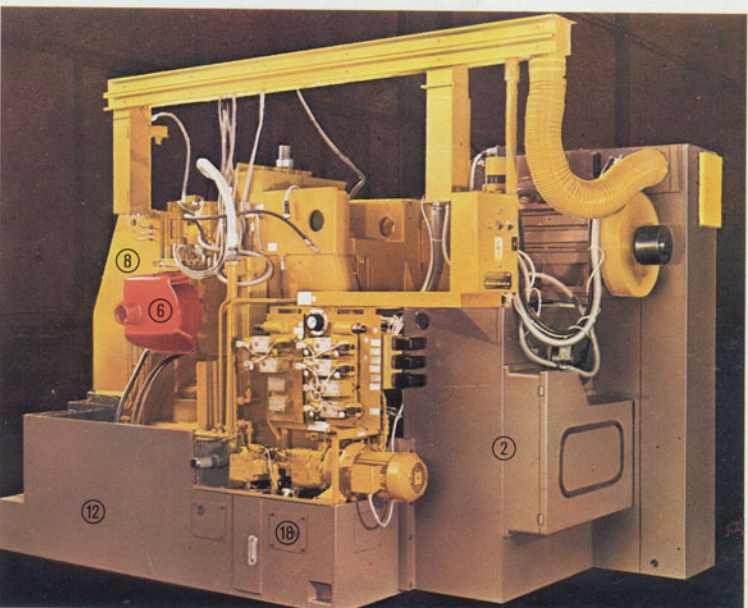
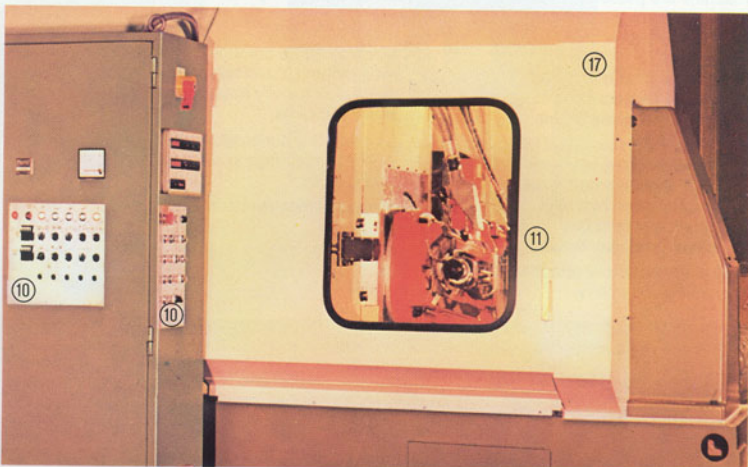


Jlts. 5 and 6
Operator's view

Jlt. 7
Rear view (complete enclosure of work area removed)

- | | |
|--|---------------------------------------|
| ① Machine bed | ⑧ Tailstock column |
| ② Separate gear box | ⑨ Tailstock |
| ③ Radial slide (hob moves radially to workpiece) | ⑩ Control panels |
| ④ Axial slide (hob moves axially to workpiece) | ⑪ Splashguard door |
| ⑤ Tangential slide (hob moves tangentially to workpiece) | ⑫ Coolant reservoir |
| ⑥ Hob head | ⑬ Chip conveyor |
| ⑦ Work table | ⑭ Chip box |
| | ⑮ Control cabinet (free-standing) |
| | ⑯ Programmable controller (PC) |
| | ⑰ Complete enclosure of work area |
| | ⑱ Coolant and hydraulic oil reservoir |



Concept for a new design

Production hobbing machine for transmission gears up to 350 mm (13.8 in.) diameter to meet the following requirements: High static and dynamic rigidity, high thermal stability, easily automated, high table speeds (for hobbing gears with small numbers of teeth and for use of multi-start hobs).

Elimination of backlash in table and feed drives, efficient chip removal, no separate auxiliary units, high accuracy and consistent performance, convenient operation, quick and easy set-up, simple maintenance, compliance with environmental protection standards.

