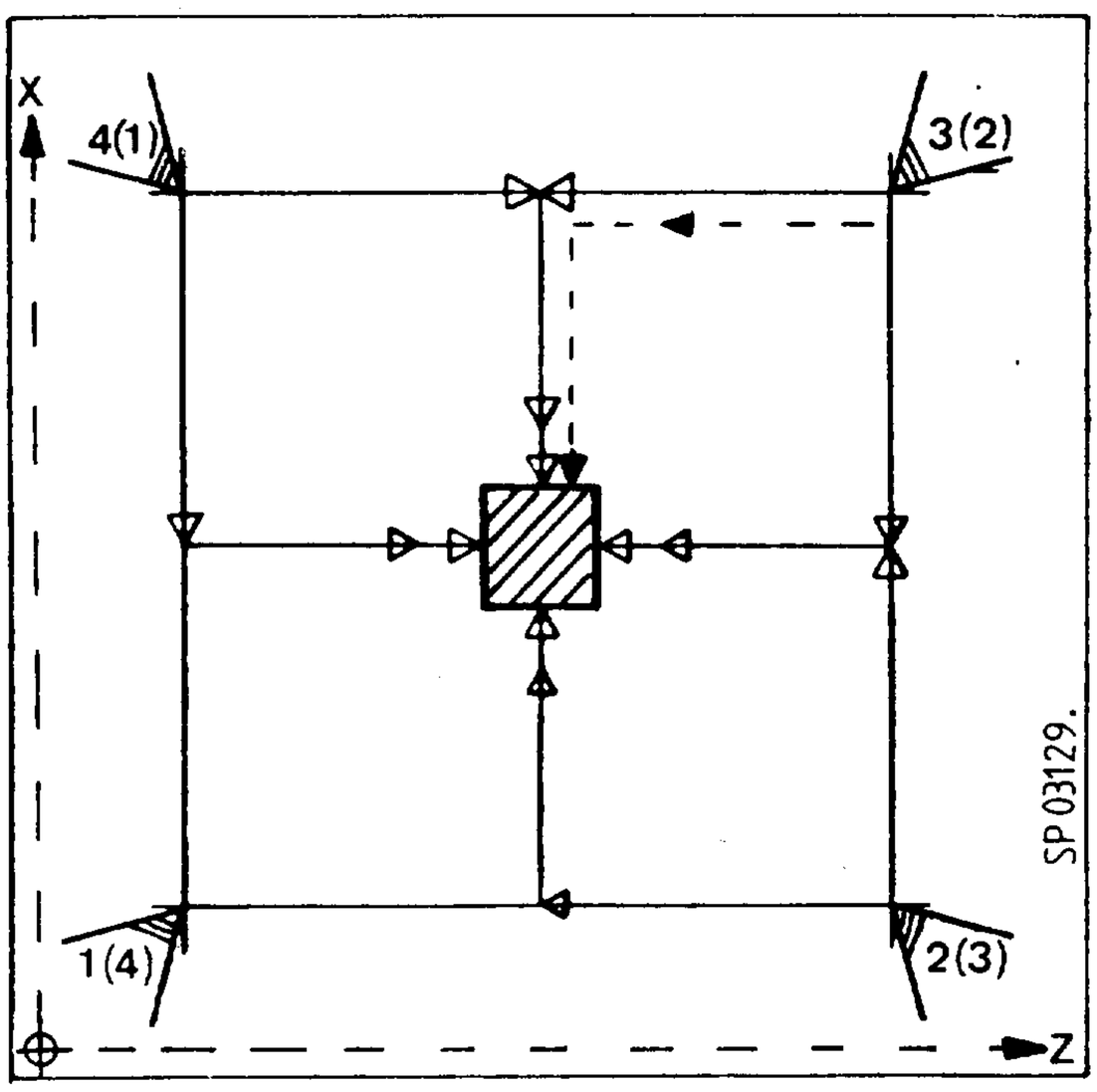


Fig. 11 Overview machine data "Measure tool"



Example: ---
Positioning for tool nose vector 3 and measurement in minus X direction

1,2,3,4:
Tool nose vector:
Machining behind the centre of rotation

(1), (2), (3), (4):
Tool nose vector:
Machining in front of the centre of rotation

Fig. 12 Start positions with "Measure tool"

The tool must be brought to these positions before the measuring cycle is called (start position).

Tool measurement	System 3 L91 System 8 (F) L972
Measure tool	System 8 (S) L982

Definitions

The following parameters must be defined prior to call:

R11 0 - 20 Empirical value memory no.

R20 0 Tool measurement

R27 1 - 10 Number of measurements at same location
(see Part 0 2.5)

R28 1 - 10 Multiplication factor for measurement path "2a"

R30 Number of measuring axis
1 X axis
2 Z axis

R33 Zero offset range (see Part 0 2.3.1)

R36 Safe area (see Part 0 2.3.1)

R37 Dimensional deviation check (see Part 0 2.3.1)

The following values are available in R parameters on completion of the cycle.

R42 Old tool length
R43 New tool length
R44 Set/actual difference D
R45 Empirical value
R46 Empirical value memory no.
R47 Tool offset number

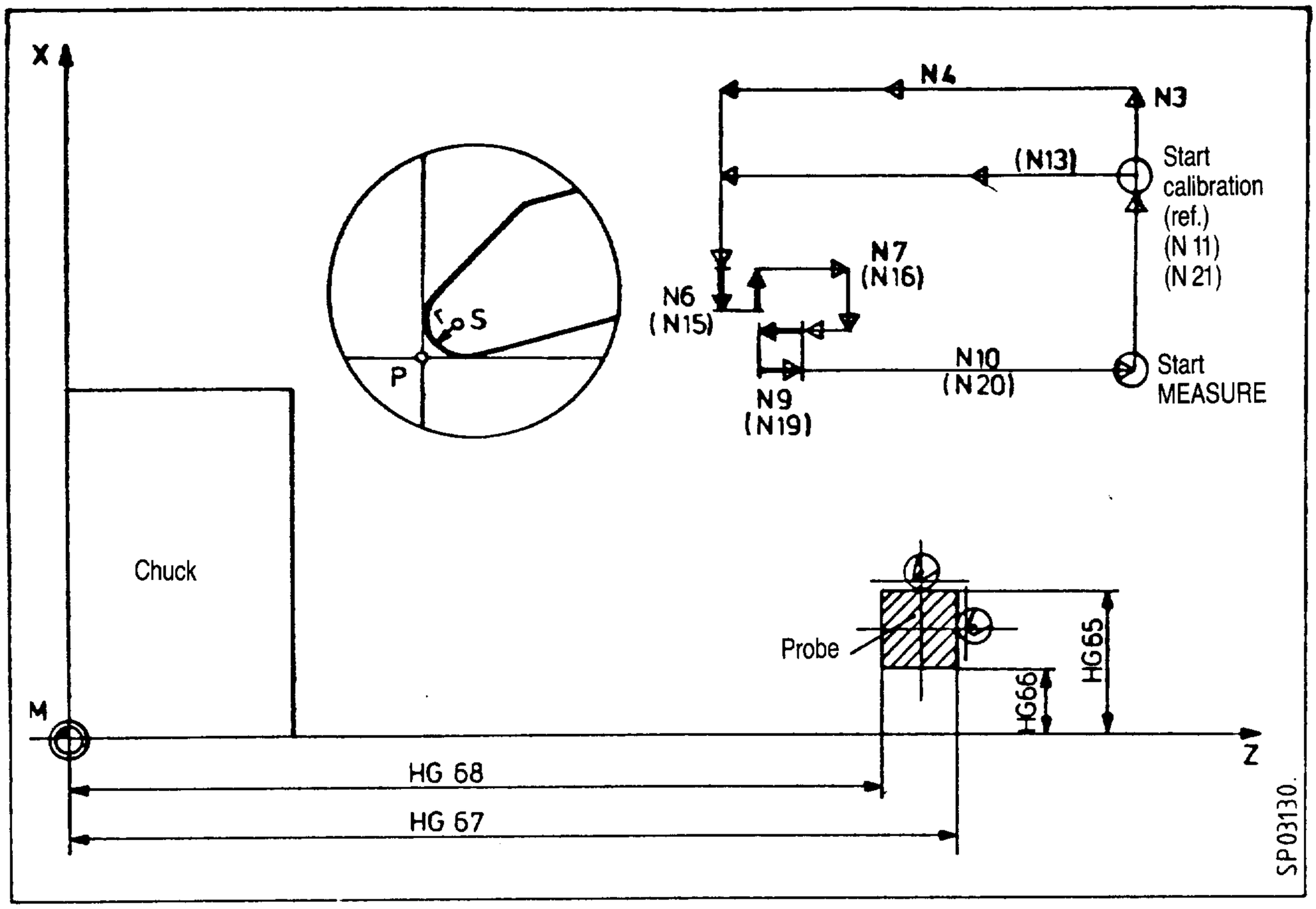


Fig. 13 Measure tool

Tool measurement		
	System 3	L91
	System 8 (F)	L972
Measure tool	System 8 (S)	L982

Programming example: Calibrate tool probe and then measure a tool T3 in accordance with Fig. 13.

```
%91
:
:
N3   G53 X595 TO
N4   G53 Z250 T0700                          /Call calibrating tool
N5   R20 1 R27 2 R28 1 R30 1 R33 0 R36 1     /Parameter definition
N6   L91                                     /1st call calibration
                                              cycle X axis

N7   G53 G0 Z200
N8   R30 2                                   /Parameter definition
N9   L91                                     /2nd call calibration
                                              cycle Z axis

N10 G00 G53 Z520
N11 G53 X575
N12 T328                                     /Call of tool to be
                                              measured

N13 Z250
N14 R11 0 R20 0 R27 1 R 28 1 R30 1           /Parameter definition
    R33 0 R36 1 R37 0.8
N15 L91                                      /Measure tool in minus
                                              X axis

N16 G00 Z400
N17 R30 2                                    /Parameter definition
N19 L91                                      /Measure tool in minus
                                              Z axis

N20 G00 G53 Z250 TO
N21 G53 X560
M30
```

Instead of the blocks N3 - N9, the subroutine L10 can be applied (machine-specific calibration program, see Section 4.2.1.1)

For further simplification, the tool measurements can be performed with the measuring cycle program L90 (L971, L981).
This cycle is described in the next Section 4.2.2.

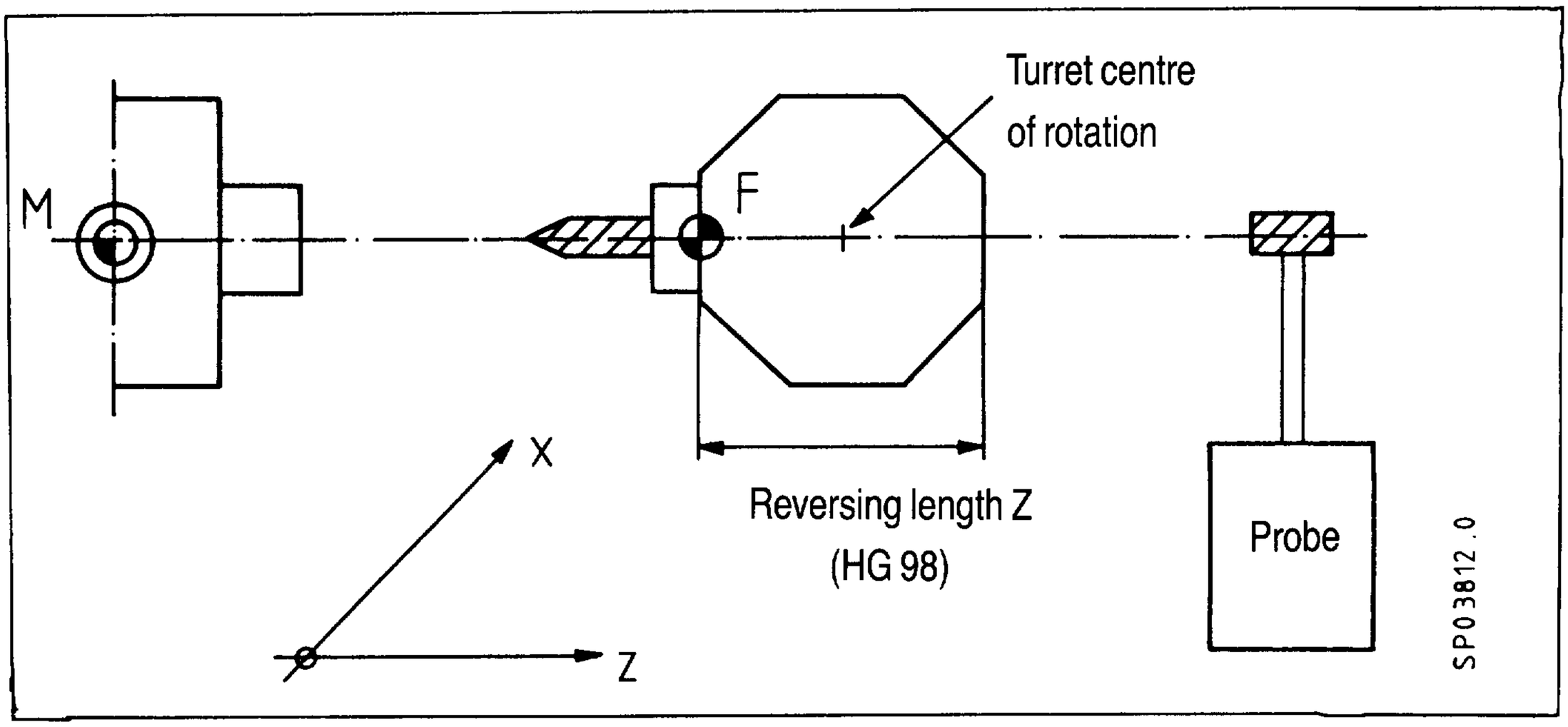


Fig. 14 Measure tool, Z axis mirror-imaged

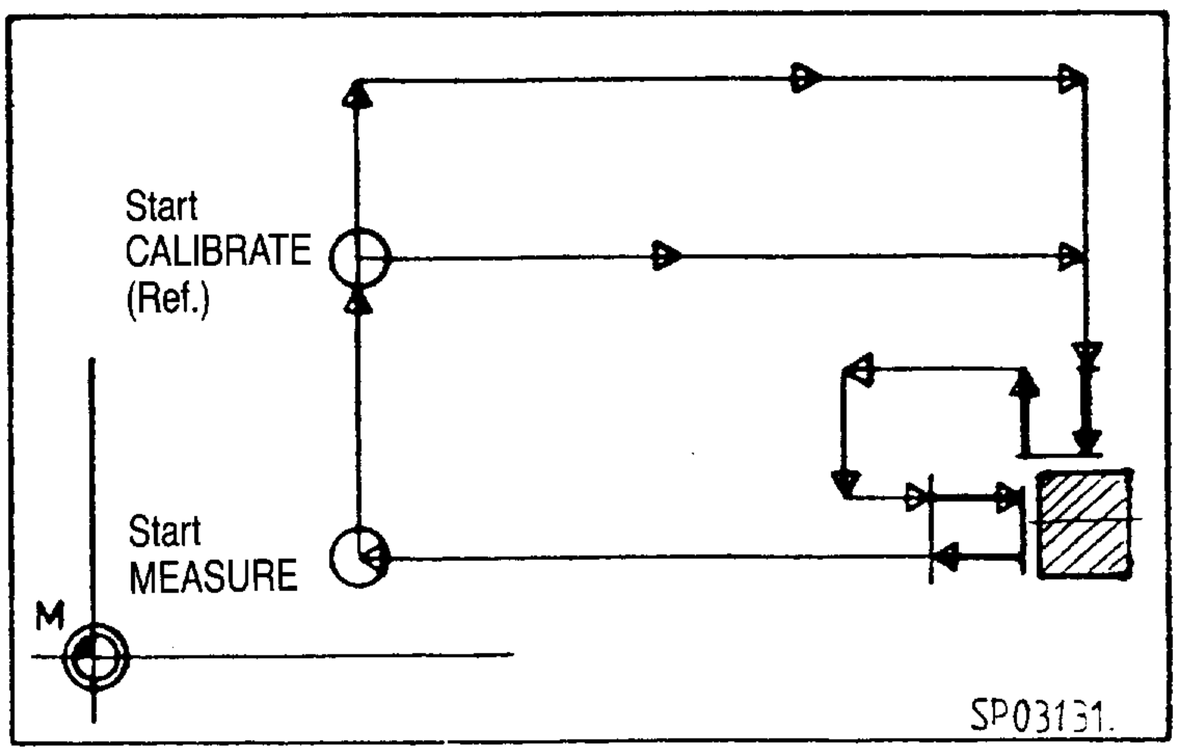


Fig. 15 Calibrate tool probe measure tool
(Z axis mirror-imaged)

Tool measurement	System 3 L91 System 8 (F) L972
Measure tool	System 8 (S) L982

Parameter recommendations for reliable program execution

Measured tool

a) Calibrate L91 (L972, L982)

Zero offset range	R33	0.001
Safe area	R36	1

b) Measure L91 (L972, L982)

Zero offset range	R33	0.001	
Safe area	R36	1	(Continuous run)
Safe area	R36	3	(Setup)
Dimension difference check	R37	0.3	(Continuous run)
Dimension difference check	R37	3	(Setup)

In the case of the X axis, all values refer to the diameter.

Tool measurement	System 3 L90 System 8 (F) L971
Automatically depending on tool nose vector	System 8 (S) L981

4.2.2 Automatic tool measuring cycle

Function and application

The cycle positions the tool to the tool probe in accordance with the tool nose vector.
First the "Tool change position" N, stored in background memory HG 58/59 or program under R18/19, is approached. The tool is then measured in the X axis and subsequently in the Z axis (see Fig. 17).

The cycle calls the tool measuring cycle L91 (L972, L982).

If empirical values are used (R11 # 0), the specified empirical value memory no. R11 = m is used for the X axis (see Part 0, 2.4).

For the Z axis, the cycle defines R11 m+1. Two consecutive memories are used.

The maximum value that can be specified for the constant m is 19 when tool nose vectors 1-4 are used.

For the next tool, R11 0 m+2 must be specified.

Vectors 0,5,6,7 and 8 are measured in one axis only.
Tool nose vector 9 cannot be measured with this cycle. It must be measured directly with L91 (L971, L981) (alarm message).

Depending on the definition of R23, the tool lengths are calculated according to "PN" or "SN", i.e. referred to the tool tip or tool radius centre.

When measuring has been completed, "N" is located at the position stored in background memory 58/59 if R18/19 has been defined with the value 0.

In the case of R18/19 # 0, "N" is positioned each time at a distance corresponding to the amount of R18/19 away from the tool probe (see Figs. 15 and 16).

Tool measurement		
	System 3	L90
	System 8 (F)	L971
Automatically depending on tool nose vector	System 8 (S)	L981

Nesting:

```
%1234
    :
    : ==> L123 (optional subroutine)
              :
              : ==> L90 (above-mentioned cycle)
                        :
                        : ==> L91 (tool measuring cycle L91
                        :     is called by L90)
                        :
                    : <== M17
                    :
                    : ==> L79 (alarm text cycle L79 is
                              :  called by L90)
                              :
                    : <== M17
                    :
              : <== M17
   : <== M17
   :
M30
```

Precondition

- The background memories HG58 and HG59 (see Fig. 15) must be loaded.

  With these values, a position

  "Tool change position" N

  must be defined at which all tools which are ever applied on this machine can be changed without collision on the tool probe.

- It must be possible to approach the change position without collision.

Tool measurement	System 3	L90
	System 8 (F)	L971
Automatically depending on tool nose vector	System 8 (S)	L981

Definitions

The following parameters must be defined prior to call:

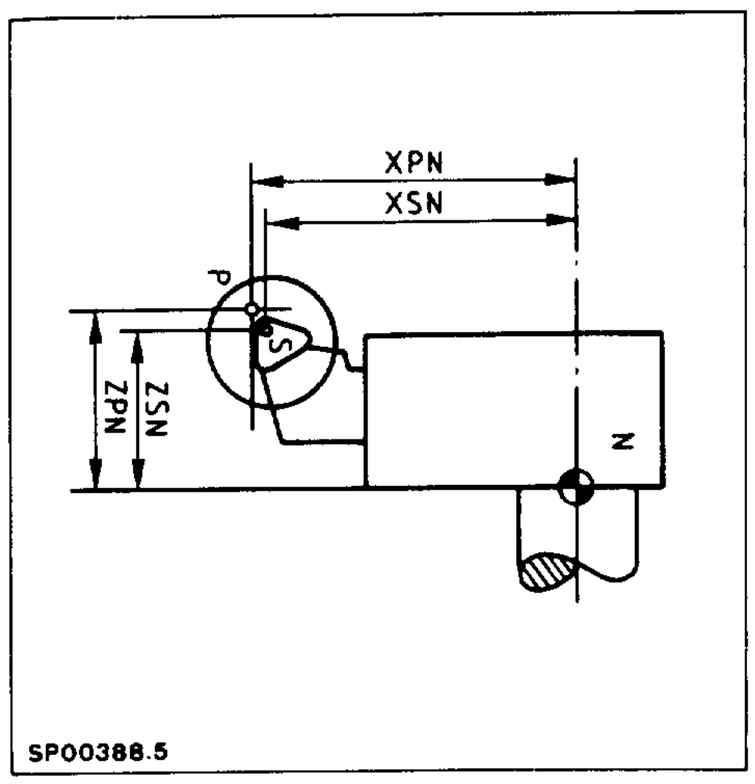
R10 1 - 32 Tool offset memory no. of the tool to be measured

R11 0 - 20 Empirical value memory no. m

R18 0 Change position X axis of background memory 58
0 Variable change position X axis

R19 0 Change position Z axis of background memory 59
0 Variable change position Z axis

Tool length in TO memory		
Before cycle call	During cycle	After cycle
R23 0 XZP ZPN	XPN ZPN	XPN ZPN
R23 1 XZP ZPN	XPN ZPN	XSN ZSN
R23 2* XSN ZSN	CPN ZPN	XSN ZSN



Tool length definition

* Caution if there is an abort in the cycle:
The value in the TO memory can be PN-related.

R27 1 - 10 Number of measurements at same location (see Part 0 2.5)

R28 1 - 10 Multiplication factor for measurement path "2a"

R33 Zero offset range (see Part 0 2.3.1)

R36 Safe area (see Part 0 2.3.1)

R37 Dimensional deviation check (see Part 0 2.3.1)

Tool measurement		
	System 3	L90
	System 8 (F)	L971
Automatically depending on tool nose vector	System 8 (S)	L981

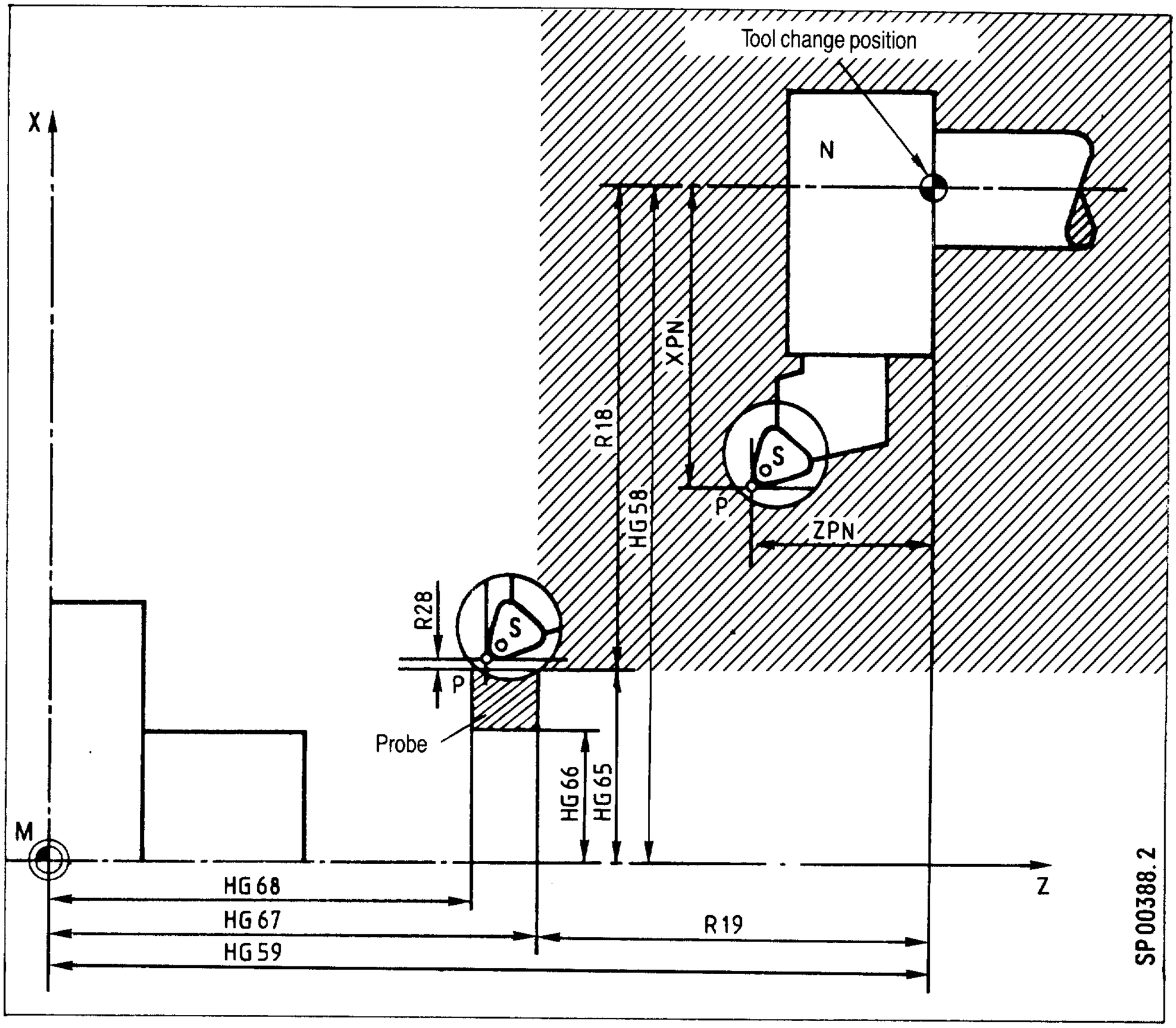


Fig. 15 Overview machine data for tool measurement

Background memories 58 and 59 specify the position from which all tools can be changed without collision on this machine.

The tool tip may be situated only in the shaded area.

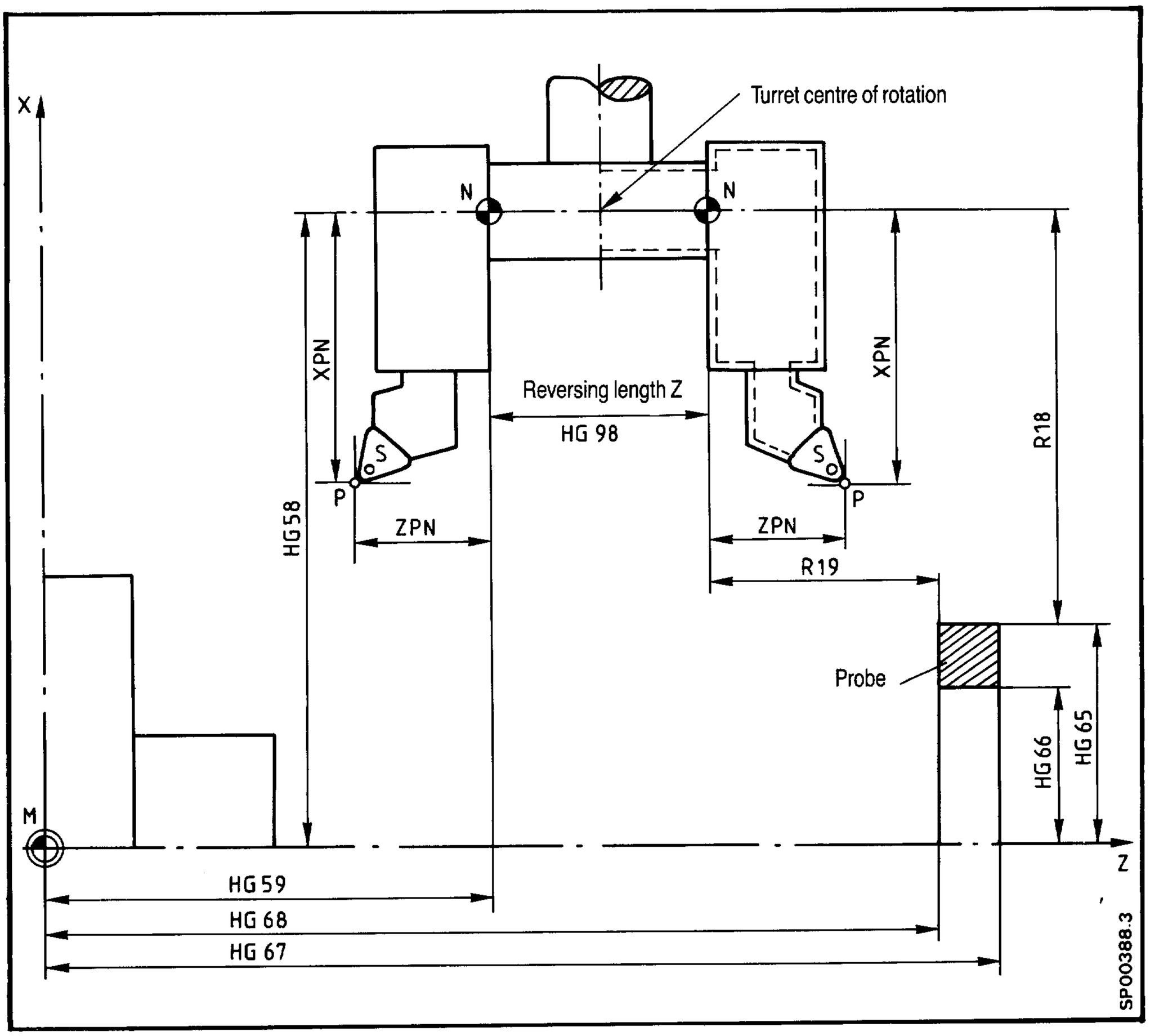


Fig 16 Overview machine data for tool measurement
(Z axis mirror-imaged)

Note:
The data given for background memories 58/59 always refer to the non-mirror-imaged point N. Programming of R18/19 always on the mirror-imaged point N (N').

