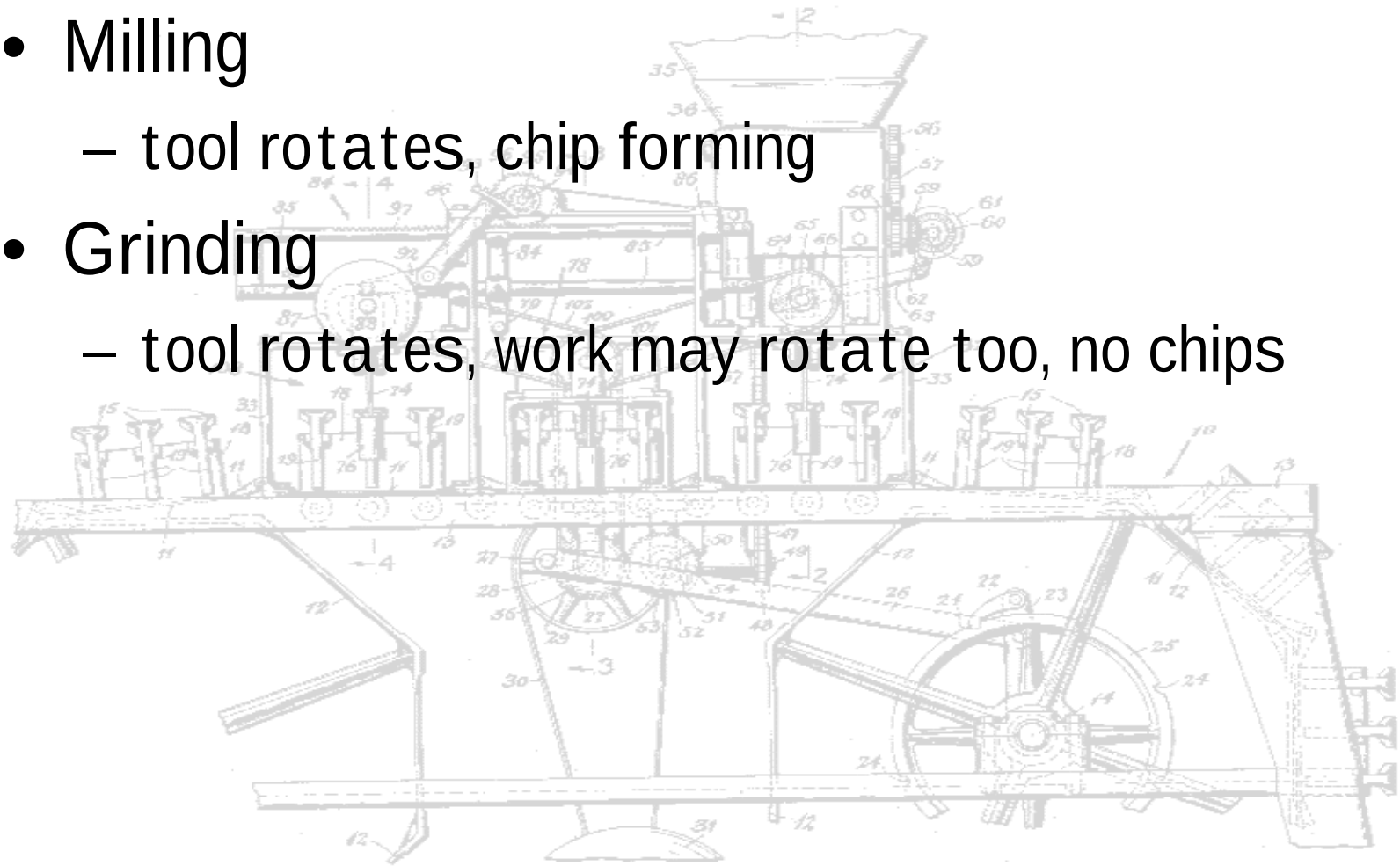
