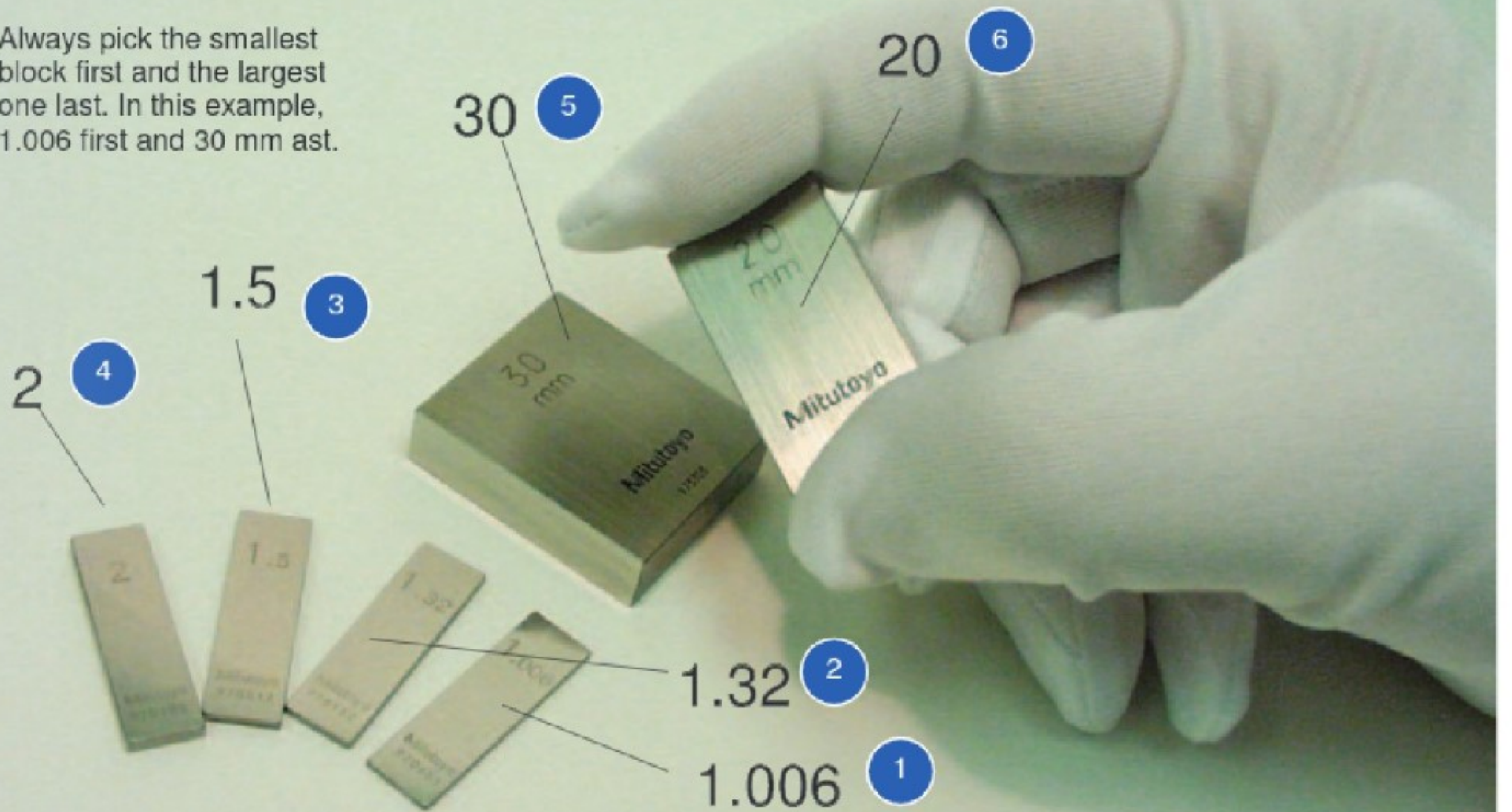


Always pick the smallest block first and the largest one last. In this example, 1.006 first and 30 mm ast.