Tool measurement		
	System 3	L90
	System 8 (F)	L971
Automatically depending on tool nose vector	System 8 (S)	L981

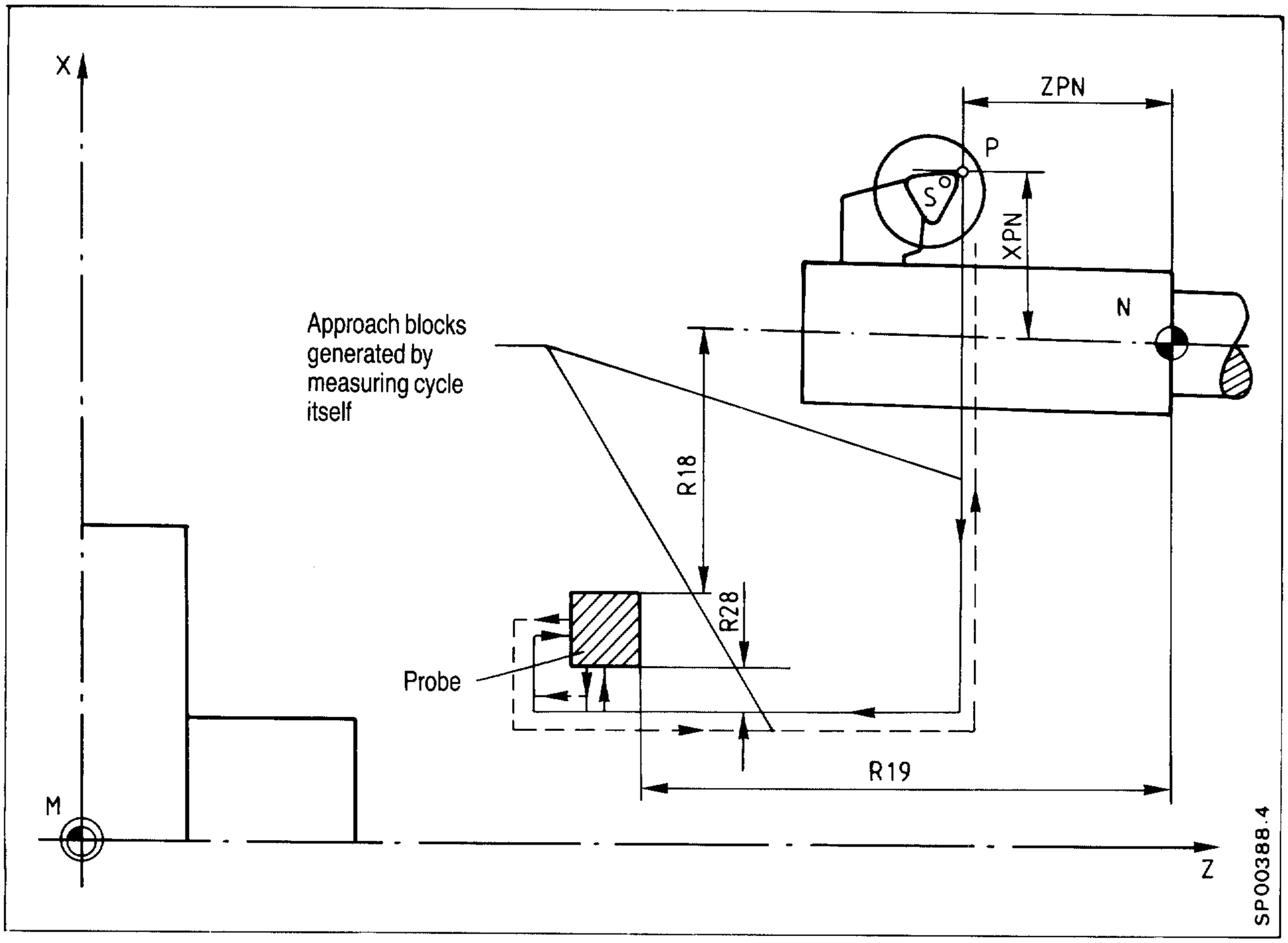


Fig. 17 Example: Tool measurement towards spindle
Tool nose vector 1

4.2.2.1 Example of application

Example: Tool measuring program

```
%90
N5 L10
N10 TO909
N15 R10 9 R11 2 R18 0 R19 0 R23 0 L90
R27 1 R28 1 R33 0 R36 1 R37 0.5

N20 T1111
N30 R10 11 R11 4 L90

N90 M30
```

```
/Program see 4.2.1.1
/Tool 9
/Parameters for L90
/R10 9  TO mem. No. 9 in NC
/R11 2: EV mem. No. 2 X axis
        EV mem. No. 3 Z axis
/R18 0: Change pos. X axis
        of background memory 58
/R19 0: Change pos. Z axis
        of background memory 59
/L90    Tool T9 is measured in
        X and Z axes
/Tool 11
/R10 11 TO mem. No. 11 in NC
/R11 4: EV mem. No. 4 X axis
        EV mem. No. 5 Z axis
/L90:   Tool T11 is measured in
        X and Z axes
```

Calibrate workpiece probe and measurement of blank Calibration in reference slot	System 3 System 8 (F) System 8 (S)	L92 L973 L983

4.2.3 Calibrate workpiece probe and measurement of blank

With this cycle, the workpiece probe can be calibrated and a blank measurement operation can be performed.
Selection is by means of definition of R21 and R23.

4.2.3.1 Calibration in reference slot

Function and application

With this measuring cycle, the probe can be calibrated in a reference slot. Calibration in the reference slot is possible in the X and Z axes.
The calculated set/actual difference is incorporated in the probe length. The resultant probe length is then loaded into the tool geometry memory.
Two consecutive tool offset memories are required for a tool probe (see Fig. 19).

Up to 4 pairs of calibration slots can be selected with the parameter R12 (Fig. 10). When R12 is specified, the valid reference slot dimensions, specified in the background memory, are selected. The specification in the R12 parameter refers to n-1, e.g. calibration slot 1 ==> R12 0 . There are 2 basic types of probe (see Fig. 18).
The cycle automatically positions the selected probe into the associated calibration slot (see Fig. 20); this is performed paraxially with linear interpolation along the shortest path. Calibration is performed on only one surface at any one time (axial direction) in the slot.

When the calibrating operation has been completed, the probe is located in the slot centre.

Preconditions

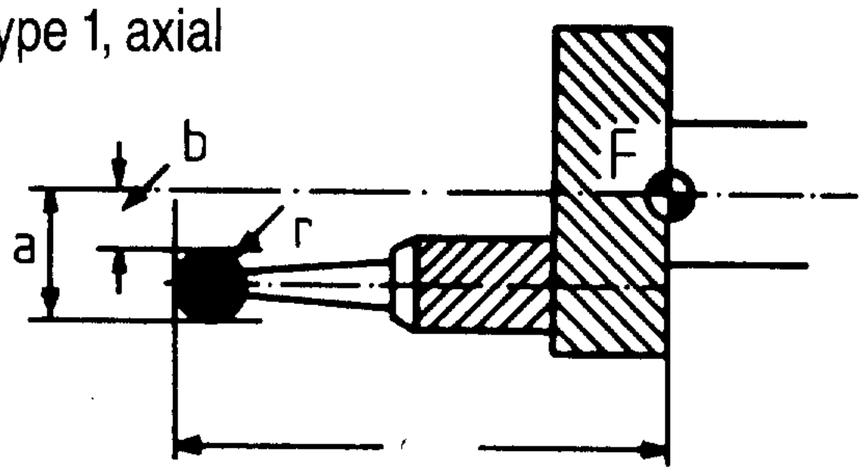
- The probe must be called with the 1st compensation number and with G53 (cancel zero offset).
- The dimensions of the reference slot with respect to machine datum must be input in the background memory HG69 -HG96.
- The valid reference slot dimension is defined with R12 (4 ranges possible).
- The probe type must be defined (R22).
- Start point optional (cycle commences with paraxial movements).

Calibrate workpiece probe and measurement of blank
Calibration in reference slot

System 3 L92
System 8 (F) L973
System 8 (S) L983

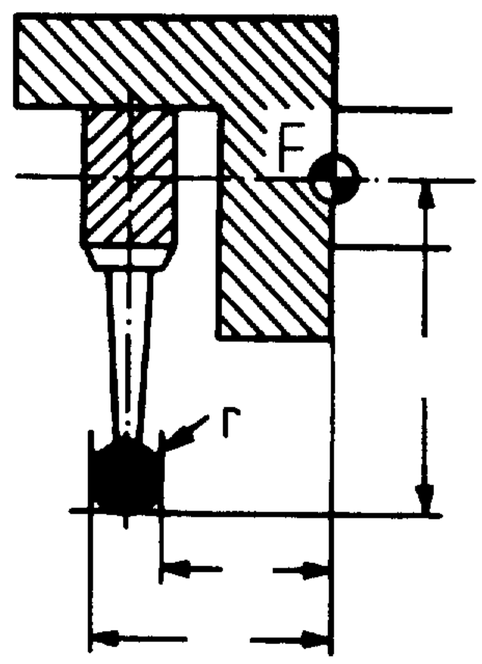
Workpiece probe TO memory

Type 1, axial



Type 1, axial	X	Z	B	A
1st compensation value, (n)	a	c	r	-
2nd compensation value, (n+1)	b	d	r	-

Type 2, radial



Type 2, radial	X	Z	B	A
1st compensation value, (n)	e	g	r	-
2nd compensation value, (n+1)	f	h	r	-

SP03813.0

Fig. 18 Probe types; geometry data

Two consecutive pairs of compensations must be assigned for each probe type.
When called, only the 1st compensation pair (n) must be called in all cases (programming simplification).

Probe call: Txxn
+-- n two places

Example:

A probe has tool number 8 and TO memories 14 and 15

Probe call: T0814

Calibrate workpiece probe and measurement of blank Calibration in reference slot	System 3 L92 System 8 (F) L973 System 8 (S) L983

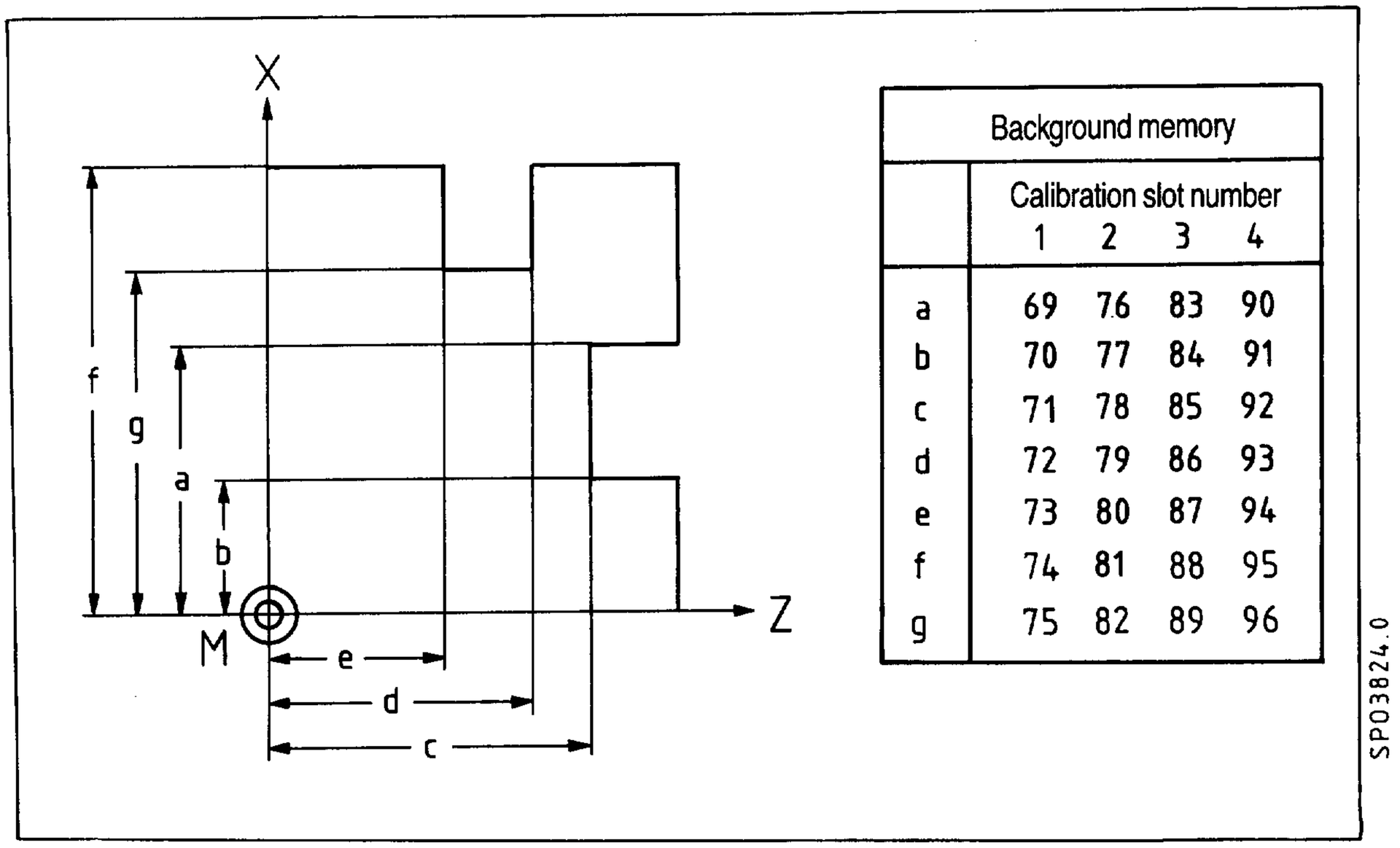


Fig. 19 Machine data calibration slot

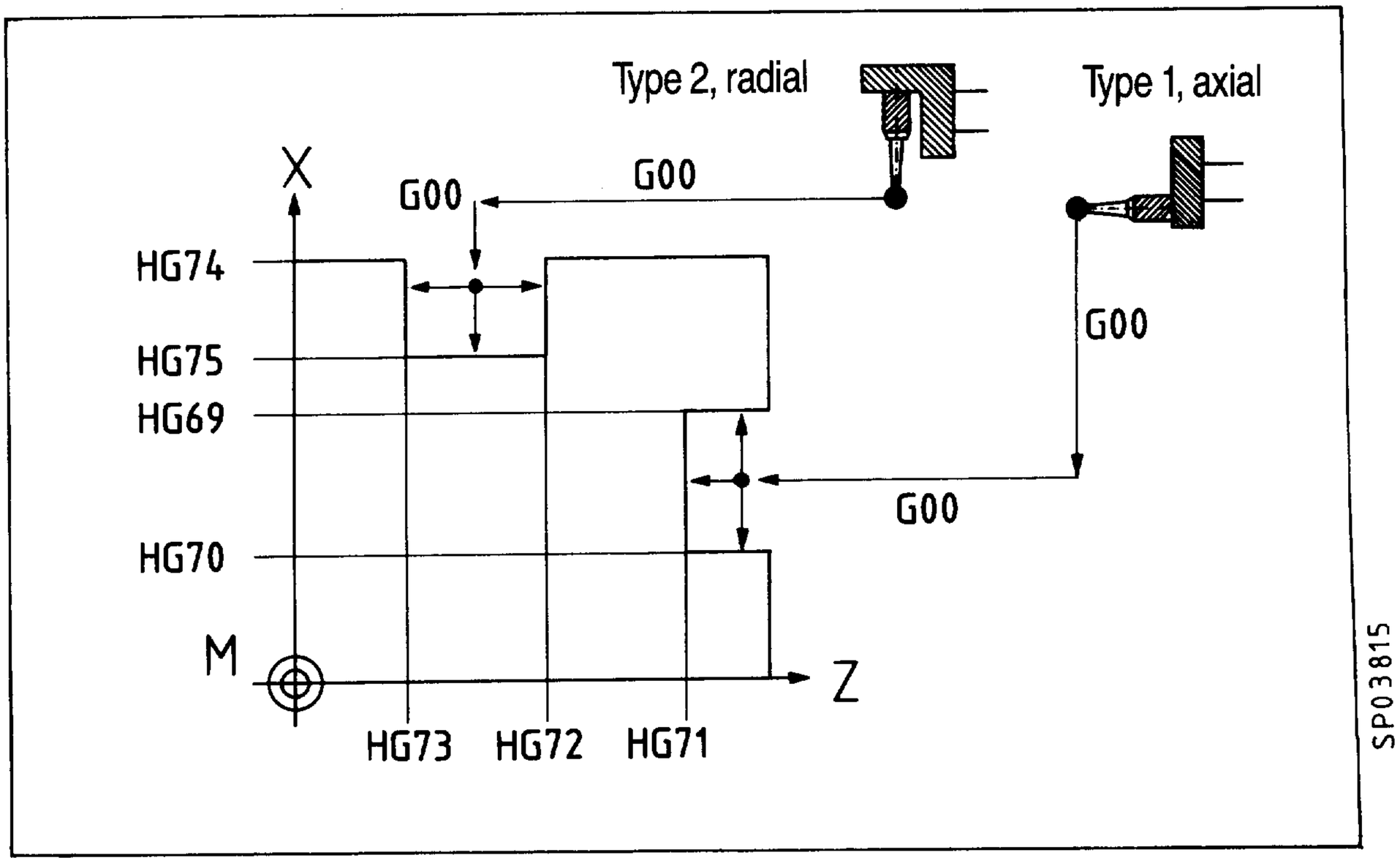


Fig. 20 Machine data calibration slot, e.g. calibration slot 1 (R12 = 0)

Calibrate workpiece probe and measurement of blank	System 3	L92
	System 8 (F)	L973
Calibration in reference slot	System 8 (F)	L983

Definitions

The following parameters must be defined prior to call:

R11	0 - 20	Memory no. for average value (see Part 0 2.4) Calculation is without empirical value.
R12	0 - 3	Selection of calibration slot pair
R21	0	Calibration in reference slot
R22	1	Workpiece probe type 1
	2	Workpiece probe type 2
R23	0	Calibration workpiece probe
R27	1 - 10	Number of measurements at same location (see Part 0 2.5)
R28	1 - 10	Multiplication factor for measurement path "2a"
R29	1 - 4	Weighting factor k for averaging (see Part 0 2.3)
R30		Number of measuring axis
	1	X axis
	2	Z axis
R31	0	Positive axis direction
	1	Negative axis direction
R33		Zero offset range (see Part 0 2.3.1)
R34		Average value compensation (see Part 0 2.3.1)
R36		Safe area (see Part 0 2.3.1)

The following values are available in R parameters on completion of the cycle:

R43	Actual value (radius for X axis)
R44	Set/actual difference
R46	Memory no. for average value
R47	Tool offset no., probe
R49	Average value

Calibrate workpiece probe and measurement of blank	System 3	L92
	System 8 (F)	L973
Calibration on random surface	System 8 (S)	L983

4.2.3.2 Calibration on random surface

Function and application

With this measuring cycle, the probe can be calibrated at any surface, e.g. workpiece.

When the calibration process has been completed, the probe is at a distance "a" away from the calibration surface.

Definition R21 1 and R23 0.

Preconditions

- The probe is called with the 1st compensation number (see Fig. 18) and positioned without G53 (with offset) opposite the calibration surface.

- When calibrating below the centre of rotation in the plus X axis or left of the workpiece datum W in the plus Z axis, the setpoint (R32) must be specified as the negative value.

- The probe type must be defined (R22).

Calibrate workpiece probe and measurement of blank Calibration on random surface	System 3 System 8 (F) System 8 (S)	L92 L973 L983

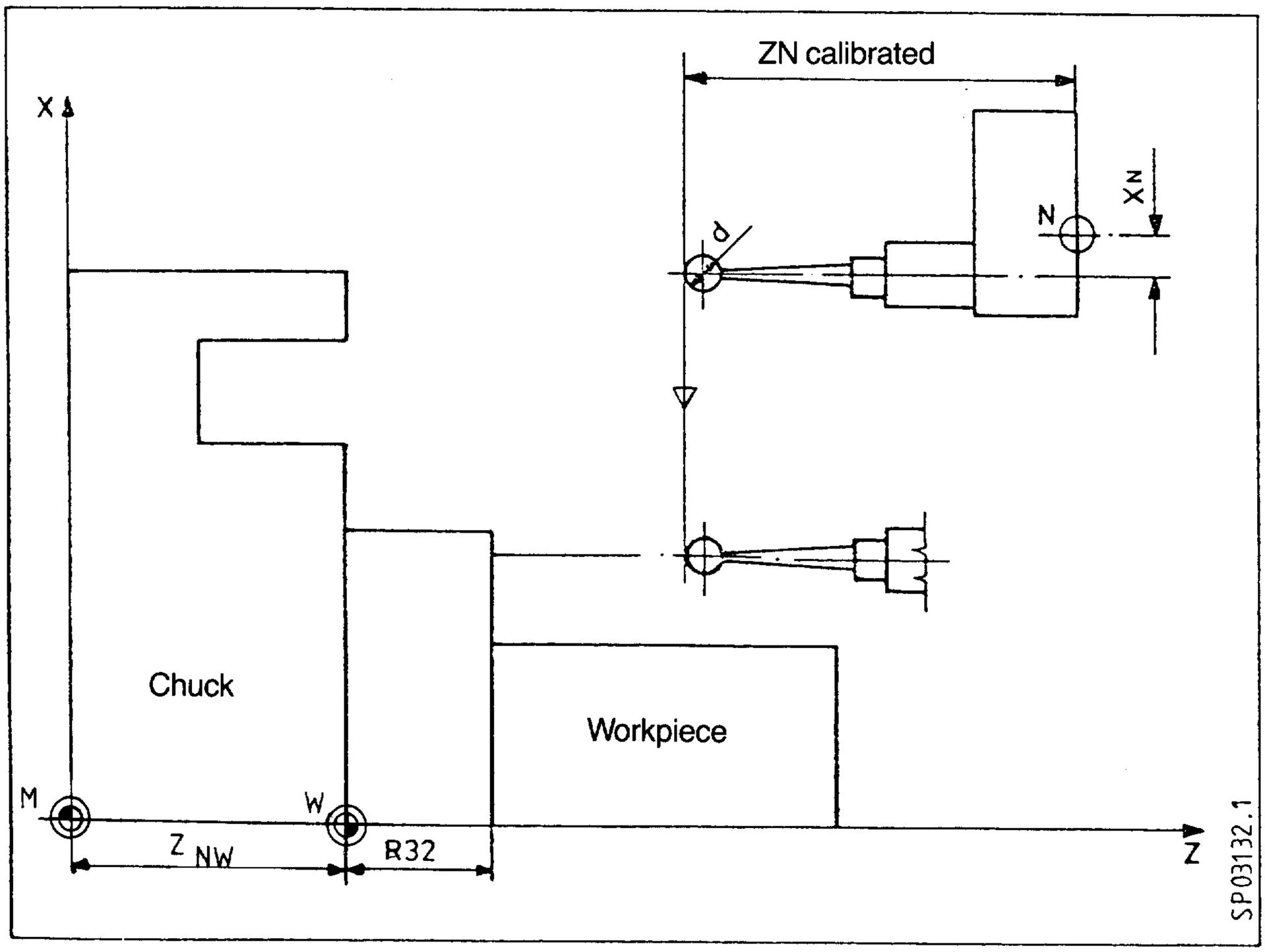


Fig. 21 Positioning at any surface with "Calibrate workpiece probe"

Calibrate workpiece probe and measurement of blank	System 3	L92
	System 8 (F)	L973
Calibration on random surface	System 8 (S)	L983

Definitions

The following parameters must be defined prior to call:

R11 0 - 20 Memory location no. for average value (see Part 0 2.4)
Calculations are performed without empirical value.

R21 1 Calibrate on random surface

R22 1 Workpiece probe Type 1
2 Workpiece probe Type 2

R23 0 Calibrate workpiece probe

R27 1 - 10 Number of measurements at same location (see Part 0 2.5)

R28 1 - 10 Multiplication factor for measurement path "2a"

R29 1 - 4 Weighting factor k for averaging by formula
(see Part 0 2.3)

R30 Number of measuring axis
1 X axis
2 Z axis

R31 0 Positive axis direction
1 Negative axis direction

R32 Setpoint referred to workpiece datum, for X axis in diameter.
When calibrating below the centre of rotation in plus X axis or left of the workpiece datum in plus Z axis, the setpoint must be specified as a negative value.

R33 Zero offset range (see Part 0 2.3.1)

R34 Average value compensation (see Part 0 2.3.1)

R36 Safe area (see Part 0 2.3.1)

The following values are available in R parameters on completion of the cycle.

R42 Calibration surface setpoint
R43 Actual value (radius in X axis)
R44 Set/actual difference
R46 Memory no. for average value
R47 Tool offset no. probe
R49 Average value

Calibrate workpiece probe and measurement of blank	System 3	L92
	System 8 (F)	L973
Measurement of blank	System 8 (S)	L983

4.2.3.3 Measurement of blank

Function and application

The measuring cycle establishes the actual value of a blank. The difference to the programmed workpiece datum is added to the programmable zero offset G59. With the multiplication factor for measurement path "2a" the variation range of the length (setpoint) can be allowed for.

After the cycle, the probe is located at a distance "a" away from the surface of the blank.

Definition R21 1 and R23 1 .

Preconditions

- The measuring axis must be programmed with the 1st tool no. of the probe and programmed without G53 (cancel zero offset).
- The probe type must be specified (R22)
- The probe must be positioned opposite the surface to be measured before the cycle is called.

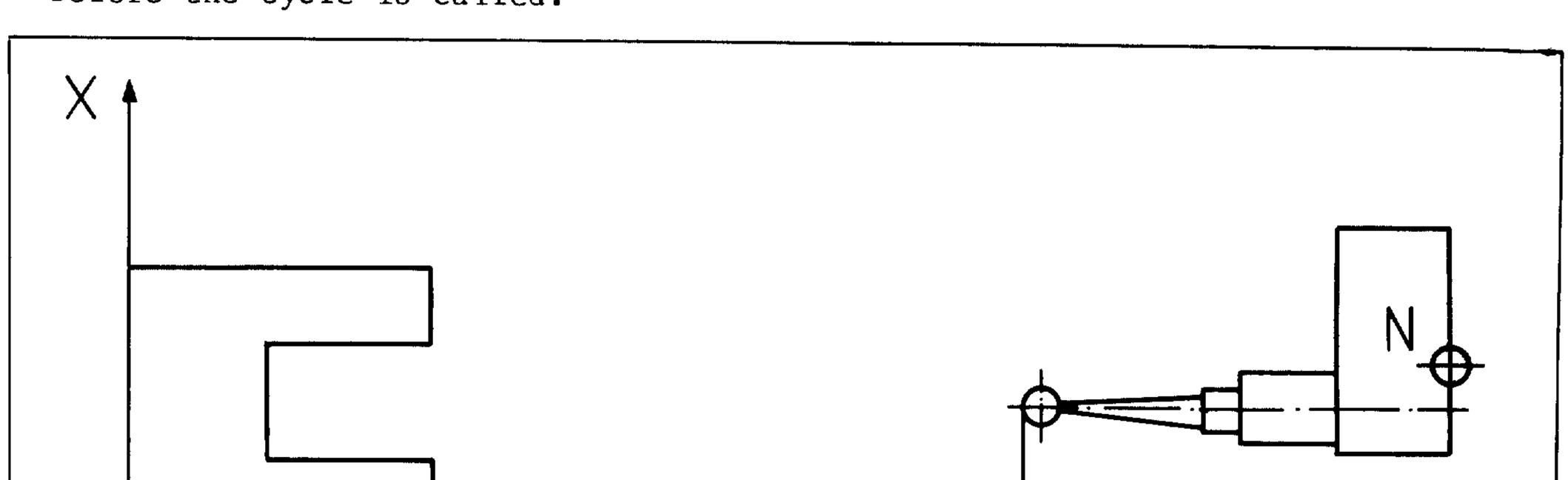


Fig. 21a Measurement of blank in the Z axis

Calibrate workpiece probe and measurement of blank	System 3	L92
	System 8 (F)	L973
Measurement of blank	System 8 (S)	L983

Definitions

The following parameters must be defined prior to call:

R21 1 Calibrate on random surface

R22 1 Workpiece probe Type 1
2 Workpiece probe Type 2

R23 1 Measurement of blank

R27 Number of measurements at same location (see Part 0 2.5)

R28 Multiplication factor for measurement path "2a"

R30 Number of measuring axis
1 X axis
2 Z axis

R31 0 Measuring in positive axis direction
1 Measuring in negative axis direction

R32 Setpoint referred to workpiece datum, for X axis in diameter

R36 Safe area (see Part 0 2.3.1)

The following values are available in R parameters on completion of the cycle:

R42	Setpoint	(ØX axis)
R43	Actual value of blank	(ØX axis)
R44	Set/actual difference	(ØX axis)

Workpiece measurement	System 3	L93
	System 8 (F)	L974
	System 8 (S)	L984

4.2.4 Workpiece measurement

Function and application

The measuring cycle establishes the actual value of the workpiece in the selected measuring axis with respect to the workpiece datum as well as the set/actual difference.
An empirical value stored in the background memory is then allowed for with the correct sign. The average value is formed over several parts and the tolerance ranges are checked in accordance with Section 2.3.

The cycle automatically corrects the compensation memory selected via R10 in the measuring axis; in System 8, the value is changed in the wear memory.

Measurements can be performed in all axial directions without restrictions (inside/outside diameters, holes, slot).

Measurement variants:

1-point measurement
1-point measurement with rotation
2-point measurement on diameter
Multi-point measurement on circumference
Multi-point measurement on cylinder

The selection is by means of R24 and R25.