The PA 320

Excellent thermal stability

All major sources of heat in the machine are placed to reduce their influence upon the accuracy of the gear produced:

- Separate gear box ① at end of machine bed contains most of the drives and transmissions;
- coolant reservoir ② and lubricating and hydraulic oil reservoir attached to side of machine bed. Coolant, lubricating and hydraulic oil flow through machine bed for a more uniform heat distribution;
- all electric motors attached to the machine externally.

High static and dynamic rigidity

These properties essential for any modern heavy-duty machine are assured by:

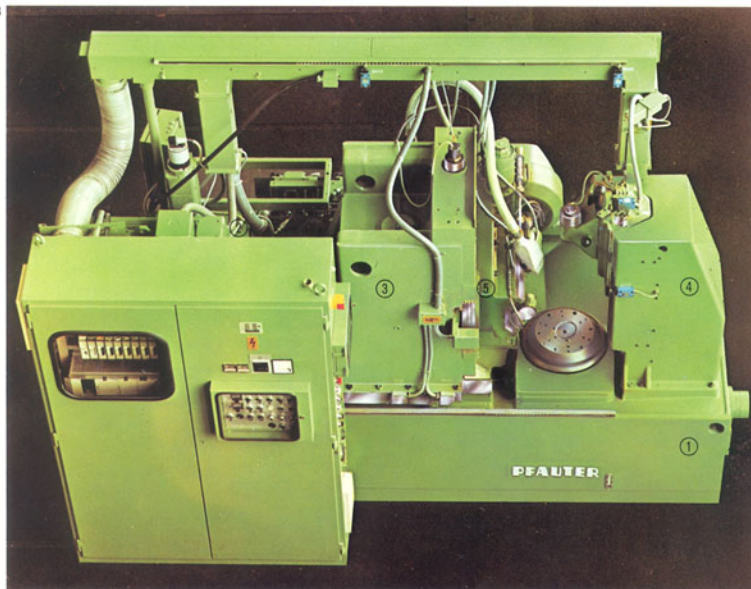
- Machine frame components (bed ①, main column ② and tailstock column ③) heavily ribbed without major openings;
- a generously dimensioned hob head ④ with roller bearings and a very rigid hob spindle;
- a double index worm drive ⑤.

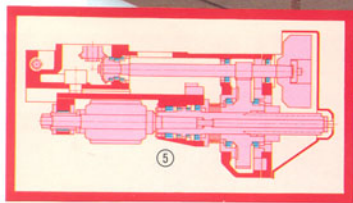
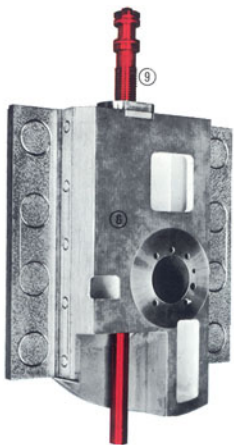
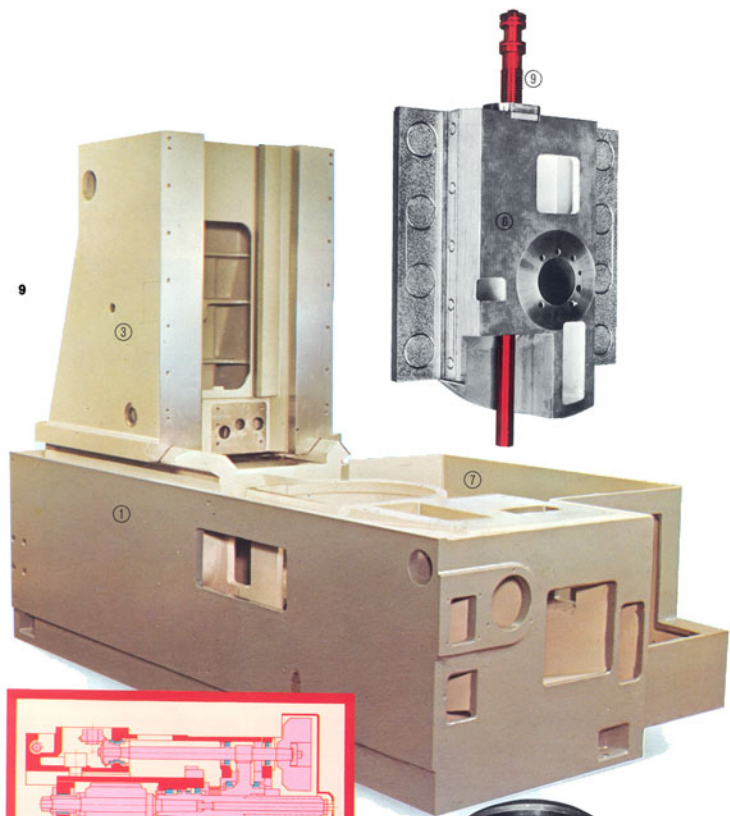
JII. 8
Top view

