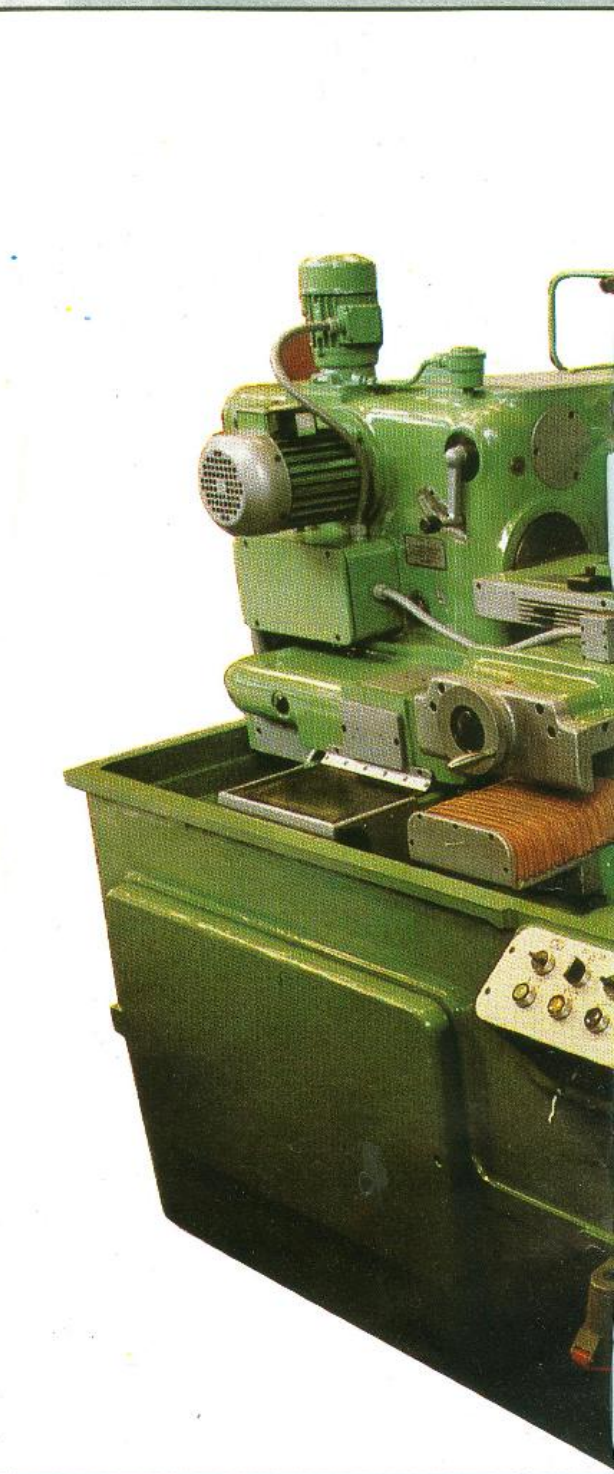
CSEPEL

WORKS MACHINE TOOL FACTORY

FKP 326-10 GEAR GRINDING MACHINE

CSEPEL WORKS MACHINE TOOL FACTORY has been producing machine tools for more than 60 years. 38000 CSEPEL machines are producing components in 56 countries of the world and this number is growing by 500-600 machines a year.
The Gear Grinding Machine using a worm grinding wheel in a generating process suitable for the precision, high productivity grinding of the gear profile has been built in batches since 1966.
The working area has been significantly increased, the machining accuracy has been improved and the high level of automation provides convenient operating conditions as a result of the continuous development.
Currently about 500 CSEPEL Gear Grinding Machines are grinding gears in different parts of the world.



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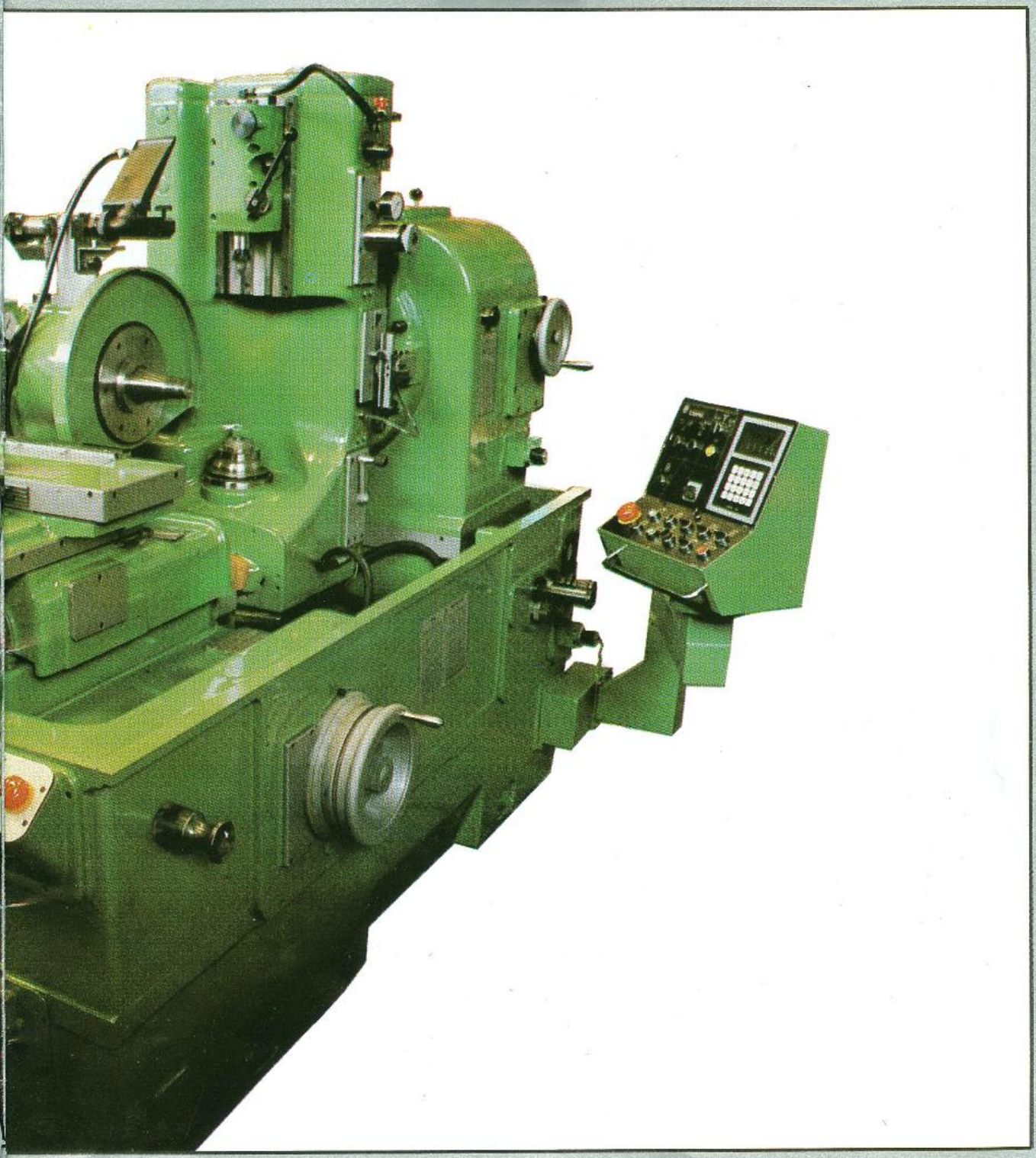


FKP 326-10

GEAR GRINDING MACHINE

TECHNICAL CHARACTERISTICS

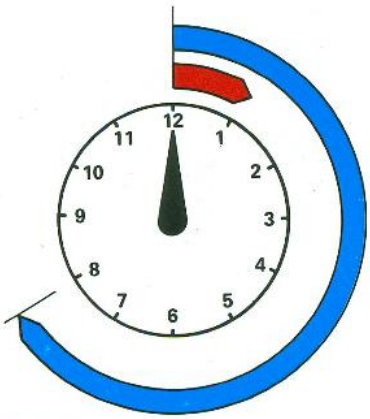
	FKA 326-10	FKP 326-10	FKP 326-10 S	FKE 356-10	
Component range					
Gear diameter – minimum – maximum	10 320	10 320	10 320	10 320	mm mm
Maximum width of gears	150	150	150	150	mm
Number of teeth range	10-260	10-260	10-260	10-260	z
Module range – single start dressing – double start dressing	0.5-6 0.5-3	0.5-6 0.5-3	0.5-6 0.5-3	0.5-6 0.5-3	mm mm
Diametral Pitch range – single start dressing – double start dressing	48-4 48-8	48-4 48-8	48-4 48-8	48-4 48-8	DP DP
Range of pressure angles – width chisel diamond dressing – width diamond wheel dressing	14°30'-30°00' as required	14°30'-30°00' as required	14°30'-30°00' as required	14°30'-30°00' as required	α α
Maximum helix angle	±45°	±45°	±45°	±45°	β
Maximum clamping length	420	420	600	420	mm
Maximum component weight including mandrel – at 0 ° helix angle – at 45 ° helix angle	80 40	80 40	80 40	80 40	kg kg
Machine characteristics					
Tailstock travel	180	180	360	180	mm
Maximum stroke of workslide	170	170	170	170	mm
Work feed per workpiece revolution in lead direction infinitely variable	0.3-3	0.3-3	0.3-3	0.3-3	mm/rev
Tangential inching of the workhead – maximum travel by manual control – automatic set tangential inching – automatic adjustable retract	95 4 0.3-2.5	95 4 0.3-2.5	95 4 0.3-2.5	95 4 0.3-2.5	mm mm mm
Automatic infeed of the grinding wheel per stroke of workpiece	0.01-0.05	0.01-0.05	0.01-0.05	0.01-0.05	mm/stroke
Grinding wheel diameter – maximum – minimum – bore of the grinding wheel	450 320 203	450 320 203	450 320 203	450 320 203	mm mm mm
Width of the grinding wheel	84, 104	84, 104	84, 104	84, 104	mm
Grinding wheel speeds – grinding – profiling	1500 56	1500 56	1500 56	1500 56	rpm rpm
Electric supply	380/50/3	380/50/3	380/50/3	380/50/3	V/cycles/ph
Power consumption	27	27	27	27	kVA
Weight of basic machine	6500	6500	6500	6000	kg

A = Production discontinued from 1990
P = With Programmable Logic Control
S = Built to special order only
E = Electronic control system. Batch production from 1990

WHAT IS THE ADVANTAGE OF THE GENERATING PROCESS?