The following values are available in R parameters on completion of the cycle:

R40 **	Upper tolerance limit	(acc. to drawing)	
R41 **	Lower tolerance limit	(acc. to drawing)	
R42 **	Setpoint	(acc. to drawing)	(ØX axis)
R43	Actual value		(ØX axis)
R44	Set/actual difference	(compensated by empirical value)	
R45	Empirical value		
R46	Memory no. for empirical value		
R47	Tool offset no.		
R48 *	Tool location no. in the PLC with multiple tooling		
R49	Average value		

* These parameters must be defined before call.

Preconditions:

- Probe has been calibrated in the selected axis (necessary only for 1-point measurements).
- Probe must be positioned opposite the measuring surface (see Fig. 23).
- The measuring axis must be programmed with the 1st TO no. of the probe and without G53 (selection ZO).

Notes

If a collision occurs or a defect exists, it is necessary to check whether feeler and probe can still be used.

The following checks should be made:

1. Is there dirt at the point of measurement or on the probe?
2. Has the measuring equipment been installed properly (switched on?)
3. Has the measuring signal been received in the NC?

A new start must then be made with the next workpiece. The parameter (R29) for the weighting factor must be set to 1 in order to ensure that the quick compensation called by this causes only the first part to be outside of tolerance or has a large deviation and the following parts can be brought back into the tolerance band.
Work can then resume with the normal program.

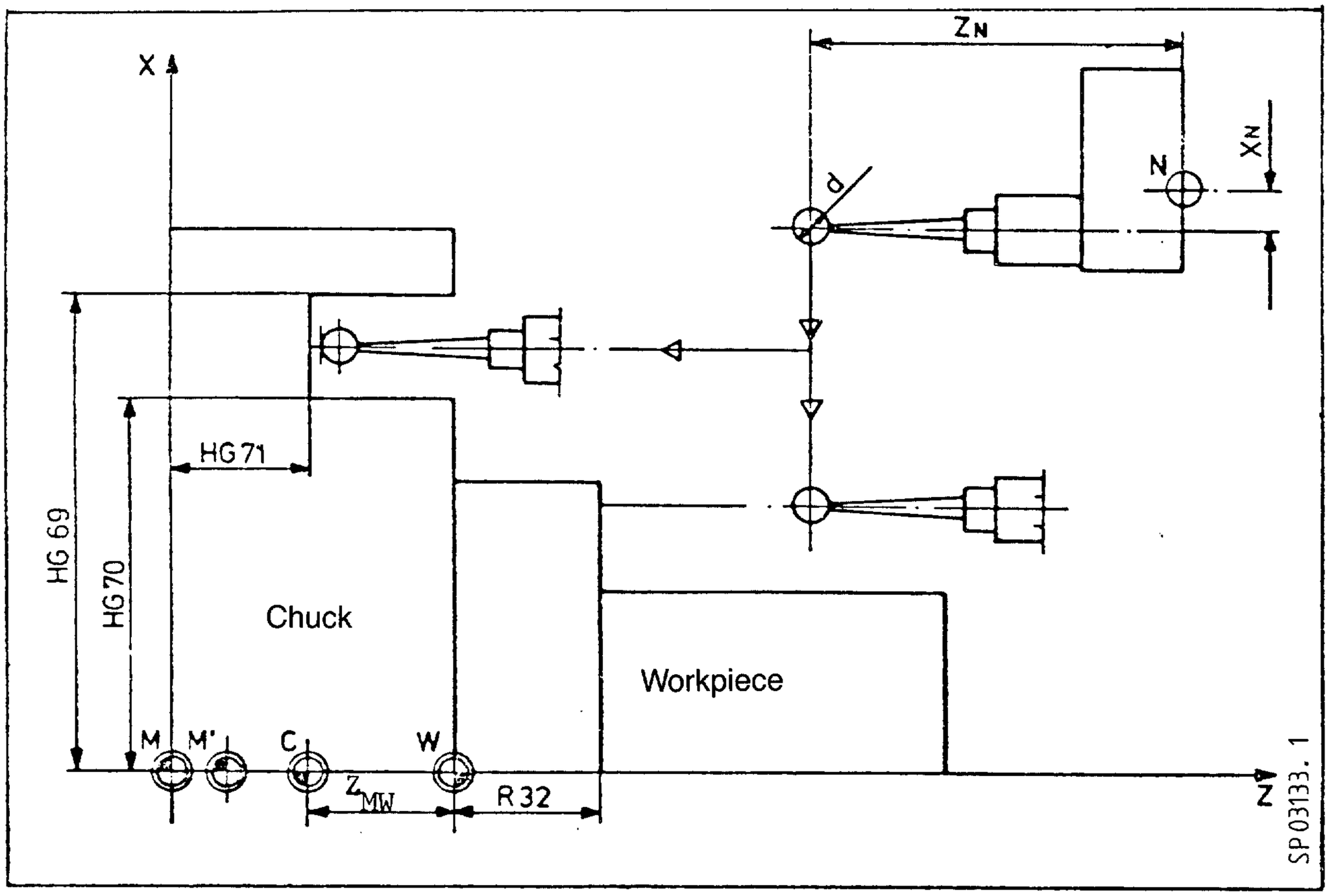


Fig. 22 Positioning when measuring a workpiece

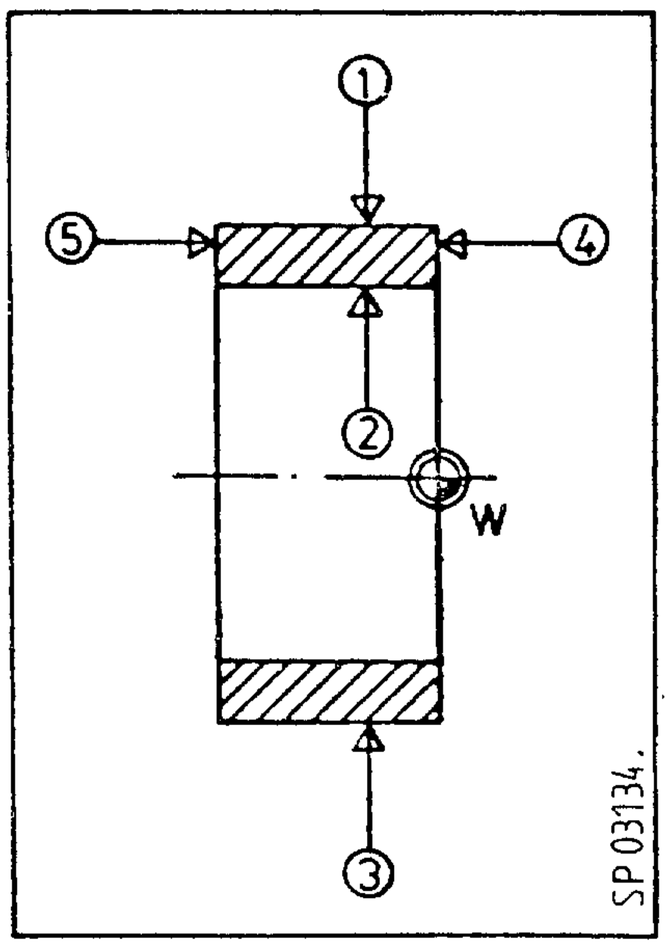


Fig. 23 Start positions

Start position

1: -X Outside diameter
2: +X Inside diameter
3: +X Outside diameter
(calibration and measurement below centre of rotation: setpoint negative)
4: -Z Measure length
5: +Z Measure length:
(left of workpiece datum in +Z direction: setpoint negative)

Workpiece measurement	System 3	L93
	System 8 (F)	L974
1-point measurement	System 8 (S)	L984

4.2.4.1 1-point measurement

The probe must be calibrated.
The workpiece must be positioned before the cycle is called, e.g. with M19.

The maximum possible diameter to be measured depends on the travel range of the turret slide in +X (Fig. 22).

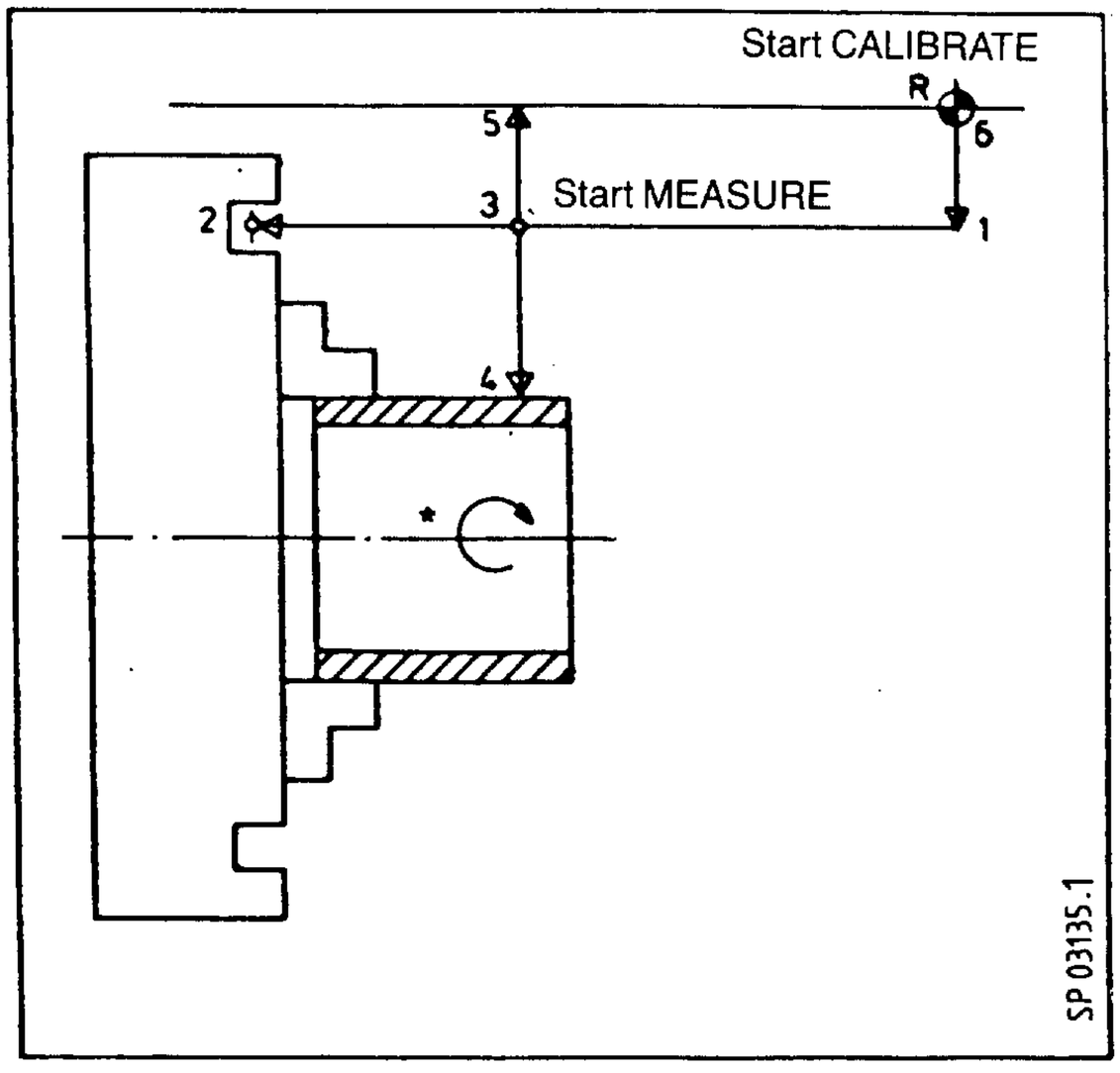
Outside diameter:

$$D_{max} = 2\ (X_{MXmax} - X_N) \quad - \text{Ø bulb} + 2a$$

Inside diameter:

$$D_{max} = 2\ (X_{MNmax} - X_N) \quad + \text{Ø bulb} - 2a$$

When measurement has been completed, the probe is located at a distance "a" away from the measuring point.



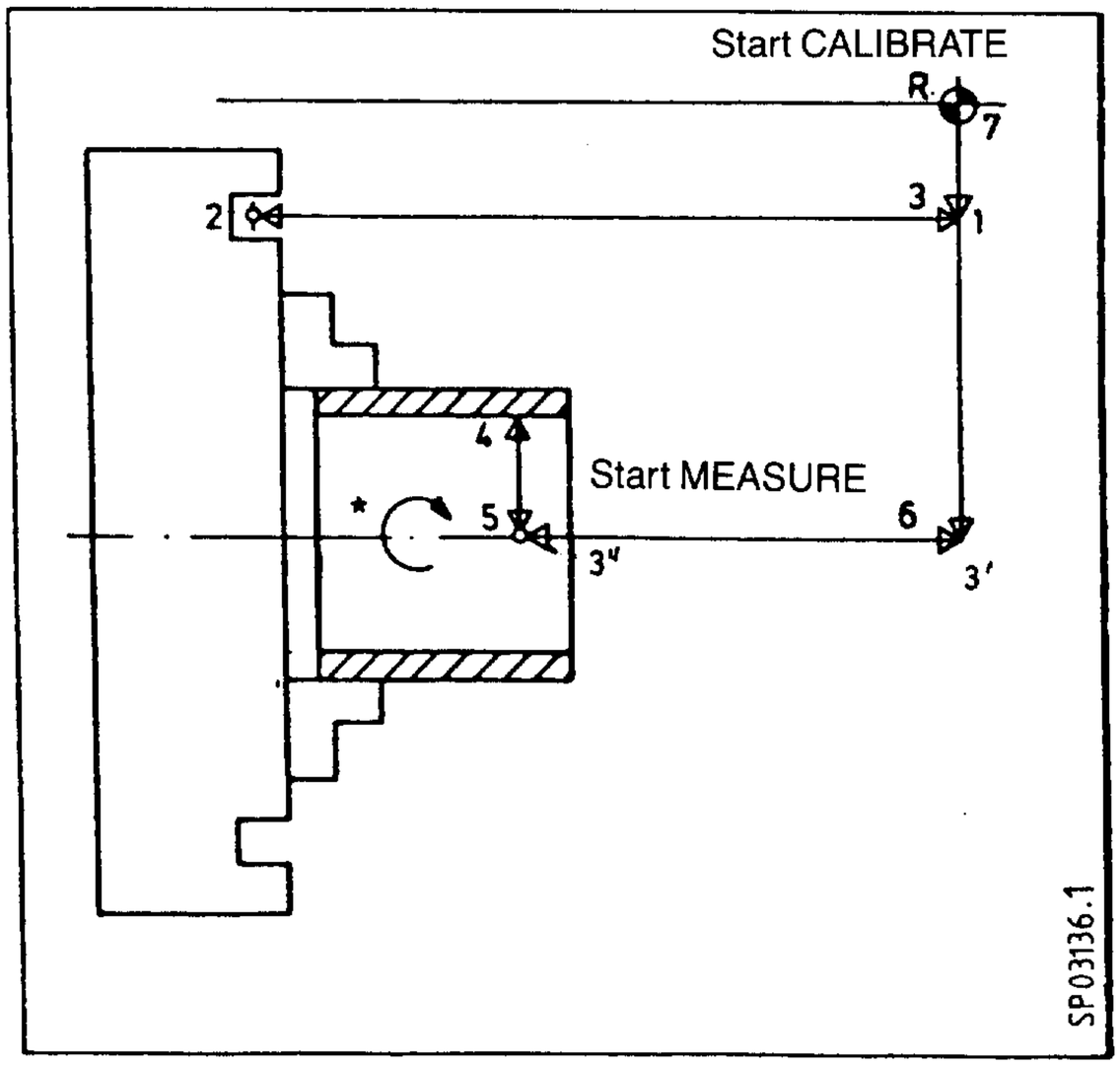
1,2 Self-generated approach paths for CALIBRATE

3 Retract paths for position Z

4 Self-generated approach paths for D_a

5,6 Retract paths to the reference point or approach to a new measuring point

Fig. 24 1 point measurement on outside diameter (1-6) with CALIBRATE



1,2 Self-generated approach paths for CALIBRATE

Retract paths
3 For position Z
3' For position X
3'' For position Z

4 Self-generated approach path for D_i

6,7 Retract paths to the reference point or approach to a new measuring point

Fig. 25 1-point measurement on inside diameter (1-7) with CALIBRATE

Workpiece measurement	System 3	L93
	System 8 8F)	L974
1-point measurement	System 8 (S)	L984

Definitions

The following parameters must be defined prior to call:

R10 1 - 32 Tool offset memory no. for automatic tool offset

R11 0 - 20 Empirical value memory no. (average value memory)

R24 0 1-point measurement

R25 0 1-point measurement without rotation

R27 1 - 10 Number of measurements at same location (see Part 0 2.5)

R28 1 - 10 Multiplication factor of measurement path "2a"

R29 1 - 4 Weighting factor k for averaging
(see Part 0 2.3)

R30 Number of measuring axis
1 X axis
2 Z axis

R32 * Setpoint referred to workpiece datum;
X axis in diameter
When measuring beneath the centre of rotation in plus X direction and left of the workpiece datum in plus Z direction, the setpoint must be specified as a negative value.

R33 Zero offset range (see Part 0 2.3.1)

R34 Average value compensation (see Part 0 2.3.1)

R35 * Specified dimension tolerance (see Part 0 2.3.1)

R36 Safe area (see Part 0 2.3.1)

R37 Dimensional deviation check (see Part 0 2.3.1)

R40 Upper tolerance limit (as per drawing)

R41 Lower tolerance limit (as per drawing)

R42 Specified value (as per drawing)

* When additional use is made of L75/L965, R32 and R35 are calculated from R40, R41 and R42. R32 and R35 need then not be defined.

4.2.4.2 1-point measurement with rotation

The probe must be calibrated.
The workpiece is positioned in the cycle with M19 to the position of R26.

The maximum possible diameter to be measured depends on the travel range of the turret slide in +X (see Fig. 22).

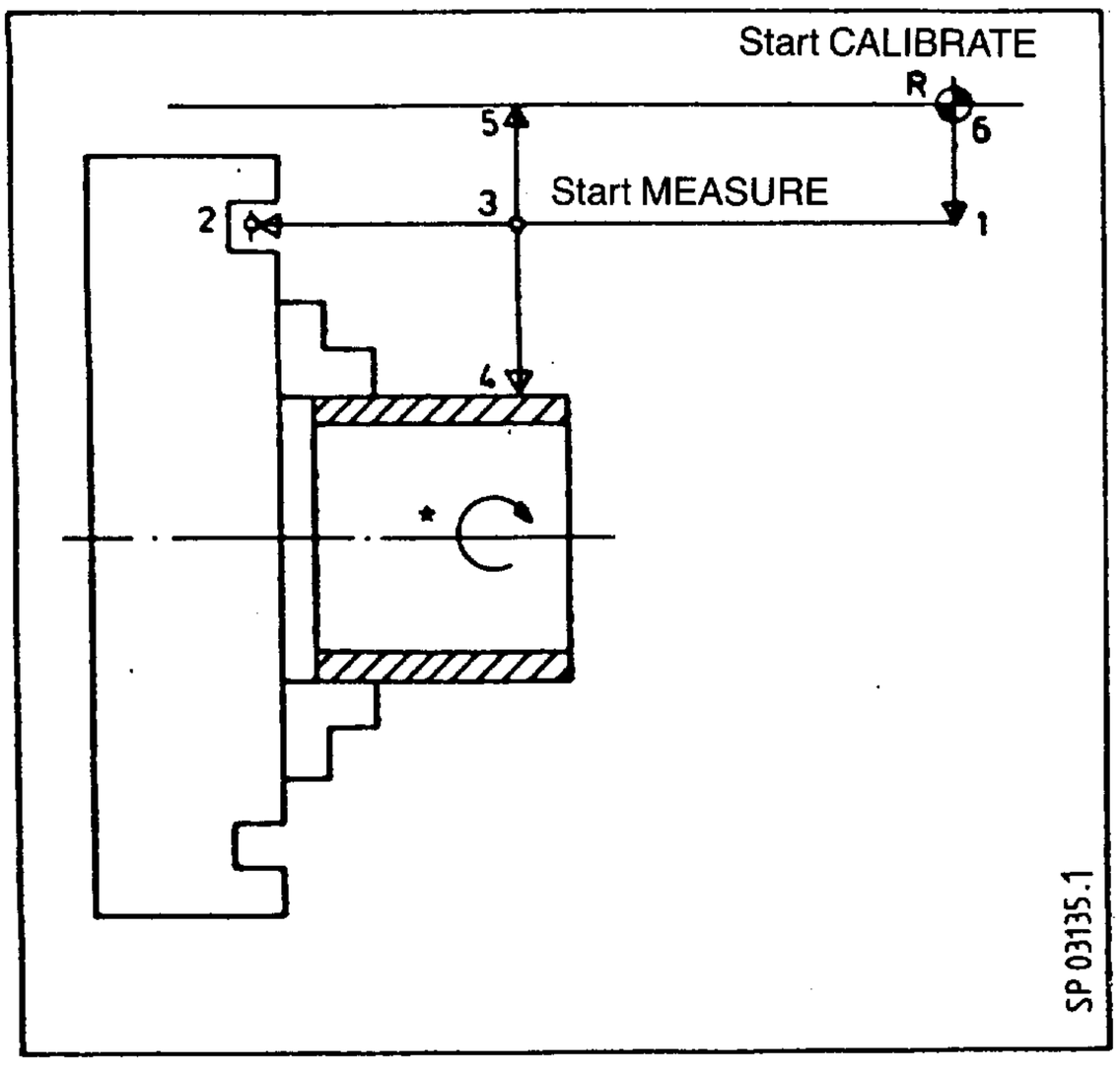
Outside diameter:

$$D_{max} = 2\ (X_{MNmax} - C_N) - \emptyset\ bulb + 2a$$

Inside diameter:

$$D_{max} = 2\ (X_{MNmax} - XN) + \emptyset\ bulb - 2a$$

When measurement has been completed, the probe is located away from the measuring point by the amount "a".



1,2 Self-generated approach paths for CALIBRATE

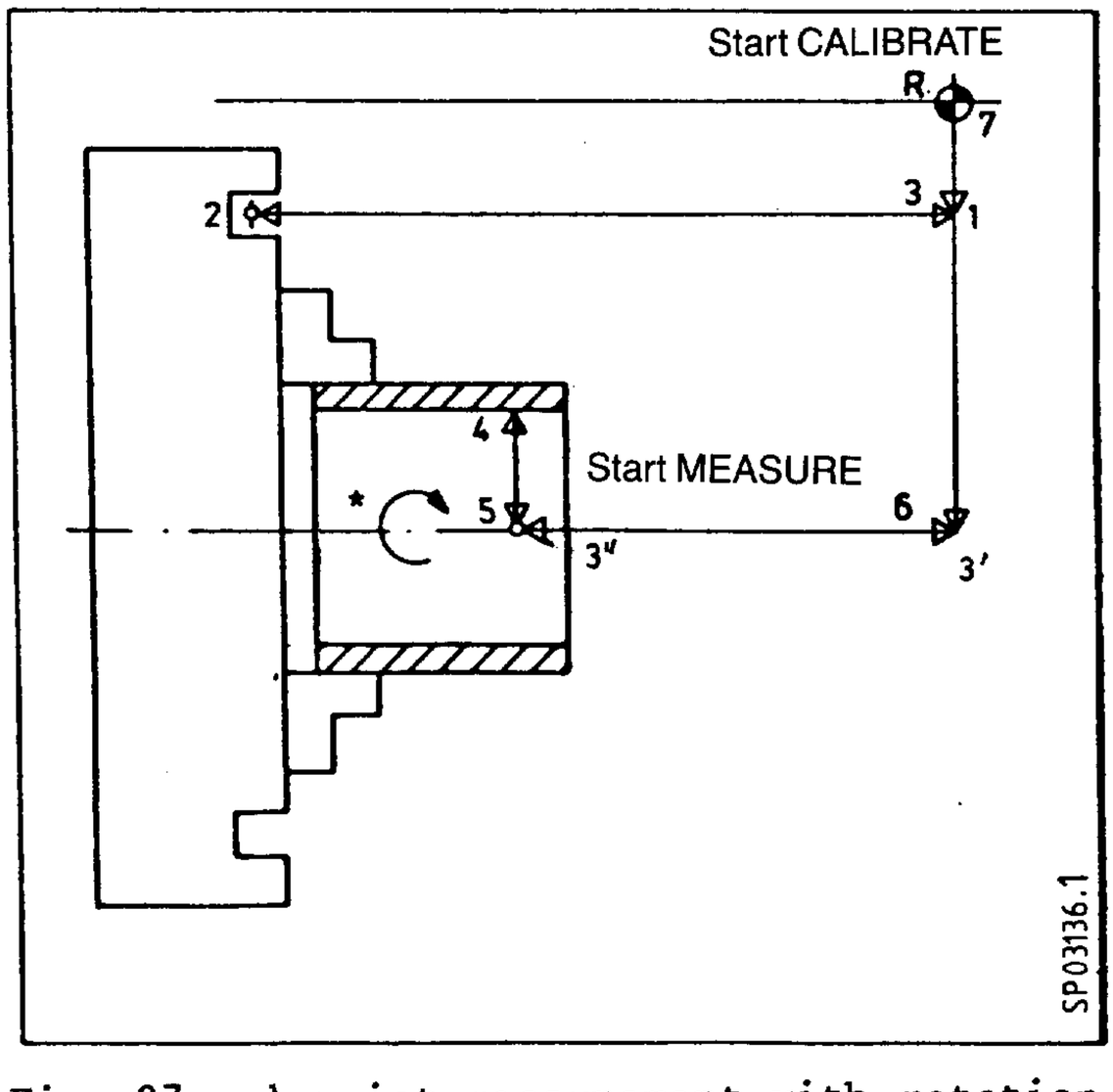
3 Retract paths for position Z

4 Self-generated approach path for D_a

5,6 Retract paths to the reference point or approach to a new measuring point

* Clearance travel to 4
180° swivel
2nd approach to 4
automatically by cycle

Fig. 26 1-point measurement with rotation on outside diameter (1-6) with CALIBRATE



1,2 Self-generated approach paths for CALIBRATE

Retract paths
3 For position Z
3' For position X
3'' For position Z

4 Self-generated approach path for D_i

5-7 Retract paths to the reference point or approach to a new measuring point

* Clearance travel to 4
180° swivel
2nd approach to 4

Fig. 27 1-point measurement with rotation on inside diameter (1-7) with CALIBRATE

Workpiece measurement		
	System 3	L93
	System 8 (F)	L974
1-point measurement with rotation	System 8 (S)	L984

Definitions

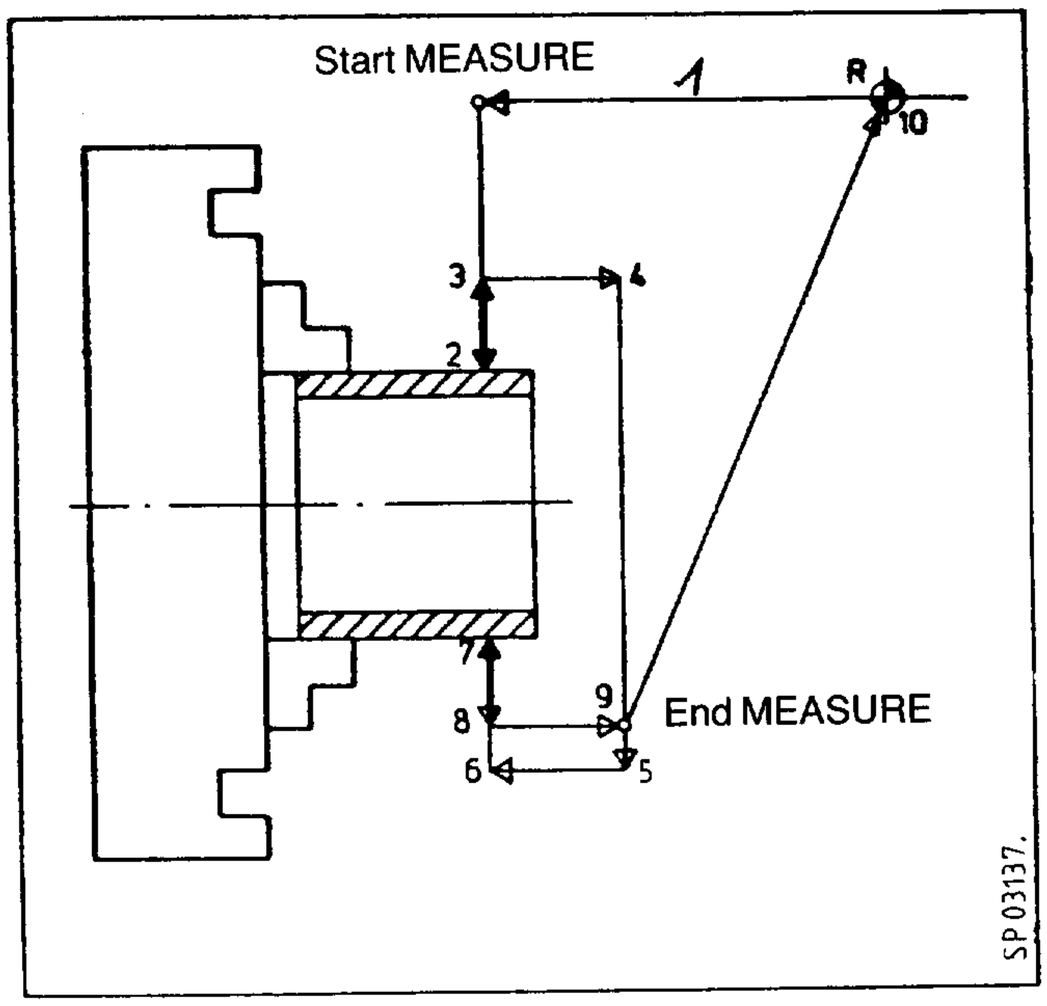
The following parameters must be defined prior to call:

R04		Spindle dwell time (System 3 only, see Part 0 3.6)
R10	1 - 32	Tool offset memory no. for automatic tool offset
R11	0 - 20	Empirical value memory no. (average value memory)
R24	0	1-point measurement
R25	1	1-point measurement with rotation
R26	0-359.5	Starting angle (only positive)
R27	1 - 10	Number of measurements at same location (see Part 0 2.5)
R28	1 - 10	Multiplication factor for measurement path "2a"
R29	1 - 4	Weighting factor k for averaging (see Part 0 2.3)
R30	1	Number of measuring axis (only X axis)
R32	*	Specified value relative to workpiece datum. For measurements below the centre of rotation in plus X direction, the setpoint must be specified as a negative value.
R33		Zero offset range (see Part 0 2.3.1)
R34		Average value compensation (see Part 0 2.3.1)
R35*		Specified dimension tolerance (see Part 0 2.3.1)
R36		Safe area (see Part 0 2.3.1)
R37		Dimensional deviation check (see Part 0 2.3.1
R40		Upper tolerance limit (as per drawing)
R41		Lower tolerance limit (as per drawing)
R42		Specified value (as per drawing)

* When additional use is made of L75/L965, R32 and R35 are calculated from R40, R41 and R42. R32 and R35 need then not be defined.

