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These instructions give a survey of all modes and operating procedures of the TEACH-IN control system in tabular form. Each table describes the sequence of operations which should be carried out to ensure that the required function of the control system is correctly performed. In the lines of the tables, the individual steps are described from the starting operation to the final operation. In the columns, the following information are given:

Column designation

No. - Consecutive number of step

MAIN SWITCH - Position of the main switch situated in the center of the control system. When this column is identical for several steps this means that the position of the main switch remains unchanged.

ACTION - This column indicates which of the push-buttons of the control system is to be depressed, held or released to make a step in the working process. If the handwheel mark appears in this column this means that the system requires particular information to be entered by means of the handwheel. In the last possible case when there is an empty window in the column the command to make a step in the working cycle is entered from the machine control panel. In this case, because of versatility of the control system, no control mark is shown since it may differ on different machines.

DISPLAY - This column indicates only important positions of the wheelhead infeed (0.000, 0.08000, etc.), and/or significant messages of the control system (e.g., the selected program). In other cases, the windows in this column remain empty since there is an infinite number of operating position variants of the wheelhead infeed.

NOTE - This column gives the verbal accompaniment and explanations of the individual steps of the working procedures, particularly in the case when the ACTION column is empty.

If these operating instructions give a reference to a machine panel-mounted switch a description of the control of this switch can be found in the machine operating instructions.

These operating instructions are applicable to any design variant of the machine. The operating facilities of the individual systems are modified to meet the customer's requirements when he is ordering the system. Therefore, some selectable facilities given in the operating instructions need not be applicable to the particular machine, but most of them can be additionally ordered. These items have been marked in the operating instructions.

1. Description of the control system

The control system is designed for drive control of the grinding machines. Fitted with no programming keyboard, it acts on the principle of TEACH-IN programming in which the operator processes the first workpiece in the usual way by operating the handwheel, the whole grinding sequence being stored in the control system. Then, recurrent grinding of the following workpieces is accomplished in the automatic cycle in which the grinding sequence is identical to that of the first workpiece.

For applications where technological values should be entered as numerical values, cycles with parametric programming are available. In this case, the individual grinding parameters (diameter, infeed rate, points of deceleration and sparking-out) are selected consecutively in the menu and the parameter values are set by rotating the handwheel.

For concave/convex grinding, only the diameter of curvature of the workpiece surface should be programmed.

The operator can interfere in the automatic TEACH-IN cycle sequence without size gauging to rectify the automatic cycle in progress by means of the handwheel. Any correction of the automatic cycle is automatically stored and put to effective use in the next automatic cycle. The control system is user-friendly, making it possible for the operator to make full use of his practical experience without the necessity of learning how to program the machine.

1.1 Grinding modes

a) Manual grinding

In manual grinding, infeed control of the wheelhead is effected directly by the handwheel with the possibility of multiplication 10x, or by the rapid-traverse keys on the machine control panel.

b) First workpiece

The first workpiece is ground in the normal way by means of the handwheel, the possibility of interrupting the grinding sequence being provided at any point to measure the workpiece. At the same time, the grinding sequence is entered into the respective program by the control system.

c) Automatic TEACH-IN cycle

The next workpiece is ground, according to the preselected program. In this case, the operator can interfere in the grinding sequence by the handwheel, any change made in this way being stored automatically for grinding the following workpiece. For each ground diameter, the finished size of the workpiece can be corrected, if required.

d) Longitudinal grinding with automatic grinding addition at reversal points - Cycle **A**

In this grinding mode, the operator presets the amount of grinding addition at the reversal points, employing the handwheel. Then, the control system ensures that this grinding allowance is reapplied till a zero is indicated on the display.

e) Plunge-cut grinding at programmable speed - Cycle **P**

In this control mode, plunge-cut grinding can be made at a preprogrammed speed.

f) Wheel dressing

Apart from automatic feed to the diamond position (X-axis), the control system permits wheel dressing to be effected at an increment preset by the handwheel, increment compensation being provided. In the automatic grinding sequence, intermediate dressing can be performed with return to the point of interrupt.

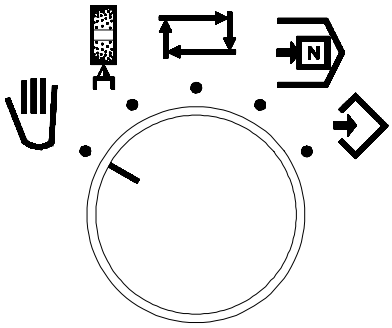
g) Concave/convex grinding

Longitudinal grinding of the concave/convex cylinders with the specified diameter of the envelope can be accomplished.

h) Grinding with preprogrammed parameters

In this mode, grinding can be carried out in an automatic grinding cycle with preprogrammed parameters. This cycle is suitable for grinding workpieces requiring the defined technological conditions of the grinding process to be repeatedly satisfied.

1.2 Main switch



Basic design

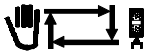
MAIN SWITCH	DISPLAY	MEANING	
•	X= 0.08000 a= 4.52350	Manual grinding Relative X-axis position Absolute X-axis position	With the **INC** push-button operated, the position of the absolute **X**-axis can be adjusted by means of the handwheel.
•		Grinding of the first workpiece or programming.	
•		Selection of the program number and functions.	
•		Automatic control mode.	
•		Wheel dressing mode.	
•		Form, concave/convex shapes and parabolas grinding. √	
•		Entering of the size of the envelope for concave/convex shapes and parabolas grinding. √	

DISPLAY	MEANING
X= 0.08000 a= 4.00235	Relative X-axis position AbsoluteX-axis position

DISPLAY	MEANING
x= 0.08000 Z= 12.8502	Relative X-axis position Relative Z-axis position √

√ - only for concave/convex or form grinding.

