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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, 2.000, 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.

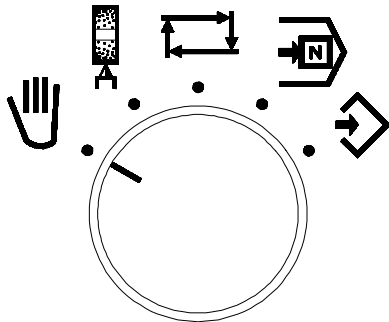
g) Concave/convex grinding

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







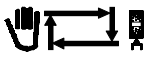





MAIN SWITCH	DISPLAY	MEANING	
	• X= 2.000 a=45.235	Manual grinding Relative X-axis position Absolute X-axis position	With the INC push-button operated, the position of the absolute X -axis can be adjusted by means of the handwheel.
	•	Grinding of the first workpiece or programming.	
	•	Selection of the 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= 2.000 a= 45.235	Relative X-axis position Absolute X-axis position





DISPLAY	MEANING
x= 2.000 Z= 12.852	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 "0.000".	
	 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 lose these 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.	
10x		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=0.000	The WSP position is relative X-axis position 0.000.
	0 ÷ 9	x=2.000	The WSP position is 2 mm away from the work zero.
	A, P, T	x=0.150	The WSP position is a work addition (X0).
		x=0.000	The WSP position is the diamond X-axis position.
	C/C	x=0.000	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.		
		C/C	Concave-convex form grinding.	
		d	Entering of corrections - for concave-convex grinding only	
		1T, 2T	Grinding of form 1 or 2.	
		3T	Grinding of the form transmitted from a PC.	
		Serial transm.	Serial data transmission PC → K51 and K51 → PC.	
		b=50.0mm	Wheel width adjustment for progressive plunge-cut grinding .	
		d=1.256km	Diameter adjustment of the wheel dressing curve.	
		ta =003	Number of sparking-out strokes in the A cycle	
		tp=00.2min	Adjustment of sparking-out time in the P cycle.	
dd =0.008	Safety distance on return to the working position after an intermediate dressing operation.			
SP= 28 m/sec SD=458 mm	Peripheral speed adjustment of the grinding wheel Wheel diameter adjustment	/*		

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= 2.356 a= 121.231	RES resets the X -axis	x= 2.356 Z= 256.458	RES resets the Z -axis
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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 "0.000". 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 wheelhead 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=0.000	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=0.000 x=2.000	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 2 mm backwards to the WSP position, the wheelhead being retracted at high speed.

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 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		INC + 	Speed=330	With the INC push-button depressed, the required grinding speed [$\mu\text{m}/\text{min}$] is adjusted by means of the handwheel.
6		RES	darkens x=0.000	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 wheelhead 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=0.000	On operation of the RES push-button, the display darkens. If the push-button is held depressed till 000.000 appears on the display the TEACH-IN cycle is terminated,
		330 x=2.000 #3	Wheelhead infeed is set 2 mm 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 2 mm 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=0.000	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=0.000 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=0.025 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=0.010 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 0.127 mm.	
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=0.000		On operation of the RES push-button, the display darkens. If the push-button is held depressed till 000.000 appears on the display the TEACH-IN cycle is terminated.
			x=0.000 ---		On the display, marker - - - lights up and the table resumes its movement to the nearest reversal point.
		x=2.000 #5		wheelhead infeed is set 2 mm 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.

Attention:

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







3.5 Plunge-cut grinding of the first workpiece with in-process size gauging

PREPARATION: In the first phase, the size gauge should be adjusted to a standard and the individual control impulses should be set.