4.2.4.3 2-point measurement on diameter

The cycle measures a diameter by measuring the upper (1st measurement) and the lower (second measurement) points without rotating the part. Calibration is no longer necessary here. The possible diameter to be measured depends on the travel range of the turret slide in negative direction and on the geometry dimension of the probe in X. Since the cycle automatically positions with G00 from the 1st measuring point to the 2nd, a protection zone must be specified with R18 and R19. When the cycle has been completed, the probe is located in the protection zone "X" and "Z".
The workpiece (spindle) must be positioned with M19 before the cycle is called.

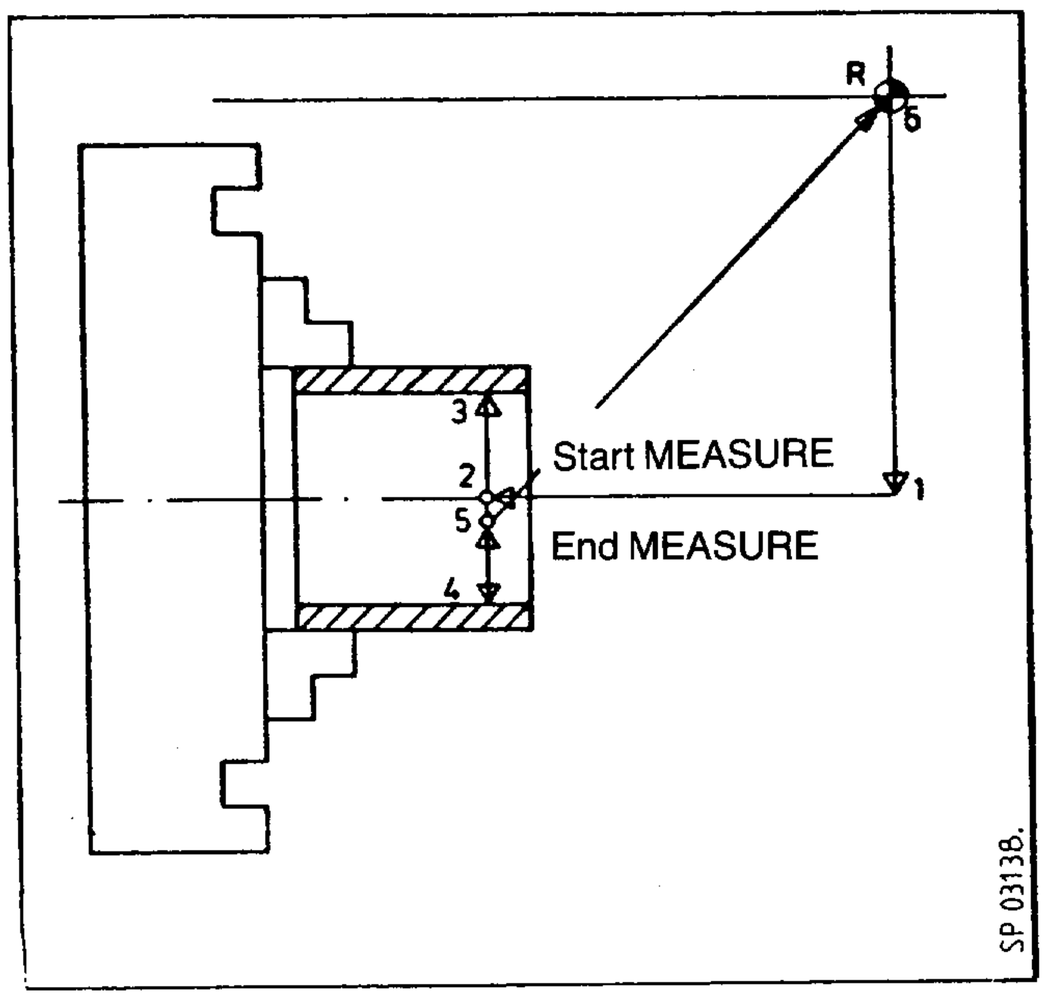


1 Approach path for outside diameter

2-9 Self-generated travel paths for measuring D_a

10 Return to reference point

Fig. 28 2-point measurement on outside diameter (1-10) without CALIBRATE



1,2 Approach paths for inside diameter

3-5 Self-generated travel paths for measuring D_i

6 Return to reference point

Fig. 29 2-point measurement on inside diameter (1-6) without CALIBRATE

Workpiece measurement		
	System 3	L93
	System 8 (F)	L974
2-point measurement on diameter	System 8 (S)	L984

Definitions

The following parameters must be defined prior to call:

R10	1 - 32	Tool offset memory no. for automatic tool offset
R11	0 - 20	Empirical value memory no. (average value memory)
R18		Protection zone around workpiece X axis (radius)
R19		Protection zone around workpiece Z axis
R24	1	2-point measurement on diameter
R25	0	2-point measurement on diameter
R27	1 - 10	Number of measurements at the same location (see Part 0 2.5)
R28	1 - 10	Multiplication factor for measurement path "2a"
R29	1 - 4	Weighting factor k for averaging (see Part 0 2.3)
R30	1	Number of measuring axis (only X axis)
R32	*	Specified value relative to workpiece datum
R33		Zero offset range (see Part 0 2.3.1)
R34		Average value compensation (see Part 0 2.3.1)
R35	*	Specified dimension tolerance (see Part 0 2.3.1)
R36		Safe area (see Part 0 2.3.1)
R37		Dimensional deviation check (see Part 0 2.3.1)
R40		Upper tolerance limit (as per drawing)
R41		Lower tolerance limit (as per drawing)
R42		Specified value (as per drawing)

* When additional use is made of L75/L965, R32 and R35 are calculated from R40 and R42. R32 and R35 need then not be defined.

4.2.4.4 Multi-point measurement on circumference

The number of measurements and the indexing angle on the circumference are defined by means of 2 parameters. Arithmetic averaging is performed.

The probe must be calibrated.
The workpiece is positioned in the cycle with M19 to the position of R26.

When measurement has been completed, the probe is located at a distance "a" away from the last measurement point.

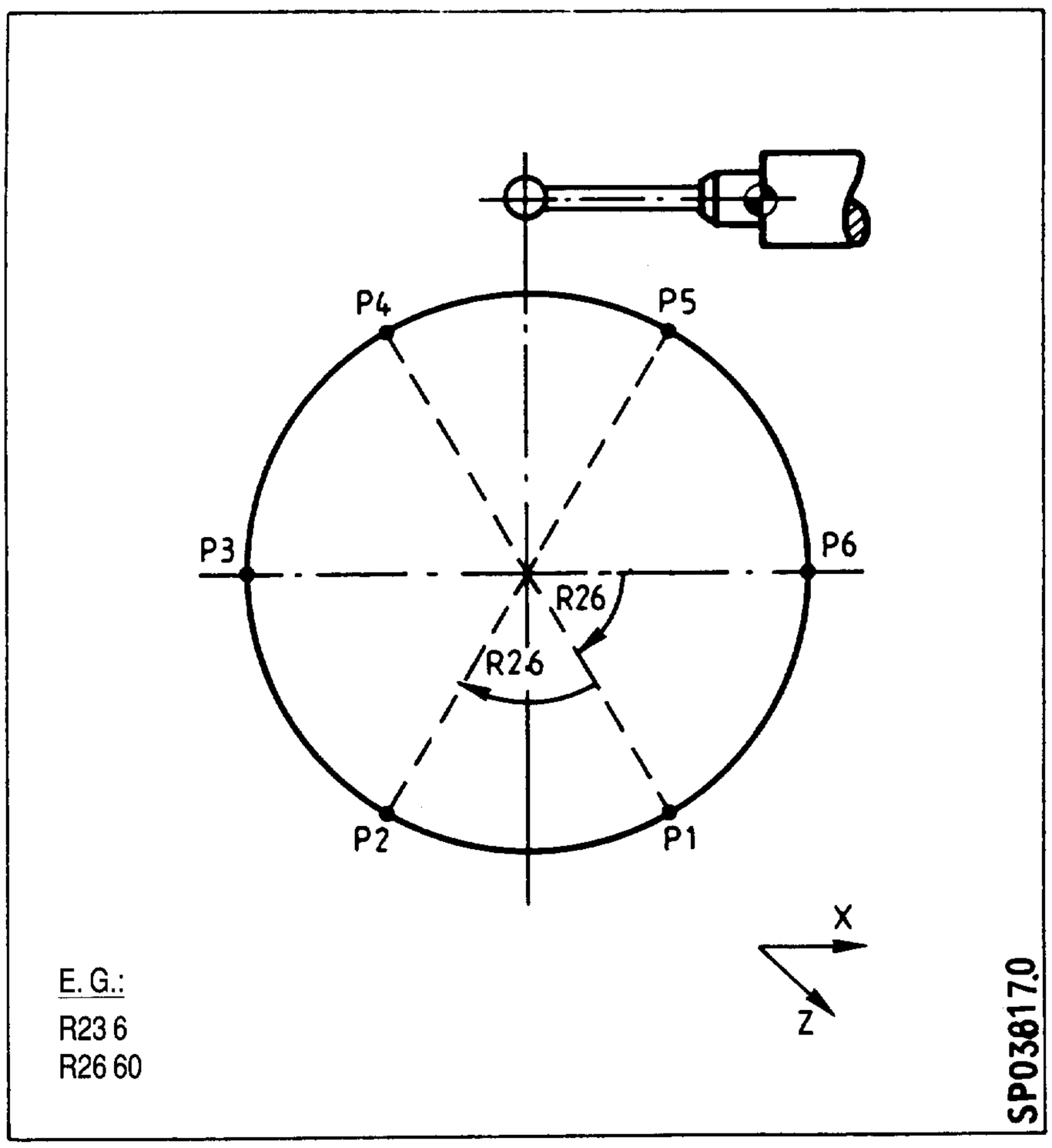


Fig. 30 Multi-point measurement on circumference (outside diameter)

Workpiece measurement	System 3	L93
	System 8 (F)	L974
Multi-point measurement on circumference	System 8 (S)	L984

Definitions

The following parameters must be defined prior to call:

R04	Spindle dwell time (only System 3, see Part 0 3.6)	
R10 1 - 32	Tool offset memory no. for automatic tool offset	
R11 0 - 20	Empirical value memory no. (average value memory)	
R23	Number of measurements on circumferance	
R24 0	1-point measurement	
R25 2	Multi-point measurement on circumferance	
R26 0-359.5	Indexing angle = starting angle (only positive)	
R27 1 - 10	Number of measurements at the same location (see Part 0 2.5)	
R28 1 - 10	Multiplication factor for measurement path "2a"	
R29 1 - 4	Weighting factor k for averaging (see Part 0 2.3)	
R30 1	Number of measuring axis (only X axis)	
R32 *	Specified value relative to workpiece datum. When measuring beneath the centre of rotation in plus X direction, the setpoint must be specified as a negative value.	
R33	Zero offset range	(see Part 0 2.3.1)
R34	Average value compensation	(see Part 0 2.3.1)
R35 *	Specified dimension tolerance	(see Part 0 2.3.1)
R36	Safe area	(see Part 0 2.3.1)
R37	Dimensional deviation check	(see Part 0 2.3.1)
R40	Upper tolerance limit	(as per drawing)
R41	Lower tolerance limit	(as per drawing)
R42	Specified value	(as per drawing)

* When additional use is made of L75/L965, R32 and R35 are calculated from R40, R41 and R42. R32 and R35 need then not be defined.

4.2.4.5 Multi-point measurement on cylinder

The number of measurements and offset of Z axis (incremental) is defined by means of 2 parameters. Arithmetic averaging is performed.

The probe must be calibrated.
The workpiece must be positioned with M19, for example, before the cycle is called.

When measurement has been completed, the probe is located at a distance "a" away from the last measuring point.

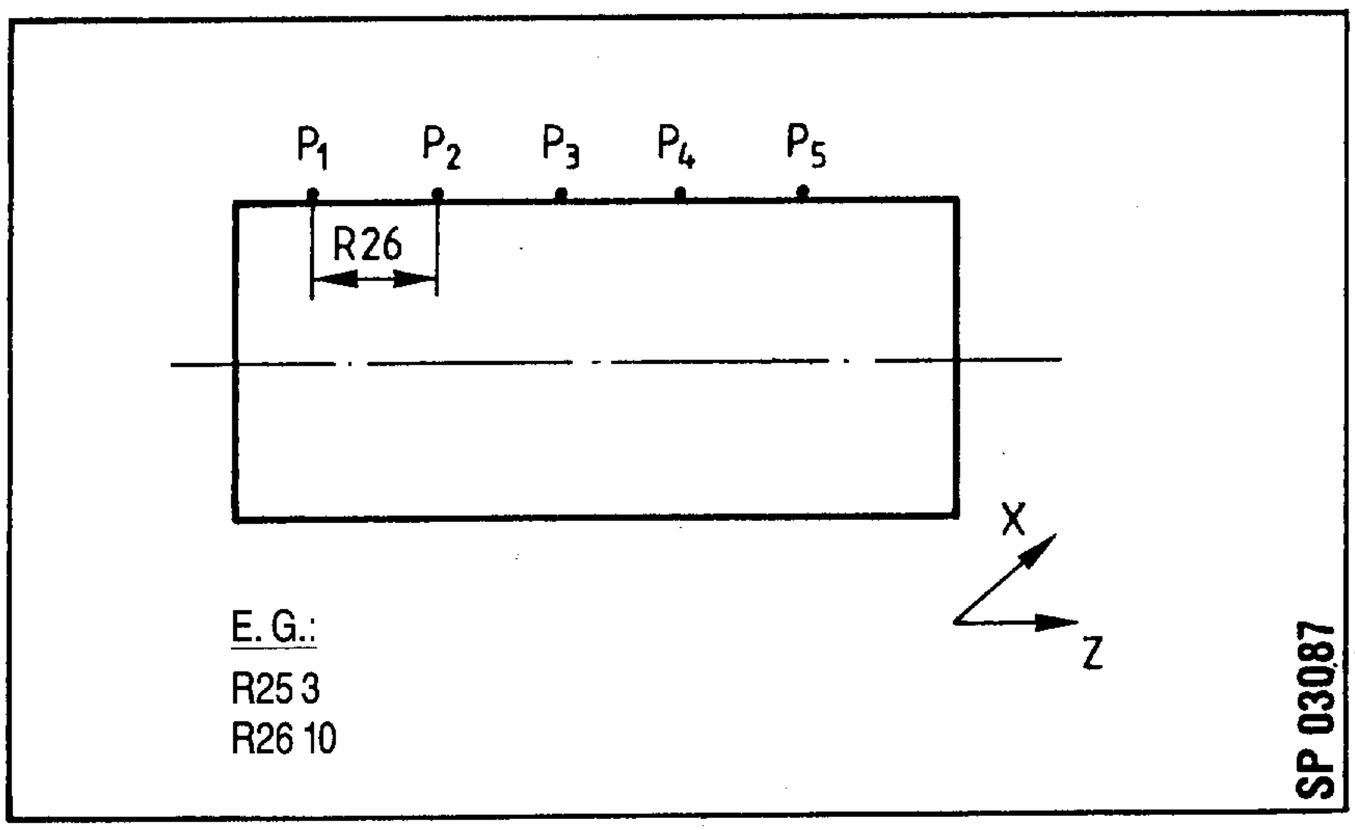


Fig. 31 Multi-point measurement on cylinder (outside diameter)

Workpiece measurement	System 3	L93
	System 8 (F)	L974
Multi-point measurement on cylinder	System 8 (S)	L984

Definitions

The following parameters must be defined prior to call:

R10 1 - 32 Tool offset memory no. for automatic tool offset.

R11 0 - 20 Empirical value memory no. (average value memory)

R23 Number of measurements on cylinder

R24 0 1-point measurement

R25 3 Multi-point measurement on cylinder

R26 Offset of Z axis (incremental)

R27 1 - 10 Number of measurements at the same location (see Part 0 2.5)

R28 1 - 10 Multiplication factor for measurement path "2a"

R29 1 - 4 Weighting factor k for averaging (see Part 0 2.3)

R30 1 Number of measuring axis (M axis)

R32 * Specified value relative to workpiece datum in diameter. When measuring below the centre of rotation in plus X direction, the setpoint must be specified as a negative value.

R33 Zero offset range (see Part 0 2.3.1)

R34 Average value compensation (see Part 0 2.3.1)

R35* Specified dimension tolerance (see Part 0 2.3.1)

R36 Safe area (see Part 0 2.3.1)

R37 Dimensional deviation check (see Part 0 2.3.1)

R40 Upper tolerance limit (as per drawing)

R41 Lower tolerance limit (as per drawing)

R42 Specified value (as per drawing)

* When additional use is made of L75/L965, R32 and R35 are calculated from R40, R41 and R42. R32 and R35 need then not be defined.

Parameter recommendations for reliable program run

Workpiece measurement

a) Calibrate L92 (L973, L983)

Zero offset range	R33 0.001	
Compensation range with averaging	R34 0.010	
Safe area	R36 1	(continuous operation)
Safe area	R36 3	(setup)

b) Measure L93 (L974, L984)

Zero offset range	R33 0.001	
Compensation range with averaging	R34 0.010	
Safe area	R36 1	(continuous operation)
Safe area	R36 3	(setup)
Dimensional deviation check	R37 0.3	(continuous operation)
Dimensional deviation check	R37 3	(setup

All values are relative to the diameter for the X axis.

Workpiece measurement	System 3 L93 System 8 (F) L974 System 8 (S) L984)

4.2.4.6 Examples of application for workpiece measurement with previous calibration

The workpiece shown in this diagram is to be measured with the aid of a probe.

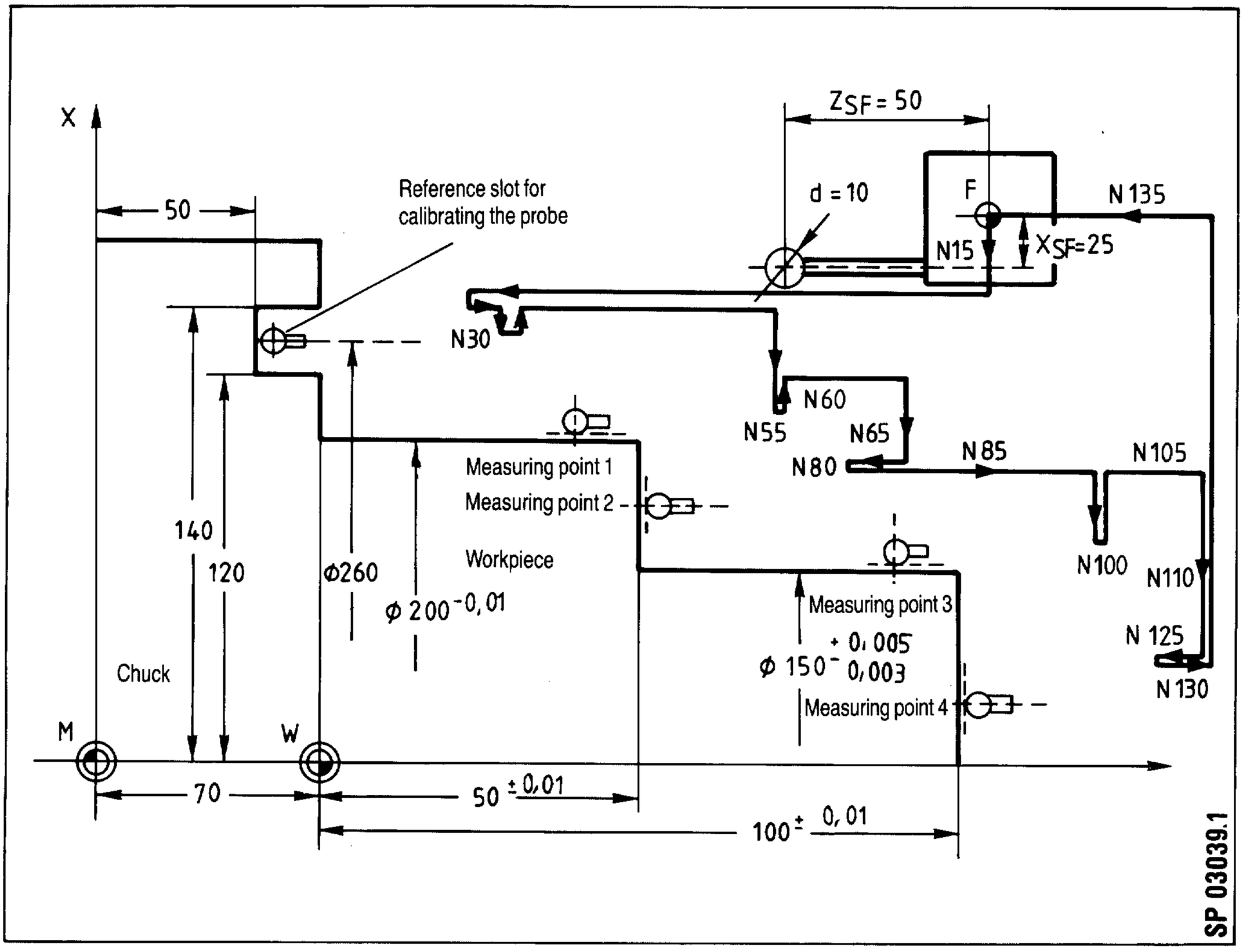


Fig. 32 Workpiece measurement

Workpiece	System 3	L93
	System 8 (F)	L974
	System 8 (S)	L984

Programming example: Calibrate workpiece probe, perform workpiece measurement with L92, L93 and application of L75 (data as given in Fig. 32)

```
%931
N5   G53 T0131                              /Cancel ZO; call T no. with TO no.
N10  R11 1 R12 0 R21 0 R22 1 R23 0          /Define par. for calibration
     R27 1 R28 1 R29 3
N15  R30 2 R31 1 R33 0 R34 0 R36 1
N20  L92                                    /Calibrate probe in minus Z axis
N25  R11 2 R30 1                            /Define parameters for calibration
N30  L92                                    /Calibrate probe in minus X axis
N35  G54 G00 Z40                            /Cancel ZO; position Z axis opposite
                                             measuring point 1
N40  R10 8 R11 3 R24 0 R25 0 R27 1          /Define parameters for measurement
     R28 1 R29 2 R30 1
N45  R33 0.002 R34 0.005 R36 0.3
     R37 0.2 R40 0 R41-0.01
     R42 200
N50  L75                                    /Calculate parameters R32 and R35
N55  L93                                    /Measure MP1
N60  G00 Z70                                /Position probe opposite MP2
N65  X175
N70  R10 9 R11 4 R30 2 R40 0.01             /Define parameters for measurements
     R41-0.01 R42 50
N75  L75                                    /Calculate parameters R32 and R35
N80  L93                                    /Measure MP2
N85  G00 Z180                               /Position probe opposite MP3
N90  R10 10 R11 5 R30 1 R40 0.005           /Define parameter for measurement
     R41-0.003 R42 150
N95  L75                                    /Calculate parameters R32 and R35
N100 L93                                    /Measure MP3
N105 G00 Z150                               /Position probe opposite MP4
N110 X50
N115 R10 11 R11 6 R30 2 R40 0.01            /Define parameters for measurement
     R41-0.01 R42 100
N120 L75                                    /Calculate parameters R32 and R35
N125 L93                                    /Measure MP4
N130 G53 G00 Z250 TO                        /Retract Z
N135 G53 X280 M30                           /Retract X
```

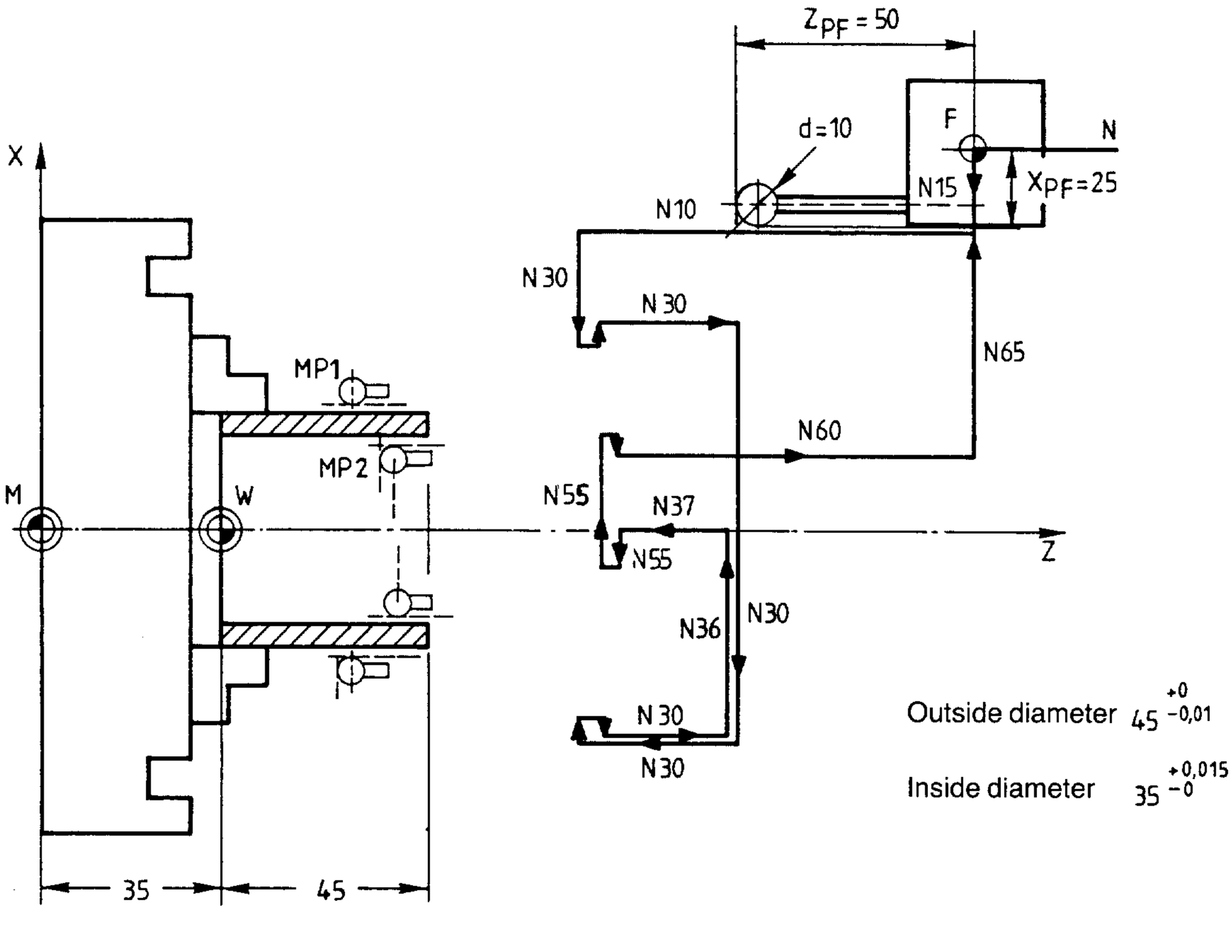


Fig. 33 Workpiece measurement, 2-point measurement outside and inside

Programming example: 2-point measurement outside and inside with L93 and application of L75 (data from Fig. 33)

```
%932
N5  T0131                                  /Call probe with T0 no.
N10 G00 G54 Z30                            /Select Z0; position probe
N15 R10 3 R11 3 R18 30 R19 55              /Define parameters for measurement
    R24 1 R25 0 R27 1 R28 1 R29 3
    R30 1
N20 R33 0.002 R34 0.005 R36 0.5
    R37 0.04 R40 0 R41-0.01
    R42 45
N25 L75                                    /Calculate parameters R32 and R35
N30 L93                                    /Measure MP1
N35 T0131                                  /Call TO no., because cycle on
                                            TO no. 32 has changed (when measuring
                                            in pos. direction, TO is automatically
                                            incremented by 1) (see Section 4.2.3.1,
                                            Fig. 18).
N36 G00 X-5                                /Position probe opposite MP2
N37 Z35
N40 R10 4 R11 4 T24 1 R25 0                /Define parameter for measurement
    R27 1 R28 1 R29 3 R30 1
N45 R33 0.002 R34 0.005 R36 0.5
    R37 0.04 R40 0.015 R41 0 R42 35
N50 L75                                    /Calculate parameters R32 and R35
N55 L93                                    /Measure MP2
                                            (TO has been incremented by 1)
N60 G53 G00 Z200 TO
N65 G53 X400 M30
```

4.3 Special cycles (System 8T only)

4.3.1 Tool data transfer

Function and application

If spare tools are used, the tool data for all tools is stored in the PLC.
Since the tool magazine contains both active tools and spare tools, it must be possible to store and update all relevant data. If a tool is called by the NC part program, only the currently active tool is selected each time and supplied to the machining operation. The wear limit, for example is detected by tool measurement, life, torque or cutting force check and the next time this worn tool is called, the nearest spare tool is supplied to the machining process. Since the dimensions of the spare tool are usually not identical with those of the previous tool, the tool compensation values must be corrected accordingly in the NC. This can be accomplished by transferring the actual compensation values to the NC each time a tool is changed. Consequently, only the tool dimensions of the tool currently in use are stored in the NC.
This transfer is implemented in the cycle L910.