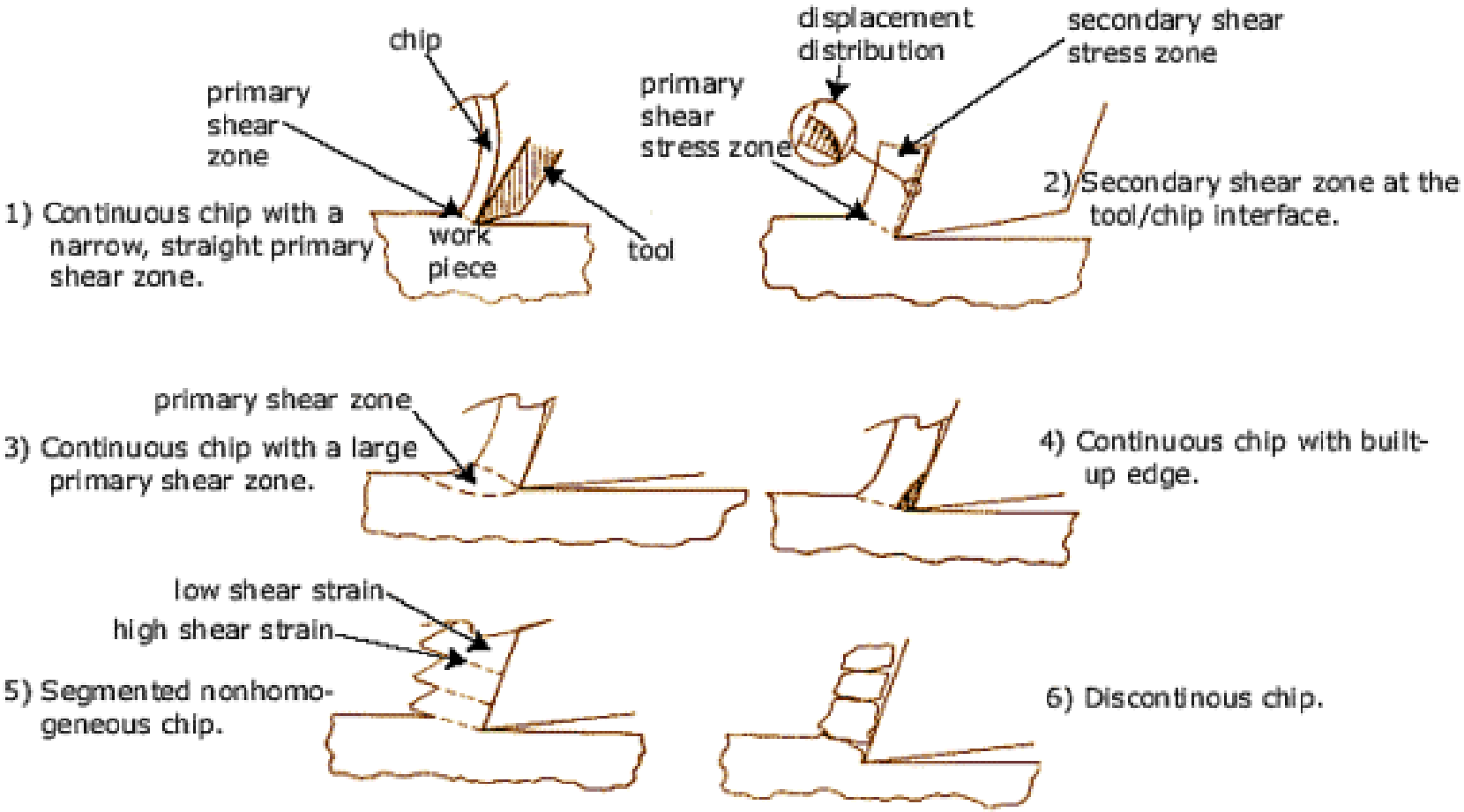
Material Removal