PRODUCTIVITY

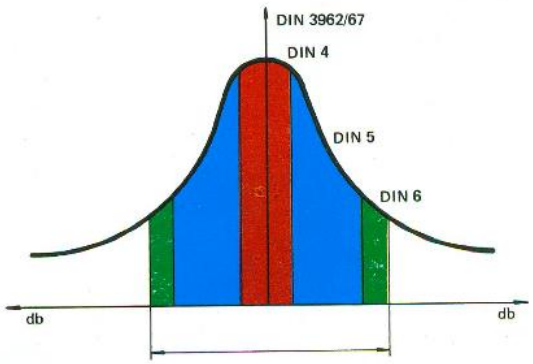
The productivity of the machines working with the principle of the generating process can be many times over of that of the profiling, single flank grinding machines. Gears between 0,5 and 1,5 modules can be ground off the solid gear blank.
The machining time can be further reduced by using a two-start or multiple-start worm wheel on gears up to 3 modules.
Generating process
Profiling process



Generating process

ACCURACY

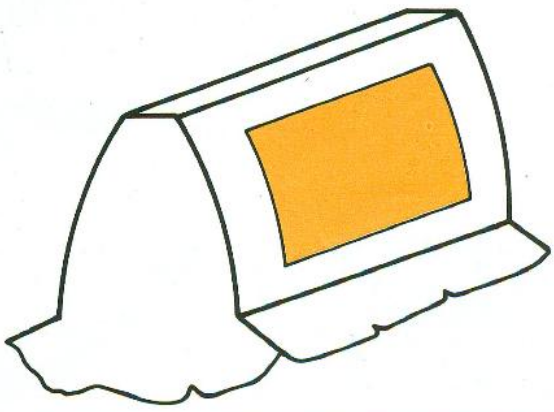
The accuracy of the final product depends on many factors.
Grinding with a worm wheel almost fully eliminates the pitch circle runout, the pitch base error and the chordal error. The involute and the lead errors mainly depend on the semi-finished product, the technology, the machine setting and the quality of the grinding wheel. It is true, generally speaking, that keeping to the productivity this process can improve two class grades on the accuracy of the semi-finished product.



Profiling process

IDEAL BEARING SURFACE

The accurate tip and root modification as well as the crowning can be easily achieved. Such a bearing surface can effectively reduce the noise level of the gears in mesh.

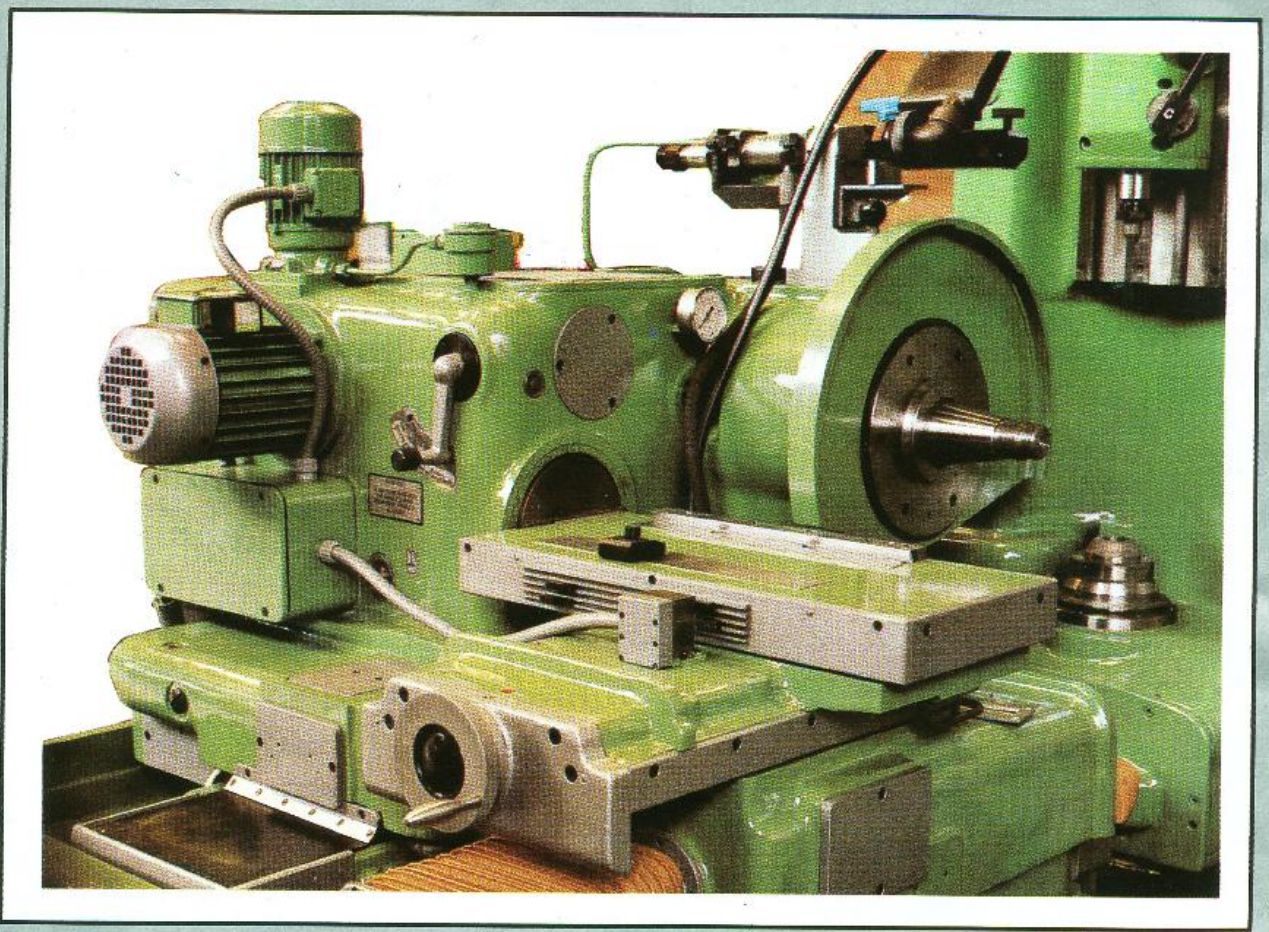

Gaussian curve of accuracy classification in batch production

INTRODUCING

FKP 326-10

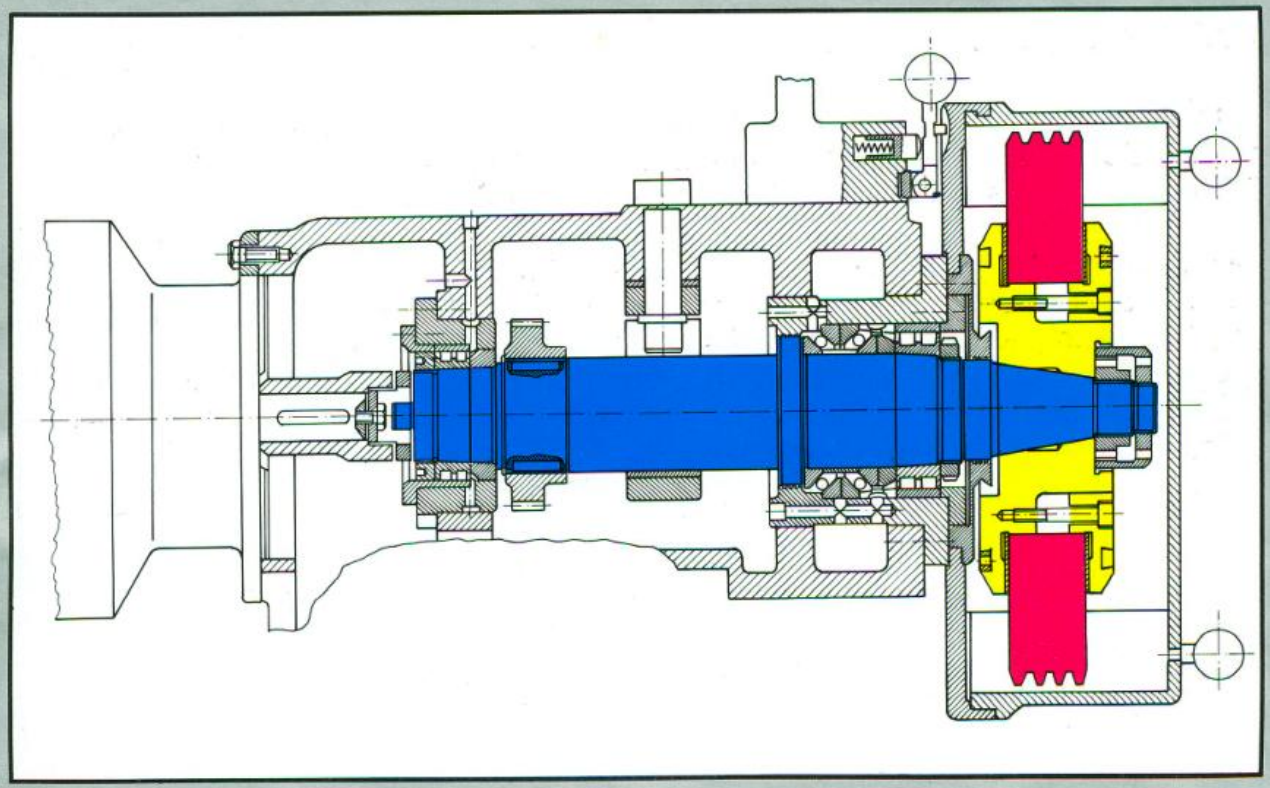
GRINDING SLIDE

The wheel head and the dressing slide are built on the grinding wheel slide. The grinding wheel slide travels on needle rollers at a right angle to the axis of the work spindle. The grinding slide can be operated manually, or in an automatic cycle according to a preset value. In case of a power failure the grinding slide automatically retracts to prevent the breaking of the wheel. The needle rollers are removed for transport and the wheel head is retained in a safe position by relief blocks to save the machine from potential damage in transit.