1.3 Keys

KEY	MODE	MEANING	
WSP		When the **WSP** push-button is depressed for 2 sec. the wheelhead is moved to position "0.00000".	
	 0 ÷ 9	When the **WSP** push-button is operated in position WSP concurrently with rotation of the handwheel a diameter correction is adjusted (provided that the program already exist).	On operation of the **WSP** push-button, the wheelhead is moved to the WSP position. (for P or A only if you don't los this programs).
	 P, A	When the **WSP** push-button is operated in position WSP concurrently with rotation of the handwheel a grinding allowance or diameter correction is adjusted (OFFSET).	
		On operation of the **WSP** push-button, the wheelhead is moved to the diamond position (diamond WSP) on the X-axis.	
10×		Multiplication of the wheelhead step 10x for the X-axis. On a new operation of the push-button, the step 1x is restored. If the Z-axis is also controlled by the handwheel multiplication of the step can be effected in the same way by means of the push-button 20x. To set numerical values for the value of absolute coordinate and some parameters when entering values for parametric and concave/convex grinding, step 100x can be selected by the key **10x**. In this case, the increased adjusting step is displayed as marker 100x.	
			
X/Z		Switching over of the X- and Z-axis representation on the display (only on machines with Z-axis measurement). At form grinding, the amount of overall material removal **e** is also displayed.	
INC		When the push-button is operated concurrently with rotation of the handwheel adjustment of the parameters is made.	
		When the push-button is depressed concurrently with rotation of the handwheel the absolute X-axis position is adjusted. If multiplication 10x has been selected value 100x holds good.	
RES		On operation of the **RES** key, the relative X- or Z-axis is reset. It is only the axis marked in capital letters that is always reset.	
		On every short operation of the **RES** push-button, the relative X-axis is reset. When the **RES** push-button is depressed for 5 sec. the TEACH-IN cycle is initiated or terminated.	
		On operation of the **RES** push-button, wheel wear compensation is provided.	

1.4 WSP position

MODE	CYCLE	DISPLAY	MEANING
		x=0.00000	The WSP position is relative X-axis position 0.00000.
	0 ÷ 9	x=0.08000	The WSP position is 0.08000 inch away from the work zero.
	A, P, T	x=0.00150	The WSP position is a work addition (X0).
		x=0.00000	The WSP position is the diamond X-axis position.
	C/C	x=0.00000	The WSP position is the grinding start position.

√ - only for concave/convex or form grinding.

1.5 Selection of the program number and functions

When the switch on the control system panel is in position  the program number or the selected function lights in the lower right corner of the display. The number of the desired program or the function can be selected by means of the handwheel.

MAIN SWITCH	ACTION	DISPLAY	NOTE
		#0÷2	Plunge-cut TEACH-IN grinding !!
		P3÷P4	Plunge-cut parametric grinding !!
		#5÷7	Longitudinal TEACH-IN grinding !!
		A8÷A9	Longitudinal parametric grinding. !!
		W	Special longitudinal parametric grinding . !!
		l=0 r=0 A	Longitudinal grinding with automatic feed at the reversal points .
		Speed=220 P	Plunge-cut grinding at a programmed speed .
		Adj Dia	Adjustment of diamond position and wheel dressing mode .
		Set up	Machine SET UP (clearing of all programs and positions).
		Parameters	On operation of the INC key, the machine constants of the grinding machine can be adjusted. This adjustment should be made by a trained operator, according to separate operating instructions.
		For a special design variant required by the customer, the offered control system can perform further functions.	
		Serial transm.	Serial data transmission PC ➜ K51 and K51 ➜ PC.

Designated functions: :

!! Dividing programs into plunge-cut and longitudinal grinding routines can be selected when ordering.

/* Data switching can be made by the **INC** key being repeatedly operated.

When no program has been programmed the message No Program # and the selected program number are displayed.

2. Manual grinding

2.1 Manual plunge-cut grinding

The manual control mode is the basic method used for infeed control of the grinding machine. It can be used e.g. for readjustment of the wheelhead to the position for wheel change, adjustment of the wheelhead to the workpiece grinding allowance position, approach of the wheelhead to the diamond position for dresser adjustment, and manual plunge-cut and longitudinal grinding. Entry into the manual control mode is ensured by moving the switch on the system control panel to position . In this case, letter H (Hand) lights up in the lower right-hand corner of the display. Infeed control is provided by the handwheel, it being possible to follow the wheelhead position on the display.

The displayed data can be cleared at any time by operating the RES key on the system control panel. It is only the data marked in capital letters that are always cleared.
Example:

X= 0.02356 a= 12.10231	**RES** resets the **X**-axis	x= 0.02560 Z= 25.64580	**RES** resets the **Z**-axis

The infeed rate controlled by the handwheel can be increased by means of key 10x. The original rate (1x) can be restored by operating the key again or by changing the position of rapid feed. To indicate the increased feed rate, a lighted display of marker 10x is provided. To adjust numerical values for the value of absolute coordinate and some parameters when entering values for parametric and concave-convex grinding, rate 100x can be selected by key 10x. In this case, the increased feed rate is shown on the display by marker 100x.

For adjustment of the wheelhead over a larger distance, the rapid feed keys fitted on the machine panel can be used. For forward movement, the wheelhead should be in the front position of rapid feed. On operation of the key, the wheelhead starts moving at a low speed first and then gradually increase its speed after a while.

When the WSP key is depressed for 3 seconds the wheelhead is brought into position "0.00000". In manual grinding, this function can be used to bring the wheelhead into the same point or back into the original position after dressing.

2.2 Absolute measurement

The absolute position of the **X**-axis is shown in the lower line of the display and designated **a=** . Adjustment of the value on the display is carried out during installation, on wheel change or when the displayed value differs from the actual one. After the workpiece has been ground retraction should be made at high speed, the workpiece should be measured and, with the **INC** push-button depressed, the measured value should be put down on the display by means of the handwheel. Rate 100x can be selected by means of key **10x**. In this case, the increased feed rate is shown on the display by marker 100x. Adjustment of the absolute **X**-axis position entails no change in the wheelhead position (only the display is changed).

All positions of the programs remain unchanged, but the final diameter FV in the parametric cycles is related to the absolute **X**-axis whose position, when varies, causes even the final position (zero) of all of these cycles to change. This can be turned to use for simultaneous compensation of all cycles.