- Turning
  - work rotates, chip forming
- Milling
  - tool rotates, chip forming
- Grinding
  - tool rotates, work may rotate too, no chips



Chip Formation

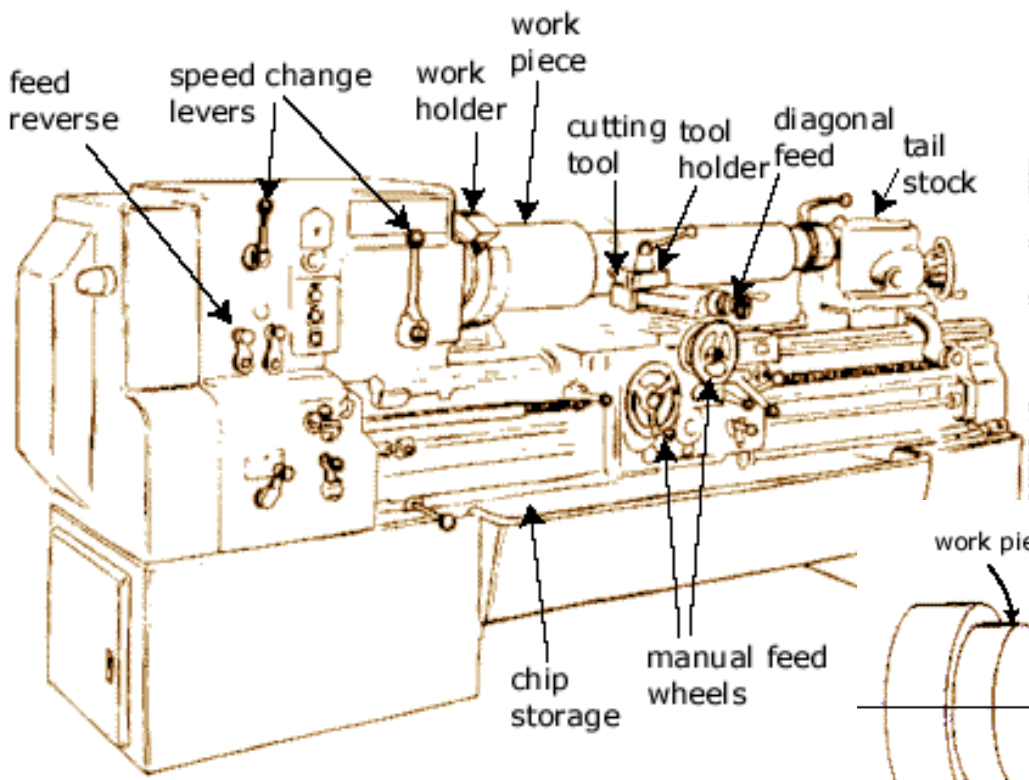


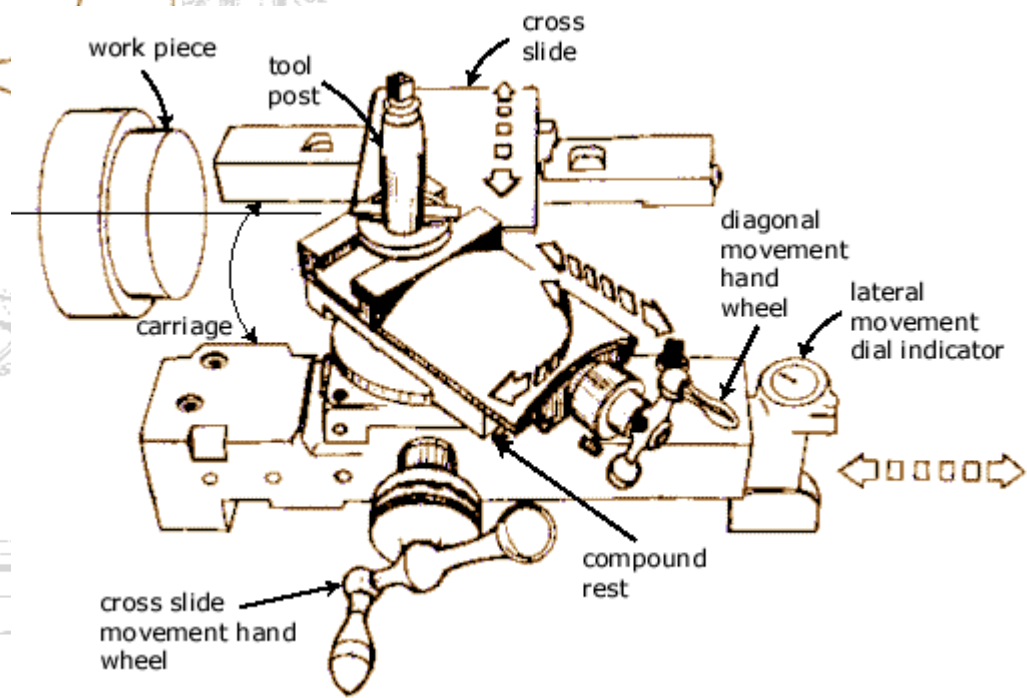
- Cutting rate -> dist/time (RPM * cutter diam * pi)
- Feed rate -> dist/time (rate of work motion * # teeth)