Tool data transfer NC <===> PLC

T no.	Life	GEO				Wear		Wear limit		DUPLO	MOMENT	Ident.: Tool meas. 0 = no 1 = yes
		X	Z	Rad. B	Vector A	X	Z	X	Z			
Data in R parameters		R60	R61	R62	R63	R64	R65	R66	R67			R68

Fig. 34 Tool data block in the PLC
Wear limit only pos. values (for X axis only in the radius)

PLC function:

M function (b. mem. 52):

- Read R80 (tool number)
- Load corresponding tool data block into the R parameters R60 - R68

If data block without wear:
do not load R64 and R65

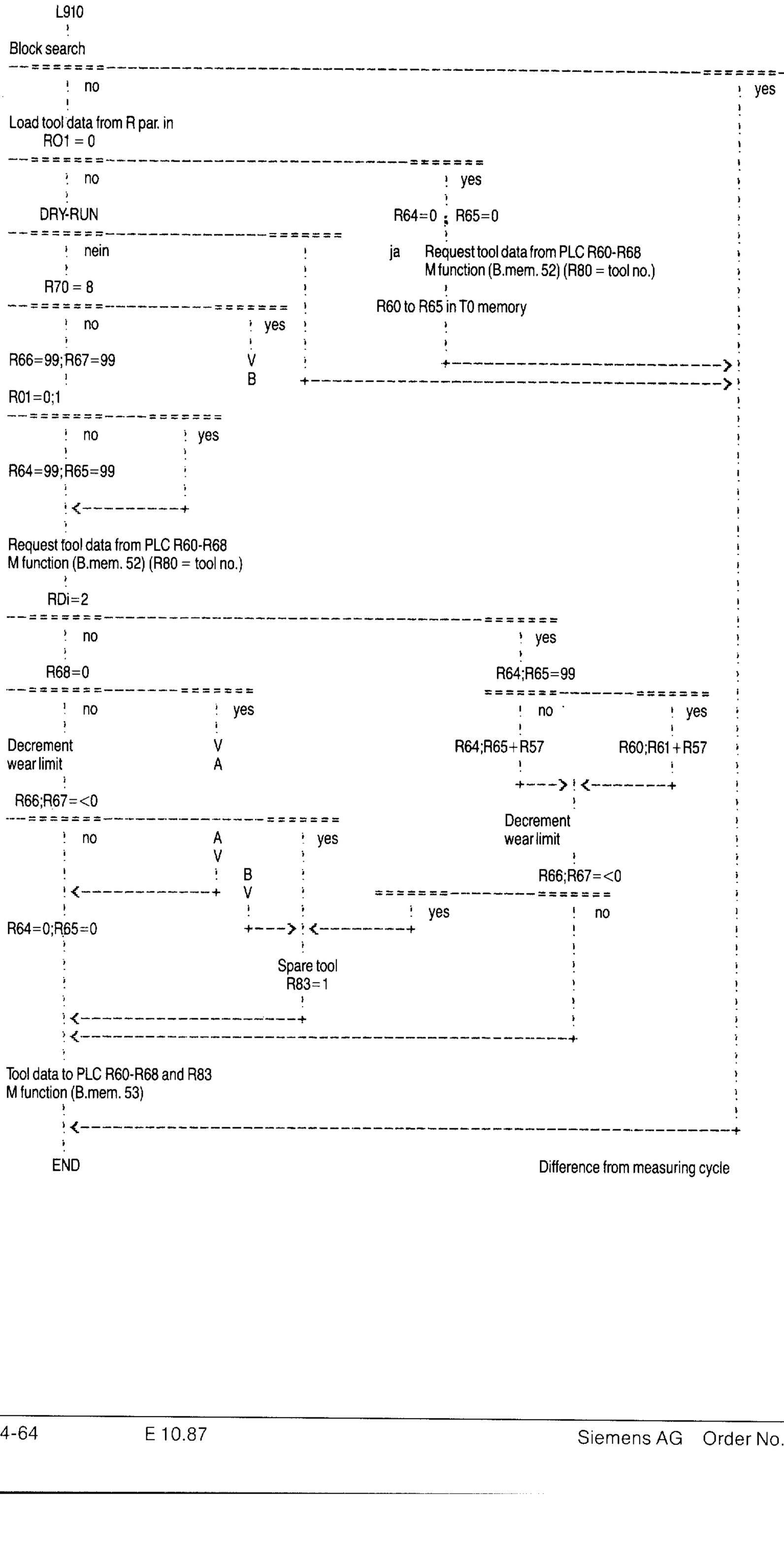
If data block without wear limit:
do not load R66 and R67

M function (b. mem. 53):

- Read R80 (tool number)
- Transfer contents of R60 - R68 and R83 into the appropriate PLC memory.

R83 = 0 accept data
R83 = 1 do not accept data; use spare tool

Program run:


L910
Block search
no
yes
Load tool data from R par. in
RO1 = 0
no
yes
DRY-RUN
R64=0
R65=0
nein
ja
Request tool data from PLC R60-R68
M function (B.mem. 52) (R80 = tool no.)
R70 = 8
R60 to R65 in T0 memory
no
yes
R66=99;R67=99
V
B
R01=0;1
no
yes
R64=99;R65=99
Request tool data from PLC R60-R68
M function (B.mem. 52) (R80 = tool no.)
RDi=2
no
yes
R68=0
R64;R65=99
no
yes
no
yes
Decrement
wear limit
V
A
R64;R65+R57
R60;R61+R57
R66;R67=<0
Decrement
wear limit
no
A
V
yes
B
V
R66;R67=<0
yes
no
R64=0;R65=0
Spare tool
R83=1
Tool data to PLC R60-R68 and R83
M function (B.mem. 53)
END
Difference from measuring cycle

Definitions

The following parameters must be defined prior to call:

R01 0 Request tool data block from PLC and load into TO memory no. 1.

1 Tool measurement has been performed.
- Tool data block is requested by PLC
  If R68 = 0: First measurement of tool.
  Wear limit is not decremented
  Cycle sets R68 = 1 (tool measured)
- Wear is deleted
- Wear limit is decremented
- Updated data block is transferred to the PLC

2 Workpiece measurement has been performed.
- Tool data block is requested by PLC
- Wear is updated
- Wear limit is decremented
- Updated data block is transferred to the PLC

4.3.2 Decision program: Measure tool?

Function and application

With R68 = 0, the cycle call the measuring cycle L971. If R68 = 1, the tool is not measured.

The parameter R68 is supplied from the PLC.

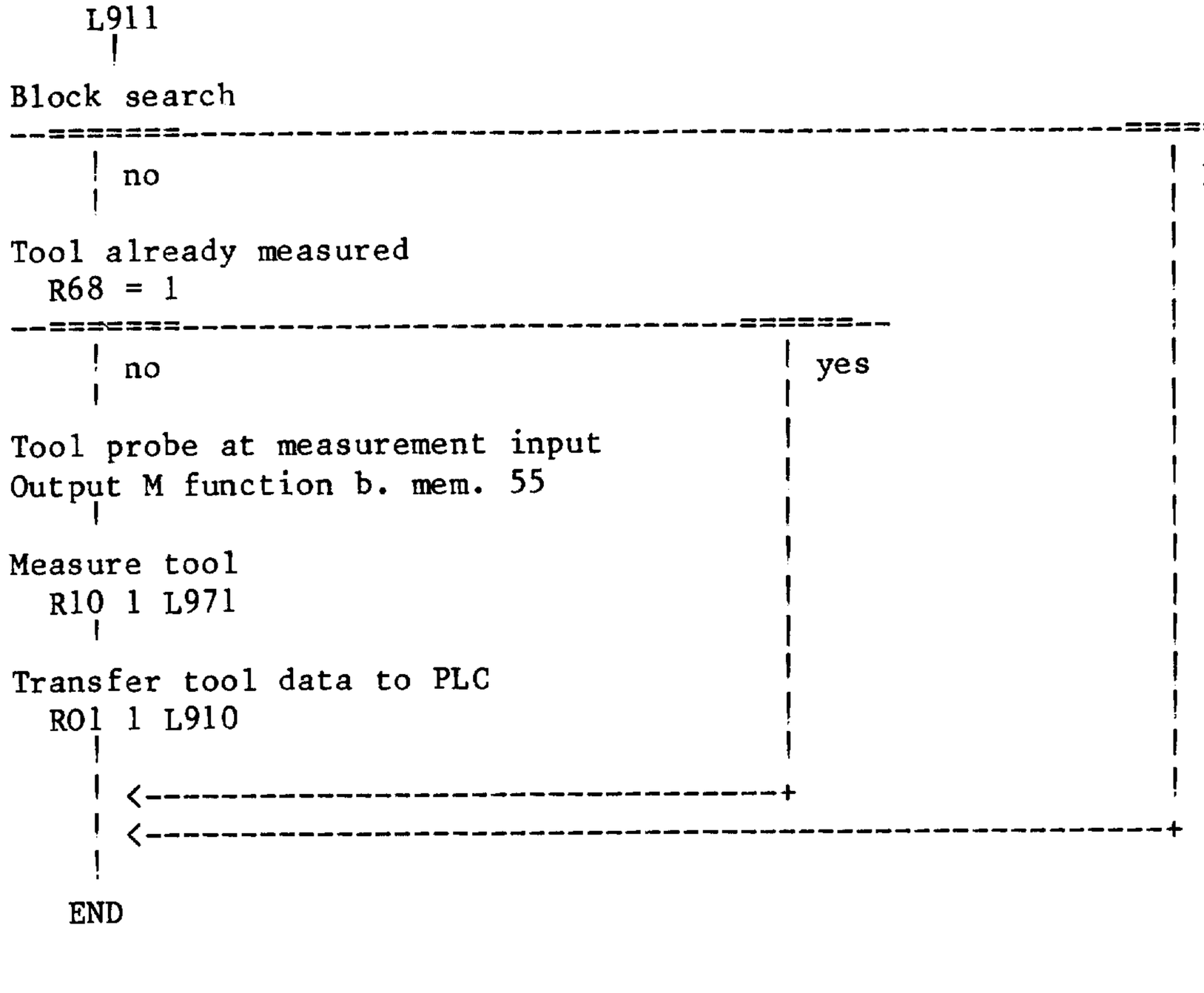
The tool from TO memory 1 is always measured.

Nesting:

```
%1234
     :
     : ==> L911
               :
               : ==> L971
                         :
                         : ==> L972
                                   :
                         : <==  M17
                         :
                         : ==> L899
                                   :
                               : <==  M17
               : <==  M17
               :
               : ==> L910
                         :
               : <==  M17
               :
     : <==  M17
     :
M30
```

Decision program: measure tool ?

Program run:



Definitions

The following parameters must be defined prior to call:

R11	0 - 20	Empirical value memory no.
R18	0	Change position X axis from background memory 58
	# 0	Variable change position X axis
R19	0	Change position Z axis from background memory 59
	# 0	Variable change position Z axis
R23	0 - 2	Tool lengths definition (see Part 1 4.2.2)
R27	1 - 10	Number of measurements at same location (see Part 0 2.5)
R28	1 - 10	Multiplication factor for measurement path "2a"
R33		Zero offset range (see Part 0 2.3.1)
R36		Safe area (see Part 0 2.3.1)
R37		Dimensional deviation check (see Part 0 2.3.1)

Decision program: measure tool?

Programming example: Workpiece machining with tool measurement and workpiece measurement with L910, L911, L965 and L974

```
%911
:
:
N10   T0101
N15   M06                          /Install tool T1
N20   R01 0 L910                    Load tool data block from PLC in
                                    R par. R65-R68
                                    Tool data in TO memory no. 1
N25   R11 0 R18 0 R19 0 R23 0      /Define R par. for L911
      R27 1 R28 2 R33 0 R36 2
      R37 0.1
N30   L911                         /Measure tool?
                                    R68 = 0 measure ==> call L972
                                    R68 = 1 do not measure

N35   :
      :
      Machining
      :
      :
N200  T0201                        /Search for tool T2 in magazine
      :
      :
N250  M06                          /Install tool T2
N255  R01 0 L910
N260  R..
N265  L911
N270  :
      :
      Machining
      :
      etc.
      :
      :
N810  T9001                        /Search for workpiece probe
      :
      :
N850  M06                          /Install workpiece probe
                                    no data transfer, because GEO of
                                    probe in TO no. 31 and 32
N855  T9031
N860  R...                         /Define R parameter for
                                    calibration cycle
N865 L973                          /Calibrate probe
N870 X...Z...                      /Approach 1st measuring point
N875 R10...R...                    /Define R parameters for 1st measuring
                                    point
N880 L965                          /Calculation of R32 and R35
N885 L974                          /Measure 1st measuring point
N890 R01 2 L910                    /Update tool in PLC
N895 M53                           /Measurement data to host
```

(continued on next page)

Programming example (continued)

```
N900  X...Z...                    /Approach 2nd measuring point
N905  R10... R...                 /Define R par. for 2nd measuring point
N910  L965                        /Calculation of R32 and R35
N915  L974                        /Measure 2nd measuring point
N920  R01 2 L910                  /Update tool in PLC
N925  M53                         /Measurement data to host
      :
      :
N950  M30
```

Note: Only TO no. 1 is used here.

(Host = Production control computer)

4.3.3 Search cycle

Function and application

The tool probe and the calibration surfaces for the workpiece probe are attached to the tailstock.
Since the tailstock has no measuring system of its own, a search must be made for the positions of the tool probe and the calibration surface before measuring the tool and calibrating the workpiece probe. At the beginning and at the end of the cycle, the point "N" is positioned in the X axis, namely to the position of background memory 58 when R18 = 0. In the case of R18 ≠ 0, "N" is positioned away from the tool probe side (background memory 65) only by the value of R18 (see Fig. 35).

Nesting:

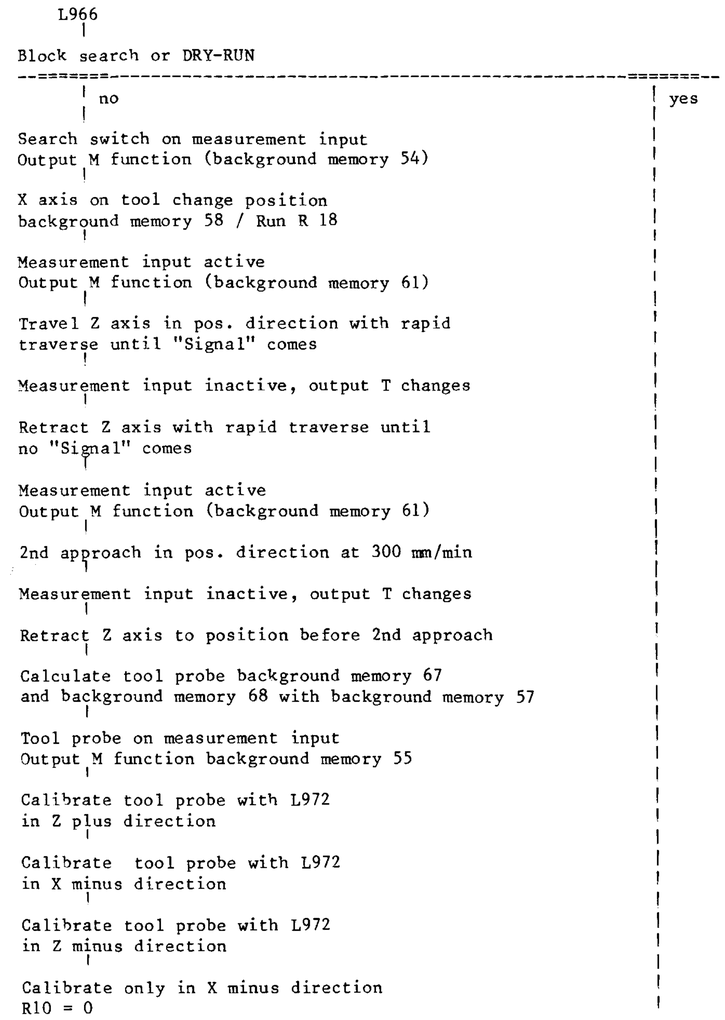
```
%1234
     :
     : ==> L966
                :
                : ==> L972
                           .
                           .
                           .
                : ==> L899
                           :
                : <==  M17
           : <==  M17
     : <==   M17
     :
   M30
```

Preconditions:

- The background memories 54 to 57, 61, 62 to 68 and 92 to 99 must be loaded (see Part 1 4.3.5).

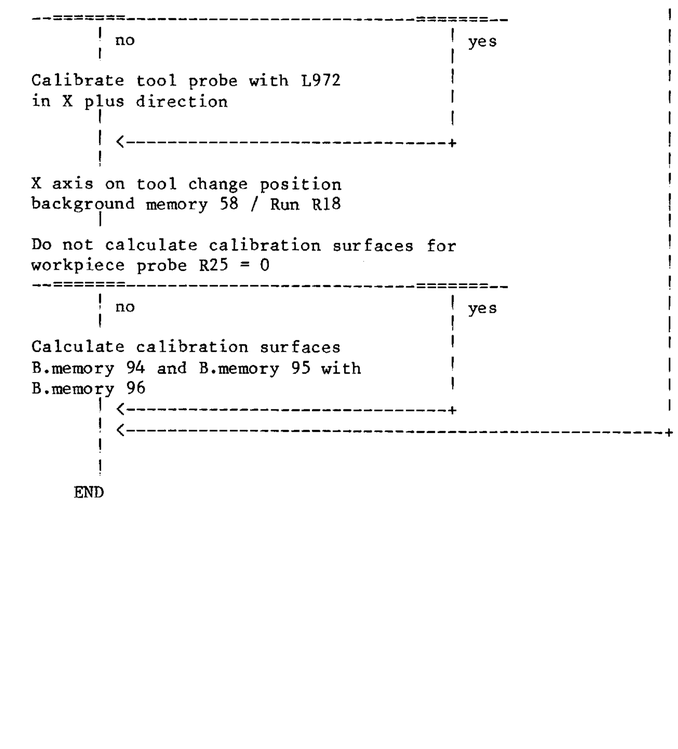
- The Z axis must be prepositioned such that the search switch can be approached in the positive direction.

Program run:



Tool measurement / workpiece measurement System 8 (F) L966

Search cycle



Definitions

The following parameters must be defined prior to call:

R18 0 Change position X axis of background memory 58
0 Variable change position X axis

R24 0 Tool probe is calibrated in the following directions:
plus Z direction
minus X direction
minus Z direction

1 Tool probe is calibrated in the following directions:
plus Z direction
minus X direction
minus Z direction
plus X direction

R25 0 Calibration surfaces for workpiece probe are not calculated

1 Calibration surfaces of workpiece probe are calibrated with the value of background memory 96 after calibration of the tool probe
The background memories 94 and 95 are updated.

R27 1 - 10 Number of measurements at same location (see Part 0 2.5)

R28 1 - 10 Multiplication factor for measurement path "2a"

R33 Zero offset range (see Part 0 2.3.1)

R36 Safe area (see Part 0 2.3.1)

Search cycle

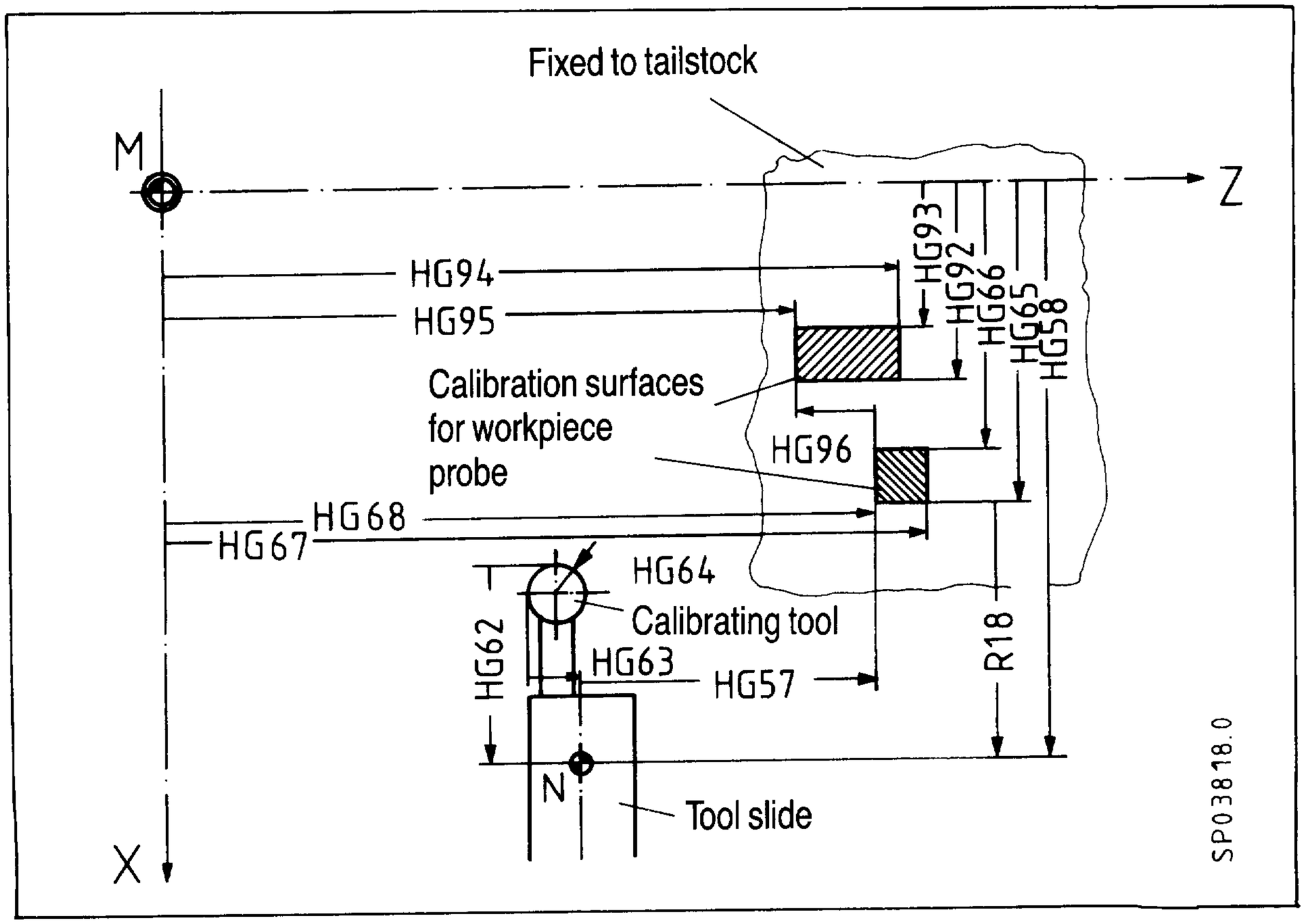


Fig. 35 Overview machine data for search cycle
(tool slide is in the search switch position)

4.3.4 Utility routine: calibrate workpiece probe on outside surfaces

Function and application

This cycle is in addition to the existing calibration cycle L973. With L967, workpiece probes of types 1 - 4 (see Fig. 37) can be calibrated on outside surfaces. The calibration surfaces must be stored in background memory 92 to 95 (relative to the machine datum). The type must be input in the TO memory under "A" (see Fig. 36). First the "tool change position" N (background memory 58 or R18) is approached in the X axis. The workpiece probe is then positioned by the cycle on the appropriate calibration surface and calibrated in all three directions with L973.

If averaging is used (R11 # 0), the specified average memory no. R11 = m is applicable for the first calibration. For the two other directions, the cycle increments the R11 by 1 in each case. For this reason, three consecutive memories are used ($R11_{max}$ = 18).

When calibration has been completed, "N" is at the position in the X axis which has been input in background memory 58 (only if R18 = 0). With R18 # 0 "N" is positioned away from the calibration surface (background memory 92) only by the amount of R18.

Nesting

```
%1234
     :
     : ==> L967
               :
               : ==> L973
                         :
                         : ==> L899
                                   :
                         : <==  M17
               : <==  M17
     : <==  M17
     :
  M30
```

Preconditions:

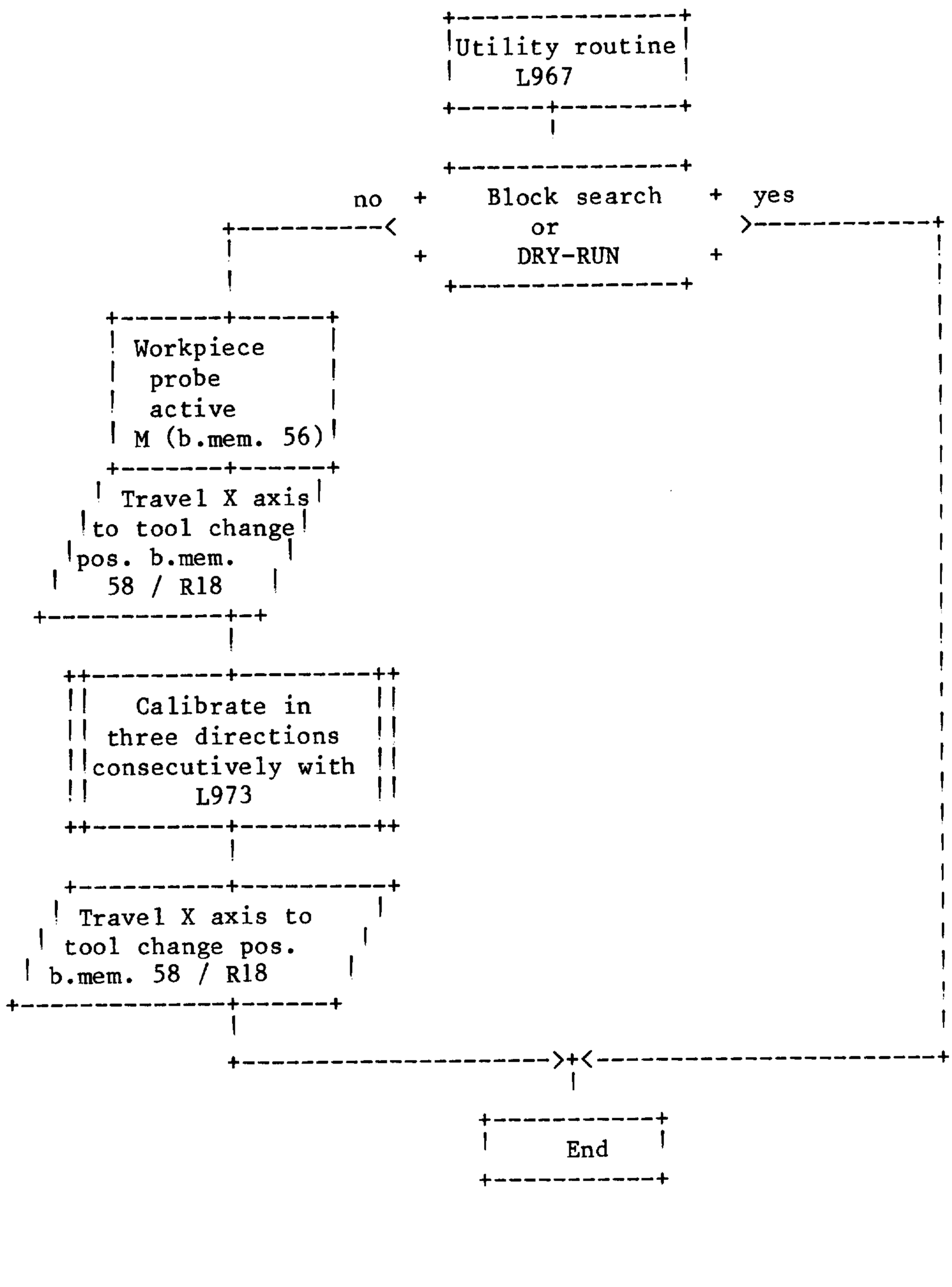
- The background memories 56, 61 and 92 to 95 must be loaded (see Part 1 4.3.5).

- The probe must be input in two consecutive TO memories.

- The probe must be called with the 1st compensation number and without G53 (select ZO).