High geometric and kinematic accuracy

These properties important for the accuracy of the workpieces produced are achieved by:

- A recirculating ball-type axial feed screw ⑥ with zero backlash and virtually no wear;
- double index worm drive ⑤ hydraulically loaded to maintain constant flank contact under all conditions including high table speeds;
- precision manufacture and high final transmission ratios of the gear trains.

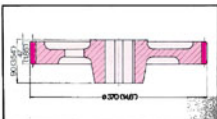




Jil. 9
 Bed ①, main column ①, hob head ②,
 axial slide ③ with recirculating ball screw ④,
 coolant reservoir ④ and
 double index worm drive ⑤.

High performance and accuracy

The design of the machine frame and gear train assure maintenance of high production rates with high accuracy up to the rated capacity of the machine.



Hobbing of a cylindrical spur gear

Workpiece data		
Module	5 mm	D.P. 5
Number of teeth	72	
Face width	47 mm	1.85 in.
Material	GGG 50	

Hob data		
Type	HSS hob with inserted segments	
Accuracy class	AA DIN 3688	
Tip diameter	119 mm	4.69 in.
Number of starts/hand of hob	1/R.H.	
Toothed length	160 mm	6.30 in.
Number of tooth segments	12	

Machining data		
Operation	Finish hobbing	
Number of gears damped	2	
Cutting speed		
- 1st cut	60 m/min	197 sfm
- 2nd cut	71 m/min	233 sfm
Hob speed		
- 1st cut	160 min ⁻¹	
- 2nd cut	190 min ⁻¹	
Axial feed		
- 1st cut	7 mm p.t.*	.278 i.p.t.*
- 2nd cut	2 mm p.t.*	.079 i.p.t.*
Axial feed direction		
- 1st cut	Climb hobbing	
- 2nd cut	Conventional hobbing	

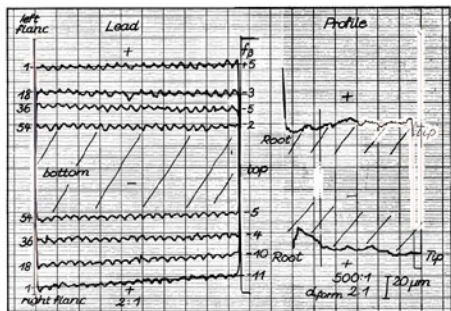
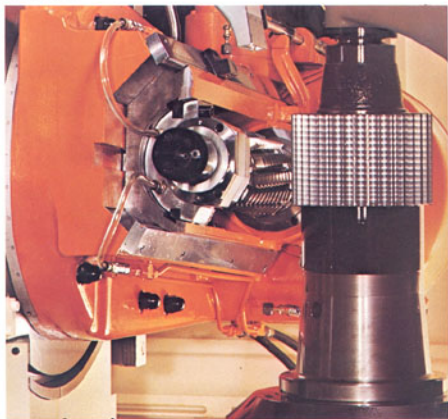
Hobbing time	
Hobbing time per stack	28.1 min
Hobbing time per piece	14.1 min

Hob life	
Hob shift per stack	3.5 mm .138 in.
Hob wear/total tooth length	.5 mm/176 m .020 in./577 ft.
Number of gears hobbled per sharpening	52

* mm or in. per workpiece revolution

J11.10
Workpiece described in the above example

J11.11
Strip-chart recording of the test results of the workpiece described in the above example.