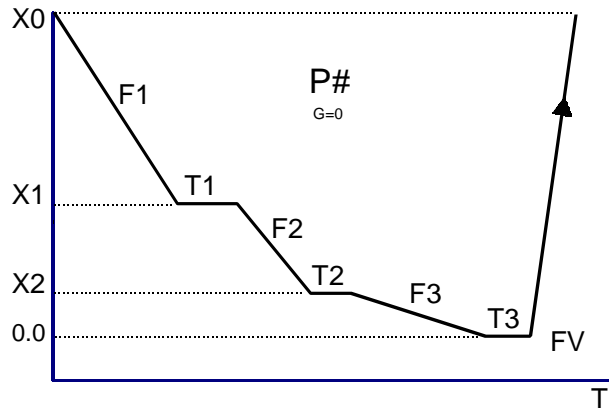
No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				The number of the program which will be created should be selected by the handwheel - see Chapter "Program selection".
2.				By deflecting the main lever forward, the wheelhead is moved forward at high speed.
3.				By operating the handwheel, wheelhead infeed is adjusted to bring the wheelhead into contact with the workpiece.
4.		RES	darkens x=0.000	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.
5.				Rough grinding of the workpiece is carried out by rotating the handwheel and infeeding the wheelhead.
6.				By rotating the "Size Gauge" switch to the forward position, the size gauge is brought into the measuring position. (In the next grinding cycle, the "Size Gauge Forward" switch should be moved to the "Automatic Cycle" position. Thus, at the given instant, the size gauge is moved forward automatically). The switch is mounted on the machine control panel.
7.				The TEACH-IN cycle goes on by infeeding the wheelhead.
8.		1. IMP. 2. IMP.		During grinding, the first and second impulses are obtained from the in-process size gauge. At these points, it is advisable to incorporate a dwell and to reduce the infeed rate.
9.		3. IMP.		After the size gauge issues the third impulse infeed is reset, the wheelhead being moved backward at high speed. Thus, the TEACH-IN cycle has been completed. ATTENTION! Unlike the TEACH-IN cycle without size gauging, the RES push-button should not be operated at the end. By rotating the "Size Gauge" switch to the backward position, the in-process size gauge head is reset.

3.6 Longitudinal grinding of the first workpiece with in-process size gauging

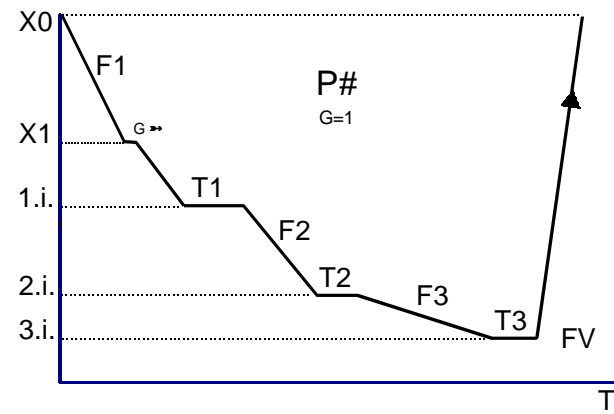
PREPARATION: In the first phase, the size gauge should be adjusted to a standard and the individual control impulses should be set.

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				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.		RES	darkens x=0.000	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.
5.			x=0.000	The direction of table travel can be changed by moving the main lever to the reversal point at which the working cycle will start.
6.				By rotating the panel-mounted "Size Gauge" switch to the forward position, the size gauge is brought into the measuring position.
7.				The grinding cycle is resumed by wheelhead infeed at the reversal points.
8.		1. IMP. 2. IMP.		During grinding, the first and second impulses are obtained from the control size gauge. At these points, it is advisable to incorporate a dwell and to reduce the increment at the reversal points.
9.		3. IMP.		After the in-process size gauge issues the third impulse infeed is reset at the nearest reversal point, the wheelhead being moved backward at high speed. Thus, the TEACH-IN cycle has been completed. ATTENTION! Unlike the TEACH-IN cycle without size gauging, the RES push-button should not be operated at the end. By rotating the "Size Gauge" switch to the backward position, the in-process size gauge head is reset.