Turning

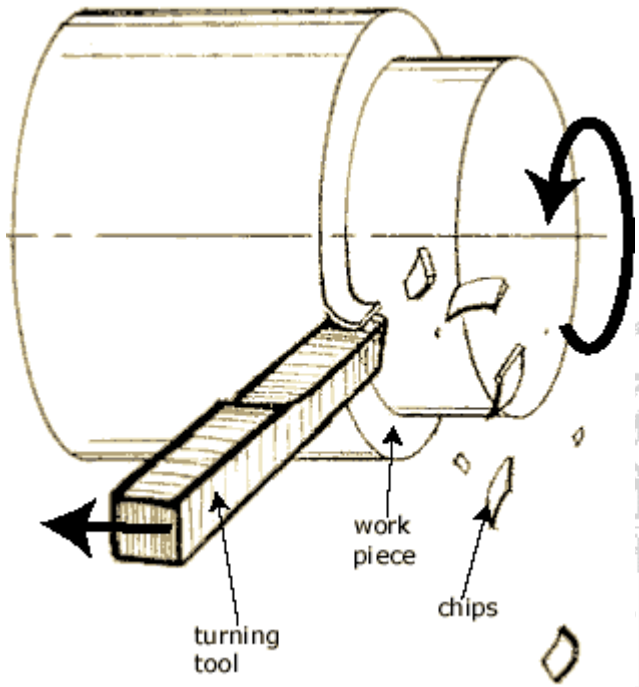
- Lathe
- Turning Center

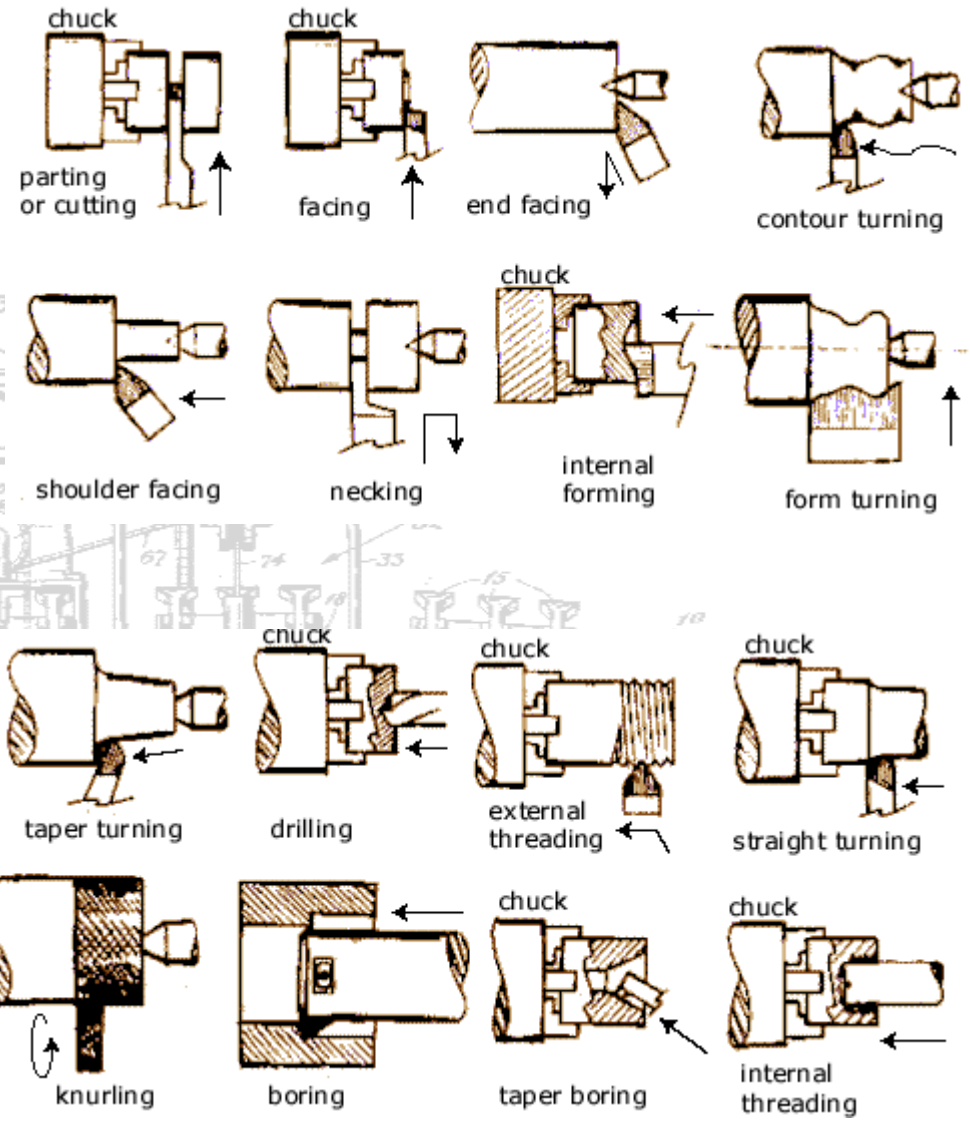
Lathe


feed reverse
speed change levers
work holder
work piece
cutting tool
tool holder
diagonal feed
tail stock
chip storage
manual feed wheels

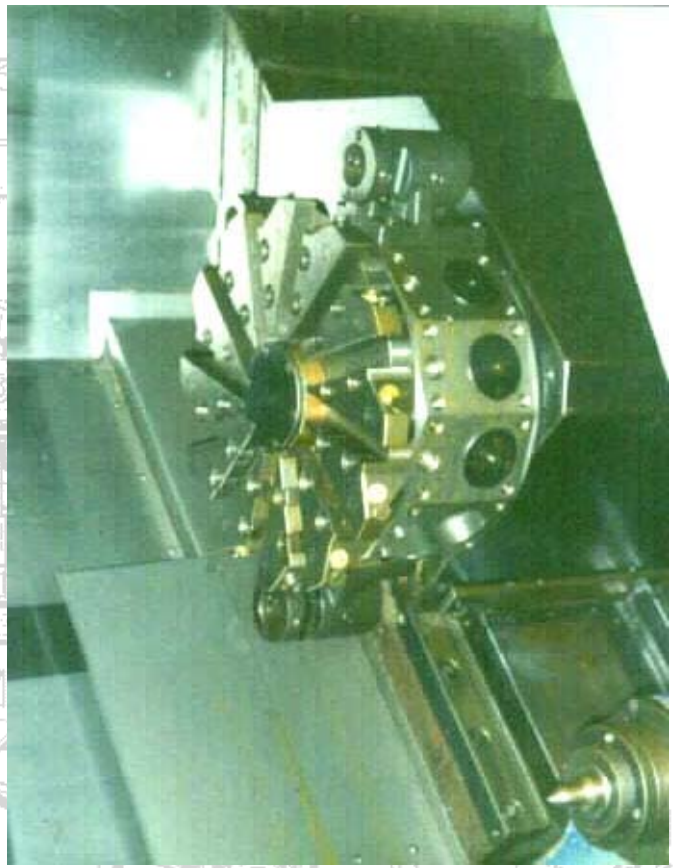

work piece
tool post
cross slide
diagonal movement hand wheel
lateral movement dial indicator
carriage
compound rest
cross slide movement hand wheel