2.3 Dwell at reversal points

When the machine incorporates facilities whereby dwell adjustment can be made by potentiometers or hydraulically, the above dwell adjusting procedure may be ineffective.

With the table approaching the reversal point in the front position of the wheelhead, depress and hold the **INC** push-button. After the table reaches the reversal point letter **L** or **R** lights up on the right side of the display to inform the operator that the end position of table travel has been reached, the table being automatically arrested. With the **INC** push-button still depressed, a dwell at the reversal point can be adjusted by means of the handwheel. The adjusted amount of dwell is displayed in seconds (0 to 35 s). At each reversal point, the dwell can be adjusted separately. This adjustment remains valid in all operating modes of the machine except for wheel dressing.

Right reversal point

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				On the machine control panel, table travel to the left is started. (The direction of table travel can be changed by deflecting the main lever).
2.		**INC**	Delay=0sec R	With the **INC** push-button operated, the table is arrested at the right reversal point.
3.			Delay=5sec R	By operating the handwheel, the amount of dwell in seconds is adjusted. (The **INC** push-button should be held depressed all the time).

Left reversal point

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				On the machine control panel, table travel to the right is started. (The direction of table travel can be changed by deflecting the main lever).
2.		**INC**	Delay=0sec L	With the **INC** push-button operated, the table is arrested at the left reversal point.
3.			Delay=5sec L	By operating the handwheel, the amount of dwell in seconds is adjusted. (The **INC** push-button should be held depressed all the time).

The duration of dwell at the reversal point at which its amount is entered, begins at the instant of table stop. For example, for entering a dwell of 4 s., the amount of dwell to be entered is 10 sec since, on release of the **INC** push-button (after entering the value), the table remains at the reversal point for further 6 seconds. If a shorter dwell were adjusted the table would start moving immediately the **INC** push-button is released.

3. TEACH-IN cycles and programming of parametric cycles

The TEACH-IN cycle is a procedure in which the operator grinds the first workpiece in a usual way by means of the handwheel, the whole grinding sequence being stored by the control system. The following workpieces are then ground in an automatic cycle in the same sequence of operations, at the same speed and with sparking-out as the first workpiece.

At the end of the TEACH-IN cycle, a note concerning the diameter for the given program number is automatically stored. With the main switch in position , this note is displayed. When the **INC** push-button is depressed the note can be modified by means of the handwheel, if required. This value has no effect on the workpiece diameter, but serves only as information about the programmed diameter.

Parameter programming

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.			P3÷P4 A8÷A9	Parameter programming should be selected by the handwheel.
2.				The required parameter is selected by operating the handwheel.
3.		**INC** +	Value	With the **INC** key operated, the parameter value can be set by rotating the handwheel. (For this purpose, the **INC** key should be held depressed).

When programming the value of final diameter FV for several different diameters, allowance should be made for the correction of position with respect to the summing error of the ball screw lead.

For adjustment of numerical values of the parameters, rate 100x can be selected by means of the key **10x**. In this case, the increased feed rate is indicated on the display by marker 100x.

3.1 Plunge-cut grinding TEACH-IN cycle

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.			#0÷4	The number of the program which will be created should be selected by the handwheel.
2.				By deflecting the main lever forward, the wheel-head is moved forward by hydraulic drive.
3.				By operating the handwheel, wheelhead infeed is adjusted to bring the wheelhead into contact with the workpiece.
4				By deflecting the main lever forward, the wheelhead is moved forward at high speed.
5		**RES**	darkens x=0.00000	On operation of the **RES** push-button, the display darkens. If the push-button is held depressed for 5 sec., the display lights up anew, the TEACH-IN cycle being initiated.
6				By operating the handwheel, the workpiece can be ground to the required size, breaks in the infeed showing up as spark-out dwells; the workpiece can be measured and dressed at any point of the TEACH-IN cycle (see below).
7		**RES**	darkens x=0.00000 x=0.08000	On operation of the **RES** push-button, the display darkens. If the push-button is held depressed for 5 sec., the display lights up anew, the TEACH-IN cycle being completed. Electronic wheelhead infeed is set 0.08000 inch backwards to the WSP position, the wheelhed being retracted at high sped.

3.2 Plunge-cut grinding TEACH-IN cycle at a programmable speed

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1			# 0÷4	The number of the program which will be created should be selected by the handwheel.
2				By deflecting the main lever forward, the wheel-head is moved forward at high speed.
3				By operating the handwheel, wheelhead infeed is adjusted to bring the wheelhead into contact with the workpiece.
4				By deflecting the main lever forward, the wheelhead is moved forward at high speed.
5		**INC** + 	Speed=1.30	With the **INC** push-button depressed, the required grinding speed [in/min] is adjusted by means of the handwheel.
6		**RES**	darkens x=0.00000	On operation of the **RES** push-button, the display darkens. If the push-button is held depressed till the display lights up anew, the TEACH-IN cycle is initiated.
7				On initiation of the TEACH-IN cycle, the wheel-head moves at the programmed speed. The rate of travel can be increased or decreased in % of the programmed speed by operating the handwheel or potentiometer (for K51-2). When "0%" has been adjusted infeed is stopped and sparking out is programmed. The workpiece can be measured and dressed at any point of the TEACH-IN cycle (see below).
8		**RES**	darkens x=0.00000	On operation of the **RES** push-button, the display darkens. If the push-button is held depressed till 0.00000 appears on the display the TEACH-IN cycle is terminated,
			1.30 x=0.08000#3	Whelhead infeed is set 0.08000 inch backwards to the WSP position and the wheelhead is moved backward at high speed.

In the event of a cycle interrupt, the wheelhead is moved 0.08000 inch backward. Prior to a new start of the TEACH-IN cycle, the wheel should be moved in the manual control mode to contact the workpiece.