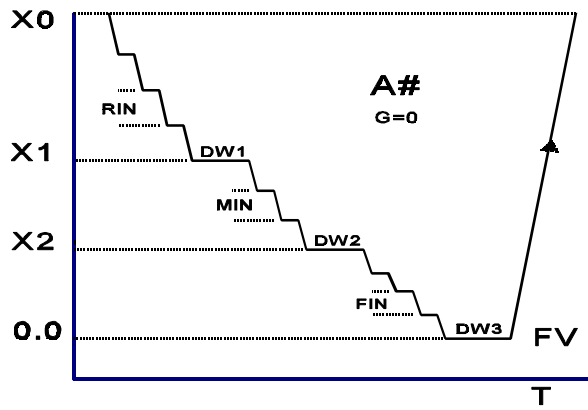
3.7



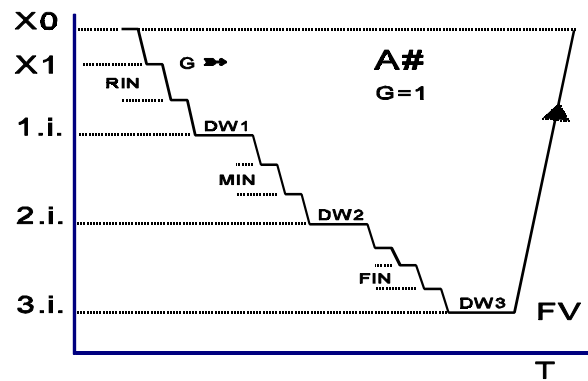
3.8







3.9



3.10



3.7 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
2		 + INS	G	With size gauge = YES; without size gauge = NO
			FV	Workpiece diameter, related to the absolute X-axis 〈 1 ÷ 700 〉 mm
			X0	Amount of grinding allowance + safety 〈 0.01 ÷ 10 〉 mm
			X1	End of rough grinding speed 〈 0.01 ÷ X0 〉 mm
			X2	End of grinding speed 〈 0 ÷ X1 〉 mm
			X3	End of finish grinding speed 〈 0 ÷ X2 〉 mm
			F1	Rough grinding speed 〈 20 ÷ 9000 〉 µm/min
			F2	Grinding speed 〈 5 ÷ 5000 〉 µm/min
			F3	Finish grinding speed */ 〈 5 ÷ 3000 〉 µm/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), **VERRIDE** 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 ± 0.127 mm.

*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.


3.8 Parameters for the plunge-cut grinding cycle P# with size gauge

PREPARATION: In the first phase, the size gauge should be adjusted to a standard and the individual control pulses should be set.

No.	Main switch	Action	Display	Note
1			P#	The required cycle No. is selected by means of the handwheel
2		 + INS	G	With size gauge = YES ; without size gauge = NO
			FV	Workpiece diameter, related to the absolute X-axis 〈 1 ÷ 700〉 mm
			X0	Amount of grinding allowance +safety 〈 0.01 ÷ 10〉 mm
			X1	Point of size gauge infeed 〈 0 ÷ X0〉 mm
			F1	Rough grinding speed 〈 20 ÷ 9000〉 µm/min
			F2	Grinding speed 〈 5 ÷ 5000〉 µm/min
			F3	Finish grinding speed 〈 5 ÷ 3000〉 µm/min
			T1	Sparking-out after the first impulse 〈 0 ÷ 120〉 sec
			T2	Sparking-out after the second impulse 〈 0 ÷ 120〉 sec
			T3	Sparking-out after the third impulse (0.0) 〈 0 ÷ 120〉 sec





At the approach point of the size gauge, infeed is stopped till the size gauge is brought into the front position.

Value T3 is normally programmed to be 0.

After the parameters have been programmed they are checked by the system. When an error is detected **ERROR** is displayed, the incorrect parameter being indicated. After programming all parameters, rotate the main switch into position  and operate the **WSP** push-button. Consequently, the wheelhead is brought into the starting position. The automatic machine cycle can be started by means of the main lever.

Final diameter compensation of the workpiece can be made by setting "0" on the size gauge (See "Axis position correction during grinding with size gauging"). OVERRIDE can be adjusted in per cent of the programmed speed by means of the handwheel or potentiometer (for K51-2). When "0" has been adjusted infeed is stopped.

3.9 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		 + INS	G	With size gauge = YES; without size gauge = NO
			FV	Workpiece diameter, related to the absolute X-axis 〈 1 ÷ 700 〉 mm
			X0	Amount of grinding allowance + safety 〈 0.01 ÷ 10 〉 mm
			X1	End of rough grinding increment 〈 0 ÷ X0 〉 mm
			X2	End of grinding increment 〈 0 ÷ X1 〉 mm
			RIN	Rough grinding increment 〈 0.002 ÷ 15 〉 mm
			MIN	Grinding increment 〈 0.002 ÷ 10 〉 mm
			FIN	Finish grinding increment 〈 0.001 ÷ 8 〉 mm
			Finc	Rate of increment 〈 60 ÷ 60000 〉 µm/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 〉

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.


3.10 Parameters for the longitudinal grinding cycle A# with size gauge

PREPARATION: In the first phase, the size gauge should be adjusted to a standard and the individual control pulses should be set.

No.	Main switch	Action	Display	Note
1			A#	The required cycle No. is selected by means of the handwheel
2		 + INS	G	With size gauge = YES ; without size gauge = NO
			FV	Workpiece diameter, related to the absolute X-axis 〈 1 ÷ 700 〉 mm
			X0	Amount of grinding allowance + safety 〈 0 ÷ 100 〉 mm
			X1	Point of size gauge infeed 〈 0 ÷ X0 〉 mm
			RIN	Rough grinding increment 〈 0.002 ÷ 15 〉 mm
			MIN	Grinding increment 〈 0.002 ÷ 10 〉 mm
			FIN	Finish grinding increment 〈 0.001 ÷ 8 〉 mm
			Finc	Rate of increment 〈 60 ÷ 60000 〉 µm/min
			DW1	Number of sparking-out strokes after the first impulse 〈 0 ÷ 120 〉
			DW2	Number of sparking-out strokes after the second impulse 〈 0 ÷ 120 〉
			DW3	Number of sparking-out strokes after the third impulse (0.0) 〈 0 ÷ 120 〉



Value DW3 is normally programmed to be 0.