Lathe


work
piece
chips
turning
tool

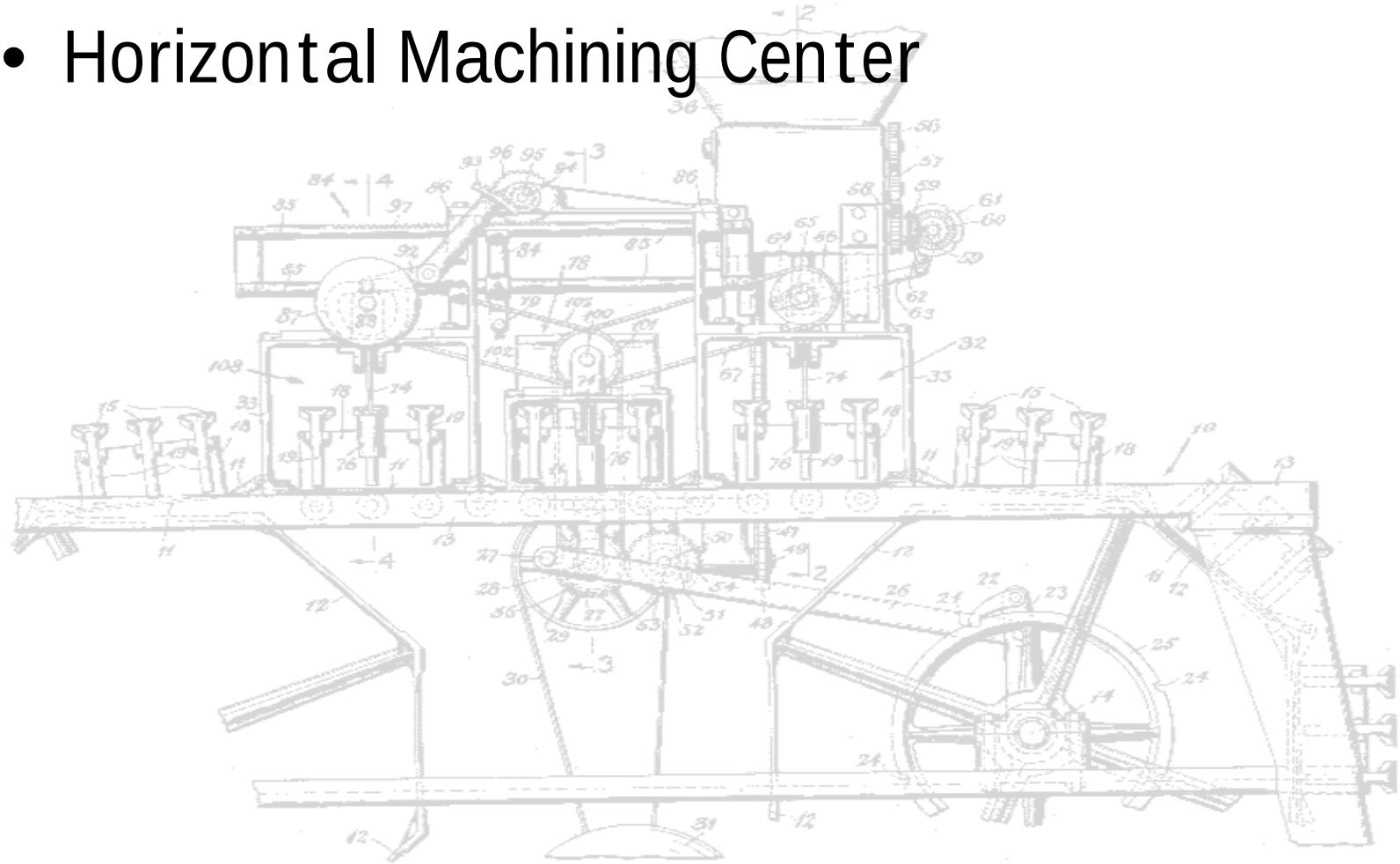

chuck
parting
or cutting
chuck
facing
end facing
contour turning
shoulder facing
necking
chuck
internal
forming
form turning
taper turning
chuck
drilling
chuck
external
threading
chuck
straight turning
knurling
boring
chuck
taper boring
chuck
internal
threading