3.3 Longitudinal grinding TEACH-IN cycle

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1			# 5÷9	The number of the program which will be created should be selected by the handwheel.
2				By deflecting the main lever forward, the wheelhead is moved forward at high speed.
3				By operating the handwheel, wheelhead infeed is adjusted to bring the wheelhead into contact with the workpiece.
4				By deflecting the main lever forward, the wheelhead is moved forward at high speed.
5		**RES**	darkens x=0.00000	On operation of the **RES** push-button, the display darkens. If the push-button is held depressed till the display lights up anew, the TEACH-IN cycle is initiated.
6			X=0.00000 R	The direction of table travel can be changed by the main lever being thrown to the reversal point at which the working cycle will start. At the reversal point letter L or R lights up on the right side.
7			x=0.00250 R	The amount of grinding allowance at the reversal point is selected by the handwheel. (It is advisable that table travel is slowed down or arrested at the reversal point to permit the amount of grinding allowance to be easily entered).On machines with motor-driven table feed, the table can be delayed a bit at the reversal point by deflecting and holding the main lever to permit the amount of grinding addition to be programmed. After the lever has been released table feed is resumed.
8			X=0.00100 L	At the other reversal point of longitudinal feed, the amount of the second grinding allowance can be entered. At each reversal point, a different amount of grinding allowance can be adjusted, even a negative value being possible. The zero amount of grinding allowance shows up by sparking out.The maximum amount of grinding addition is 0.005 inch.
9				Entering the amounts of grinding allowance can continue in this way till the required value is reached. The workpiece can be measured and dressed at any point of the TEACH-IN cycle.
10		**RES**	darkens x=0.00000	On operation of the RES push-button, the display darkens. If the push-button is held depressed till 0.00000 appears on the display the TEACH-IN cycle is terminated.
			x=0.00000 ---	On the display, marker - - - - lights up and the table resumes its movement to the nearest reversal point.
			x=0.08000#5	wheelhead infeed is set 0.08000 inch backward to the WSP position and the wheelhead is moved backward at high speed.

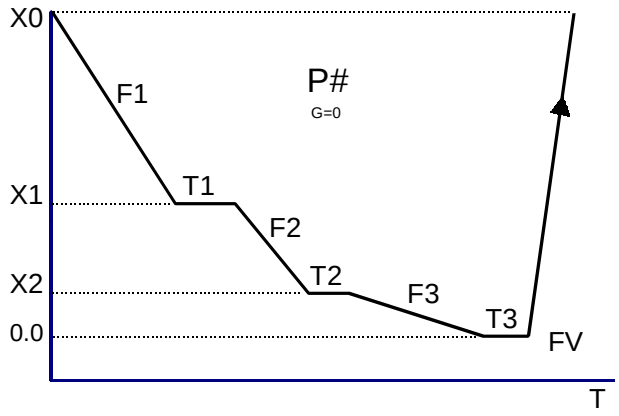
3.4 Work size gauging during the TEACH-IN cycle

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.			WAIT	By rotating the "Grinding Enable" switch to position "0", the possibility of wheelhead infeed by means of the handwheel is suspended.
2.			WAIT	By deflecting the main lever, the wheelhead is moved backward at high speed, the workhead and table travel being arrested. Thus, the workpiece can be measured.
3.			WAIT	On completion of the workpiece measurement, the wheelhead is moved forward at high speed by means of the main lever being deflected forward, the workhead and table travel being started up.
4.				By rotating the "Grinding Enable" switch to position "1", the TEACH-IN cycle is permitted to resume working.

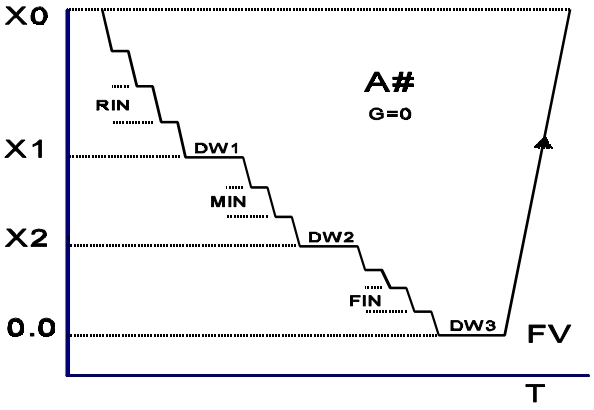
Atention:

On no account, the "Grinding Enable" switch can be rotated to position "0" during concave/convex grinding.

3.7


X0
F1
P#
G=0
X1
T1
F2
X2
T2
F3
T3
0.0
FV
T

3.9


X0
A#
G=0
RIN
X1
DW1
MIN
X2
DW2
FIN
DW3
0.0
FV
T

3.5 Parameters for the plunge-cut grinding cycle P# without size gauge

No.	Main switch	Action	Display	Note
1			P#	The required cycle No. is selected by means of the handwheel
			FV	Workpiece diameter, related to the absolute X-axis
			X0	Amount of grinding allowance + safety 〈 0.00039÷ 0.39370 〉 inch
			X1	End of rough grinding speed 〈 0.00039÷ X0 〉 inch
			X2	End of grinding speed 〈 0÷ X1 〉 inch
			X3	End of finish grinding speed 〈 0÷ X2 〉 inch
			F1	Rough grinding speed 〈 0.7÷ 354 〉 in/min
			F2	Grinding speed 〈 0.2÷ 196 〉 in/min
			F3	Finish grinding speed */ 〈 0.2÷ 118 〉 in/min
			T1	Sparking-out in the X1-axis 〈 0÷ 120 〉 sec
			T2	Sparking-out in the X2-axis 〈 0÷ 120 〉 sec
			T3	Sparking-out at the zero point */ 〈 0÷ 120 〉 sec

With the **INC** push-button operated, the parameter value can be adjusted by turning the handwheel. (For this purpose, the **INC** push-button should be held depressed).

After all parameters have been programmed the handwheel should be rotated backwards (to the left) so that they can be checked by the system. When an error is detected an ERROR message is displayed, the incorrect parameter being set on the display for correction. The data should be corrected and the handwheel should be rotated again to the left (backwards). When no error has been found in the programmed parameters the main switch can be rotated to position  . In case that any data has not been programmed at all or has been programmed incorrectly, the program is not released, the message NO PROGRAM being displayed.