10

11

Quick and convenient operation, set-up and maintenance

Operation

- All controls are arranged for ease of operation and set-up making the machine adaptable to both high volume production and small and medium lot sizes.
- All change gears have the same face width, bore and module (pitch) and can be used for any of the several drives.
- Neither a tie bar nor the complete enclosure interfere with free access to the work area of the machine from above. Heavy blanks or stacks of blanks can be easily loaded on the work table with a crane.

Numerical control

For the economical production of small series and single workpieces involving a number of time-consuming set-up procedures per shift the PA 320 is available with numerical control as PA 320 NC. The number of teeth, the number of hob starts, the helix angle of the gear, the hob head swivel angle, all slide travels, the finishing allowance and the amount of crown and taper are set conveniently and rapidly via decade switches reducing set-up time considerably. Hob speeds and feeds for first and second cut may be infinitely varied.

The mechanical gear train of the PA 320 was replaced in the PA 320 NC by individual drives of the various shafts linking the reciprocal machine motions electrically. Change gears, trip dogs, templates and set-up procedures are thus eliminated. (For more details on the PA 320 NC see separate brochure.)

Maintenance

Easy maintenance over long intervals is assured by the following characteristics of the PA 320:

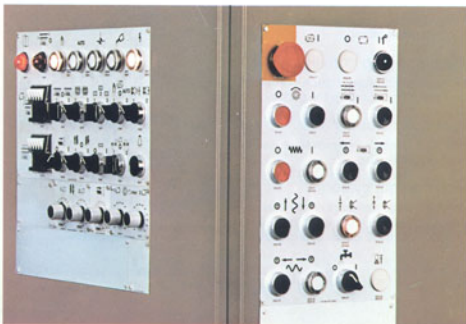
- A programmable controller (PC) without contacts and therefore wear-free results in a highly reliable electric control and facilitates trouble shooting.
- All drives, controls and auxiliary units are arranged in easily accessible locations externally or next to the machine to facilitate service or replacement in a minimum of time.
- All guideways and bearings are amply dimensioned and lubricated to keep wear within minimum tolerances for longer life.
- Extensive use of ball and roller bearings eliminates the need for readjustments.

Operating reliability

Great operating reliability of the PA 320 combined with high productivity and consistent accuracy are guaranteed by our leadership in design and the advanced manufacturing technologies utilized in our plant.

Jll. 12
Programmable controller (PC)

Jll. 13
Arrangement of operating controls



Standard equipment

Hob head

with tangential slide for automatic hob shifting.

Automatic incremental hob shifting

for distributing the wear over the total usable length of the hob. Amount and direction of hob shift as well as number of workpieces per hob shift can be preselected.

4 hob speeds

(4-step V-belt pulleys)

Axial feed

infinitely variable in mm or in. per workpiece revolution (D. C. motor).

Radial slide

Moved hydraulically to hobbing depth and/or returned for workpiece change.

Index drive

designed as double index worm drive for complete elimination of backlash in the table drive.

Automatic work cycles

for axial hobbing by the climb or conventional method.

Magnetic chip conveyor

for highly efficient separation of steel and cast iron chips from the coolant.

Tailstock column

with rigid tailstock arm moved up and down hydraulically.

Hob coolant system

with complete enclosure of the work area, coolant reservoir with a capacity of 350 l = 92.5 US Gallon and chip box.

Hydraulic equipment

Pressure for the radial slide and tailstock motions is supplied by the pressurized lubrication system. Reservoir (for lubricant and hydraulic oil) is attached to the machine.

Complete enclosure of work area

Safety interlock of splashguards

with automatic start of cycle.