Utility routine: calibrate workpiece probe on outside surfaces

Outline flowchart



Utility routine: calibrate workpiece probe on outside surfaces

Definitions

The following parameters must be defined for call:

R11	0 - 20	Average value memory no. calculation is performed without empirical value
R18	0	Change position X axis of background memory 58
	# 0	Variable change position X axis
R20	0	Tool probe is not in front of the calibration surfaces
	1	Tool probe is in front of the calibration surfaces
R27	1 - 10	Number of measurements at same location (see Part 0 2.3.1)
R28	1 - 10	Multiplication factor for the measurement path "2a"
R29	1 - 4	Weighting factor k for averaging (see Part 0 2.3.1)
R33		Zero offset range (see Part 0 2.3.1)
R34		Average value compensation (see Part 0 2.3.1)
R36		Safe area (see Part 0 2.3.1)

Utility routine: calibrate workpiece probe on outside surfaces

Probe type 4	25	X (Trigger point)	Z (Trigger point)
	26	B (Bulb radius)	A 4 (Type)
Probe type 3	27	X (Trigger point)	Z (Trigger point)
	28	B (Bulb radius)	A 3 (Type)
Probe type 2	29	X (Trigger point)	Z (Trigger point)
	30	B (Bulb radius)	A 2 (Type)
Probe type 1	31	X (Trigger point)	Z (Trigger point)
	32	B (Bulb radius)	A 1 (Type)

Fig. 36 Example: Workpiece probe data in the TO memory

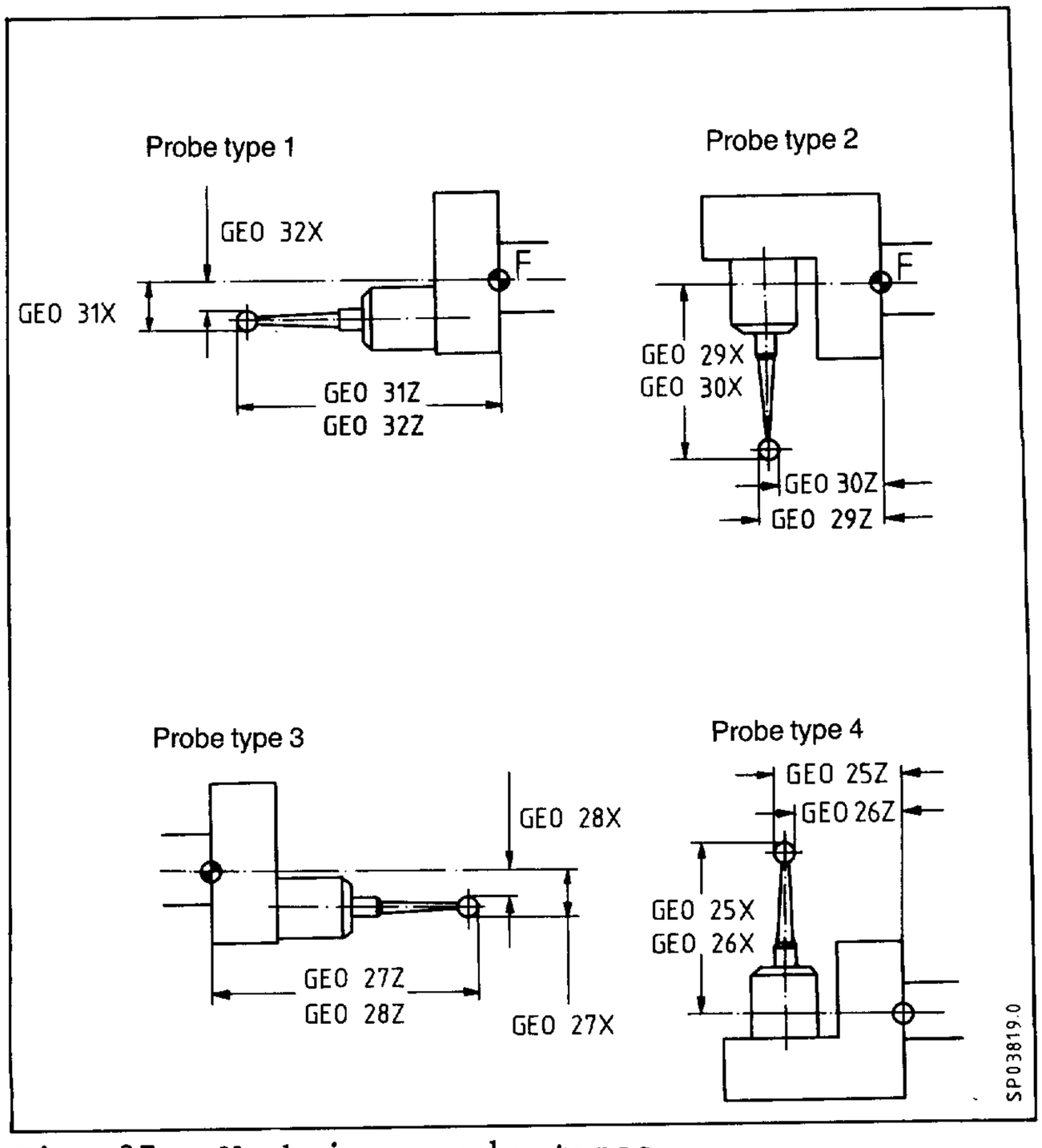


Fig. 37 Workpiece probe types

Utility routine: calibrate workpiece probe on outside surfaces

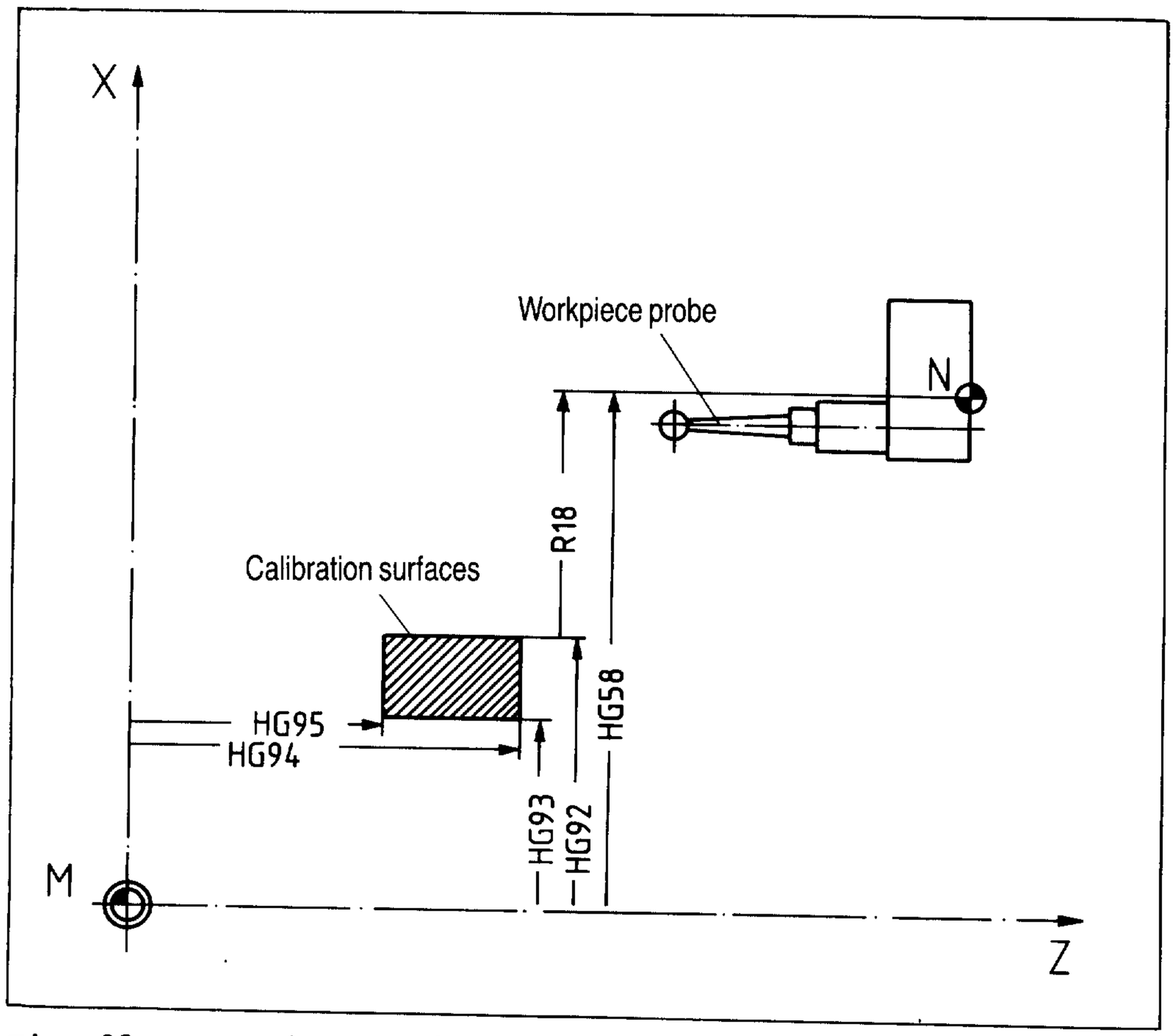


Fig. 38 Overview machine data for calibrating on outside surface

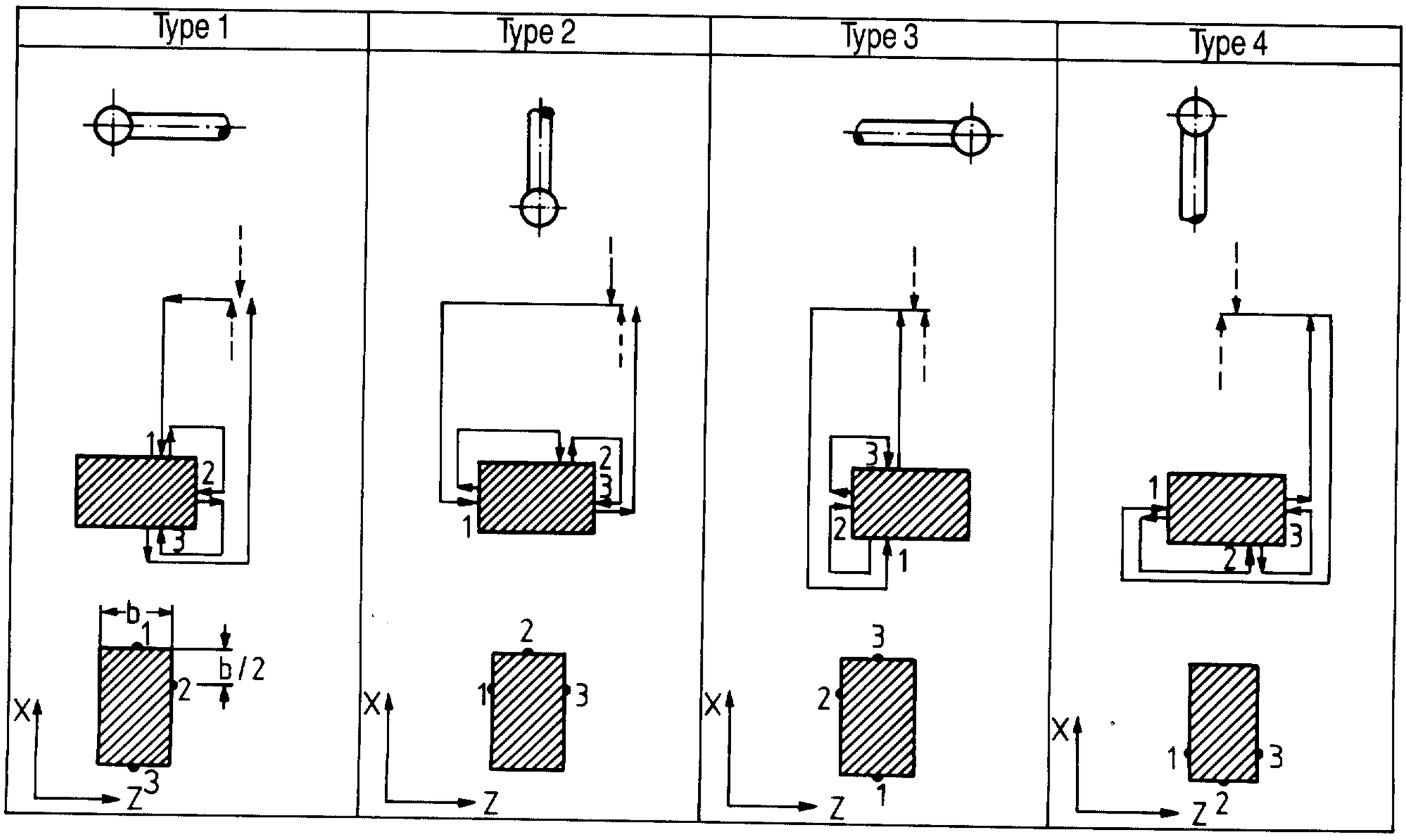


Fig. 39 Representation of the calibration positions on the calibration surfaces

Utility routine: calibrate workpiece probe on outside surfaces

Programming example:

```
%967
N1 G54 ...
  +------------------+
  |Workpiece program |
  +------------------+
N500 .....
N505  T0925                          /Call probe with compensation
                                      without programming a path

N510  R11 1 R18 0 R27 1 R28 1
      R29 1 R33 0.004 R34 0.01 R36 1
N515  L967                           /Probe is calibrated
  +---------------------+
  |Workpiece measurement|
  +---------------------+
N605  T1027                          /Call probe with compensation
                                      without programming a path

N610 R11 4 R18 0 R27 1 R28 1
     R29 1 R33 0.004 R34 0.01 R36 1
N615 L967                            /Probe is calibrated
  +---------------------+
  |Workpiece measurement|
  +---------------------+
N700  M30
```

4.3.5 Backgound memory allocation for special cycles

00 01 :	Empirical values
20	
21 :	Average values
41	
42 :	Unassigned
51	
52	M function tool data from PLC ==> NC
53	M function tool data from NC ==> PLC
54	M function switch for search cycle
55	M function tool probe
56	M function workpiece probe
57	Distance from "N" to tool probe background memory 68 (search cycle)
58	Tool change position X axis for tool measurement
59	Tool change position Z axis for tool measurement
60	M function for unlatching with M19
61	M function probe active
62	X Deviations calibration tool
63	Z
64	B
65	Minus X direction
66	Plus X direction Tool probe
67	Minus Z direction
68	Plus Z direction
69	a
70	b Calibration slot deviations
71	c
72	d with R12 = 0
73	e
74	f
75	g
76	a
77	b Calibration slot deviations
78	c
79	d with R12 = 1
80	e
81	f
82	g

Background memory allocation for special cycles (continued)

83	a
84	b Calibration slot deviations
85	c
86	d with R12 = 2
87	e
88	f
89	g
90	
91	
92	Minus X direction
93	Plus X direction Calibration surfaces for workpiece probe
94	Minus Z direction
95	Plus Z direction
96	Distance from tool probe background memory 68 to calibration surface background memory 95
97	Rotation dimension X axis
98	Rotation dimension Z axis

	7	6	5	4	3	2	1	0
99						PLC management	SPI-X	SPI-Z

Input in bit pattern

Background memory No. 99

SPI-Z	0	During tool measurement, Z axis not mirror-imaged
	1	During tool measurement, Z axis mirror-imaged
SPI-X	0	During tool measurement, X axis not mirror-imaged
	1	During tool measurement, X axis mirror-imaged
PLC-management	0	No PLC management of tools
	1	PLC management of tools

The following values are provided in R parameters:
R70 Alarms, see alarm list
R57 Compensation amount
R30 Number of measuring axis
1 = X axis
2 = Z axis
R10 Compensation number

4.4 Flying measurement in JOG mode

This function applies for System 3T basic version 4B.

Function and application

The "Flying measurement in JOG mode" function determines the tool length compensations semi-automatically and stores these in the NC as tool compensations.

Preconditions

- Machine data 348, input speed with JOG measurement.
- Machine data 425, bit 7=1 flying measurement in the JOG mode is set.
- Probe calibrated with calibration cycle (L91).
- The background memories 00-20, 65-68 and 97 to 99 must be allocated.

Flying measurement in JOG mode

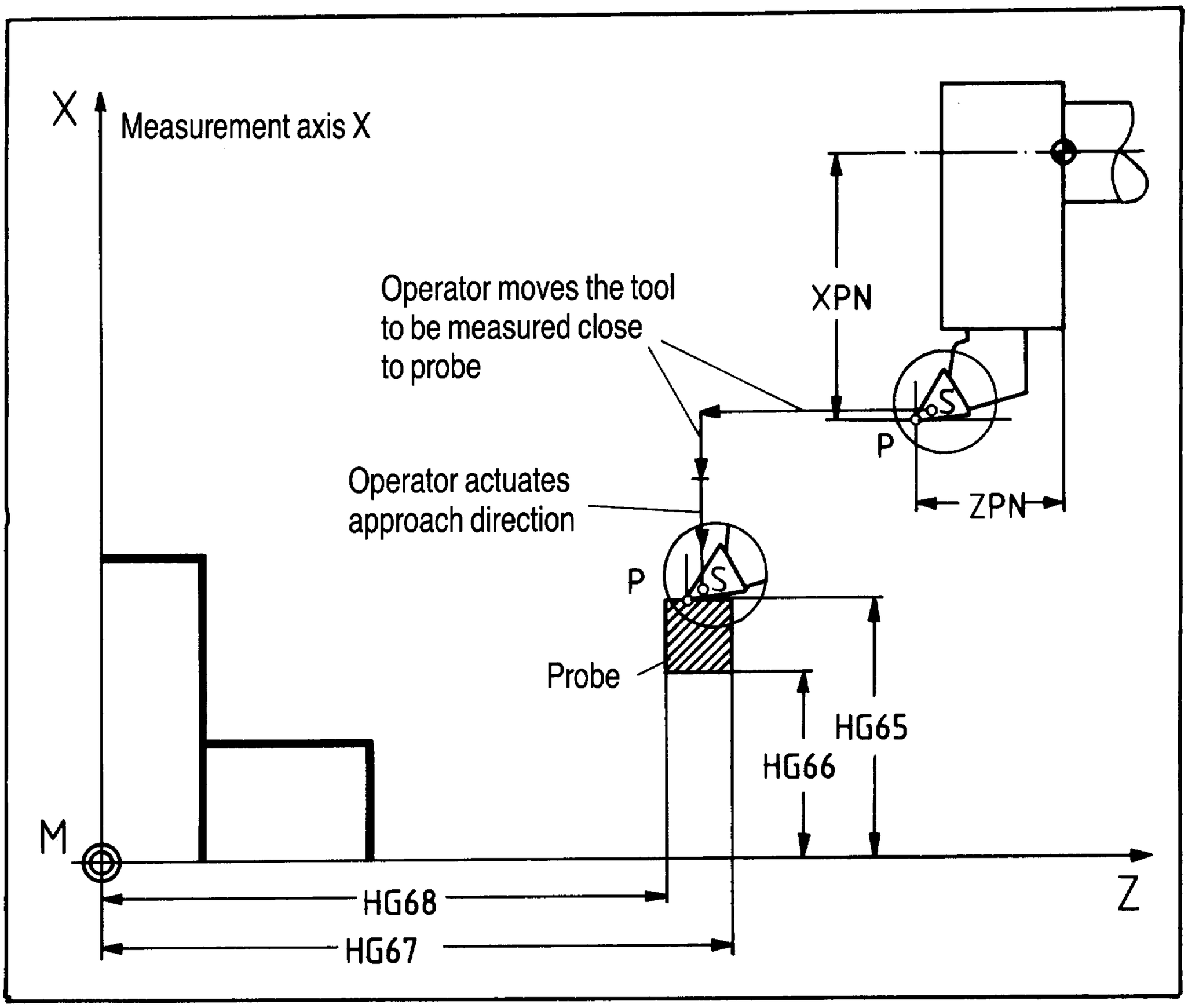


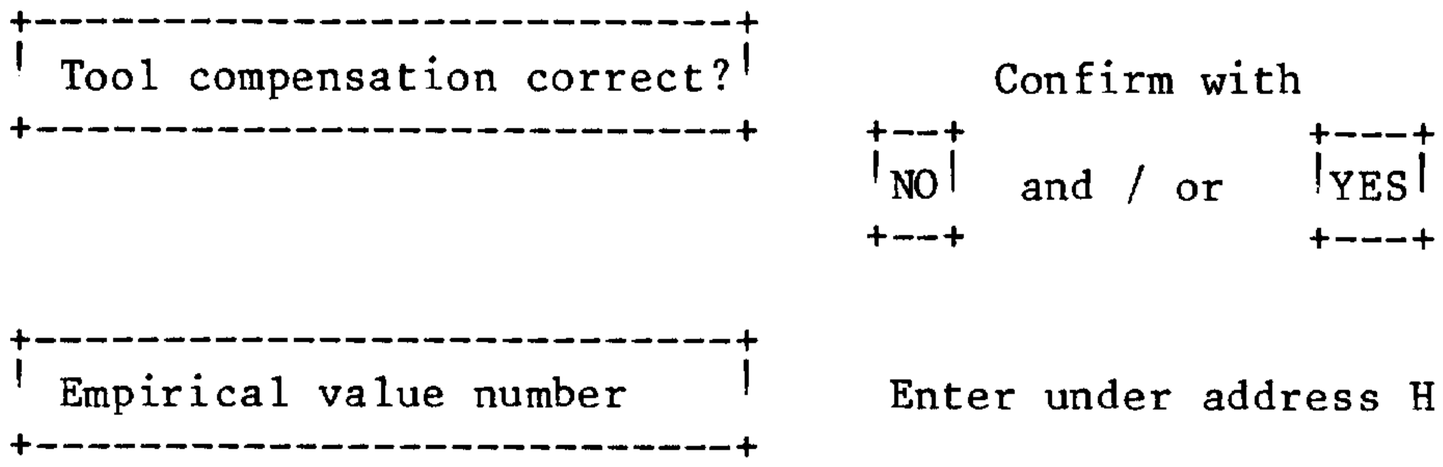
Fig. 40 Flying measurement in JOG mode

Sequence:

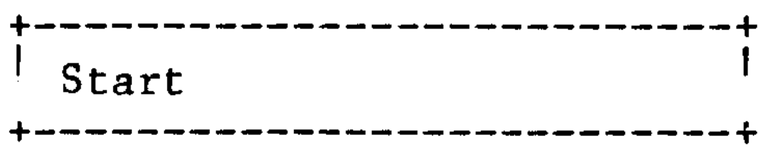
- In JOG mode, move the tool into the vicinity of the probe
- Activate "Flying measurement" signal via PLC
- The direction of travel operated once in the JOG mode is frozen, i.e. rapid traverse and all other directions of travel are disabled.
- The tool travels at measuring speed (MD348) to the probe.
- Probe is swung out, axis remains unchanged.
  The display portrays the tool offset determination.

Flying measurement in JOG mode

Prompts:



The empirical value number H 0 always has the value 0.



After start, the offset is calculated.

- After the offset has been calculated, the tool can be moved clear of the probe by the logic installed for this purpose. All directions of travel other than that opposite to the direction of approach and rapid traverse are then disabled for the time being. The basic display is shown on the screen.

- When the "Flying measurement" signal is removed, travel can continue in the normal JOG mode.

– The measuring process must then be performed for the other axis

- The measuring process is aborted with resets,or by changing the operating mode. All directions of travel and rapid traverse are then possible.

Notes

While the offset is being calculated, the probe must remain swivelled out, otherwise alarm 512 appears.

4.5 Example of a measuring task (here with System 3)

Problem:

8 measuring points are to be approached in the sequence A-B-C-D-E-F-G-H.
The measuring point "A" corresponds to the workpiece datum "W".
The reference of the measuring point with respect to setpoint/actual value and set/actual difference must be established in accordance with the drawing (see Fig. 41). The setpoints A-H are specified by manual input into a PLC display (see PLC display 1), and also the measuring positions of the X axis DA-DH (see PLC display 2).

Notes:

Normally, cycle L93 puts the corrections automatically into a TO memory. In this task, however, this is not required.
In order to disable this automatic compensation, bit 2 (PLC management) can be set in background memory 99. If this bit has been set, automatic compensation is not performed (see Appendix, Table I-1).
This bit can be set and reset with cycle L900, according to the program.
For storing the actual dimensions, for calculating the paths in accordance with the specification (E-F; E-G; E-H; B-F; C-G; D-H9), background memories 62-69 are used. These memories can be used because tool measurement is not applied.

TO memories 31 and 32 are used for the probe.

Outline solution:

- From Table IV in the Appendix Part 1, select the cycle which supplies the required data.
  The following data is required:
  Actual value and difference (see PLC display 1)
  This data is available when L93 has been completed.

- Define function of the PL; in this example M52.

- Create flowchart

- Create NC program

- Input and test program in NC

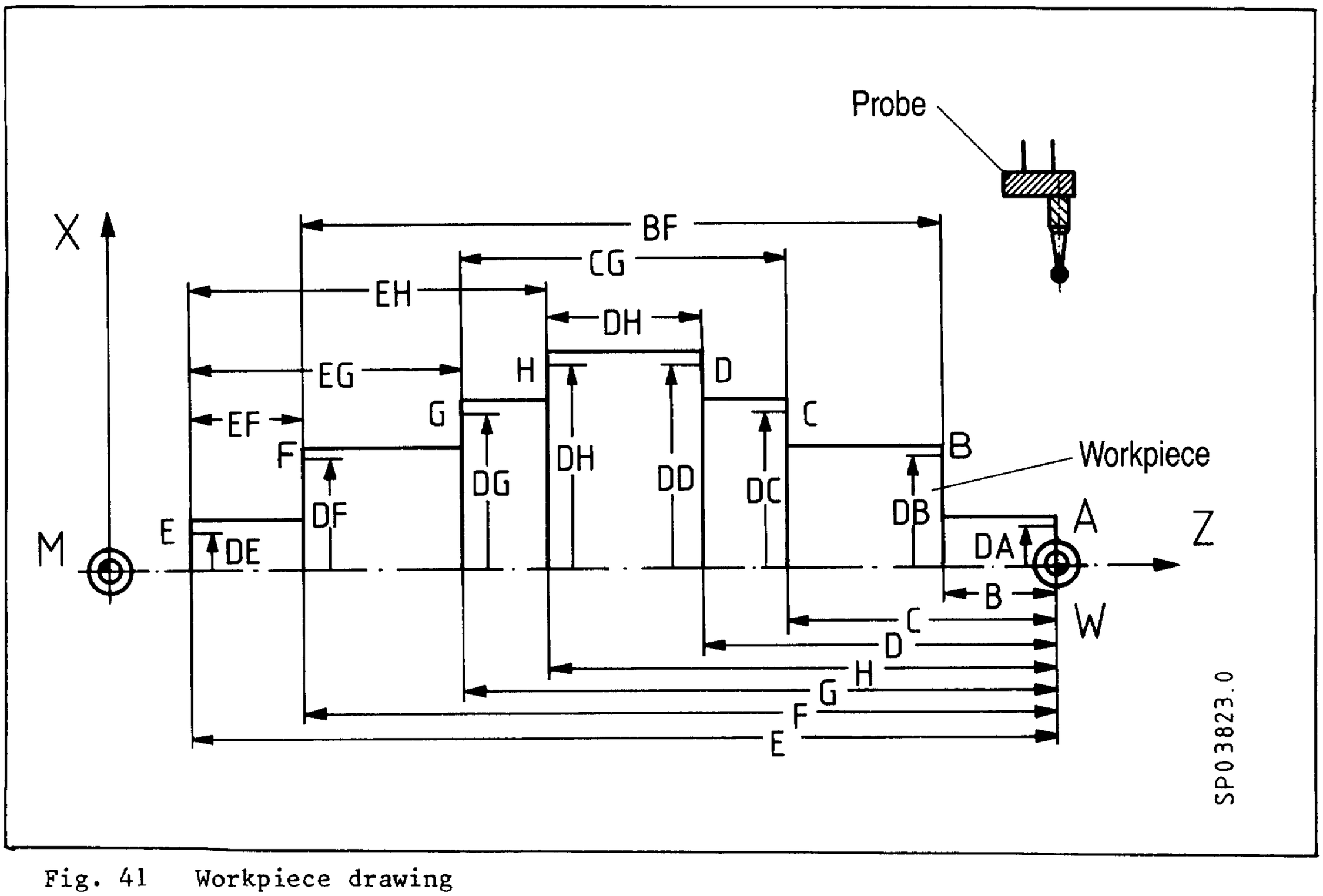


Fig. 41 Workpiece drawing

Function in the PLC:

M52 PLC reads R15,

if R15 1 - 8 ==> Transfer diameter from PLC display 2 in R38 and

Transfer setpoint from PLC display 1 in R42

Enter value from R43 and R44 in PLC Table 1

if R15 0 ==> PLC reads R16

R16 1 - 6 ==> Enter value from R39 in PLC display 2.