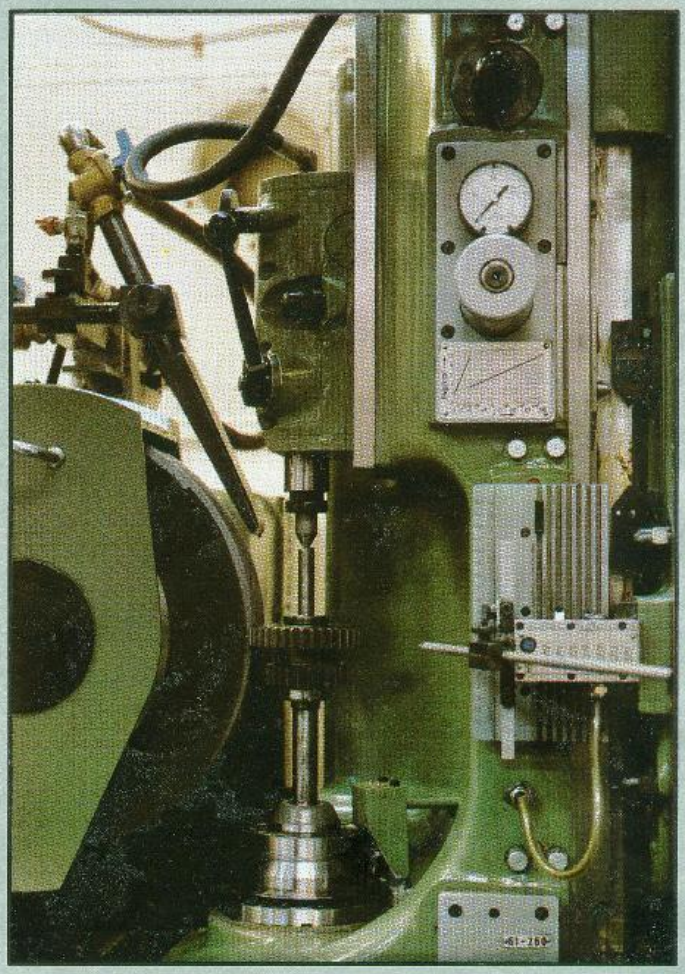
GRINDING SPINDLE

The grinding spindle house is made of mechanite casting and is stress relieved before machining. The high accuracy is achieved during the final machining on SIP and Dixi jig borers in a temperature controlled workshop.
The grinding spindle is made of hardened, high-tensile steel. Special care and skill is required to assemble the spindle in the housing. The bearings are of ultra precision accuracy grade, preloaded and dynamically balanced together with all the rotating parts before being built in.
The grinding spindle is coupled through an Oldham clutch to the driving motor which is also of special design and is dynamically balanced.
The grinding spindle is driven by an auxiliary motor during wheel dressing and profiling. The spindle must be stationary to engage the gears of this auxiliary motor.
A break with an adjustable breaking force is built in to stop the grinding spindle. The optimum breaking time is 10 to 20 seconds.
The grinding spindle taper running is accurate within $\pm$ 0,001 mm.



WORK SLIDE

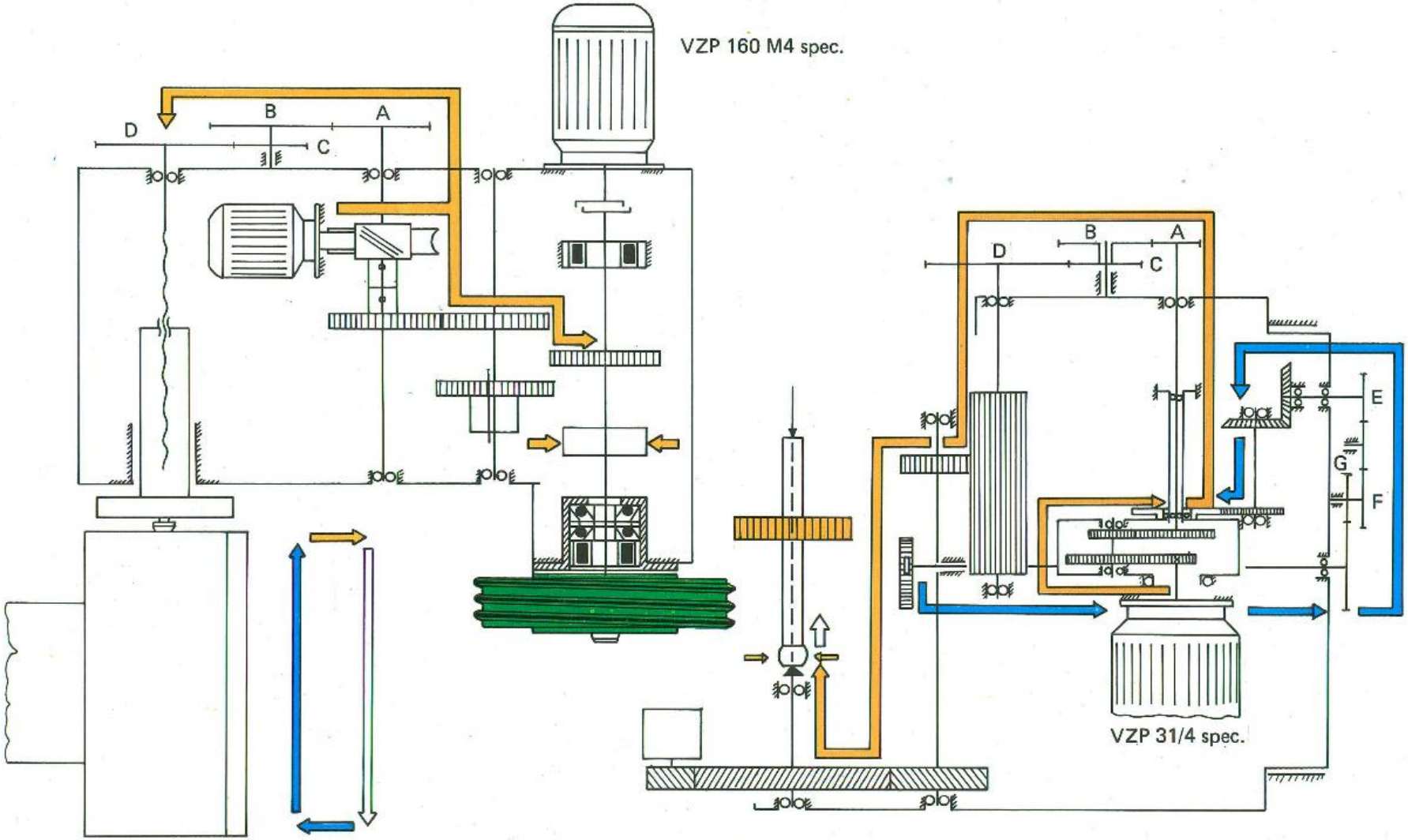
A rigid mechanite casting, which travels on a slideway at an infinitely variable speed, operated by a hydraulic cylinder. The gear to be ground held by a cylindrical or taper shank mandrel is supported between the centres of the work spindle and the tailstock and is clamped by a hydraulic collet. The collet on the work spindle will only close when the synchronised rotation between the grinding wheel and the work spindle is achieved.
On the model S the centre distance can be increased to 600 mm and the diameter of the gear can be 345 mm at a certain section of the work slide. Please refer to the drawing of the working area on page 14.
When heavy components or shaft gears are ground, hydraulic pressure can be applied through the tailstock centre.



WORK HEAD

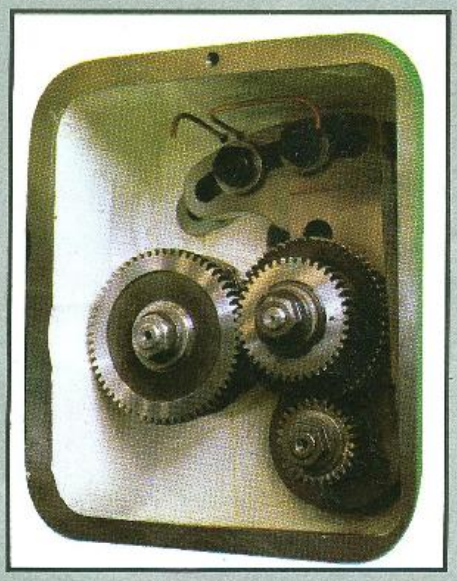
In the case of the FKA and the FKP models the workpiece is rotated from a synchronous motor, through a gearbox to the clamping collet.
Two separate change gear systems serve the correct machine setting when gears with different number of teeth and different helix angle are ground. The calculation and the fitting of these change gears must be made with utmost care. The nylon bushes which carry the change gears have to be kept in a good condition and should be replaced if signs of wear show on them.
A break pump provides the backlash elimination of the kinematic chain. The breaking is adjustable, and it has a significant effect when the grinding wheel starts or finishes cutting.