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 the parameters have been programmed they are checked by the system. When an error is detected **ERROR** is displayed, the incorrect parameter being indicated. After programming all parameters, rotate the main switch into position  and operate the **WSP** push-button. Consequently, the wheelhead is brought into the starting position. The automatic machine cycle can be started by means of the main lever.


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

3.11 Parameters for the longitudinal cycle W#

No	MAIN SWITCH	ACTION	DISPLAY	NOTE
1			W#	The required number of the cycle should be selected by the handwheel.
			FV	Workpiece diameter, related to the absolute X-axis 〈 1 ÷ 700 〉 mm
			X00	Grinding addition at the reversal point 〈 0.0 ÷ 100 〉 mm
			X01	Grinding addition at the reversal point 〈 0.0 ÷ 100 〉 mm
			X02	Grinding addition at the reversal point 〈 0.0 ÷ 100 〉 mm
			:	- " -
			X50	Grinding addition at the reversal point 〈 0.0 ÷ 100 〉 mm

With the **INC** key operated, the parameter value can be adjusted by means of the handwheel (the **INC** push-button should remain depressed).

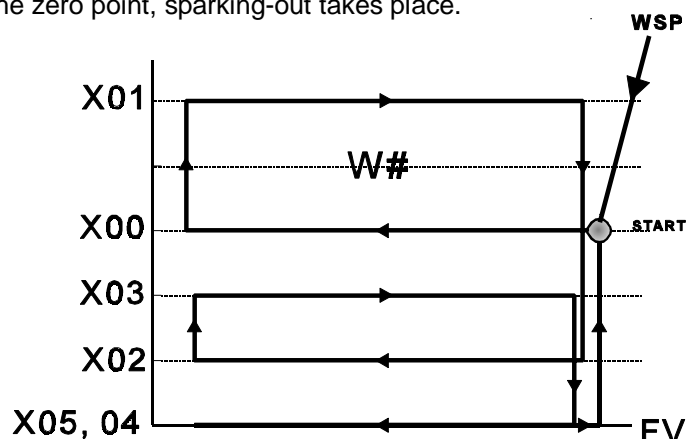
After the grinding allowance (relative position with respect to FV) has been programmed at the reversal point the handwheel should be rotated to the next parameter which is then programmed. Up to 50 values of grinding addition can be programmed. For programming the end of the automatic cycle, the **RES** key should be operated. As a result, the END OF GRINDING message appears on the display instead of the GRINDING ALLOWANCE AT REVERSAL POINT message, so that the following parameters cannot be called. Nevertheless, the END OF GRINDING indication can be cancelled by means of the **RES** key to resume programming.

After all parameters have been programmed the main switch should be rotated to position  and 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.

The automatic cycle proceeds in such a way that, at the reversal point, the wheelhead is moved into the relative position with respect to FV, which can be programmed as Xnn. If the same value is programmed several-times consecutively the wheelhead is not displaced at the reversal point, sparking-out being provided. Withdrawal from the workpiece can be programmed so that the following value is larger than the preceding one.




Example of the grinding program with travel without contact with the workpiece:

- FV =258.500mm Final size, related to axis a=
- X00 =1.500mm First grinding, the wheel is 1.500 mm in front of the zero point.
- X01 =2.500mm The wheel is withdrawn to 2.500 mm, i.e. 1 mm away from the material.
- X02 =0.500mm Second grinding, the wheel is 0.500 mm away from the zero point, i.e. with chips of 1 mm.
- X03 =1.000mm The wheel is withdrawn to 1.000 mm, i.e. 1 mm away from the material.
- X04 =0.000mm Third grinding, the wheel is at the zero point, i.e. with chips of 0.500 mm.
- X05 =0.000mm The wheel remains at the zero point, sparking-out takes place.
- X06 =0.000mm **RES** End of grinding




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=2.000	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			x=0.000 x=2.000	After the workpiece has been ground to its final size the automatic cycle is terminated, wheelhead 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	-0.012	With the WSP push-button depressed, the amount of correction related to the diameter (positive or negative) can be adjusted by means of the hand-wheel.
3.		WSP	x=2.012	On release of the push-button, the WSP position corrected by the amount of correction is displayed.
4.		WSP	x=2.000	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 0.127 mm.