In this case, the **WSP** key should be operated so that the wheelhead is brought back into the outgoing position. The automatic cycle of the machine can be started by means of the main lever.

By operating the handwheel or potentiometer (for K51-2), OVERRIDE can be set in per cent of the programmed speed. When "0" has been set infeed is stopped.

Prior to starting the automatic cycle, final diameter compensation (OFFSET) can be effected by means of the handwheel while the **WSP** push-button is held depressed. The maximum value is ± 0.005 inch.

When setting positive OFFSET, a lower value than the amount of grinding allowance should be entered.

When programming a new value of final diameter (FV=), OFFSET is automatically cleared.

*/ Request G (with size gauge/without size gauge) and values X3 and T3 are available in a special design variant only and need not be contained at all events.

3.6 Parameters for the longitudinal grinding cycle A#

No.	Main switch	Action	Display	Note
1			A#	The required cycle No. is selected by means of the handwheel
2		 + **INC**	G	With size gauge = YES; without size gauge = **NO**
			FV	Workpiece diameter, related to the absolute X-axis 〈 1÷ 700 〉 inch
			X0	Amount of grinding allowance + safety 〈 0.00039÷ 0.39370 〉 inch
			X1	End of rough grinding increment〈 0.00039÷ X0 〉inch
			X2	End of grinding increment 〈 0÷ X1 〉inch
			RIN	Rough grinding increment 〈 0.00008÷ 0.60 〉inch
			MIN	Grinding increment 〈 0.00008÷ 0.40 〉inch
			FIN	Finish grinding increment 〈 0.00004÷ 0.31 〉inch
			Finc	Rate of increment 〈 2.3÷2362 〉in/min
			DW1	Number of sparking-out strokes in the X1 〈 0 ÷ 120 〉
			DW2	Number of sparking-out strokes in the X2 〈 0 ÷ 120 〉
			DW3	Number of sparking-out strokes at the zero point 〈 0 ÷ 120 〉
			uv r= 0 L R	To set, in witch of the ends will be incremented.

With the **INC** push-button operated, the parameter value can be adjusted by means of the handwheel. (For this purpose, the **INC** push-button should be held depressed.

After the parameters have been programmed they are checked by the system. When an error is detected an ERROR message is displayed, the incorrect parameter being set on the display for correction. After all parameters have been programmed the WSP key should be operated so that the wheelhead is brought back into the outgoing position. The automatic cycle of the machine can be started by means of the main lever.

Prior to initiation of the automatic cycle, final diameter compensation (OFFSET) can be accomplished by means of the handwheel while the **WSP** push-button is being held depressed. The maximum value is ± 0.127.

When setting positive OFFSET, a lower value than the amount of grinding allowance should be entered.

When programming a new value of final diameter (FV=), OFFSET is automatically cleared.

For X1, X2, X3 = 0, the table moves without incrementing for each breakpoint (3x). For grinding with a single increment without sparking-out, it is preferable to program the breakpoints in multiples of the increment.

4. Automatic control mode

4.1 Initiation and termination of the automatic cycle

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1			# 0÷4	The number of the program which has been created, can be selected by the handwheel.
2		**WSP**	x=0.08000	By deflecting the main lever backward or operating the **WSP** push-button, wheelhead infeed is adjusted to the starting position.
3				By deflecting the main lever forward, the automatic cycle which has been programmed in the TEACH-IN cycle, can be initiated from the starting WSP position or a position exceeding WSP.
4		OVERRIDE	95%	The required override is selected by means of the handwheel.
5			x=0.00000 x=0.08000	After the workpiece has been ground to its final size the automatic cycle is terminated, wheel-head infeed being reset.

4.2 Automatic cycle RESET

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				The automatic cycle can be interrupted at any point by deflecting the main lever backward. In this case, wheelhead infeed is adjusted to the starting WSP position, the wheelhead is moved backward at high speed and the workhead, table travel and cooling are stopped.

4.3 Automatic cycle interrupt

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				When the "Grinding Enable" switch is rotated to the position "0" the automatic cycle is suspended as long as the switch remains in this position. The resumption of the automatic cycle is conditioned by bringing the switch back into position "1". The table is not arrested.

4.4 Infeed rate change at plunge-cut grinding and increment change at longitudinal grinding

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.			# 0÷4	The infeed rate can be changed at any point of the automatic cycle by means of the handwheel. This change is automatically included in the grinding program for the next workpiece by the control system.

When the handwheel is rotated forward the infeed rate included in the program is added to the speed of handwheel rotation. When the handwheel is rotated backward, its speed is subtracted from the infeed rate included in the program. If the two speeds are identical or the speed of backward rotation of the handwheel is higher than the programmed forward speed, sparking-out is incorporated in the grinding program for the next workpiece, the final workpiece size remaining unchanged.

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.			# 5÷6	The same as in the TEACH-in mode, increments can be changed at the reversal points during the automatic longitudinal grinding cycle. After the first change of increment has been made the following changes should be carried out as in the TEACH-IN cycle.

No program changes will be put down in the program when the automatic cycle is sped up or terminated untimely by throwing the hand lever backward.

4.5 Final diameter correction - OFFSET

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				From the measured value and the required workpiece size, the amount of correction is calculated.
2.		**WSP**	0	With the **WSP** push-button depressed, the amount of correction related to the diameter (positive or negative) can be adjusted by means of the handwheel.
3.		**WSP**	x=0.08039	On release of the push-button, the WSP position corrected by the amount of correction is displayed.
4.		**WSP**	x=0.08000	Infeed is adjusted to a new starting WSP position by operating the **WSP** push-button.

For the parametric cycles, the maximum value for OFFSET is 0.00500 inch.

When entering a positive OFFSET value, the entered value should be smaller than the grinding addition.

When programming a new value of final diameter (PV=), OFFSET is automatically cleared.