KINEMATIC SCHEME



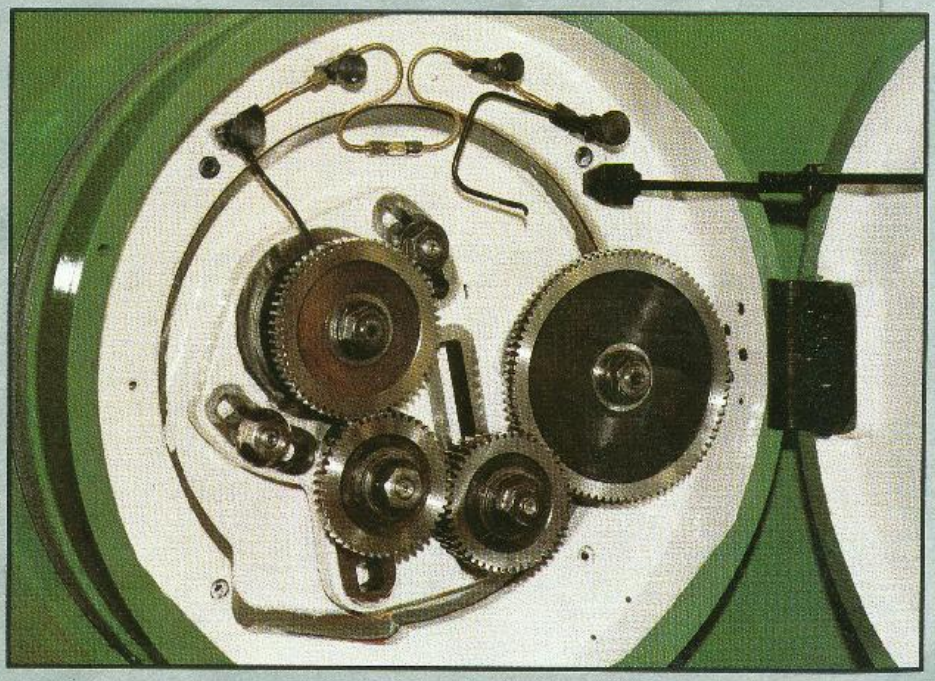
CHANGE GEARS

The wide range of gears to be ground requires flexible adaptation to the needs of the customer. The change gears in the kinematic chain help achieving this flexibility. The right choice, the accuracy and the correct fitting of these change gears may have a strong effect on the quality of the final product.



Change gears in the grinding wheel house for profiling different modules and Diametral Pitch values.

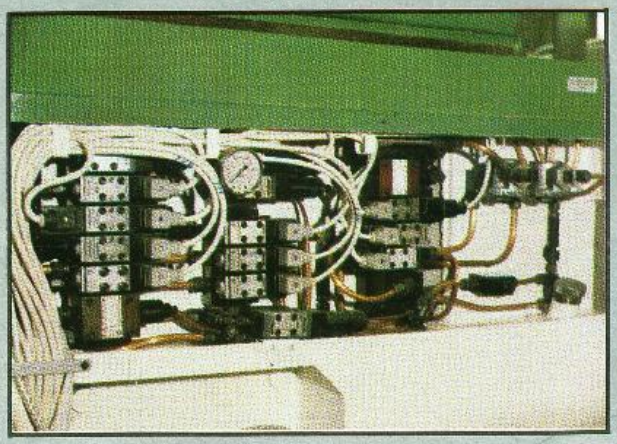
Number of teeth change gears on the top of the work head.

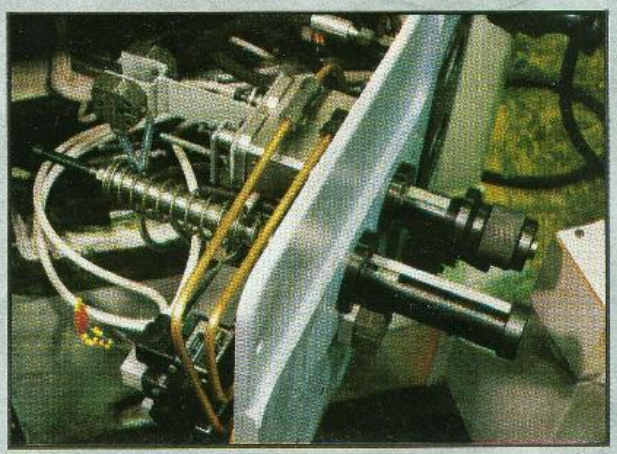


Differential gears for the additional movement required by helical gears are at the side of the work head.

HYDRAULIC SYSTEM

The automatic working cycle is operated by a central hydraulic system powered by a double pump of 18 and 20 bar capacity. A separate breaking pump is built in to eliminate the backlash in the work head gearbox and to control the process when the grinding wheel starts and finishes cutting metal.
In the case of a power failure the grinding head retracts in rapid traverse by 50 mm to prevent the breaking of the grinding wheel.
The pump of the coolant equipment delivers 30 litres of cutting oil per minute, but if required a second pump can be fitted as an extra to increase the supply of the coolant to 60 litres per minute. A centrifuge separates the dirt and the metal particles before recycling the coolant oil to the area of cut. It is important that the recommended type of coolant and hydraulic oil be used. Frequent checking, the cleaning of the filters and the centrifuge are also imperative.





PROGRAMMING THE FKP

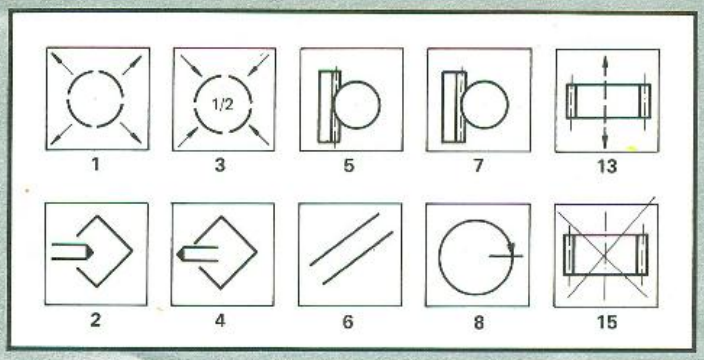
The Programmable Logic Control provides within the automatic working cycle a number of variations to achieve the best technology and the required quality. It is very easy to learn the programming of the machine.

Operations which can be preselected:

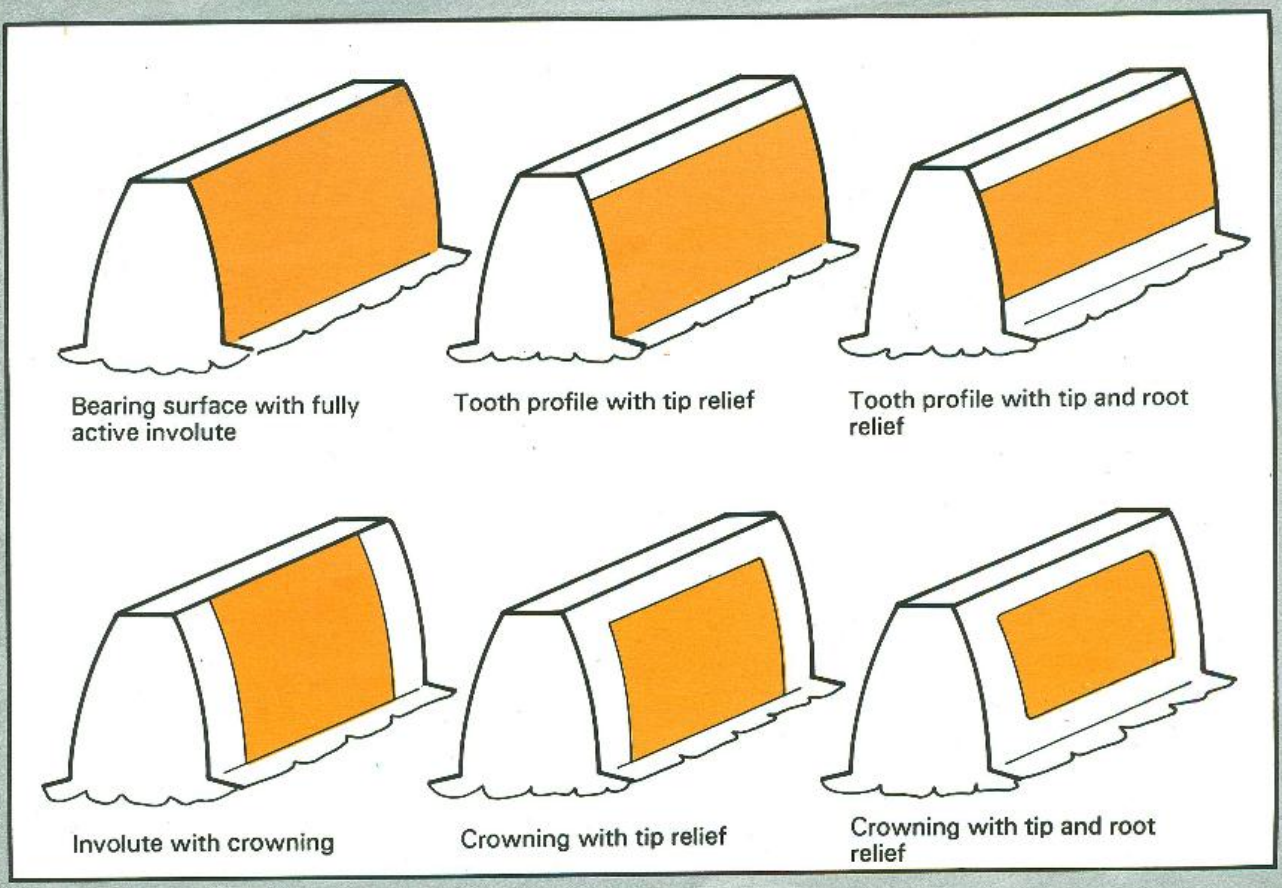
1. Basic cycle
2. Basic cycle + tangential travel of the workhead by manual control
3. Setting up
4. Wheel profiling
5. Wheel periphery dressing
6. Automatic cycle

Functions:

1. Collet open
2. Enter data
3. Collet half closed
4. Display data
5. 1st tangential inching
6. Clear data
7. 2nd tangential inching
8. Feed handwheel revolution counter
13. Beginning of sparkout
15. End of sparkout