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	ACTIO N	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.			$l=0 \quad r=0 \quad A$	Change-over to the control mode A is made by means of the handwheel.
4.		RES	$x=0.000$	The display is cleared by the RES push-button.
5.		WSP + 	-0.065 $X=0.065$	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 5 mm). On release of the WSP push-button, 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.			$X=0.065$ $l=15 \quad r=12$	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 cancelled 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% (**VERRIDE**) 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=560	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 $\mu\text{m}/\text{min}$, related to the workpiece diameter. This speed is adjusted in steps of 20%.
5.		RES	x=0.000	On operation of the RES push-button, the display is cleared.
6.		WSP + 	-0.15	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 5 mm taking place on the display).
7.		WSP	x=0.150	On release of the WSP push-button, the amount of grinding allowance is displayed.
<p>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.</p>				





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
4			#0÷2,P3÷P4 #5÷7,A8÷A9 C/C, T	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 "0.000" 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 "0.000". 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.

*/ On the machine with motor-driven table feed, the dressing stops of the table are set at ± 60 mm away from the actual position of the table. Their position can be readjusted by bringing the table into a new position and operating the corresponding key for setting the stop. If the diamond is on the left-hand side of the grinding wheel operate the left key. If the diamond is on the right-hand side of the grinding wheel the right key should be operated.





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= 8.125 x= 0.000	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=-0.010 L x=-0.030 R x=-0.040 L x=-0.050 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=-0.050 x= 0.000	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=0.123	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=0.000 *	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=0.000 *	By deflecting the main level the table is brought into a position between the working stops.
5.		WSP	x=2.000 *	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=0.123	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=0.123	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=0.000 *	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=0.000 *	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 \gt the workpiece diameter, the order of operations 2 - 3 and 4 - 5 should be observed.

If the absolute diamond position \lt 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=0.123	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=0.000 *	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=0.000 *	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 \gt the workpiece diameter, the order of operations 2 - 3 and 4 - 5 should be observed.

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

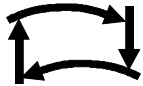
8. Progressive plunge-cut grinding

In this control mode, plunge-cut grinding can be carried out, according to program **#0** or **P**. In this case, a plunge grind having been completed, the wheelhead is brought back to the WSP position and the table is automatically moved by the amount of programmed wheel width. Thereafter, a new plunge grind is carried out. When the system incorporates facilities for progressive concave/convex grinding any concave-convex cylinder can ground progressively, employing program # 0 only.

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.			b=0.000	The symbol for wheel width adjustment (the amount of table feed) is set on the display by means of the handwheel.
2.		INC + 	b=80.000	With the INC push-button operated, the wheel width, i.e. the reduced amount of table feed (depending on the set table speed), is set on the display by means of the handwheel.
3.			P	The preprogrammed plunge-cut grinding cycle #0 or P is selected by the handwheel.
4.				The table is moved to the first plunge grind position by deflecting the main lever. By deflecting the main lever sideways, the direction of table movement in progressive plunge-cut grinding is determined. Table feed is started by a switch on the machine control panel.
5.			x=0.250	The working cycle is started by deflecting the main lever forward.

After the control system has completed the plunge grind the wheelhead is returned to the WSP position and the table is moved automatically by the amount of programmed wheel width. Thereafter, a new plunge grind is carried out. While the table is moved to a new position the wheelhead is not withdrawn at high speed, marker TM being displayed.

This cycle is repeated till the table, while travelling, strikes against the stop where the last plunge grind is effected, the control system being automatically switched over to the control mode **A**. (In this case, the "zero" in the mode **A** coincides with the "zero" of the preceding plunge grind). Then, longitudinal grinding in the control mode **A** can be carried out.



9. Concave - convex grinding

Preparation: Setting of stops, wheel dressing.