5. Longitudinal grinding with automatic addition at reversal points - Cycle A

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				By deflecting the main lever forward, the wheelhead is moved forward at high speed.
2.				The workpiece is slightly ground by means of the handwheel. By deflecting the main lever backward, the wheelhead is moved backward at high speed. The amount of grinding addition is measured.
3.			l=0 r=0 A	Change-over to the control mode **A** is made by means of the handwheel.
4.		**RES**	x=0.00000	The display is cleared by the **RES** push-button.
5.		**WSP** + 	-0.00065 X=0.00065	With the **WSP** push-button depressed, the taken--down amount of grinding allowance is adjusted on the display by rotating the handwheel to the right (into the cut). (In this case, the wheelhead remains at rest, only the negative value on the display being changed (up to 0.196 inch). On release of the **WSP** pushbutton, the amount of grinding allowance (positive value) is displayed. When an error occurs the display can be cleared by the **RES** push-button and a new value can be adjusted.
6.				By deflecting the main lever forward, the wheelhead is moved forward at high speed. The table can be started by means of the table feed starting switch.
7.			X=0.00065 l=15 r=12	Both at the left and right reversal points letter L or R being ON on the right side below), the amount of automatic grinding allowance (which may be different at either reversal point, or even negative in one direction) is set by means of the handwheel.
8.	In a table position between the reversal points (letter L or R on the right side of the display remains OFF), the grinding addition can be canceled simultaneously at both reversal points by the handwheel being moved a step backwards. During further rotation of the handwheel, the wheelhead can be withdrawn from the workpiece by an arbitrary amount. For subsequent grinding, increments should be set anew at the two reversal points. In a table position between the reversal points, the wheelhead is moved into the cut by rotating the handwheel forward. The forward movement is limited by a displayed zero.			
9.	After adjustment of the increments, automatic infeed at the reversal points is carried out till a zero is displayed. Then, three table travels should be made without increment (sparking-out) (depending on the adjusted value t_a), the wheelhead being retracted by the amount of grinding addition at high speed. The point of wheelhead retraction is determined by the amount of grinding allowance and the both increments. At a new start by means of the hand lever, the next workpiece is ground up to "zero" in the same way.			

The amount of grinding allowance can be changed by rotating the handwheel in the corresponding direction. At start-up, this new position of grinding allowance is stored. On completion of the automatic cycle, the wheelhead is automatically brought back into this new position.

With the **WSP** push-button depressed, a correction of the final workpiece diameter can be made by means of the handwheel.

6. Plunge-cut grinding at programmable speed - Cycle P

In this control mode, plunge-cut grinding can be carried out at a preprogrammed speed. During grinding, the infeed rate can be changed within a range of 0 to 150% (OVERRIDE) by means of the handwheel or potentiometer (for K51-2).

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				By deflecting the main lever forward, the wheelhead is moved forward at high speed.
2.				By rotating the handwheel, the workpiece is ground by a small amount and the grinding allowance is then measured. By deflecting the main lever backward, the wheelhead is moved backward at high speed. The amount of grinding allowance is then measured again.
3.			**P**	Change-over to the control mode **P** is made by the handwheel.
4.		**INC** + 	Speed=2.3	With the **INC** push-button depressed, the required infeed rate related to the workpiece diameter can be adjusted on the display in steps of 20% within the infeed range of 6 to 1500 in/min, related to the workpiece diameter. This speed is adjusted in steps of 20%.
5.		**RES**	x=0.00000	On operation of the **RES** push-button, the display is cleared.
6.		**WSP** + 	-0.0015	With the **WSP** push-button depressed, the taken--down amount of grinding allowance is set on the display by rotating the handwheel to the right (into the cut). (In this case, the wheelhead remains at rest, only a change in the negative value up to 0.196 inch taking place on the display).
7.		**WSP**	x=0.00150	On release of the **WSP** push-button, the amount of grinding allowance is displayed.
Moving the main lever forward initiates the automatic cycle in which the workpiece is ground up to the "zero" at a preset speed, sparking-out taking place within 5 sec (or a time preset by parameter T_p). Then, the automatic cycle is terminated by automatic resetting of the wheelhead to grinding allowance and infeed withdrawal at high speed.				

The amount of grinding allowance can be changed by rotating the handwheel in the corresponding direction. At start-up, this new position of grinding allowance is stored. On completion of the automatic cycle, the wheelhead is automatically brought back into this new position.

With the **WSP** push-button depressed, a correction of the final workpiece diameter can be made by means of the handwheel.

7. Wheel dressing

7.1 Wheel dresser gauging

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1				The wheel is brought into contact with the diamond through wheelhead infeed and is dressed, employing the handwheel.
				If radius wheel dressing is also used, the grinding wheel is positioned with its center opposite the diamond.
2			Adj Dia Pos	Diamond position setting on the display Adj Dia is selected by operating the handwheel.
3		**RES**	Adj Dia 09 Adj Dia OK	The display is cleared by depressing and holding the **RES** push-button for 9 sec. and a new diamond position is set. As a result, the diamond position adjustment is terminated. */
4			#0÷2,P3÷P4 #5÷7,A8÷A9	The number of the program or cycle is selected by means of the handwheel.

Whenever change-over from any position of the switch to the dressing position is made the relative distance of the grinding wheel from the diamond is displayed. The operation of the **WSP** push-button causes the wheelhead to be moved to position "0.00000" in which it is automatically arrested. The movement is controlled in such a way that clearance in the infeed mechanism is always taken up. This means that, during infeed from the front position to the diamond position, automatic overtravel of the diamond takes place, followed by return to position "0.00000". The wheelhead can be readjusted forward by the amount of a dressing increment to carry out dressing.