PLC display 1

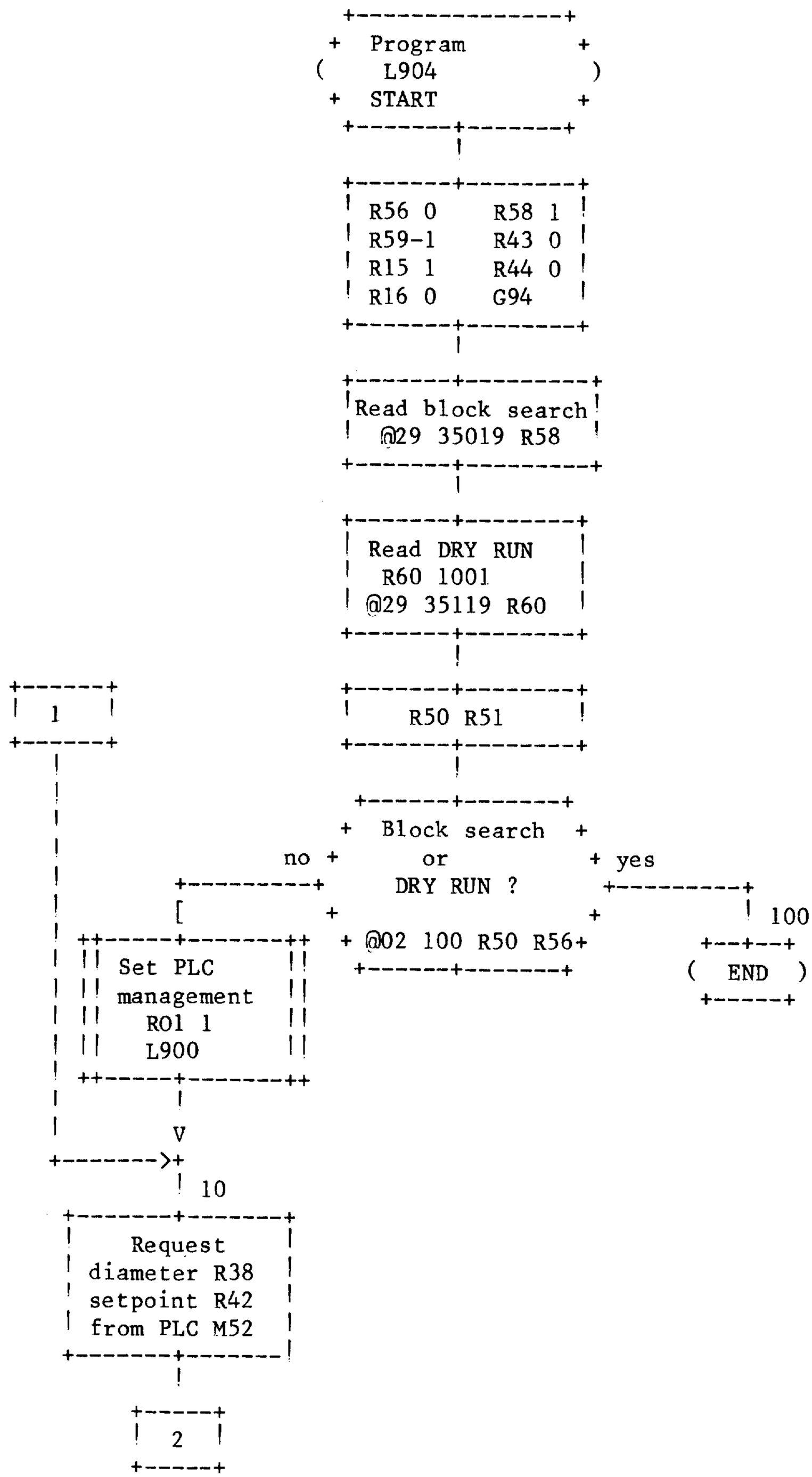
MP	SETPOINT	ACTUAL VALUE	DIFF
A	+ 0.000	+ 0.000	+ 0.000
B	+ 0.000	+ 0.000	+ 0.000
C	+ 0.000	+ 0.000	+ 0.000
D	+ 0.000	+ 0.000	+ 0.000
E	+ 0.000	+ 0.000	+ 0.000
F	+ 0.000	+ 0.000	+ 0.000
G	+ 0.000	+ 0.000	+ 0.000
H	+ 0.000	+ 0.000	+ 0.000
	R42	R43	R44

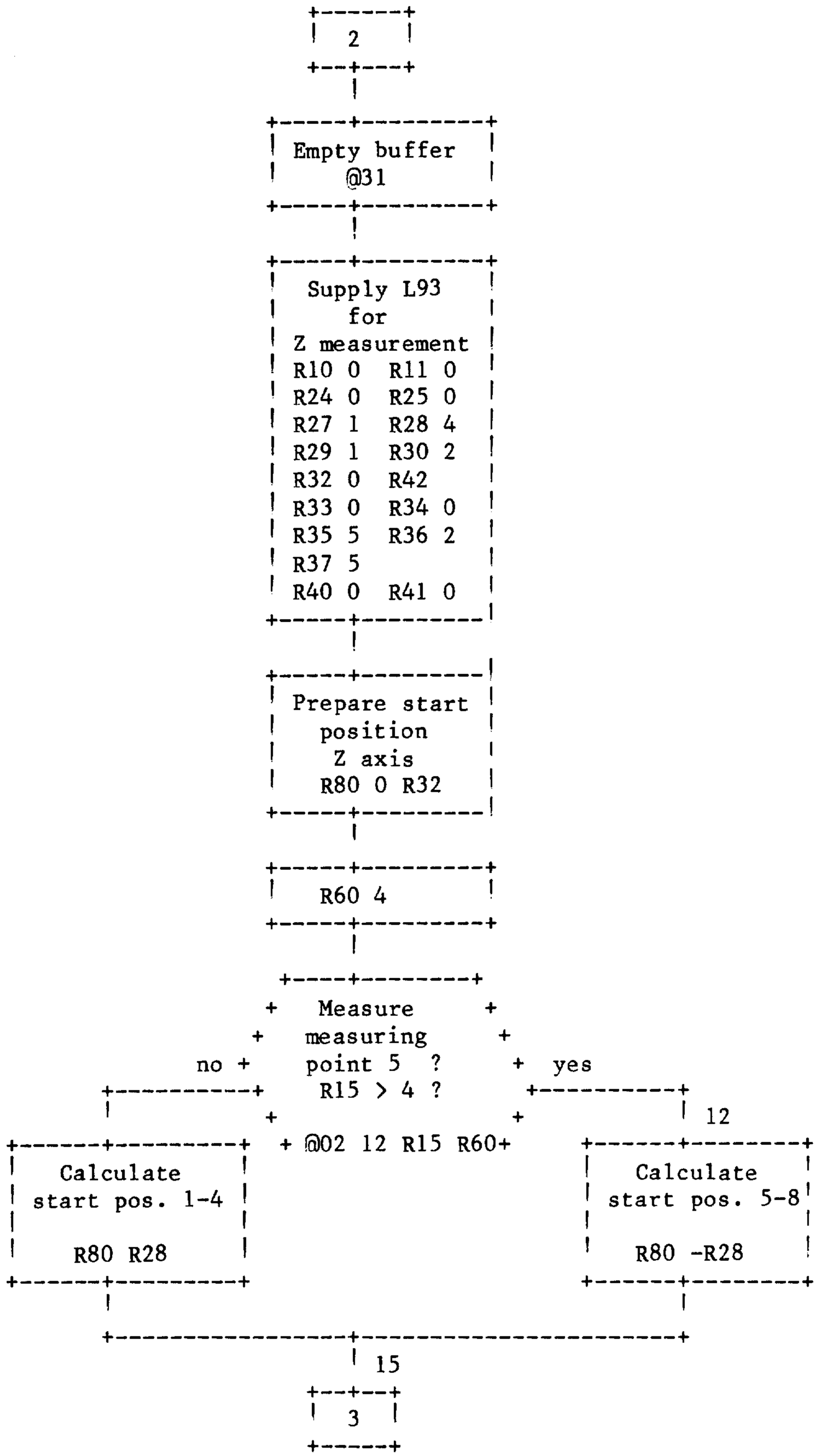
The SETPOINT (Z axis) is input via the keyboard in the operator panel.

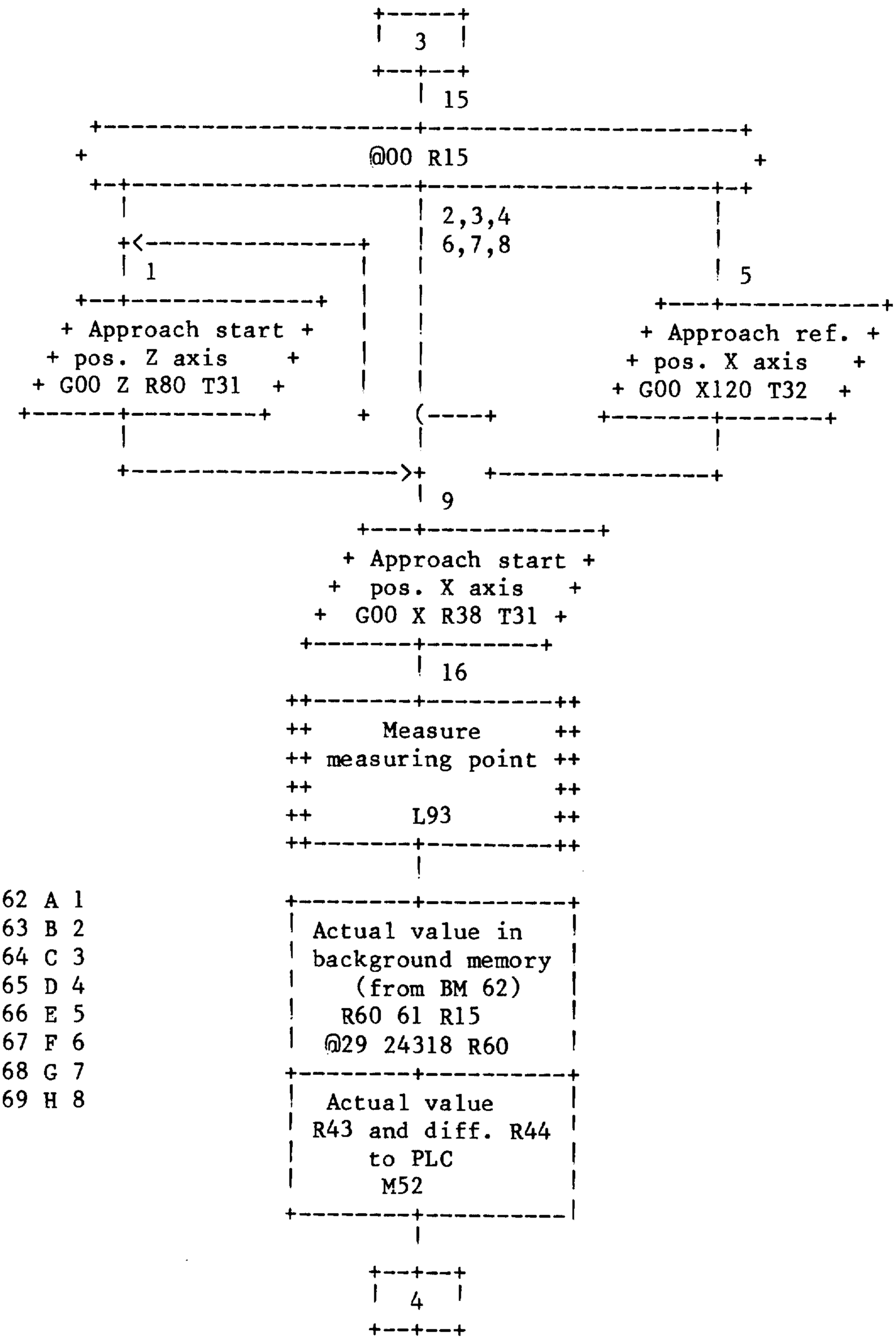
PLC display 2

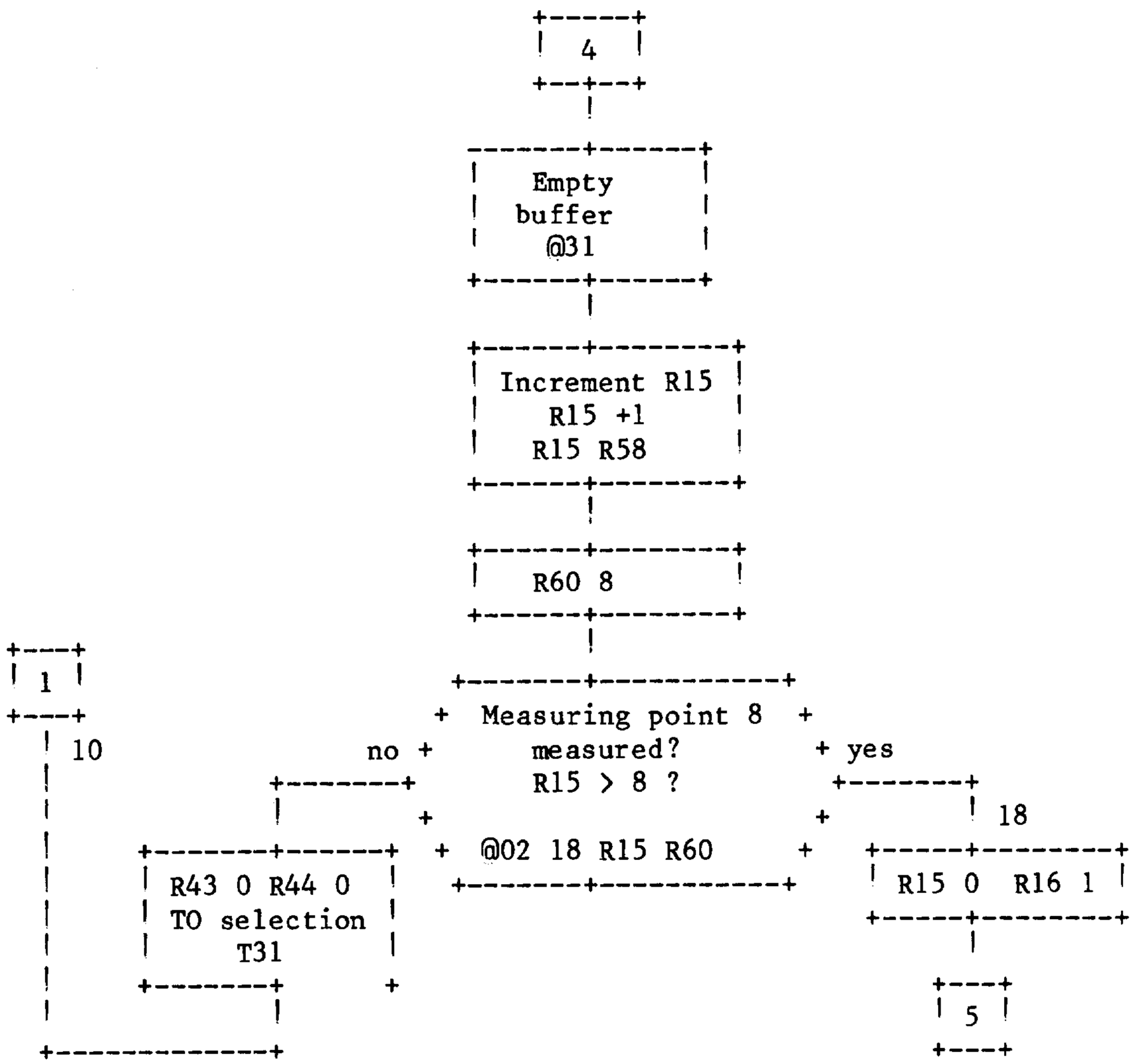
MP	CALCULATION	DIAMETER	
E-F	+ 0.000	DA=DE	+ 0.000
E-G	+ 0.000	DB=DF	+ 0.000
E-H	+ 0.000	DC=DG	+ 0.000
B-F	+ 0.000	DD=DH	+ 0.000
C-G	+ 0.000		
D-H	+ 0.000		
	R39		R38

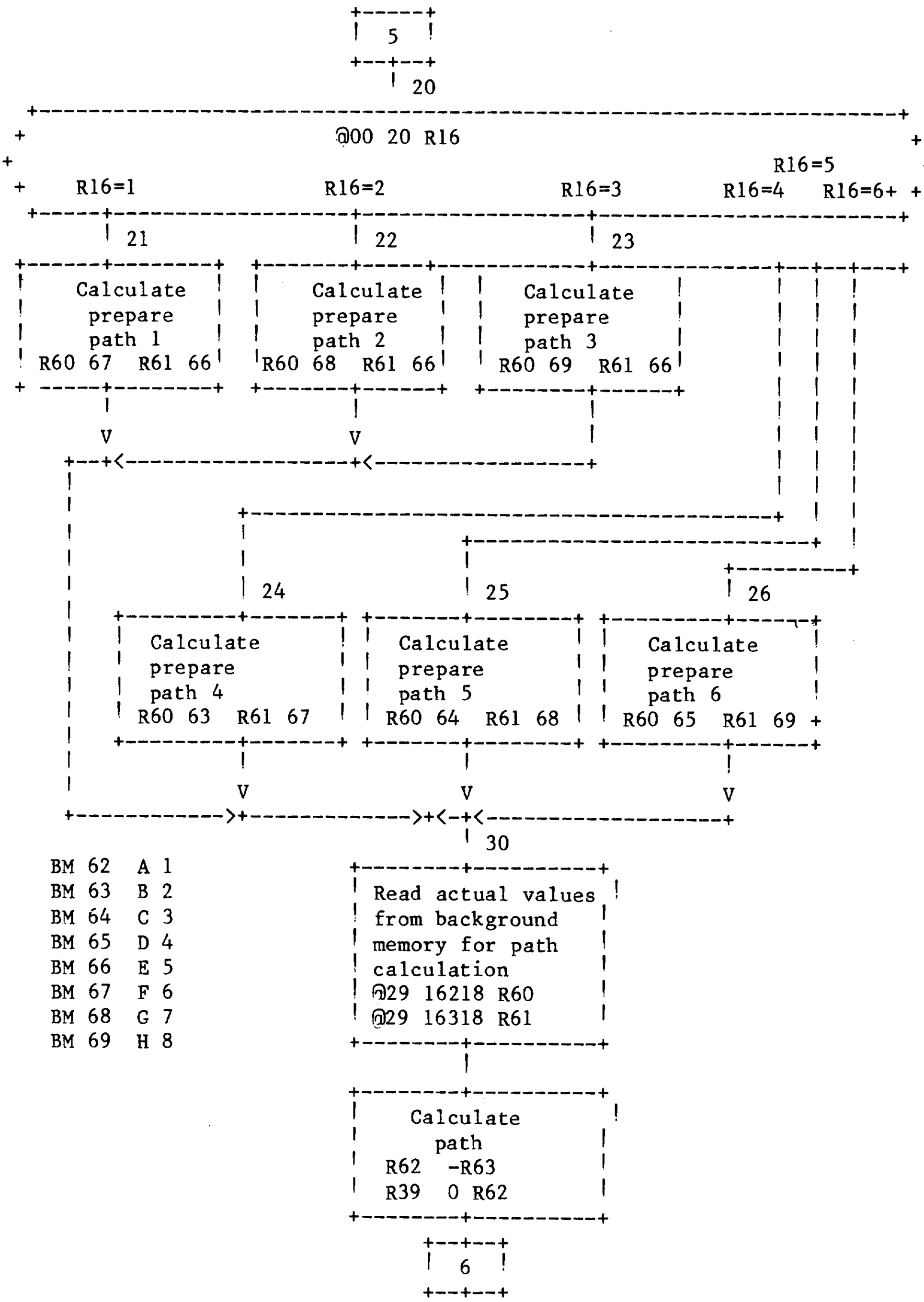
DIAMETER is input via the keyboard in the operator panel.

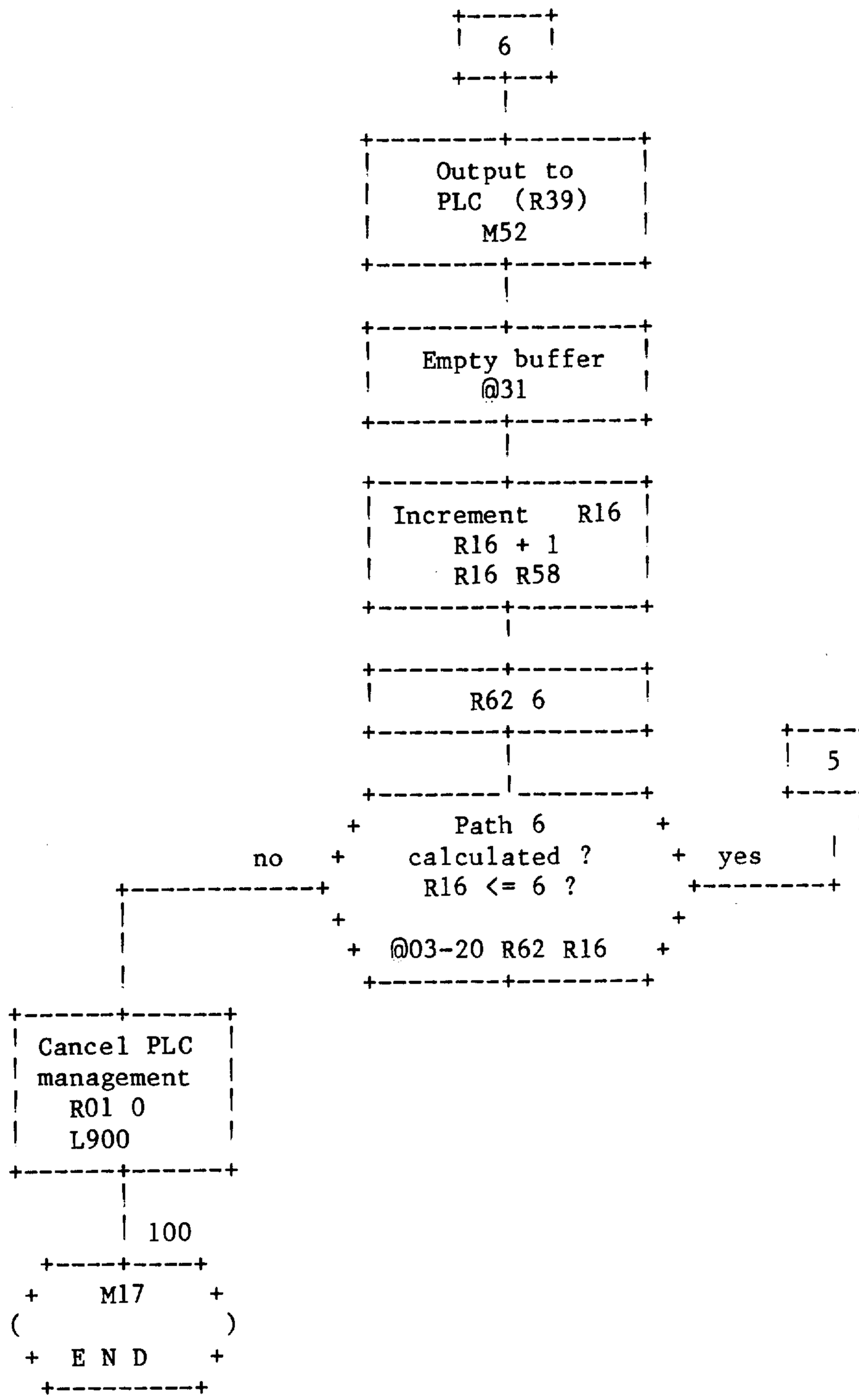

Program
L904
START
R56 0
R59-1
R15 1
R16 0
R58 1
R43 0
R44 0
G94
Read block search
@29 35019 R58
Read DRY RUN
R60 1001
@29 35119 R60
R50 R51
1
Block search
or
DRY RUN ?
no
yes
@02 100 R50 R56
100
END
Set PLC
management
RO1 1
L900
V
10
Request
diameter R38
setpoint R42
from PLC M52
2


2
Empty buffer
@31
Supply L93
for
Z measurement
R10 0 R11 0
R24 0 R25 0
R27 1 R28 4
R29 1 R30 2
R32 0 R42
R33 0 R34 0
R35 5 R36 2
R37 5
R40 0 R41 0
Prepare start
position
Z axis
R80 0 R32
R60 4
Measure
measuring
point 5 ?
R15 > 4 ?
no
yes
@02 12 R15 R60
12
Calculate
start pos. 1-4
R80 R28
Calculate
start pos. 5-8
R80 -R28
15
3


3
15
@00 R15
2,3,4
6,7,8
1
Approach start
pos. Z axis
G00 Z R80 T31
5
Approach ref.
pos. X axis
G00 X120 T32
9
Approach start
pos. X axis
G00 X R38 T31
16
Measure
measuring point
L93
BM 62 A 1
BM 63 B 2
BM 64 C 3
BM 65 D 4
BM 66 E 5
BM 67 F 6
BM 68 G 7
BM 69 H 8
Actual value in background memory
(from BM 62)
R60 61 R15
@29 24318 R60
Actual value
R43 and diff. R44
to PLC
M52
4


4
Empty buffer @31
Increment R15
R15 +1
R15 R58
R60 8
1
10
Measuring point 8 measured?
R15 > 8 ?
no
yes
R43 0 R44 0
TO selection T31
@02 18 R15 R60
18
R15 0 R16 1
5


5
20
@00 20 R16
R16=1
R16=2
R16=3
R16=4
R16=5
R16=6
21
22
23
Calculate prepare path 1
R60 67 R61 66
Calculate prepare path 2
R60 68 R61 66
Calculate prepare path 3
R60 69 R61 66
24
25
26
Calculate prepare path 4
R60 63 R61 67
Calculate prepare path 5
R60 64 R61 68
Calculate prepare path 6
R60 65 R61 69
30
BM 62 A 1
BM 63 B 2
BM 64 C 3
BM 65 D 4
BM 66 E 5
BM 67 F 6
BM 68 G 7
BM 69 H 8
Read actual values from background memory for path calculation
@29 16218 R60
@29 16318 R61
Calculate path
R62 -R63
R39 0 R62
6


6
Output to PLC (R39) M52
Empty buffer @31
Increment R16 R16 + 1 R16 R58
R62 6
Path 6 calculated ? R16 <= 6 ?
no
yes
5
20
@03-20 R62 R16
Cancel PLC management R01 0 L900
100
M17
E N D

Tool measurement	System 3	L93
	System 8 (F)	L974
Example of a measuring task	System 8 (S)	L984

NC programs:

```
%SP
L90000
(SET/RESET PLC MANAGEMENT [R01])
R58 1 R60 99 R61 100
@29 16318 R60
@01 5 R01 R58
R62-100 @03 10 R63 R61
@00 15
N5 R62 100 @03 15 R63 R61
N10 R63 R62
N15 @29 26318 R60
M17

%SP
L90400 R56 0 R58 1 R15 1 R16 0 R43 0 R44 0 G94
@29 35019 R58
R60 1001 @29 35119 R60
R50 R51 @02 100 R50 R56
R01 1 L900
N10 M52
@31
R10 0 R11 0 R24 0 R25 0 R27 1 R28 4 R29 1 R30 2 R32 0 R42
R33 0 R34 0 R35 5 R36 2 R37 5 R40 0 R41 0 R80 0 R32 R60 4
@02 12 R15 R60
R80 R28 @00 15
N12 R80 -R28
N15 @00 R15
N1 G Z R80
N9 G X R38 T31
@00 16
N2
N3
N4
N6
N7
N8 @00-9
N5 GO X120 T32
@00-1
N16 L93
R60 61 R15 @29 24318 R60
M52
@31
R15 R58 R60 8
@02 18 R15 R60
R43 0 R44 0 T31
@00-10
N18 R15 0 R16 1
N20 @00 20 R16
N21 R60 67 R61 66 @00 30
N22 R60 68 R61 66 @00 30
N23 R60 69 R61 66 @00 30
N24 R60 63 R61 67 @00 30
N25 R60 64 R61 68 @00 30
N26 R60 65 R61 69
N30 @29 16218 R60
@29 16318 R61
R62 -R63
R39 0 62
M52
@31
R16 R58
R62 6 @03-20 R62 R16
R01 0 L900
N100 M17
```

APPENDIX

Tables Part 1

Measuring cycles for turning machines

Table I-1 Background memory allocation for turning machines

00 01 :	Empirical values
20	
21 :	Average values
41	
42 :	Unassigned
57	
58	Tool change position X axis for tool measurement
59	Tool change position Z axis for tool measurement
60	M function for enabling with M19
61	M function probe active
62	X Deviations calibration tool
63	Z
64	B
65	Minus X direction
66	Plus X direction Tool probe
67	Minus Z direction
68	Plus Z direction
69	a
70	b Calibration slot deviations Calibration slot no. 1
71	c
72	d for R12 = 0
73	e
74	f
75	g
76	a
77	b Calibration slot deviations Calibration slot no. 2
78	c
79	d for R12 = 1
80	e
81	f
82	g

Table I-1 Background memory allocation for turning machines (continued)

83	a	
84	b	Calibration slot deviations Calibration slot no. 3
85	c	
86	d	for R12 = 2
87	e	
88	f	
89	g	

90	a	
91	b	Calibration slot deviations Calibration slot no. 4
92	c	
93	d	for R12 = 3
94	e	
95	f	
96	g	

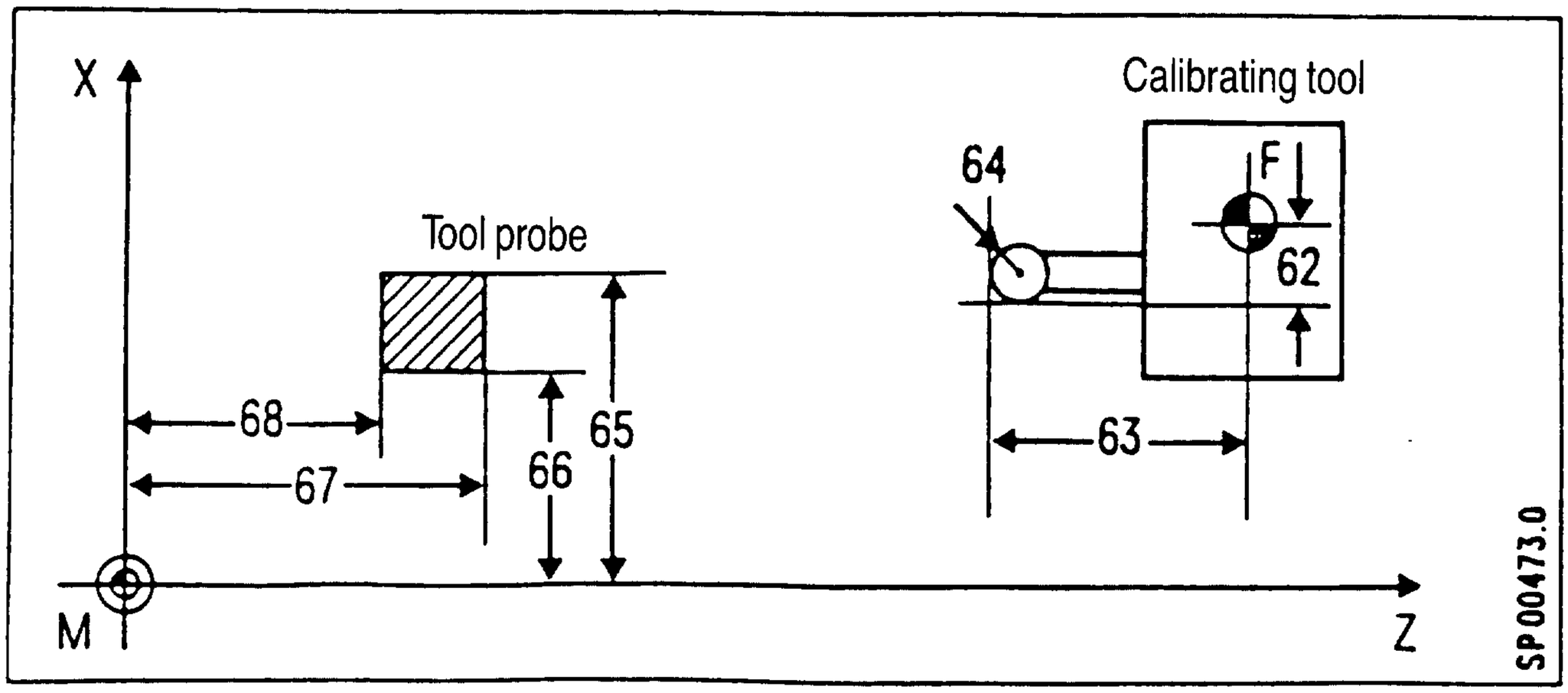
97	Rotation dimension X axis
98	Rotation dimension Z axis