Automatic lubrication

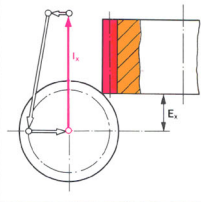
Recirculating or oil bath lubrication of all drives, circulating lubrication of hob spindle and hob arbor counter bearings, pressurized lubrication of all other lubrication points. Lubricant filter indicating extent of contamination.

Electrical equipment

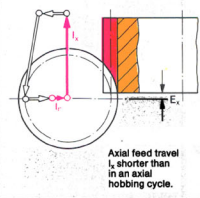
with programmable controller (PC), separate control cabinet, in compliance with IEC standards 204/1 and 2, VDE standard 0113 (DIN 57113) and VDI standard 3231.

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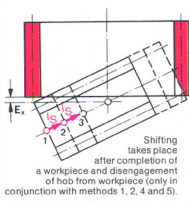
1. Axial hobbing



2. Radial-axial hobbing *)



3. Incremental hob shifting



JlIs. 14 and 15

Schematic diagrams of selected work cycles

- ← Feed movement
- ↔ Rapid traverse movement
- ⇄ Slide movement
- Switch point
- E_x Axial hob approach travel
- l_b Crown hobbing feed travel
- l_k Taper hobbing feed travel
- l_r Radial feed travel
- l_x Axial feed travel
- l_s Hob shift increment

*) With radial feed equipment only (optional equipment)

Special equipment

Differential drive

8 hob speeds

set by 4-step V-belt pulleys and a pole reconnectable main motor (1000/1500 min^{-1}) or infinitely variable D.C. motor.

Automatic two-cut work cycle

The automatic two-cut work cycle consists of two successive axial passes of different hobbing depths – roughing and finishing – on the same workpiece. Between first and second cut direction and amount of axial feed and hob speed can be changed (only on

machines with pole reconnectable motor or infinitely variable main drive). The axial rapid return travel can also be reduced after the first cut.

Automatic multi-cut work cycle

Where more than two radial disengagement points are required (for instance two-cut work cycle plus cavity hobbing) the machine may be equipped with an incremental measuring system for the radial movement.

Radial feed equipment

with infinitely variable radial feed for radial and radial-axial hobbing. Automatic feed control during hobbing is optional.

Automatic dwell equipment

for the complete finishing of teeth around the entire circumference of the workpiece during axial hobbing of teeth ending in solid material and during radial hobbing.

Two-start index drive

instead of the standard single-start index drive for hobbing workpieces with a minimum/maximum ratio of number of workpiece teeth to number of hob starts of 4/60.

Equipment for mechanizing workpiece clamping

Automatic feed control

controls the axial feed during approach and, where possible, during exit of the hob.

The automatic feed control is particularly effective in combination with the automatic two-cut work cycle permitting high feeds during approach and exit of the hob in the first cut.

Crown hobbing equipment

For hobbing cylindrical clutch and transmission gears with a crown of .01 to 10 mm (.0004 to .4 in.) in radial

direction. Depending upon the axial movement the radial movement is controlled by a computer. The calculated amount of crown and the position of the high point of the crown is selected by a decade switch. This equipment can also be used in conjunction with two- and multi-cut work cycles.

Taper hobbing equipment

for hobbing tapered spur and helical gears from $.2^\circ$ to 16° taper angle.

Combined crown- and taper hobbing equipment

Operation as described above. May also be used in conjunction with two- and multi-cut work cycles.

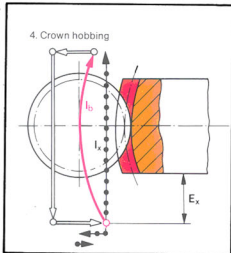
Oil mist separator

incorporated in complete enclosure of work area. Connection to central oil mist separator on request.

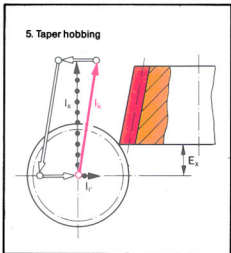
Coolant centrifuge

required for wet hobbing of cast iron.