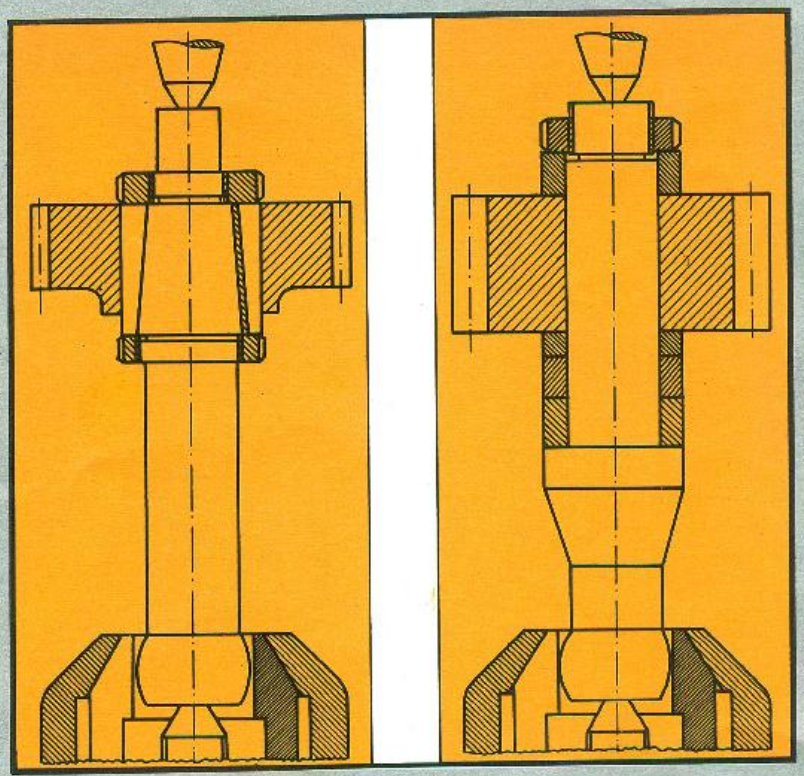


TOOTH PROFILES

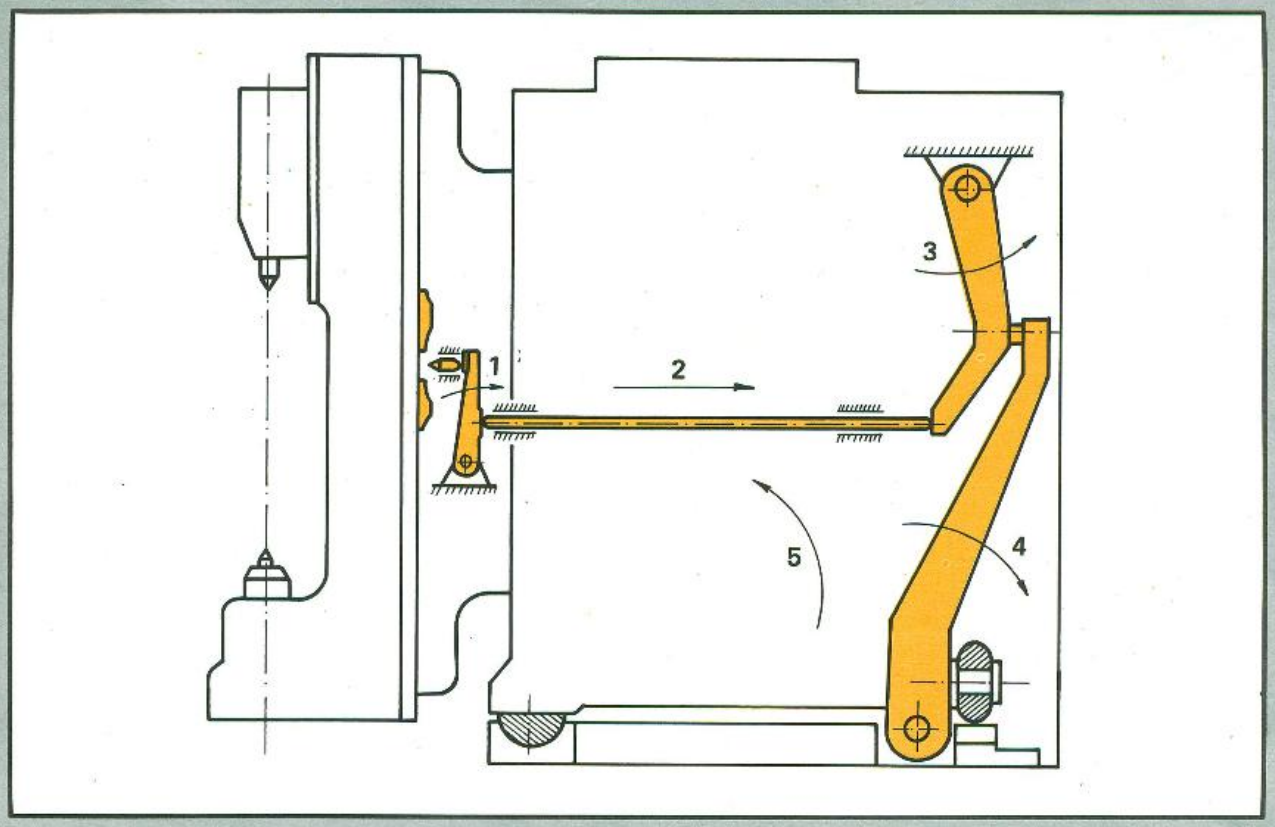


Clamping methods

The correct clamping of the components is one of the conditions of the accurate machining.
The standard clamping methods are the cylindrical workpiece mandrels with spacing rings and clamping nut, or alternatively, taper shank workpiece mandrels with hardened and ground expansion sleeves and clamping nuts.
Special clamping mandrels have to be designed for large diameter thin gears or shaft or block types of gears.

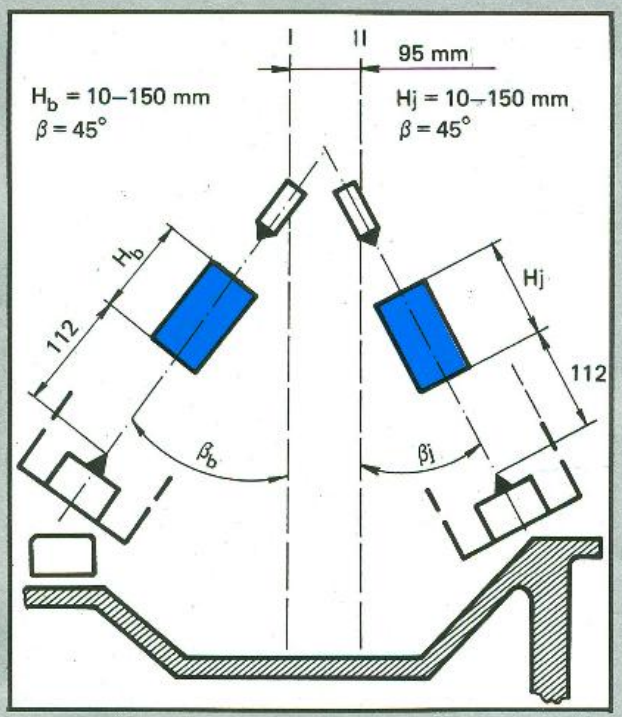


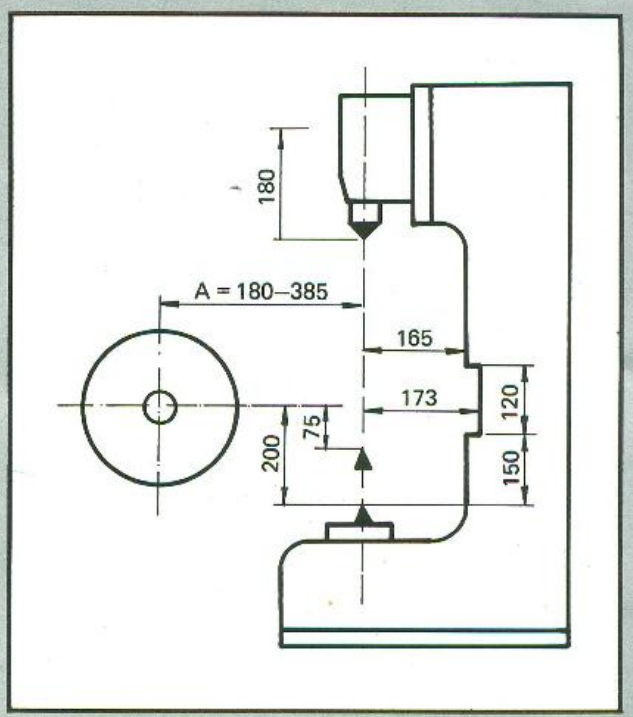
KINEMATIC SCHEME OF CROWNING



Specially designed templates are to be fitted onto the work slide to achieve the required crowning effect. The extent of crowning depends on the profile and the position of these templates.

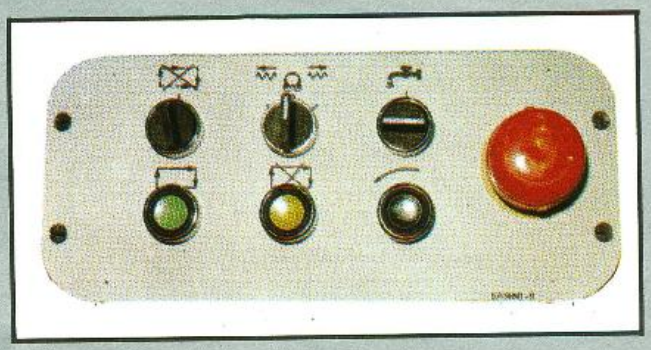
WORKING AREA



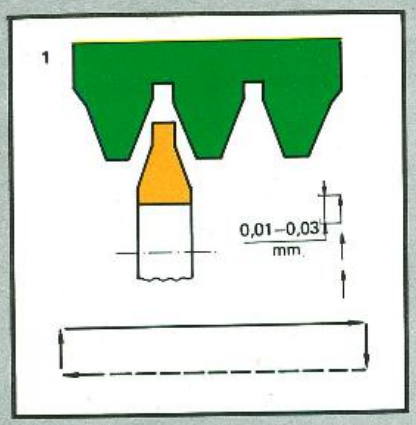


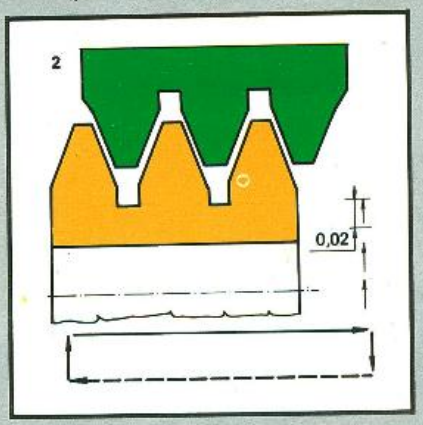
PROFILING THE GRINDING WHEEL

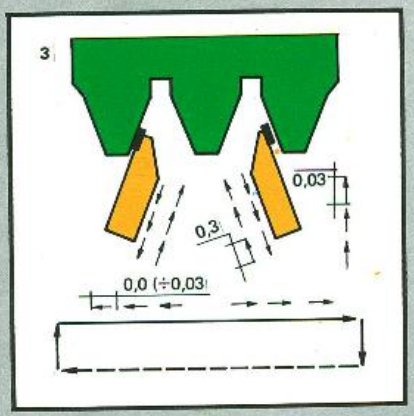
A highly accurate module or DP thread has to be cut into the periphery of the grinding wheel. The use of a preprofiled grinding wheel is recommended to save the machine from extra work load.
Forming the final profile and accuracy is a result of several subsequent operations done with great care.
The dressing control panel is retained at the left hand end of the machine adjacent to the dressing slide.