Turning Center



Milling

- Vertical Mill
- Horizontal Mill
- Horizontal Machining Center



Milling - Horizontal Mach Center

Milling - 5 Axis Machining Center

Milling

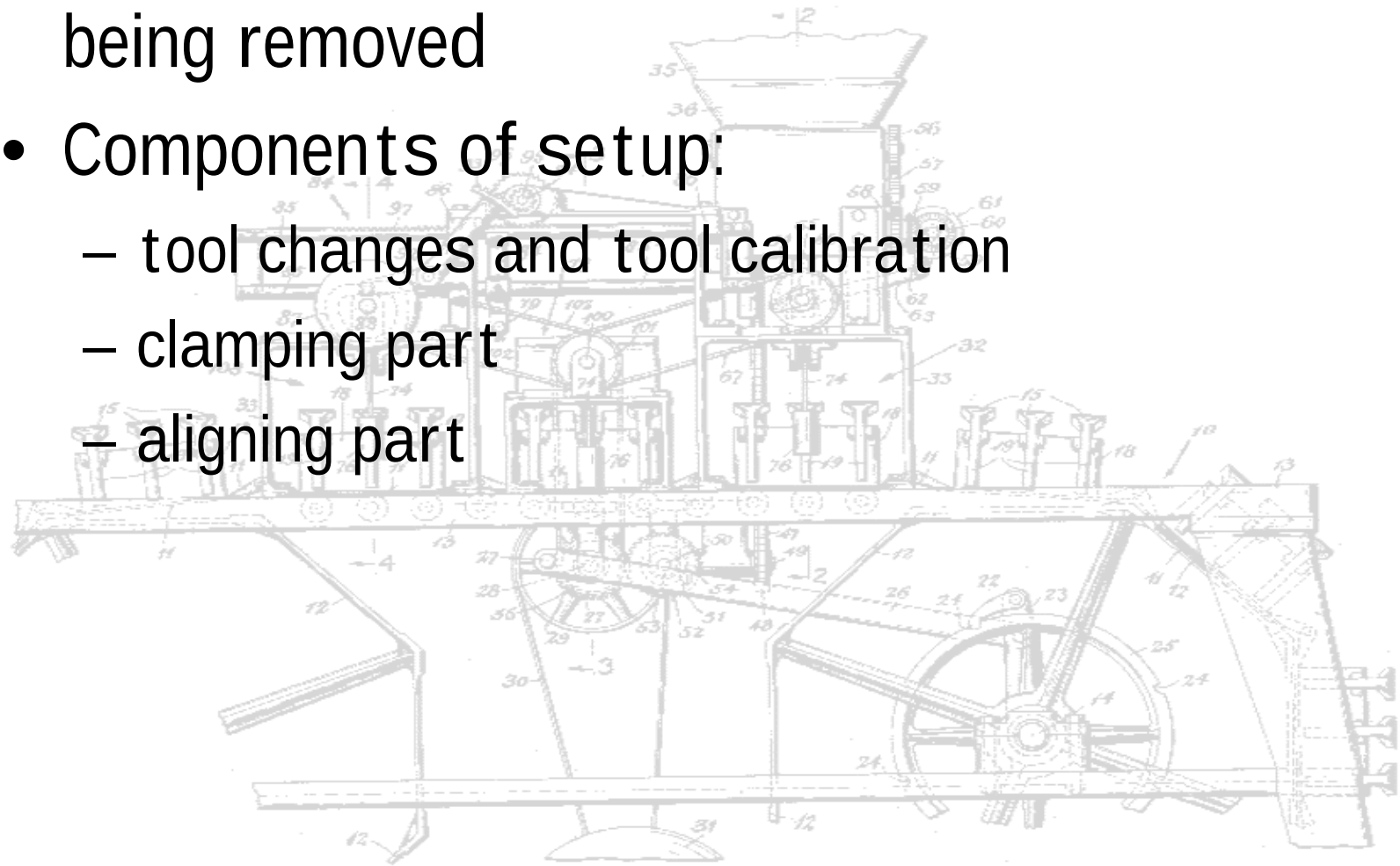
- CNC programming
- Clamping and fixturing

CNC Programming

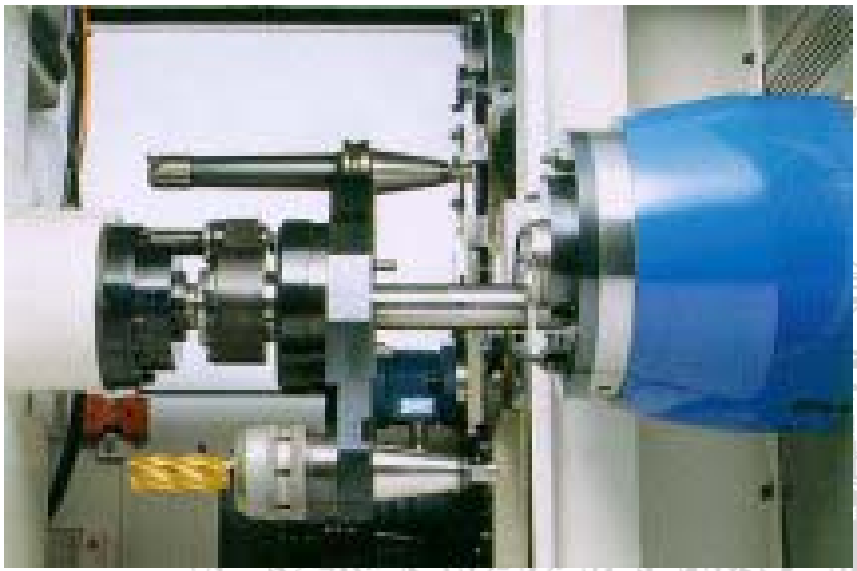
G00Z0.1	Linear translation, raise bit to 0.1”
X1.Y1.382	Linear tran, to 1” in X, 1.382” in Y
G01Z-0.75F10	Linear feed, -.75” in Z, Feed rate “10”
G03X1.382Y1.I0.382J0.F20	CCW Arc, Start pnt, radius, arc len
G01X3.618	Linear feed, same feed rate
G03X4.Y1.382I0.J0.382	CCW Arc
G01Y2.4589	Linear feed
X1.382	
G03X1.Y2.618I0.J-0.382	CCW Arc
G01Y1.382	Linear feed
G00Z0.1	Linear translation (raise bit)
X0.1511Y3.5	Linear translation (move to new
G01Z-0.75F10	Linear feed to -0.75” depth
...	...
M30	End of data