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1				The grinding wheel, after it has been dressed, is positioned with its center opposite the concave-convex workpiece by deflecting the main lever to the left or right. (Automatic table feed is stopped.)
2				By deflecting the main lever forward and rotating the handwheel, the wheel is brought into contact with the workpiece through wheelhead infeed. */
3		RES X/Z	Z=0.000	After operation of the X/Z key, the Z -axis position is reset by means of the RES push-button.
4			C/C grinding C/C	Change-over to the control mode C/C is made by the handwheel. The switch is in position [N].
5			D=1.234 Diameter in km	The switch is in position [P]. The diameter of the circle whose part will be the required concave-convex workpiece, is adjusted by means of the handwheel. With a positive value, a "bulge" is ground whereas, with a negative value, a "hollow" is ground. If 0 is entered a straight cylinder is ground, the possibility of correction being provided.
6		INC	E=0.080 I=05 C/C	On operation of the INC push-button, the increment I= or the amount of automatic wheel infeed can be adjusted. In the upper part of the display, the covered infeed length (E= the sum of all increments) is indicated which can be reset by simultaneous operation of the push-buttons INC and RES .
7		RES	X=0.000 z=0.000	The X -axis is cleared by the RES push-button.
8		WSP	-0.25	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.
9			X=0.250	On release of the WSP push-button, the amount of grinding allowance (positive value) is displayed.
10			x=0.247 Z=256.123	Automatic table travel at a preset speed is initiated by means of the table travel control switch. By deflecting the main lever, the automatic cycle is started. Wheelhead infeed is moved on an interpolation path with a preset diameter.
11				The wheel can be moved into the cut by means of the handwheel.

After the grinding addition has been ground off automatic sparking-out takes place due to the table traversing three-times its whole travel length, and the wheelhead is moved backward.

For calculating all parameters, a PC program is available on a diskette enabling the parameters to be calculated and a measurement report to be drafted. For the sake of information, an alignment chart has been included in these operating instructions. For calculation, the formula $(L/D)^2/h = D$ can be used. During calculation, a correction should be made with respect to the shape machined at longitudinal surface grinding surface (particularly with a specified small increase of height) and according to the mechanical work characteristics of both the wheel and the machine. In most cases, a correction is necessary.

Note: At concave-convex grinding, the whole surface of the workpiece is machined in both directions with a grinding addition at both reversal points.






On no account, the GRINDING ENABLE switch can be rotated to position "0".


*/ If a workpiece that has not the required shape (e.g., flat) is ground a sufficient distance between the wheel and the workpiece should be adjusted to avoid the risk of collision between the workpiece and the wheel.


9.1 Entering of diameter corrections, depending on the table position

The control system allows diameter corrections to be entered in steps of 16 mm at arbitrary table positions, depending on the table position. The total amount of correction is 0.254 mm per diameter. The corrections are effective only in the control mode for concave/convex grinding. If they are required to be used for straight longitudinal grinding the diameter of the envelope should be set to "0" (zero) in the concave/convex control mode. Then, the wheelhead follows only the correction curve provided that this curve has been entered.

The amount of deviations from the required shape is marked on the ground and measured workpiece in a suitable way, employing a felt-tip pen.

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.			correction d	For entering the corrections, the control mode d is selected by the handwheel.
2.				By deflecting the main lever sideways, the table is positioned so that the spot with an arbitrary marked deviation is opposite the grinding wheel.
3.			14	The marked deviation, including the sign (plus = decrease), is set by the handwheel.
4.				The table is brought into a position opposite the point of the next correction by the handwheel.
5.			-25	The following corrections are set by the handwheel. It is advisable that the end positions are set as zero positions.






With the switch in position  , the displayed value can be cleared by tipping the **RES** push-button, or all set corrections can be cancelled by operating the **RES** push-button for 5 sec. It is essential to note the difference between the zero correction value and the value which has not been adjusted at all (or has been cleared). With the correction value set to "0", the correction curve goes through the "zero", but the correction curve at the given point is not affected when no correction value has been adjusted, or the correction value has been cancelled.

Whenever the table crosses the set correction point the correction value appears on the display and can be changed by the handwheel, if required. When no correction has been set at the given point the marker ----- appears on the display. After the switch has been moved to position  the number of set correction points is displayed for a short time.

In the same correction entering cycle, the maximum value which can be entered is $\pm 99 \mu\text{m}$. In the following correction entering cycle (after changing over of the main switch), only a complement of the maximum range, i.e., $\pm 0.127 \text{ mm}$, can be entered at the point where a correction has been already set from the preceding cycle.



10. Form grinding

For form grinding, the two curves stored in EPROM and designated 1T and 2T can be used. Curve T3 can be transferred in the K 51 system from a PC. To create this program, special PC software is available.