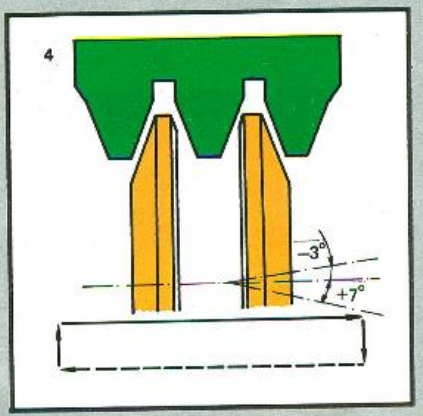


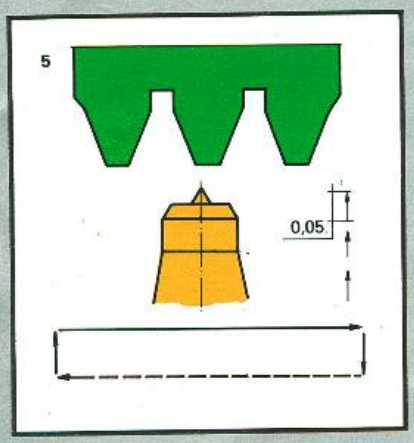
1. Root recessing
2. Preprofiling with rollers
3. Profiling with chisel diamonds
   or
4. Profiling with diamond wheels
5. Periphery dressing
6. Radius dressing
7. Profile modification with convex diamonds

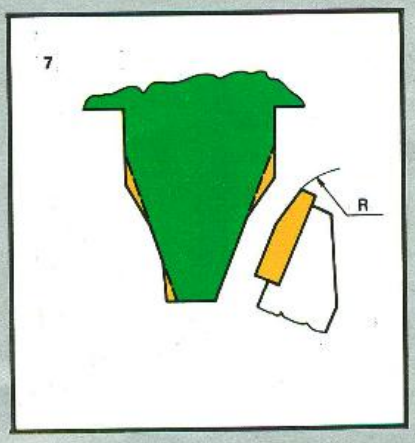


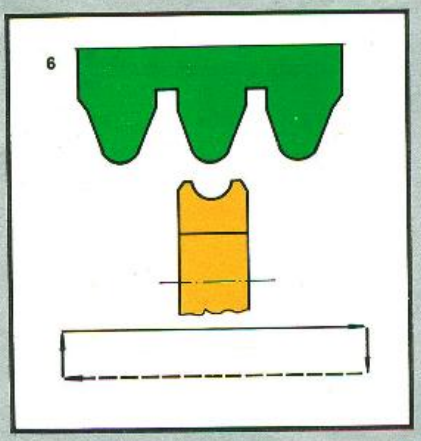




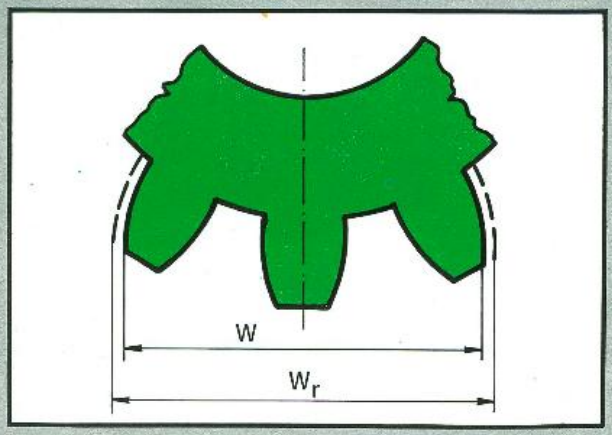








CHOOSING GRINDING TECHNOLOGY
CALCULATING GRINDING TIME



OPTIMAL GRINDING ALLOWANCE (r_{to})

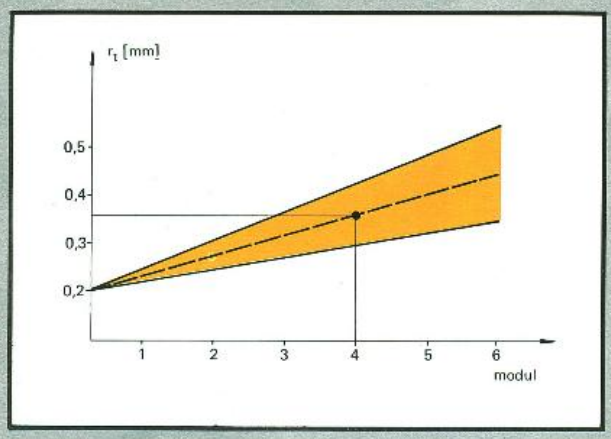
The grinding allowance highly depends on the tendency of the material to deformation. Economic production requires optimal grinding allowance.

W_r = chordal measurement with allowance
W = chordal measurement
r_t = chordal allowance ($W_r - W$)
V = total work feed of the grinding wheel
K_2 = constant

$$V = \frac{W_r - W}{2 \sin \alpha} = r_t \times K_2$$

K_2 = 1,4619 if pressure angle α = 20
K_2 = 1,9318 if pressure angle α = 15

Larger allowance will increase the grinding time. Smaller than optimal allowance requires more accurate premachining and this in turn is increasing the potential of rejects.

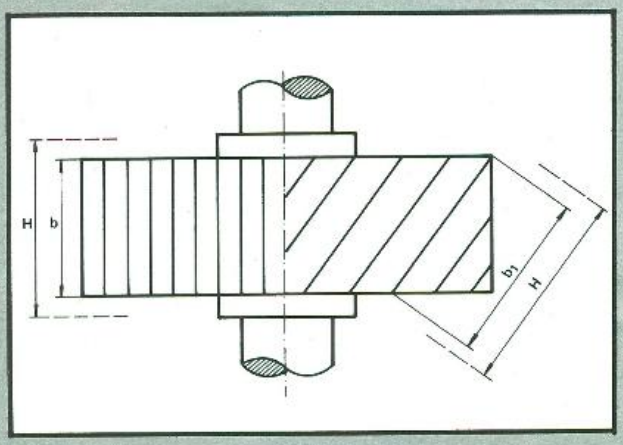


CHOOSING THE GRINDING WHEEL

Module	Grain material	Grain size	Hardness of bond	Density	Bonding material
0,5-1	EKw	180	K	15-20	X
1,25-1,75	EKw	150	K	15-20	X
2-3,25	EKw	120	K	15-20	X
3,5-4	EKw	100	K	15-20	X
4,5-6	EKw	80	K	15-20	X

The module, the quality and the hardness of the material to be ground determine the choice of the grinding wheel.
The chart is a recommendation for choosing the wheel quality based on the module according to Winterling specification.

GRINDING LENGTH (H)



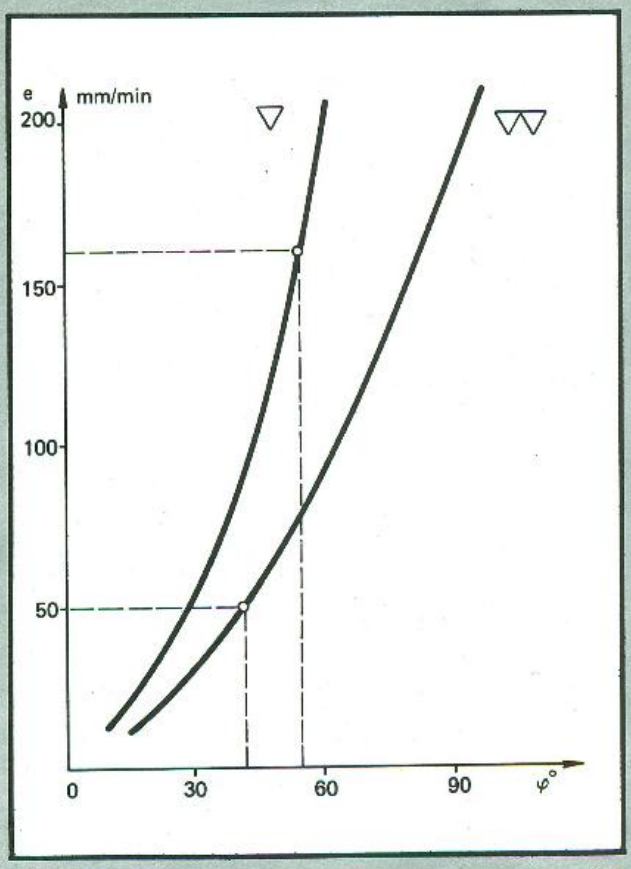
Spur gears:
$H = b + 1{,}5$ module
Helical gears:
$H = b_1 + 2$ module

DEPTH OF CUT (f)

The depth of cut can be preselected on the machine between 0,01 and 0,05 mm per stroke of the workpiece.
The depth of cut has to be selected by the technologist depending on the quality of the material to be ground, the quality of the grinding wheel, the method of component clamping and the feed.