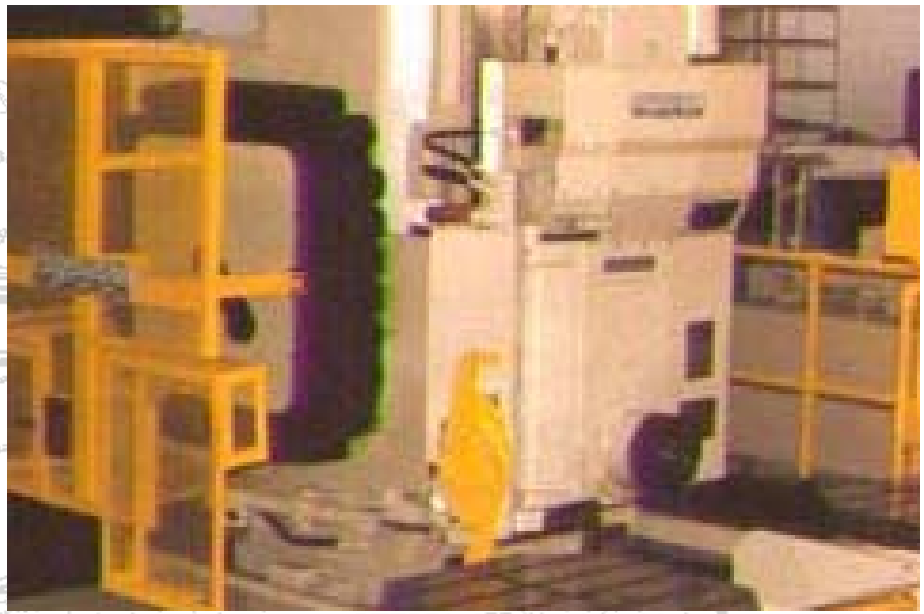
Jigs and Fixtures

- Setup time is non-productive time
- Money is only being made while material is being removed
- Components of setup:
  - tool changes and tool calibration
  - clamping part
  - aligning part