No.	MAIN SWITCH	ACTION	DISPLAY	NOTE
1.				By deflecting the main lever to the left or right, the middle of the dressed wheel is positioned opposite the origin of the shape (Z = 0).
2.			1T	Form grinding is adjusted by means of the handwheel.
3.		INC	HR456-51	On operation of the INC key, the designation of the shape appears on the display.
4.		RES X/Z	X=0.000 Z=0.000	By means of the RES key, the Y-axis position is step by step reset, followed by resetting of the Z-axis by means of the X/Z-key.
		X/Z	e=0.058	The values of increments or the whole amount of material removal (e=) can be displayed successively, followed by the display of the Z-axis.
5.				The automatic table feed at a preset speed is initiated by means of the table feed switch. By deflecting the main lever forward, the automatic cycle is started. Wheelhead infeed is moved on an interpolation path of the preset diameter.
6.				The wheel can be moved into the cut by means of the handwheel.

11. Error messages

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

DISPLAY	FAILURE	REMEDY
<i>no WSP</i>	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.
<i>no Program</i>	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.
<i>no Hdr</i>	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.
<i>Error2</i>	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.
<i>Error3</i>	The feed motor has run against the limit switch at the end of the ball screw.	
<i>Error4</i>	Checksum error in EPROM	Replace EPROM.
<i>Error5</i>	Range of the axes has been exceeded.	Machine SET UP should be effected.
<i>Error6</i>	External function failure detected by diagnostics.	Switch off/on the system.
<i>Error7</i>	Checksum error in RAM	Replace RAM.
<i>Error8</i>	Parity error detected by diagnostics.	Switch off/on the system. If the failure recurs a repair is necessary.
<i>Error9</i>	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.
<i>Error10..16.</i>	Designed for machine failure messages.	See Operating instructions of the machine.
<i>Error20</i>	Error in communication with the I/O board.	Check the connecting optical cable.
<i>Error21</i>	Failure of potentiometer.	Check the condition of potentiometer.
<i>Error22</i>	End position of the table.	Retraction from this position can be made by the handwheel only.
<i>Error23</i>	End position of the table.	
<i>Error25</i>	X-axis servo switched off with failure.	Switch of/on the machine. If the failure recurs a repair is necessary.
<i>Error26</i>	Z-axis servo switched off with failure.	
<i>Error27</i>	Error in servo initialization.	
<i>Error28</i>	Error in setting of stops.	
<i>Error34</i>	Failure of the X-axis encoder.	Check the condition and connection of the encoder.
<i>Error28</i>	Failure of the Z-axis encoder.	
<i>Error36</i>	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.
<i>Error37</i>	Control deviation Z exceeded.	
<i>Error38</i>	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.
<i>Error39</i>	Z-axis servo failure.	
<i>Error40</i>	X-axis servo failure.	
<i>Error41</i>	Z-axis servo failure.	
<i>Error42</i>	Checksum error 1/2 EPROM.	Check all parameters in EPROM and program.
<i>Error43</i>	Checksum error 2/2 EPROM.	
<i>Error45</i>	The entered value for by-pass is small.	Program, according to the instructions.
<i>Error45</i>	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.