THE FEED (e)

The feed can also be preselected using the monogram shown here. In this case the feed is defined in mm/minute.
φ = rotation angle of the setting valve
The feed can be selected between
e_n = 30 to 160 mm/minute for roughing
e_s = 10 to 60 mm/minute for finishing
depending on the module and the number of teeth.
The automatic system will switch from roughing feed (e_n) to finishing feed (e_s) according to the program.



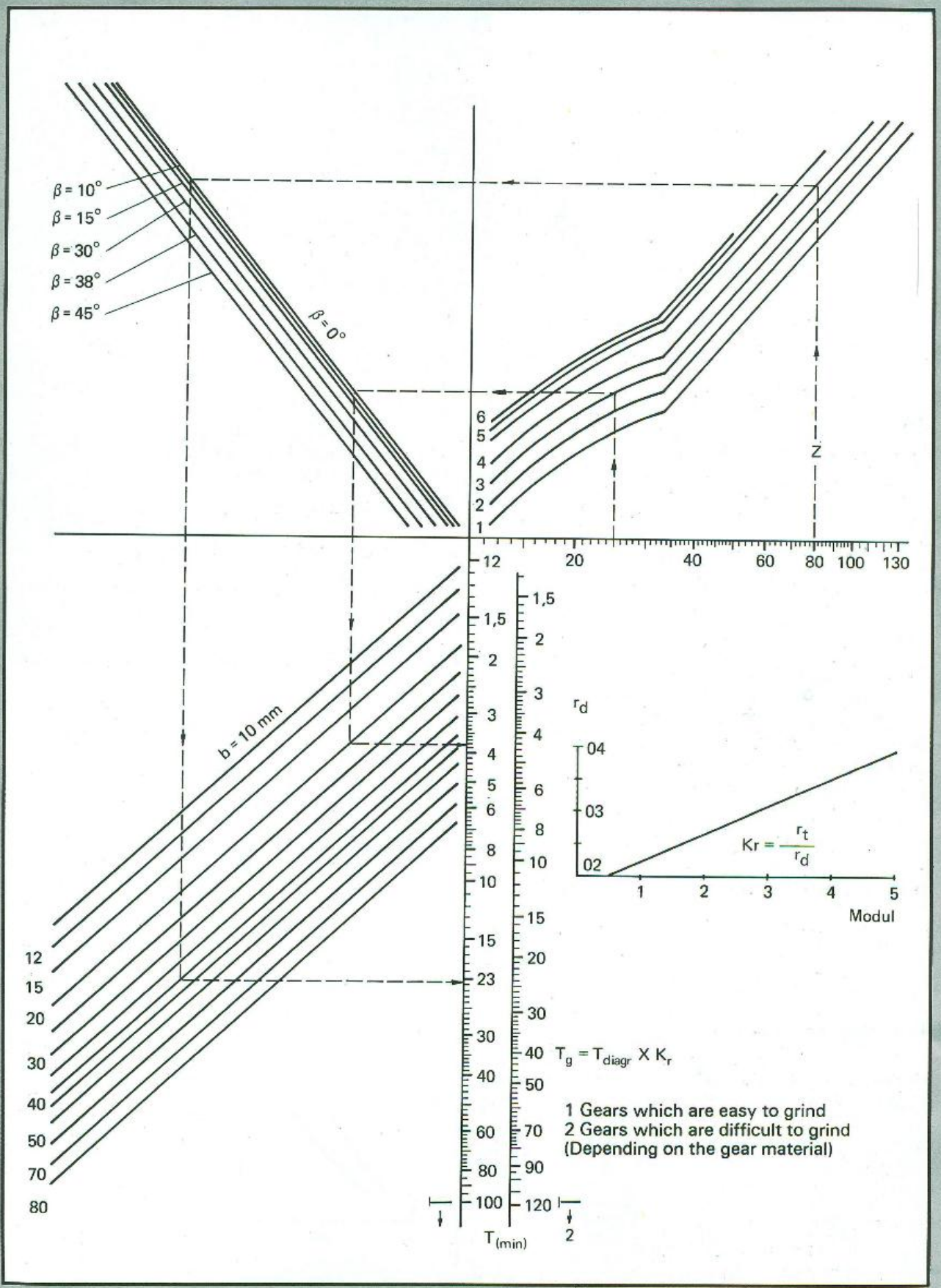
THE NUMBER OF CUTS (i)

The number of cuts depends on the amount of allowance and the depth of the cut.

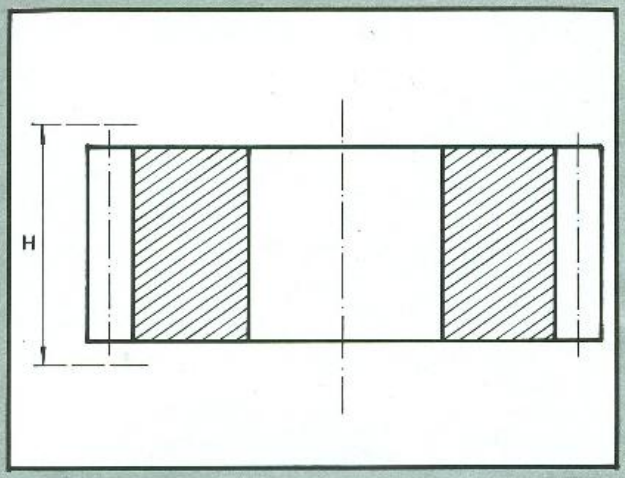
$$i = \frac{V}{f}$$

$i_{ö} = i_n + i_s$
$i_{ö}$ = total number of cuts
i_n = number of roughing cuts
i_s = number of finishing cuts

DETERMINING APPROXIMATE GRINDING TIME USING CHART



EXAMPLE TO SHOW HOW TO CALCULATE THE GRINDING TIME



GEAR DATA:

Module	$m = 3$
Number of teeth	$z = 80$
Pressure angle	$\alpha = 20^\circ$
Helix angle	$ß = 0^\circ$
Width of gear	$b = 32$ mm
Hardness	HRc = 58-62
Allowance	$r_t = 0{,}30$ mm

SELECTED TECHNOLOGY:

$f = 0{,}03$ mm

$e_n = 2{,}4$ mm/rev

$e_s = 1{,}0$ mm/rev

$$i_o = \frac{V}{f} = i_n + i_s = 13 + 2$$

WORKPIECE REVOLUTION:

$$n_t = \frac{1500}{z} = \frac{1500}{80} = 18{,}75\text{rpm}$$

MACHINING TIME:

$$T_{roughing} = \frac{H \times i_n}{n_t \times e_n} = \frac{36 \times 13}{18{,}75 \times 2{,}4} = 10{,}4 \text{ min}$$

$$T_{finishing} = \frac{H \times i_s}{n_t \times e_s} = \frac{36 \times 2}{18{,}75 \times 1} = 3{,}9 \text{ min}$$

$T_{machining} = T_r + T_f = 14{,}3$ min

AVERAGE SETTING UP AND DOWN TIMES

1. Full machine setting with wheel dressing, change gear setting and programming for grinding full involute gears	80 – 110 minutes
2. Full machine setting with wheel dressing, change gear setting and programming for grinding crowned, tip and/or root modified gears	110 – 140 minutes
3. Changing over for gears with same module, but different number of teeth	10 – 20 minutes
4. Wheel dressing with rollers and chisel diamond	30 – 40 minutes
5. Wheel dressing with rollers and diamond wheels	15 – 20 minutes
6. Component changing time	2 – 4 minutes

STANDARD ACCESSORIES

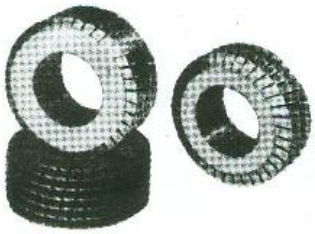
- Coolant equipment with centrifuge
- Wheel centre indicator
- Universal wheel flange
- One grinding wheel
- One centre for the tailstock
- One centre for the work spindle
- One cylindrical mandrel ø 30 mm
- One taper shank mandrel ø 40 mm
- LUB grease gun
- Machine lighting
- Wheel balancing arbor
- Taper gauge
- Set of wrenches and spanners
- Two instruction manuals
- Set of 78 precision change gears
  /z = 27 – 127/

OPTIONAL ACCESSORIES

WHEEL DRESSING DEVICE

SINGLE FORM RECESSING ROLLERS
Module range
0,5 – 1,25
1,5 – 1,75
2,0 – 2,5
2,75 – 3,25
3,5 – 4,0
4,5 – 6,0

MULTI FORM PROFILING ROLLERS
Range of 18 rollers
from 0,5 to 6,0 module
Range of 18 rollers
from 48 to 4 DP



WHEEL PROFILE CHECKING GAUGES
Pressure angle 15° and 20°
Module range 0,5 – 6,0
DP range 48 – 4
for easy checking of the wheel dressing.

PERIPHERY DRESSING DEVICE FOR THE FINE DRESSING OF THE WHEEL PERIPHERY.
1/2 carat industrial diamond is extra.

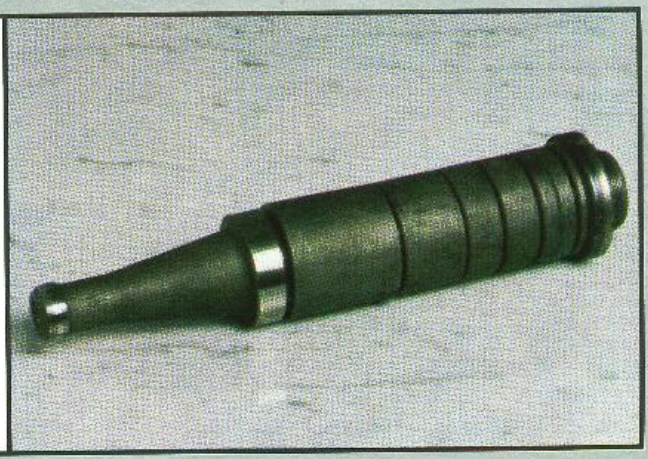
CLAMPING DEVICE FOR MANDRELS TO BE MOUNTED ON A FIRM WORKBENCH. to help fitting the gear on to the mandrels

PROFILE DRESSING DEVICE FOR USE WITH CHISEL DIAMOND TOOLS.