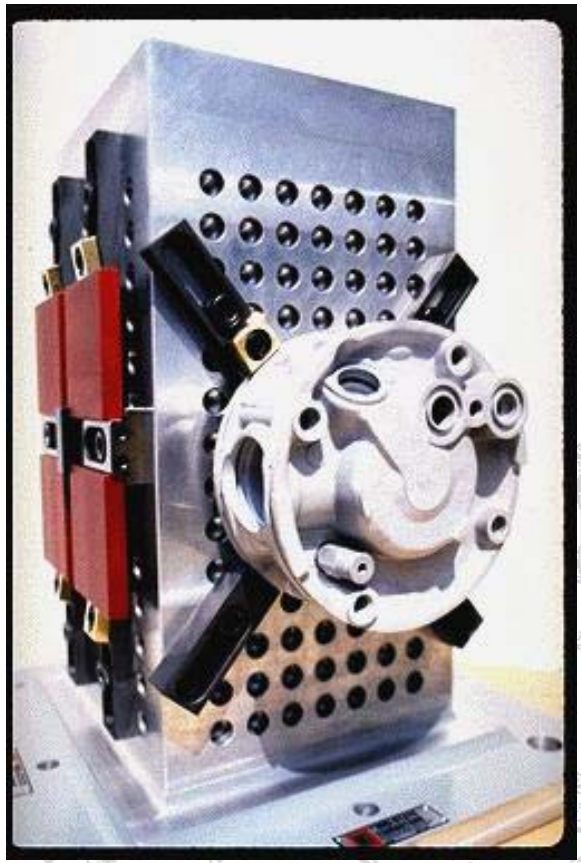
Automatic Tool Changing

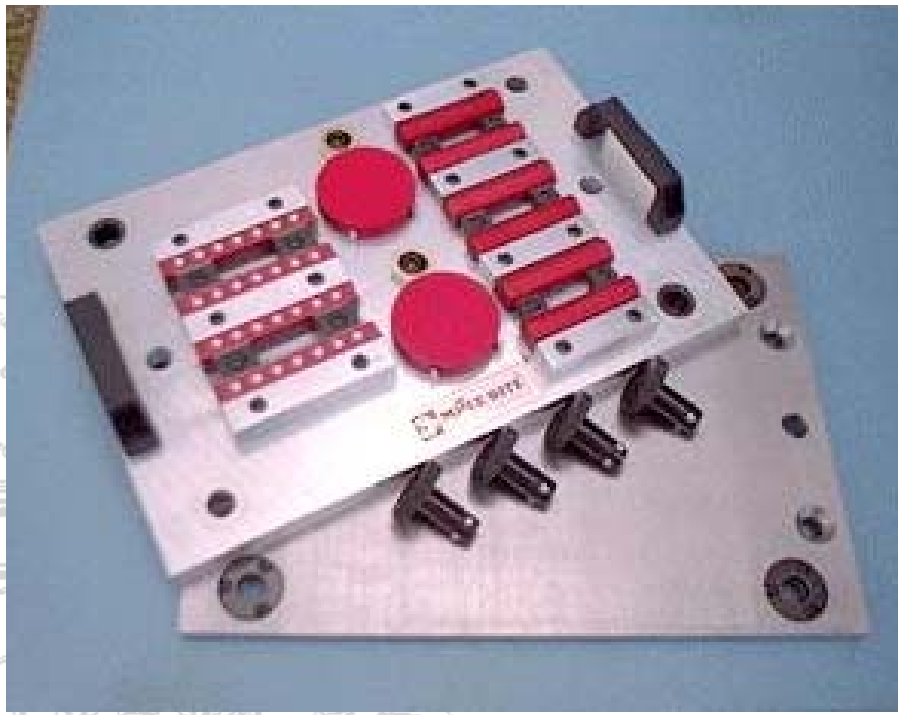


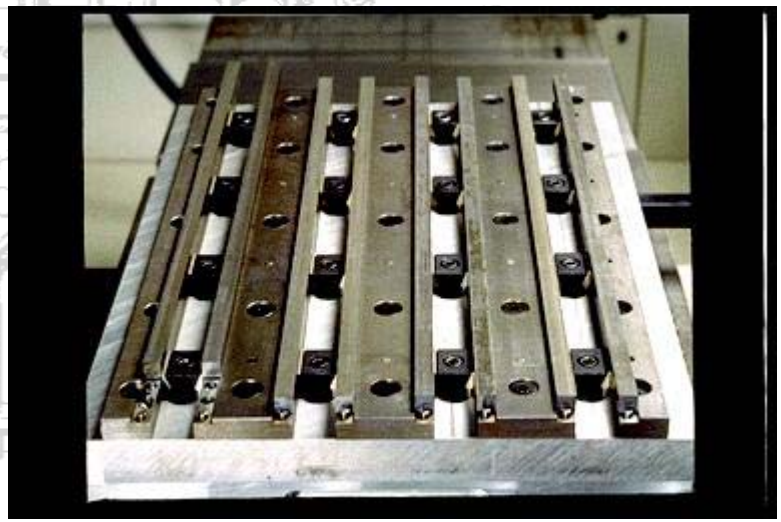


Fixturing

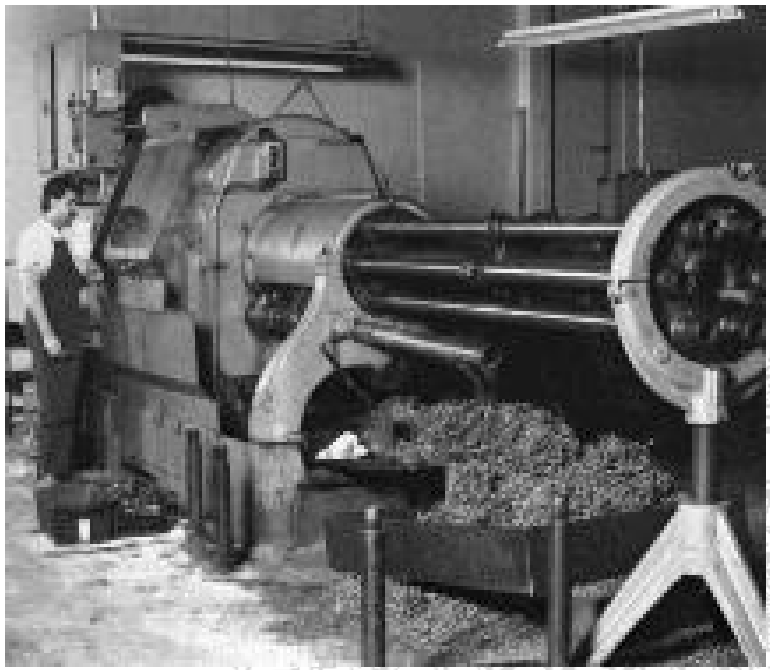
Jigs







Automatic Screw Machines



Automatic Screw Machine