12. Supplements

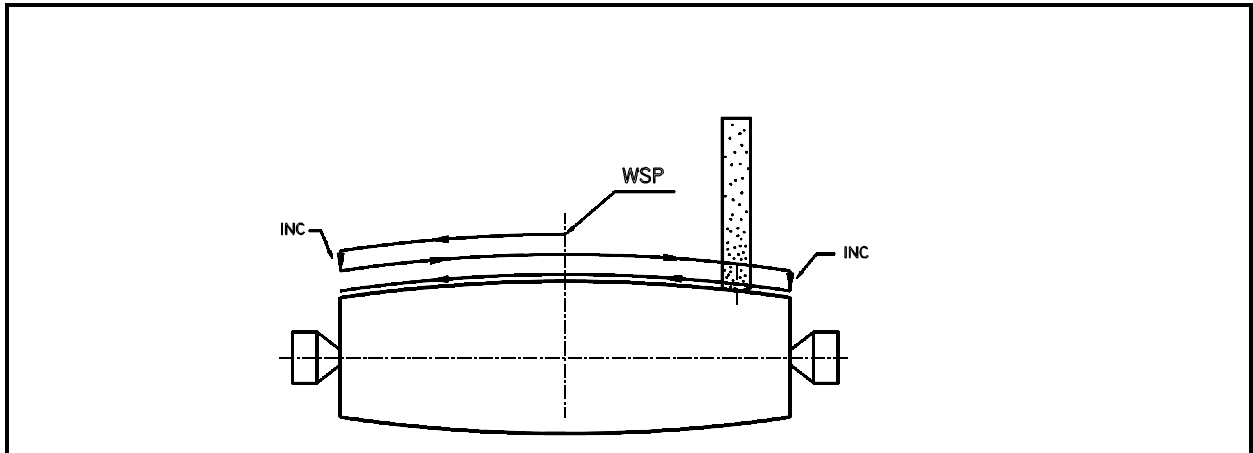


Fig.2 - Grinding wheel motion during concave-convex grinding

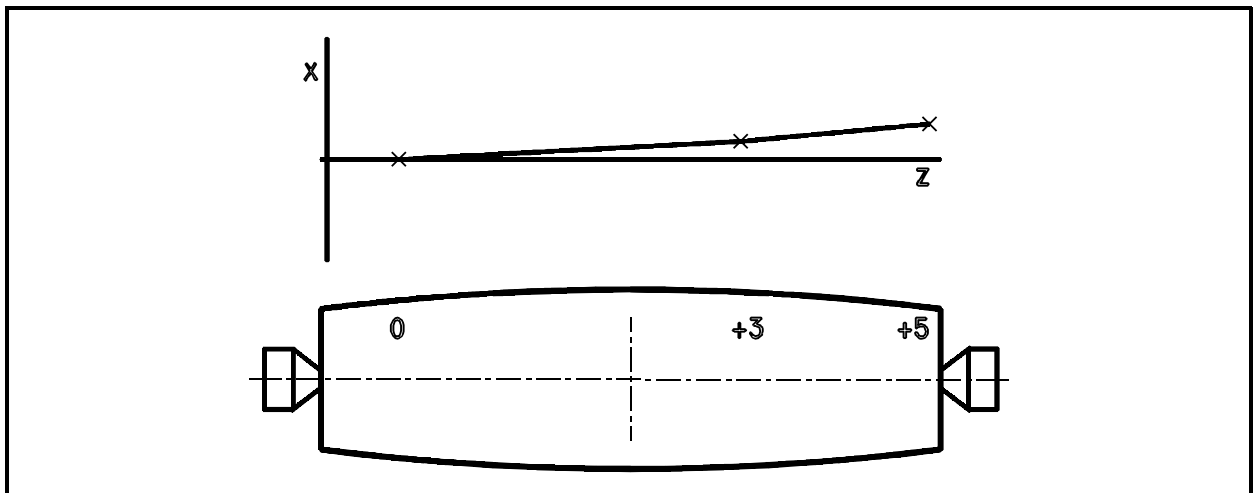


Fig.3 Taper correction

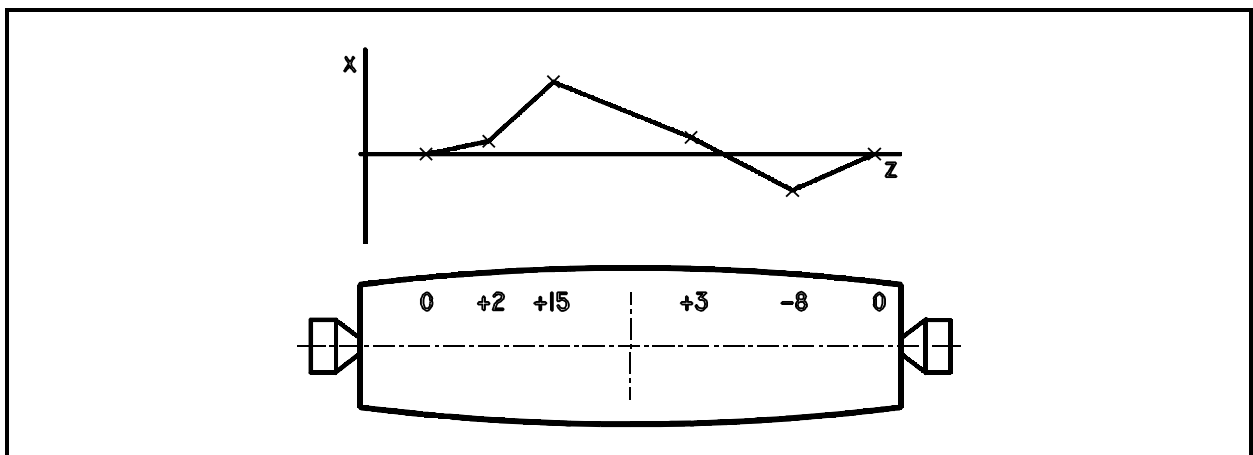








Fig.4 Form correction

12.1 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=0.000	On operation of the RES push-button, the display is cleared.
6			x=0.000 x=0.015	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.

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.