It should be noted that there is a difference in use of the **RES** push-button between the dressing mode and the **Adj Dia** operation for the diamond. On operation of the **RES** push-button even after the **Adj Dia** operation, the display is cleared and, after wheel dressing, the diamond position is set at this point. The difference consists in that, after the **Adj Dia** operation, the absolute position of the programmed diameters remains unchanged while their relative position is converted with respect to the diamond position. On operation of the **RES** key, the relative position of programmed diameters with respect to the diamond position remains unchanged while their absolute position is converted. As already stated, the **RES** push-button is thus used for wheel wear compensation after wheel dressing while the **AdJ diA** operation is used for adjusting a new diamond position after the diamond has been replaced.

When Point 4 has been cut out the message INCORRECT PROCEDURE appears on the display since it has not been determined for which cycle dressing is to be made.

7.2 Straight wheel dressing

Preparation: Wheel dresser gauging, adjustment of dressing stops

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				By deflecting the main lever to the left, the table is moved so that the grinding wheel is brought into a position opposite the diamond.
2.		**WSP**	x= 0.81250 x= 0.00000	Dressing is always started by means of the **WSP** key. On operation of the **WSP** key, wheelhead infeed is set at the starting dressing position. When wheelhead infeed has been already set at this position starting of the dressing operation is enabled.
3.				The automatic table feed at a preselected dressing speed is started by means of a panel-mounted key.
4			x=-0.0010 L x=-0.0030 R x=-0.0040 L x=-0.0050 R	At the points of reversal, the grinding wheel is moved by the amount of dressing increment (negative value) towards the diamond by means of the handwheel.
5		**RES**	x=-0.00500 x= 0.00000	At the end of wheel dressing, the **RES** push-button is depressed to clear the display, automatic wheel wear compensation after wheel dressing being provided.

For wheel dressing, changes in the wheel diameter due to wheel wear prior to dressing and material removal of the diamond should be taken into account. Therefore, special attention should be devoted to check return of the wheel to the workpiece. After dressing, the wheel seems to be larger than before dressing. It is therefore advisable to interrupt the grinding process before it is completed (prior to “zero”), to check the workpiece size and to correct the absolute axis.

7.3 Wheel dressing during the working cycle

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.			x=0.12300	The working cycle is suspended by the main switch being rotated to the said position and the wheelhead is moved backward at high speed.
2.				The table is moved to a position between the dressing stops by deflecting the main lever.
3.		**WSP**	x=0.00000 *	Wheelhead infeed is set to the diamond position, an asterisk being displayed to indicate that a wheel dressing operation takes place during the working cycle.
The dressing cycle is then resumed, as described in the Chapter "**Wheel Dressing**".				
4.			x=0.00000 *	By deflecting the main level the table is brought into a position between the working stops.
5.		**WSP**	x=0.08000 *	By operating the WSP key and deflecting the main lever forward, the wheelhead is placed back in the position in which the working cycle started.
6.			x=0.12300	By the second deflection of the main lever forward (acceleration), wheelhead infeed is set to the position in which the wheel dressing operation started. After the original position is reached, the asterisk on the left side of the display, which indicates that the intermediate wheel dressing operation is in progress, darkens. Considering the new conditions established after wheel dressing (the workpiece has not been sprung and the grinding wheel has not been worn out), attention should be devoted to the return of the wheelhead to the original grinding point. The number of intermediate wheel dressing operations is not limited.

NOTICE:

To prevent a collision between the grinding wheel and the workpiece, the operations described in Points 4 and 5 supra should be made in the given or opposite order, depending on the workpiece diameter and absolute diamond position.

If the absolute diamond position **>** the workpiece diameter, the order of operations 2 - 3 and 4 - 5 should be observed.

If the absolute diamond position **<** the workpiece diameter, the opposite order of operations 3 - 2 and 5 - 4 should be applied.

7.4 Wheel dressing during the longitudinal grinding TEACH-IN cycle

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1			x=0.12300	The working cycle is suspended by the main switch being rotated to the said position and the wheelhead is moved backward at high speed.
2				The table is moved to a position between the dressing stops by deflecting the main lever.
3		**WSP**	x=0.00000 *	The wheelhead is set to the diamond position, an asterisk being displayed to indicate that a wheel dressing operation takes place during the TEACH-IN cycle.
The dressing cycle is then resumed, as described in the Chapter "**Wheel Dressing**".				
4			x=0.00000 *	By deflecting the main lever to the right, the table is moved to the point of reversal at which the TEACH-IN process will be resumed.
5		**WSP**	*	By operating the WSP key and deflecting the main lever forward, the wheelhead is placed back in the position in which the working cycle started.
6			*	By deflecting the main lever forward, all increments which have been programmed hitherto, will be automatically executed in a rapid sequence, the wheelhead being brought into the position in which wheel dressing was incorporated in the grinding sequence.
7				After this position has been reached the asterisk darkens. Thus, the intermediate wheel dressing operation has been completed.
8				The number of intermediate dressing operations is arbitrary. The cycle is then resumed, as described in the Chapter 3.3.

NOTICE:

To prevent a collision between the grinding wheel and the workpiece, the operations described in Points 4 and 5 supra should be made in the given or opposite order, depending on the workpiece diameter and absolute diamond position.

If the absolute diamond position **>** the workpiece diameter, the order of operations 2 - 3 and 4 - 5 should be observed.

If the absolute diamond position **<** the workpiece diameter, the opposite order of operations 3 - 2 and 5 - 4 should be applied.

7.5 Wheel dressing during the plunge-cut grinding TEACH-IN cycle

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1			x=0.12300	The TEACH-IN cycle is suspended by the main switch being rotated to the said position and the wheelhead is moved backward at high speed.
2				The table is moved to a position between the dressing stops by deflecting the main lever.
3		**WSP**	x=0.00000 *	The wheelhead is set to the diamond position, a asterisk being displayed to indicate that a wheel dressing operation takes place during the TEACH-IN cycle.
The dressing cycle is then resumed, as described in the Chapter "**Wheel Dressing**".				
4			x=0.00000 *	By deflecting the main lever to the right, the table is moved to the point of reversal at which the TEACH-IN process will be resumed.
5		**WSP**	*	By operating the **WSP** key and deflecting the main lever forward, the wheelhead is placed back in the position in which the TEACH-IN cycle started.
6			*	The wheelhead is restored by means of the handwheel or is sped up by deflecting the main lever forward anew.
7				After this position has been reached the asterisk darkens. Thus, the intermediate wheel dressing operation has been completed.
8				The number of intermediate dressing operations is arbitrary. The TEACH-IN cycle is then resumed, as described in the Chapter 3.1.