	7	6	5	4	3	2	1	0
99						PLC management	SPI-X	SPI-Z

Input in bit pattern

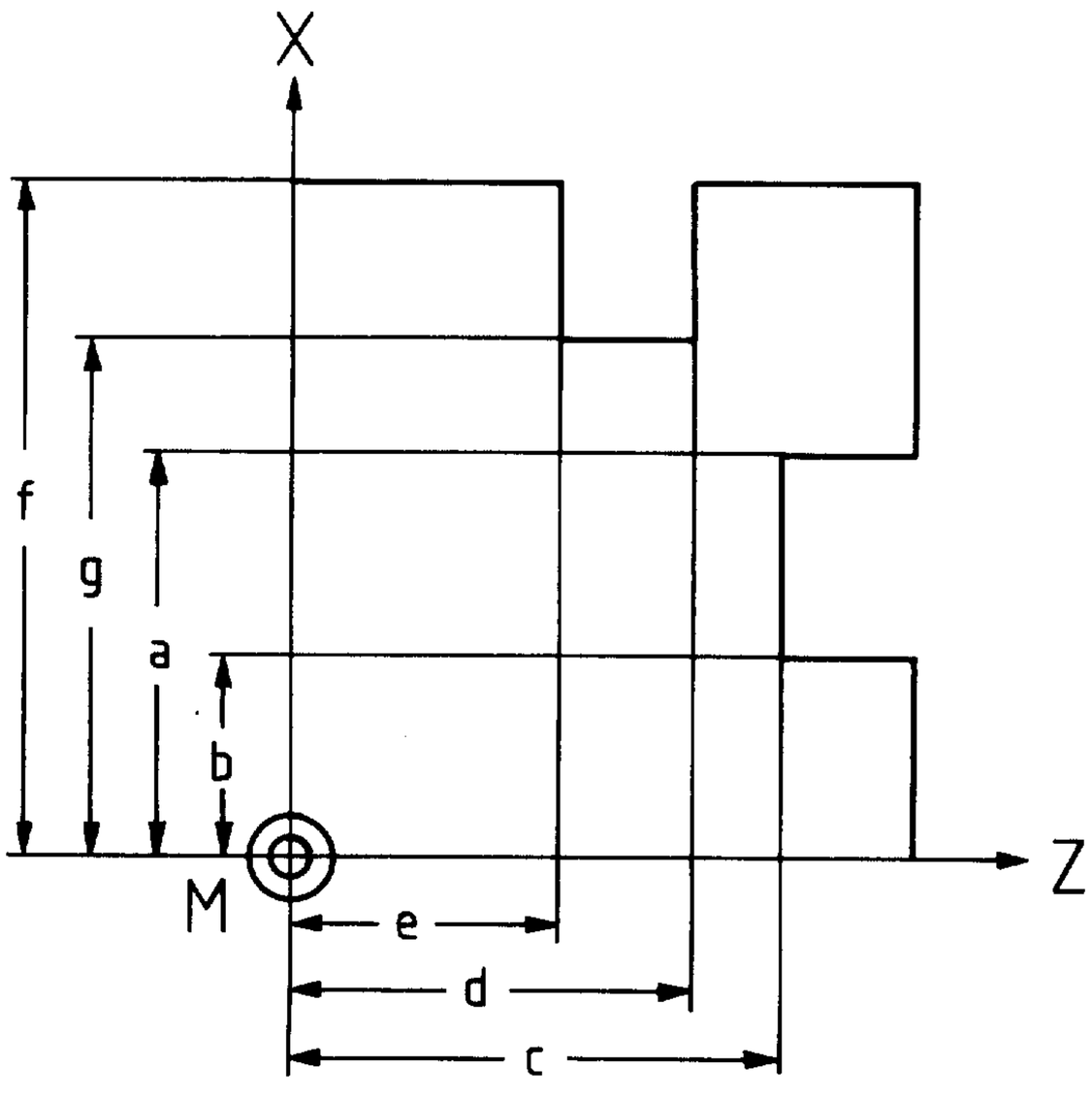
Background memories nos. 62 - 68

Calibration tool for tool probe (background memory nos. 62 - 64)
Tool probe (background memory nos. 65 - 68)



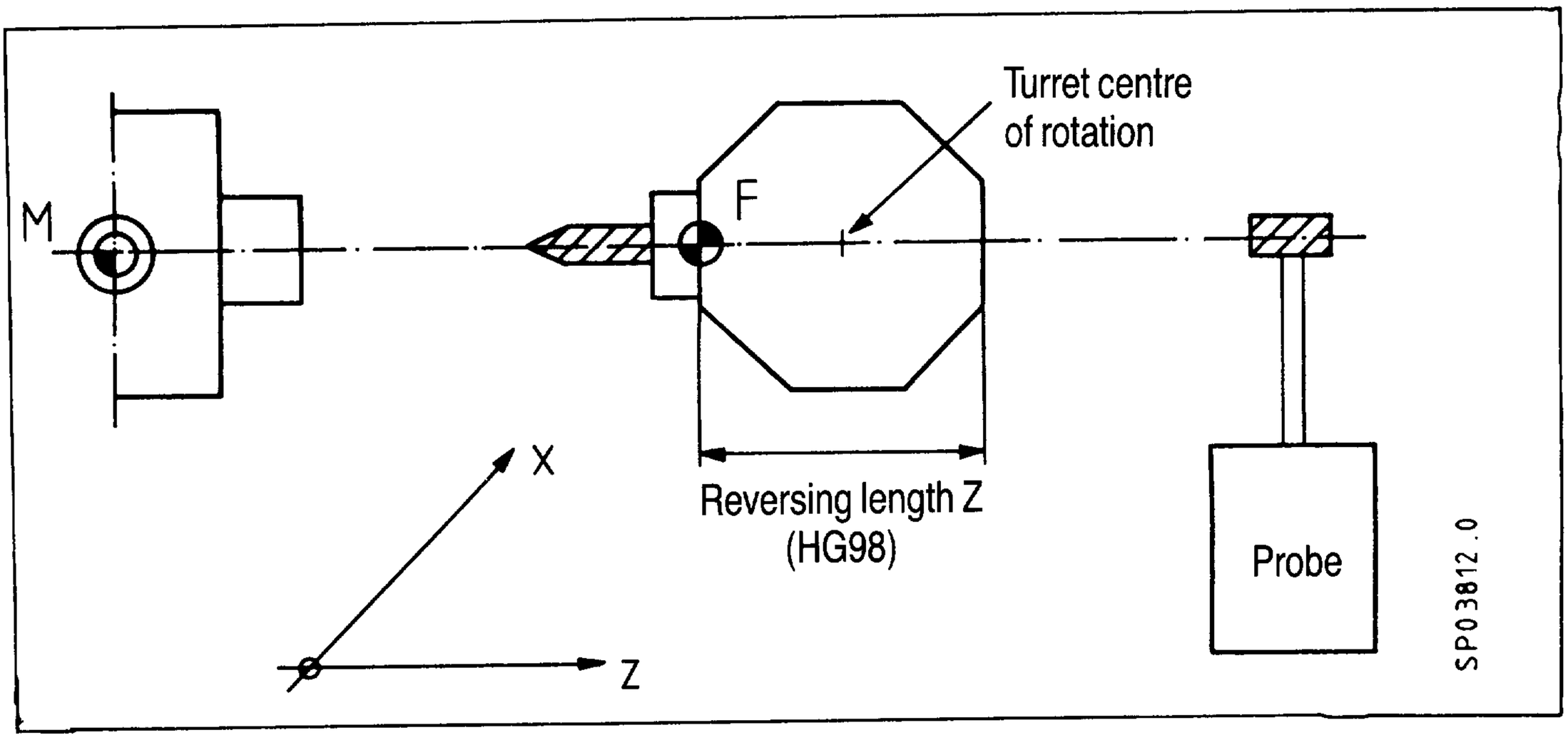
Background memory nos. 69 - 96

Calibration slots for probes Type 1 and 2



Background memory				
	Calibrating slot no.			
	1	2	3	4
a	69	76	83	90
b	70	77	84	91
c	71	78	85	92
d	72	79	86	93
e	73	80	87	94
f	74	81	88	95
g	75	82	89	96

SP03824.0



Example: For measuring, Z axis must be mirror-imaged ==>
background memory 99 = 1

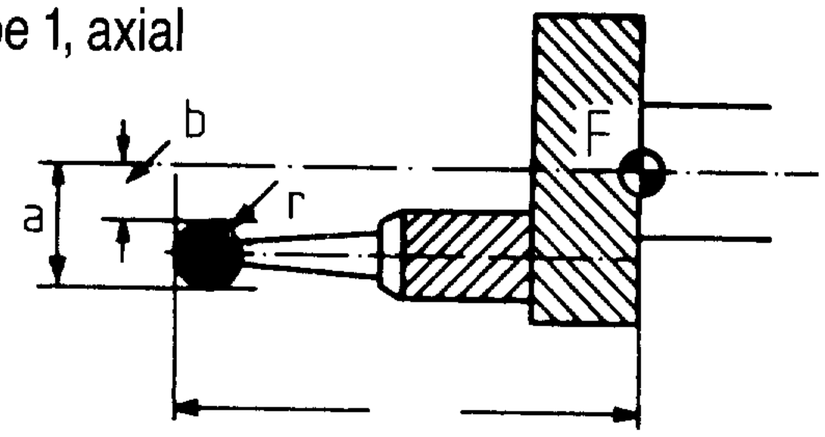
Background memory No. 99

SPI-Z	0	During tool measurement, Z axis not mirror-imaged
	1	During tool measurement, Z axis mirror-imaged
SPI-X	0	During tool measurement, X axis not mirror-imaged
	1	During tool measurement, X axis mirror-imaged
PLC-management	0	No PLC management of tools
	1	PLC management of tools

The following values are provided in R parameters:
R70 Alarms, see alarm list
R57 Compensation amount
R30 1 = X axis
2 = Z axis
R10 Compensation number

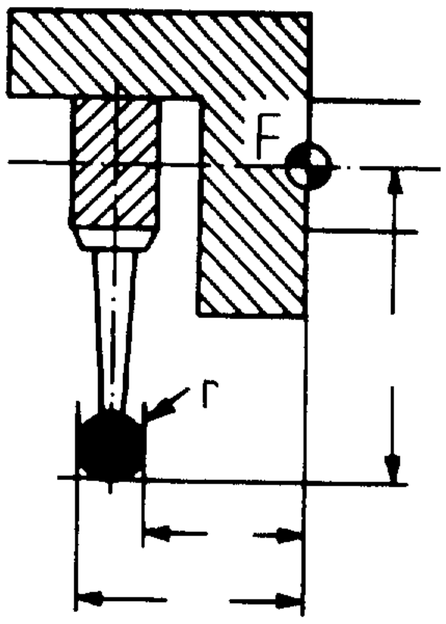
Table I-2 Workpiece probe allocation in the TO memory

Type 1, axial



Type 1, axial	X	Z	B	A
1st compensation value (n)	a	c	r	-
2nd compensation value (n+1)	b	d	r	-

Type 2, radial



Type 2, radial	X	Z	B	A
1st compensation value (n)	e	g	r	-
2nd compensation value (n+1)	f	h	r	-

SP03813.0

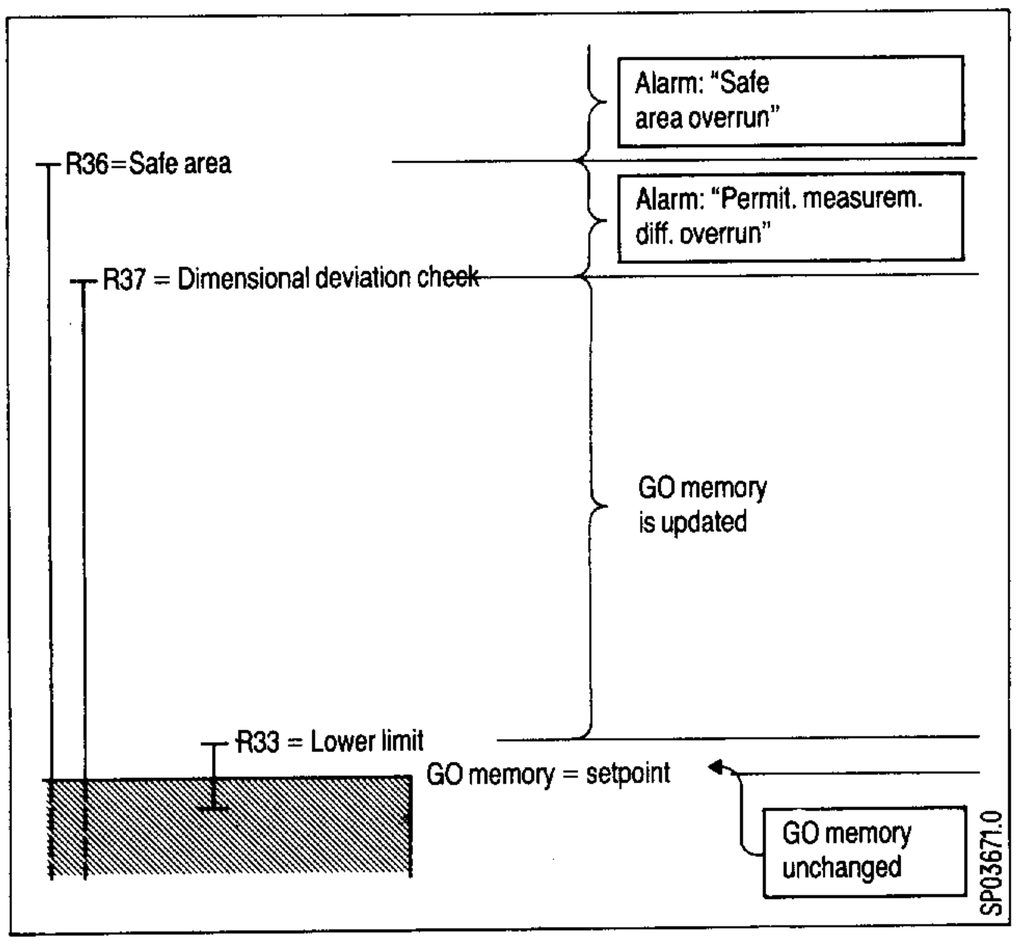
For each probe, two consecutive pairs of compensation values must be allocated.

Table II
Overview of parameter definitions

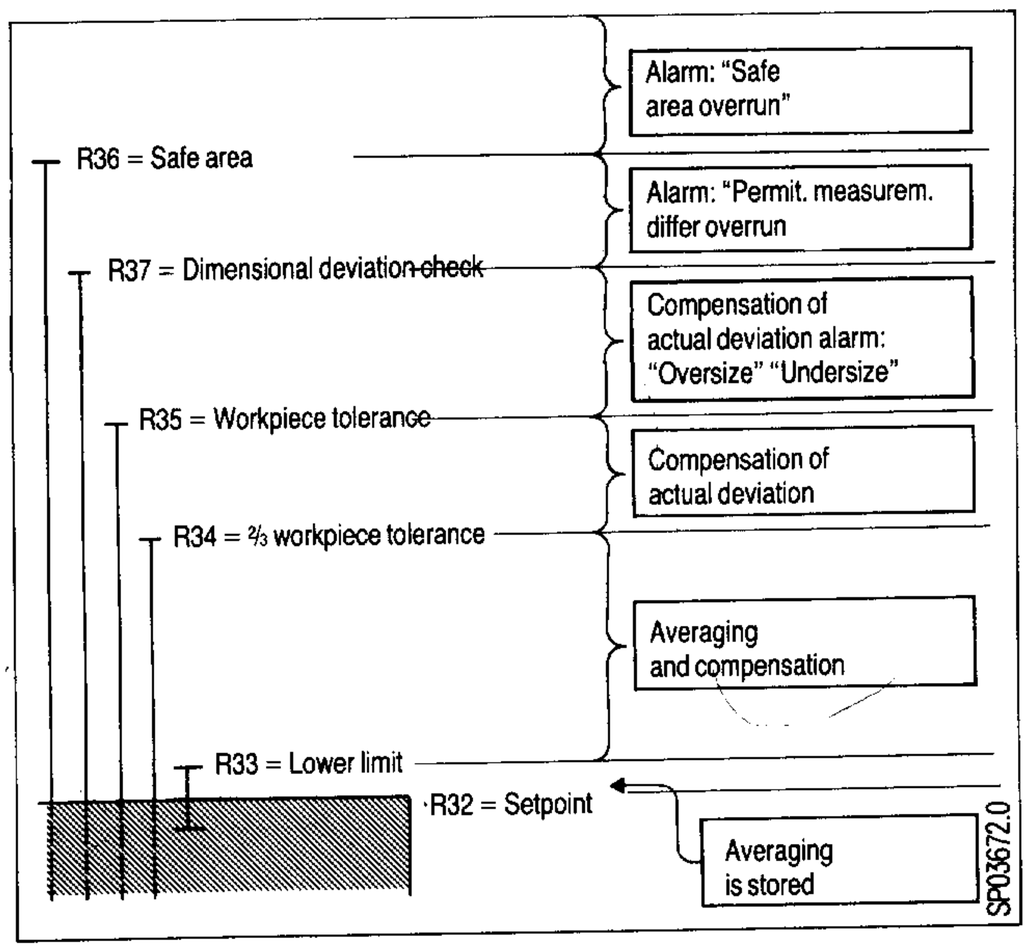
	Tool measurement			Workpiece measurement														
	L 971, L 981 L 90	L 972, L 982 L 91		L 973, L 983 L 92						L 974, L 984 L 93								
	Automatic measurement	Calibration ±X ±Z	Measurement ±X ±Z	Calibration in ref. slot +X -X +Z -Z				Calibr. on random surf. +X -X +Z -Z				Measurement of blank +X -X +Z -Z				1-point measurement ±X ±Z	1-point measurement with rotation ±X ±Z	2-point measurement on diameter ±X ±Z	Multi-point measurement on circumference	Multi-point measurement on cylinder
R 04																	Spindle dwell time System 3 only		Spindle dwell time System 3 only	
R 10	T no. of tool to be measured															Tool offset memory no. for automatic tool offset				
R 11	Empirical value memory number 0-20		Empirical value memory number 0-20	Average value memory no. 0-20 (21-41)												Empirical value memory no. (average value memory) 0- -20 (21-41)				
R 12				Selection of calibration slot pair 0-3																
R 18	Var. change pos. X axis																	Protection zone around workpiece X axis (radius)		
R 19	Var. change pos. Z axis																	Protection zone around workpiece Z axis		
R 20		1	0																	
R 21				0				1				1								
R 22				Probe type 1 1 1 2				1 1 1 2				1 1 1 2								
R 23	Tool lengths definition 0 - 2			0								1							Number of measurements	
R 24																0	0	1	0	0
R 25																0	1	0	2	3
R 26																	Starting angle 0 - 359.5		Indexing angle = starting angle (only positive)	Offset of Z axis incremental
R 27	Number of measurements at same location 1-10																			
R 28	Multiplication factor for measurement path "2a" 1-5																			
R 29				Weighting factor k for averaging 1-4												Weighting factor k for averaging 1-4				
R 30	Number of measuring axis 1 2 1 2 1 2 1 2 1 2 1 2															1 2	1	1	1	1
R 31	Axis direction 0 1 0 1 0 1 0 1 0 1 0 1																			
R 32	* * * * *							Workpiece specified dimension referred to workpiece datum W (for X axis, in diameter)												
R 33	Zero offset range (lower limit) 0.000-1.000															Zero offset range (lower limit) 0.000-1.000 (for X axis, in diameter)				
R 34				Average value compensation 0.000-1.000												Average value compensation 0.000-1.000 (for X axis, in diameter)				
R 35	* * * * *															Specified dimension tolerance 0.000-1.000 (for X axis, in diameter)				
R 36	Safe area															(for X axis, in diameter)				
R 37	Dimensional deviation check		Dimensional deviation check													Dimensional deviation check (for X axis, in diameter)				
R 40	Upper tolerance limit (as per drawing)																			
R 41	Lower tolerance limit (as per drawing)																			
R 42	Specified value (as per drawing; for X axis, in diameter)																			

*When L 965/L 75 are used, R 32 and R 35 are calculated from R 40, R 41 and R 42. R 32 and R 35 need therefore not be defined.

Table III Overview of tolerance parameters R33 – - R37



Tolerance parameters for tool measurement



Tolerance parameters for workpiece measurement

Table IV Display parameters on completion of cycle

	L91, L972, L982		L92, L973, L983		L93, L974, L984
	Calibrate tool sensor	Measure tool	Calibrate workpiece sensor	Measurement of blank	Workpiece measurement
R40					Upper tolerance * limit (as per drwg.)
R41					Lower tolerance * limit (as per drwg.)
R42	Old tool sensor length	Old tool length	Specified value (when calibrating on workpiece)	Specified value (for X axis, in diameter)	Specified value * (as per drawing) (for X axis, in diameter
R43	New tool sensor length	New tool length	Actual value (radius X axis)	Actual value (for X axis in diameter)	Actual value without empirical value (for X axis, in diameter)
R44	Set/actual difference	Set/actual difference	Set/actual difference (radius X axis)	Set/actual difference (for X axis, in diameter)	Set/actual difference with emp. value compensation
R45		Empirical value			Empirical value
R46		Memory no. Empirical value	Memory no. Average value		Memory no. Empirical value
R47	Background memory no. Tool sensor	Tool offset no.	Tool offset no.		Tool offset no.
R48					PLC location no. * (only when more than one)
R49			Average value		Average value

* These parameters must be defined specially before call

Table V Overview of alarm texts for turning machines

Text displays (appear after "PART" display called)	L90 L971 L981	L91 L972	L92 L973	L93 L974 L984	Cancelled by	R70 status
OVERSIZE				*	NC START	0
UNDERSIZE				*	NC START	1
NO PROBE SIGNAL	*	*	*	*	RESET	2
PROBE FAULT	*	*	*	*	RESET	3
TOOL NOSE RADIUS = 0	*	*			RESET	4
POS.TOOL TIP MEAS.AXIS WRONG	*	*			RESET	5
DEFINITION R11 > R20 WRONG	*	*	*	*	RESET	6
SAFE AREA OVERRUN	*	*	*	*	RESET	7
PERMIT MEASUREM. DIFF. OVERRUN	*	*		*	NC START	8
SPINDLE POSITION NOT REACHED WITHIN 6 SEC.				*	RESET	10
TOOL NOSE VECTOR 9 DEFINED	*					

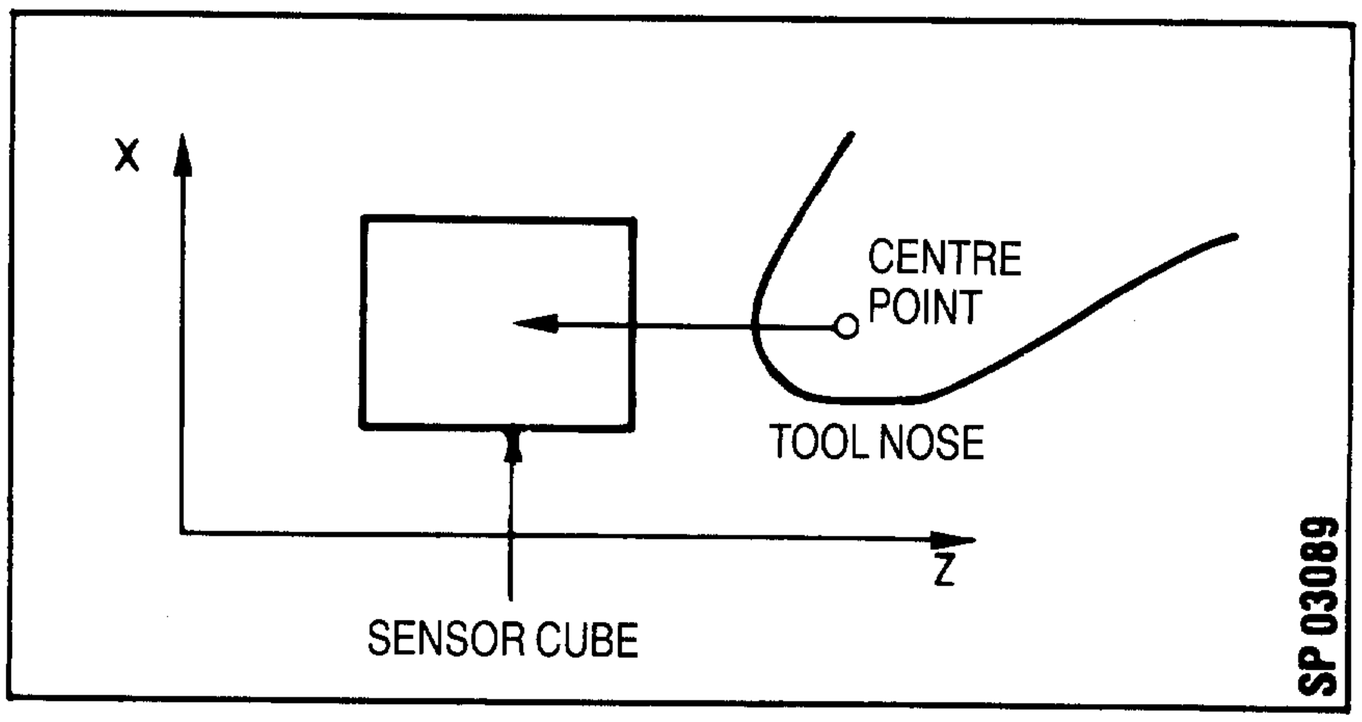
Note: These texts are stored in subroutine L79 and L899.
If the program stops in the cycle by M00 because of an operator error, they must be shown in the display.

Table VI Description of measuring cycle alarms

Oversize:	Difference between specified and actual values is greater than R35. There is still too much material at the measuring point. Re-machining is possible. Tool has been compensated.
Undersize:	Difference between specified and actual values is less than R35. Too little material at measuring point. Re-machining is not possible. Tool has been compensated.
No probe signal:	The measurement path "2a" has been completely traversed 5 times without a measurement signal being transmitted. Possible causes: 1. Specified position incorrectly stated 2. Probe not transmitting signal, in spite of deflection
Probe fault:	The probe has "1" signal even before start of measurement path "2a". Possible causes: 1. Specified position incorrectly stated (probe already deflected) 2. Probe defective, constantly transmitting "1" signal.
Tool nose radius = 0:	During tool measurement, the centre of the measuring cube is approached with the nose radius centre point in the positioning axis. In order to be able to calculate this approach position, the nose radius is required. The nose radius must be input in the TO memory under "B". (Only if nose position "A" > 0).

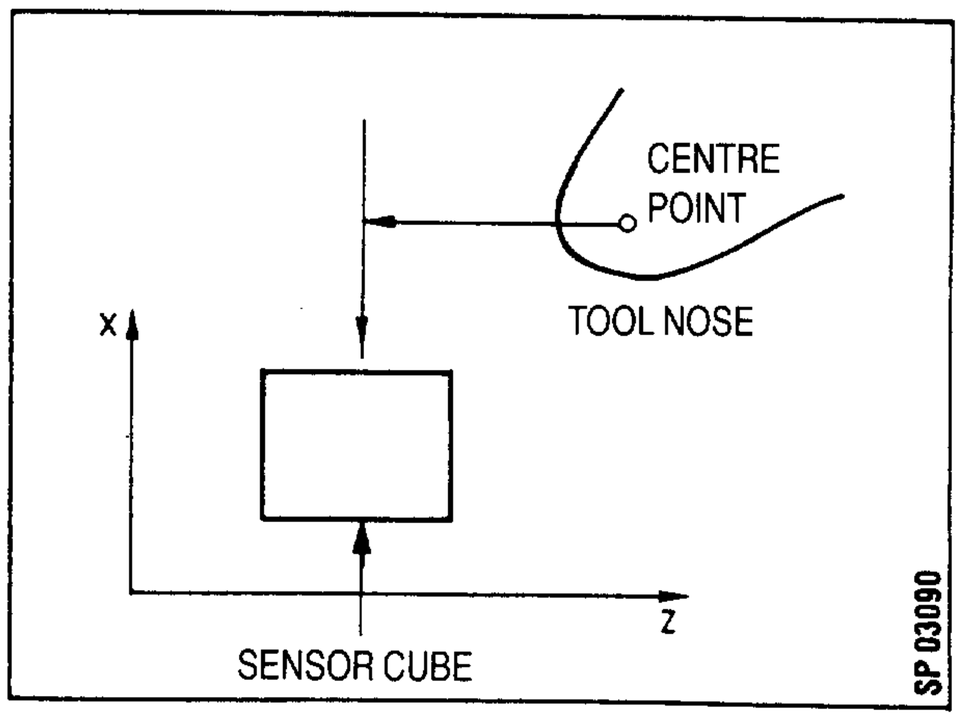
Pos. tool tip meas. axis wrong:

For example:
The tool is to be measured in the X axis. The cycle wants to position the Z axis but this would result in collision with the measuring cube.



Tool nose incorrectly positioned.

Remedy:
Preposition tool before cycle call in the X axis with larger, more positive value.



Tool nose positioned correctly.

Definition R11 > R20 wrong:	R11 must be defined before cycle call. R11 0 to R11 20 possible.
Safe area overrun:	Amount of difference greater than R36. The measuring result is not accepted. No compensation is performed. Possible causes: 1. Measuring error caused by probe 2. Measuring point dirty
Permit. measurem. diff. overrun:	Amount of difference greater than R37 Possible causes: 1. Chipping of cutting edge 2. Too much wear in last cut, e.g. because hard spots were encountered in the workpiece. No compensation is performed. The tool must be replaced.
Spindle position not reached within 6 sec.:	If function M19 is activated with axial motion, the spindle position is monitored. The measuring cycle is resumed only when the spindle has remained for approx. 0.2 s in the exact stop for M19.
Tool nose vector 9 defined:	Tool nose vector 9 cannot be measured with the cycle. Tool nose vector must be measured directly with L91, L972, L982.

To

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Suggestions

Corrections

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