4. Crown hobbing



5. Taper hobbing



Safety

Environmental protection

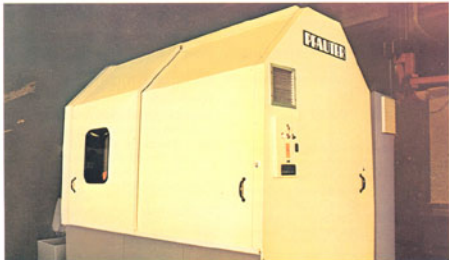
A number of safety features protect the operator and the machine:

- Limit switches control the position of the splashguard door. With the door open the limit switch prevents the start of any automatic work cycle.
- An electric interlock prevents starting the machine if a lubrication malfunction is present.
- A pressurized hydraulic reservoir (accumulator) provides clamping pressure in case of hydraulic pump failure.
- On automated machines loading and unloading is controlled by safety interlocks which automatically stop the machine in the event of a malfunction. Signal lamps indicate the location of the defect.

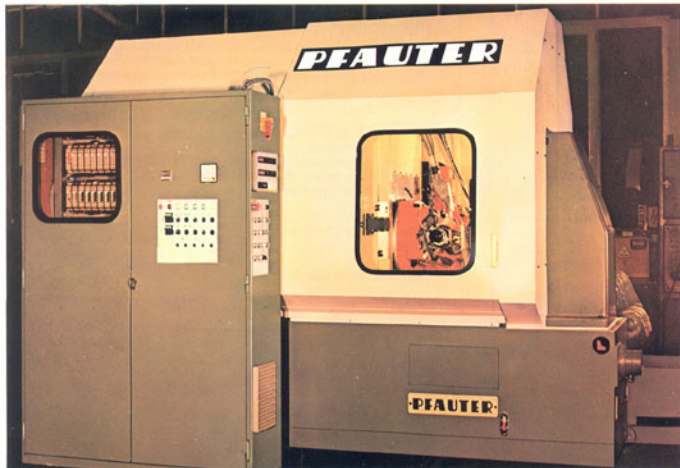
The PA 320 has been designed in accordance with approved standards of noise control. The complete enclosure of the work area included in the standard equipment contributes to the low noise level of the machine. An electro-static oil mist separator installed within the complete enclosure is available as special equipment.

J11. 16
Complete enclosure of the PA 320 work area (rear view).

J11. 17
Complete enclosure of the PA 320 work area (operator's view).

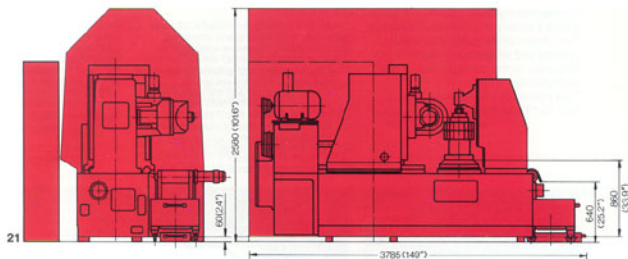


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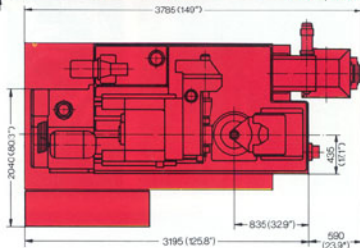


17

Technical data



J11. 21
Space requirements
of the PA 320



Capacities

Maximum workpiece diameter	350 mm	13.8 in.
Maximum module (pitch) in steel with a tensile strength of approx. 38 tons/sq.in. (600 N/mm ²)	8 mm	D.P. 3
Maximum axial slide travel	250 mm	9.8 in.
Minimum/maximum number of teeth (single-start hob)		
- Standard single-start index drive	6/120	
- Optional two-start index drive	4/ 60	
Maximum hob head swivel	± 40 degrees	
Maximum table speed:		
- Standard single-start index drive	25 min ⁻¹	
- Optional two-start index drive	45 min ⁻¹	
Maximum hob shift travel	170 mm	6.7 in.
Hob speed adjustable in steps (other ranges on request)	125 to 280 min ⁻¹	
Axial feed infinitely variable	1 to 16 mm p.r.*	.04 to .83 i.p.r.*
Coolant pump capacity	120 l/min	32 US Gallon/min
Radial feed infinitely variable (optional equipment)	4 to 138 mm/min	.157 to 5.433 in./min
Maximum radial slide rapid traverse	60 mm	2.4 in.