NOTICE:

To prevent a collision between the grinding wheel and the workpiece, the operations described in Points 4 and 5 supra should be made in the given or opposite order, depending on the workpiece diameter and absolute diamond position.

If the absolute diamond position **>** the workpiece diameter, the order of operations 2 - 3 and 4 - 5 should be observed.

If the absolute diamond position **<** the workpiece diameter, the opposite order of operations 3 - 2 and 5 - 4 should be applied.

8. Error messages

The control system checks some states and positions and issues an error message whenever it detects some discrepancies.

DISPLAY	FAILURE	REMEDY
no WSP	The wheelhead is not in the starting position for initiation of the automatic grinding process or on compensation for wheel dressing.	Operate the **WSP** key or deflect the hand lever backward.
*no Pr*ogram	For the required diameter number, no program has been created.	Change over to the control mode and grind the first workpiece.Check all parameters of cycles.
no Hdr	No supply voltage of the input circuits, hydraulic equipment not actuated.	Activate the hydraulic equipment.
Error 0	Monitoring of the stepping motor movement disabled.	Remove the jumper on the left side in the middle of the printed circuit board.
Error1 flickering DISPLAY	During the time of high-speed adjustment, a power supply failure, a failure of the output stage or motor locking occurred. Coupling of the motor to the control system has been lost. After switching off/on the power supply a flickering display appear.	After removal of the failure, display flickering can be eliminated by performing machine SET-UP, readjusting the diamond position Adj Dia and operating the **RES** key in . If the display starts flickering after switching on the standby battery should be replaced.
Error2	The feed motor has run against the limit switch at the end of the ball screw.	Retraction from this position can be made by means of the handwheel.
Error3	The feed motor has run against the limit switch at the end of the ball screw.	
Error4	Checksum error in EPROM	Replace EPROM.
Error5	Range of the axes has been exceeded.	Machine SET UP* should be effected.
Error6	External function failure detected by diagnostics.	Switch off/on the system.
Error7	Checksum error in RAM	Replace RAM.
Error8	Parity error detected by diagnostics.	Switch off/on the system. If the failure recurs a repair is necessary.
Error9	Checksum error in SMC EPROM detected by diagnostics. 9a Configuration error in Xilinx	Replace SMC EPROM. Switch off/on the system. If the failure recurs a repair is necessary.
Error10..16.	Designed for machine failure messages.	See Operating instructions of the machine.
Error20	Error in communication with the I/O board.	Check the connecting optical cable.
Error21	Failure of potentiometer.	Check the condition of potentiometer.
Error22	End position of the table.	Retraction from this position can by made by the handwheel only.
Error23	End position of the table.	
Error25	X-axis servo switched off with failure.	Switch of/on the machine. If the failure recurs a repair is necessary.
Error26	Z-axis servo switched off with failure.	
Error27	Error in servo initialization.	
Error28	Error in setting of stops.	Proceed, according to the Operating instructions of the machine.
Error34	Failure of the X-axis encoder.	Check the condition and connection of the encoder.
Error28	Failure of the Z-axis encoder.	
Error36	Control deviation X exceeded.	Switch off/on the machine. If the failure recurs a repair is necessary. Check that no mechanical braking of the axis takes place.
Error37	Control deviation Z exceeded.	
Error38	X-axis servo failure.	Switch off/on the machine. If the failure recurs a repair is necessary. Check that a green LED lights on the servo driver.
Error39	Z-axis servo failure.	
Error40	X-axis servo failure.	
Error41	Z-axis servo failure.	
Error42	Checksum error 1/2 EPROM.	Check all parameters in EPROM and program.
Error43	Checksum error 2/2 EPROM.	
Error45	The entered value for by-pass is small.	Program, according to the instructions.
Error45	The position of stops has been lost.	Set the stops, according to the instructions.

* Machine SET UP is effected in the machine control mode u by the **RES** push-button being depressed for 10 sec. The messages ERROR 10 to 16 are designed for machine failure indication, see Operating instructions of the machine.

8.1 Adjustment of the value of wheelhead infeed hysteresis

The control system provides for automatic wheelhead infeed hysteresis compensation whose amount is determined by constant BAD X. This constant is adjusted as a parameter and becomes accessible only after the correct password has been entered.

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1		**INC** + 	045 Parametr	For entering the hysteresis value, the item Parameter is selected by the handwheel. With the INC key operated, password 045 is selected.
2			p 1=08 BAD	Constant BAD X is selected by the handwheel.
3		**INC** + 	P 1=00 BAD	With the push-button depressed, 00 is adjusted by means of the handwheel.
4				Clearance in the infeed mechanism is taken up by rotating the handwheel in one direction.
5		**RES**	x=0.00000	On operation of the **RES** push-button, the display is cleared.
6			x=0.00000 x=0.00040	The handwheel is rotated in the opposite direction till the wheelhead starts moving. The wheelhead position can be observed on a thousandth indicator (comparator). Measurement is effected repeatedly in both directions.
7		**INC** + 	P 1=15 BAD	The measured value is set by rotating the handwheel while the push-button is held. It must be set in µm by use following table.

After the BAD constant has been set the handwheel should be rotated backward to select the respective program or function. No other termination of parameter entering (e.g., operation of a switch) is possible since otherwise an error in EPROM adjustment might occur.

inch	µm	inch	µm
0,00005	1	0,00055	14
0,00010	3	0,00060	15
0,00015	4	0,00065	17
0,00020	5	0,00070	18
0,00025	6	0,00075	19
0,00030	8	0,00080	20
0,00035	9	0,00085	22
0,00040	10	0,00090	23
0,00045	11	0,00095	24
0,00050	13	0,00100	25