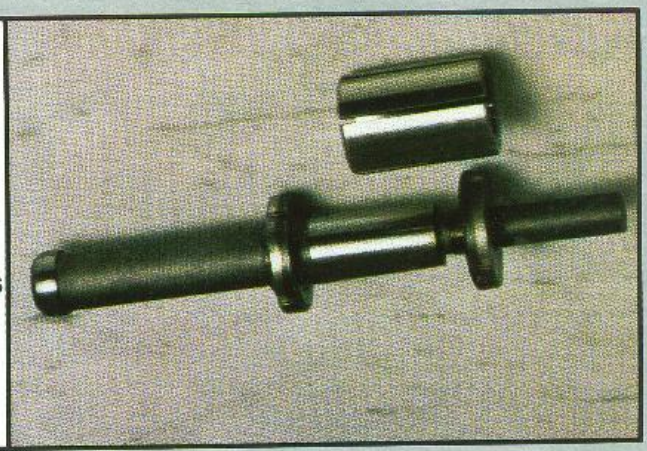
Dressing diamonds are extra:
- Pair of flat chisel diamonds
  m = 0,5 – 0,9
- Pair of flat chisel diamonds
  m = 1,0 – 6,0
- Pair of convex diamonds for modified profiles

CYLINDRICAL WORKPIECE MANDRELS COMPLETE WITH SPACING RINGS AND CLAMPING NUT.

Made within the range of 6 – 100 mm in 1 mm increments.
On special request mandrels with off-standard diameters can also be supplied.
Specially designed mandrels can be made to customer requirement.



TAPER SHANK WORKPIECE MANDRELS COMPLETE WITH CLAMPING NUTS AND ONE HARDENED AND GROUND EXPANSION SLEEVE.
Made within the range of ø 14 – 100 mm in 1 mm increments.
Six taper shank mandrels cover the full diameter range. Only the expansion sleeves are different for each diameter.
On special request expansion sleeves with off-standard diameters can also be supplied.



REVOLVING CENTRES FOR THE TAILSTOCK.

The use of revolving centres is specially recommended when grinding with hydraulic centre pressure.
Short 18,5 mm centre for long components.
Long 73,5 mm centre for short components.

UNIVERSAL WHEEL FLANGE

GRINDING WHEEL
Ø 450 x Ø 203 x 84 mm
Ø 450 x Ø 203 x 104 mm

VOLTAGE STABILIZER

Current peaks and fluctuation have a strong effect on the quality of the ground gears.
The voltage stabilizer eliminates these damaging effects.

CYCLE CONVERTER
For use with 60 cycles electric supply instead of the standard 50 cycles.

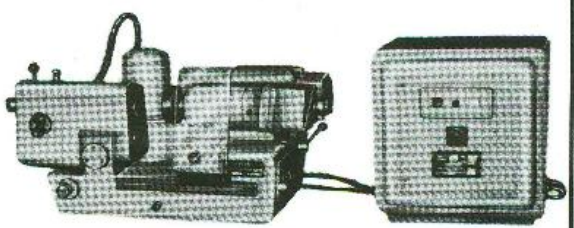
PIVOTED ARM SYSTEM TO SWING THE WHEEL ON TO THE GRINDING SPINDLE.
Helps lifting the grinding wheel to its working position without damaging the grinding spindle.

OIL MIST EXTRACTOR
High powered extractors can replace the standard version:
– ERNI CH-E-1200
– DYNAPURE CH-310
– Termo Plasztika TPMV 1001

CENTRES WITH TUNGSTEN CARBIDE TIP CAN BE SUPPLIED FOR

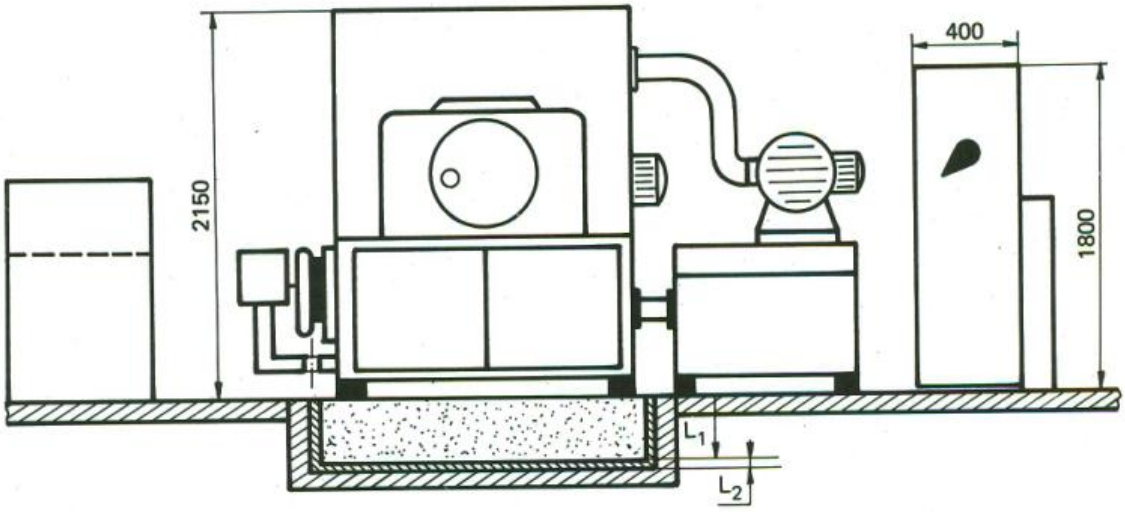
– the tailstock
– the work spindle

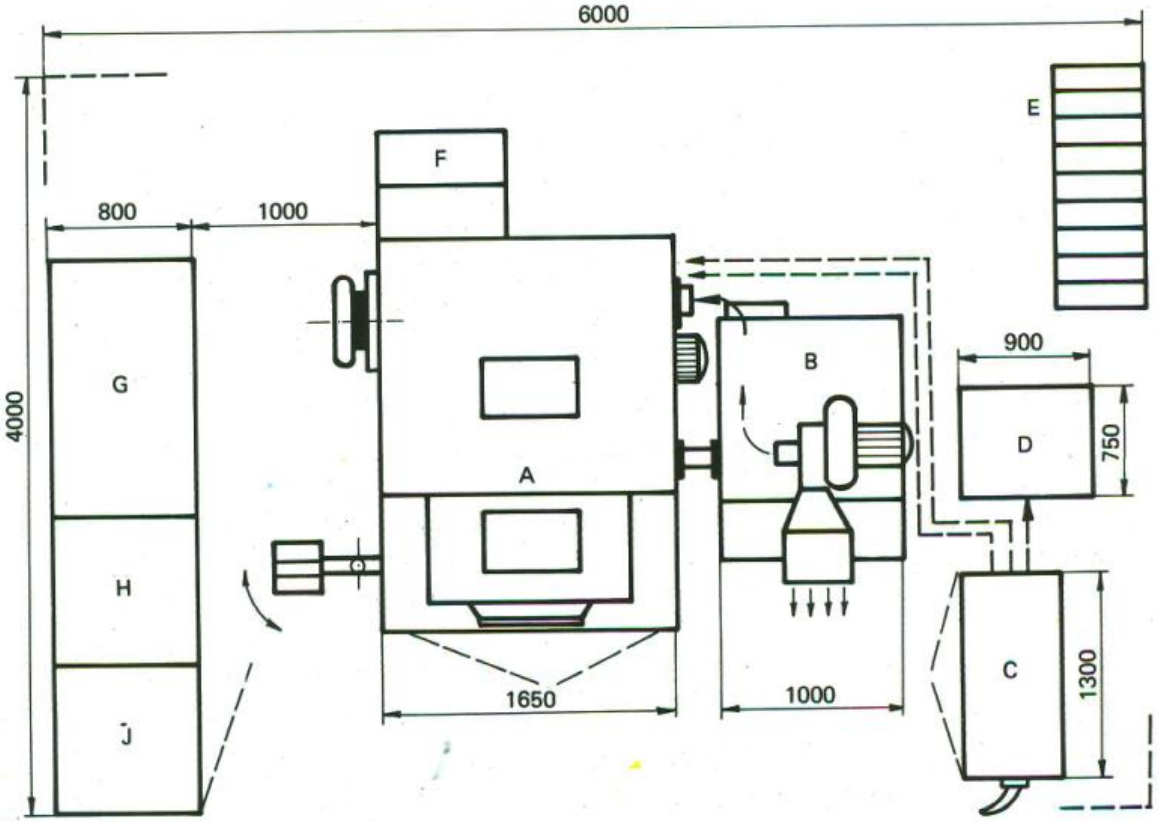
DIAMOND LAPPING MACHINE GC-1



EXTRA CHANGE GEARS IN ADDITION TO THE RANGE OF STANDARDS m = 2
z = 29, 31, 33, 34, 37, 41,
z = 47, 51, 53, 54, 55, 57, 58,
z = 59, 61, 62, 63, 65, 68, 69,
z = 74, 75, 76, 81,
z = 88, 91, 92

FOUNDATION AND SPACE REQUIREMENT





A = Gear grinding machine
B = Coolant equipment with the oil mist extractor
C = Electric control cabinet
D = Voltage stabilizer
E = Storage rack for grinding wheels
F = Platform with stairs
G = Work bench
H = Cabinet for the accessories
I = Cabinet for the change gears
Units E to I are to be supplied by the customer

L_1 = The depth of the foundation depends on the soil structure.
L_2 = 20-30 mm thick rubber sheet to absorb environmental vibrations.

Workpiece storage place

Sand filling

Unclamped levelling blocks

Concrete base