* mm or in. per workpiece revolution

Electrical data

Voltage	220/380 V
Frequency	50 Hz
(other voltages and frequencies on request)	
Main motor rating	15 kW
D.C. drive (optional) up to	30 kW
Total electric power rating	32 kW

Work area dimensions

Center distance between workpiece and hob:		
- Minimum	40 mm	1.6 in.
- Maximum	265 mm	10.4 in.
Work table diameter	300 mm	11.8 in.
Table bore diameter	80 mm	3.15 in.
Hob arbor diameter	32 mm	1.25 in.
Hob spindle taper	Morse No. 5	
Maximum hob dimensions:		
- Diameter	163 mm	6.4 in.
- Length	230 mm	9.1 in.

Weight and space requirements

Weight of machine	9,400 kg	20,750 lbs.
Floor space required with chip box and open doors:		
- Length	4,600 mm	181 in.
- Width	2,950 mm	116 in.
- Height	2,580 mm	102 in.
Export packing dimensions:		
- Length	4,000 mm	157 in.
- Width	2,200 mm	87 in.
- Height	2,600 mm	102 in.
Additional weight of packing	1,100 kg	2,500 lbs.
Cargo space required	23 m ³	810 cu.ft.

Standard equipment

Hob head with tangential slide for hob shifting – automatic incremental hob shifting – main drive with interchangeable 4-step V-belt pulleys – double index worm drive – hydraulic movement of radial slide to cutting depth and work loading and unloading position – automatic work cycles for climb or conventional hobbing of spur and helical gears – magnetic chip conveyor – tailstock column with rigid tailstock arm moved up and down hydraulically – hob cooling and lubricating system – complete enclosure of work area – automatic cycle interlocked with splashguard doors to prevent starting while doors are open – hydraulic equipment – automatic pressurized lubrication of all lubrication points – oil bath lubrication of all drives – electrical equipment including motors and control cabinet – programmable controller (PC) – locking control panel – machine in metric design.

Special equipment

Differential drive – main drive with pole-reconnectable motor or infinitely variable D.C. motor – automatic two- and multi-cut work cycles – radial feed equipment – automatic dwell equipment – two-start index drive – swing away tailstock – extended tailstock column with axial travel 550 mm (21 in.) – power clamping base – automatic interlock of work arbor in tailstock – automatic feed control – dead and live centers – crown hobbing equipment – taper hobbing equipment – combined crown and taper hobbing equipment – oil mist separator – separate lubrication and hydraulic systems – electromagnetic interlock of splashguard door – coolant centrifuge.

Standard accessories

1 machine lamp – 1 hob arbor 32 mm (1.25 in.) diameter with spacers and nut – 1 hob setting gage – 1 set of pulleys for 4 hob speeds – 1 set of 4 index change gears for one workpiece – 1 set of tools for operation and maintenance of machine – 1 operator's manual – 1 service manual.

Special accessories

Supplementary set of index and differential change gears dependent on the number of starts of the index drive – additional set of pulleys for 4 hob speeds – supplementary set of 6 index change gears for prime numbers 101 to 113 (with reduced module) – leveling wedges – accessory cabinet – hob arbors 27 mm (1.1 in.) or 40 mm (1.6 in.) diameter with spacers and nut.

We are constantly updating our equipment. For this reason all designs, dimensions and weights are subject to change without notice. Please request a current quotation.

Work area
Jil. 22 Workholding fixture
Jil. 23 Hob mounting