Optical
Flat

2



Accuracy

0.001 to 0.0001 in

The contact point is bent upward relative to the test indicator. No matter how large this angle is, it does not affect the reading, nor cause any cosine error. It is the angle in yellow line θ that should be kept low, preferably within 15°.

Dial Indicators



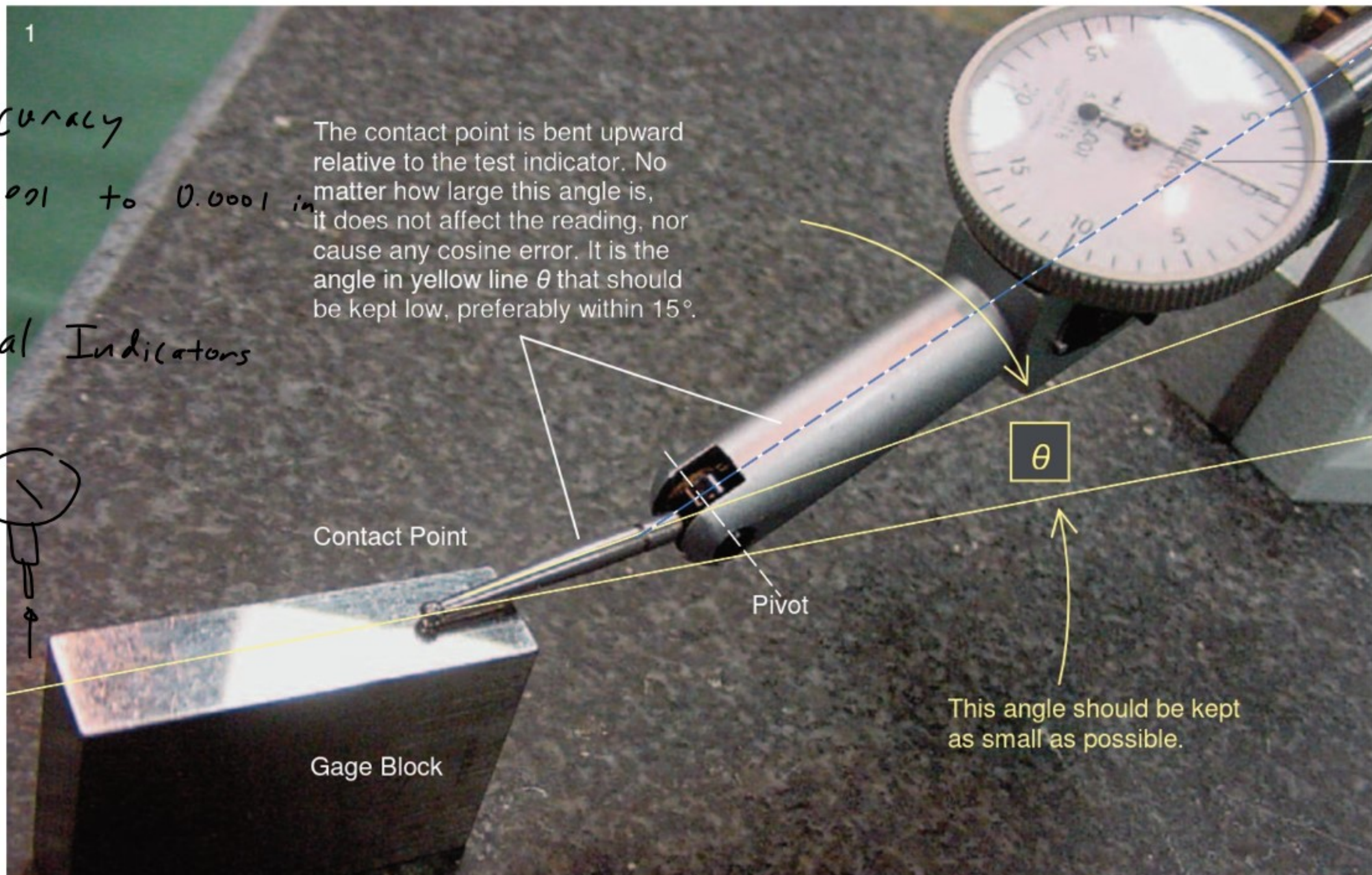
Contact Point

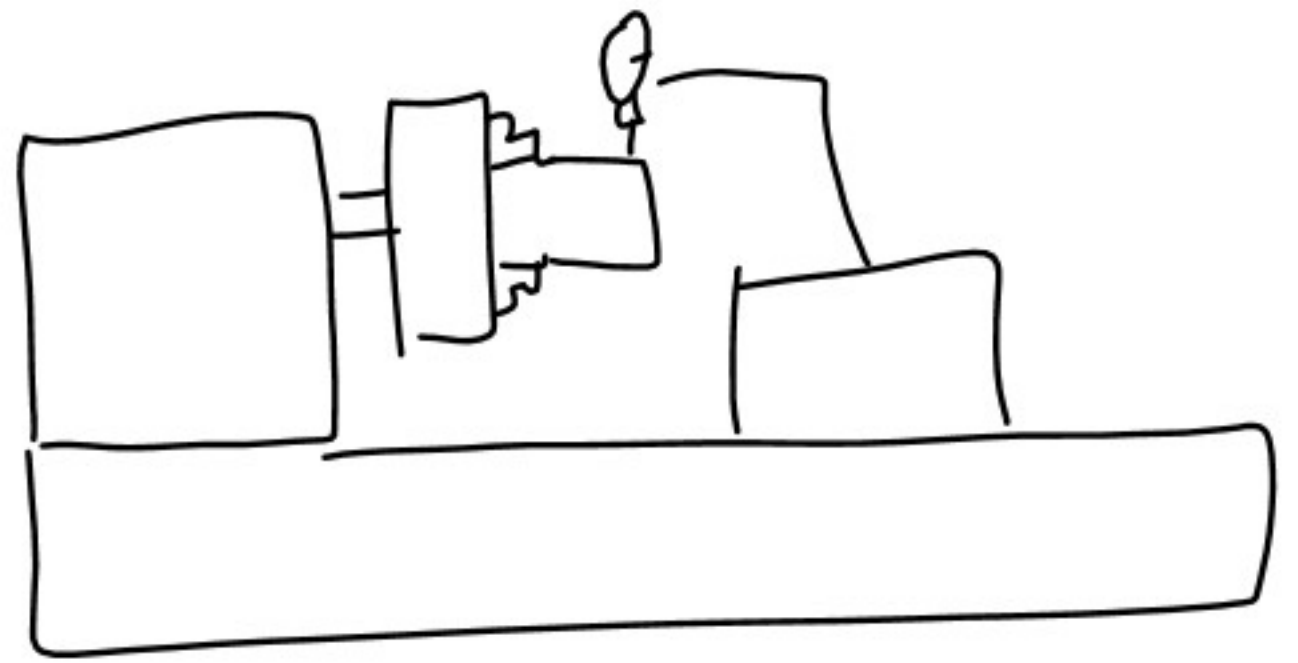
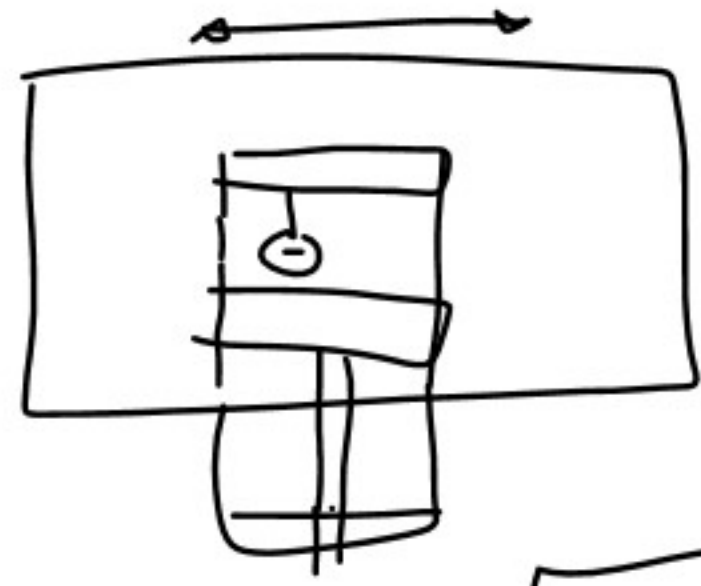
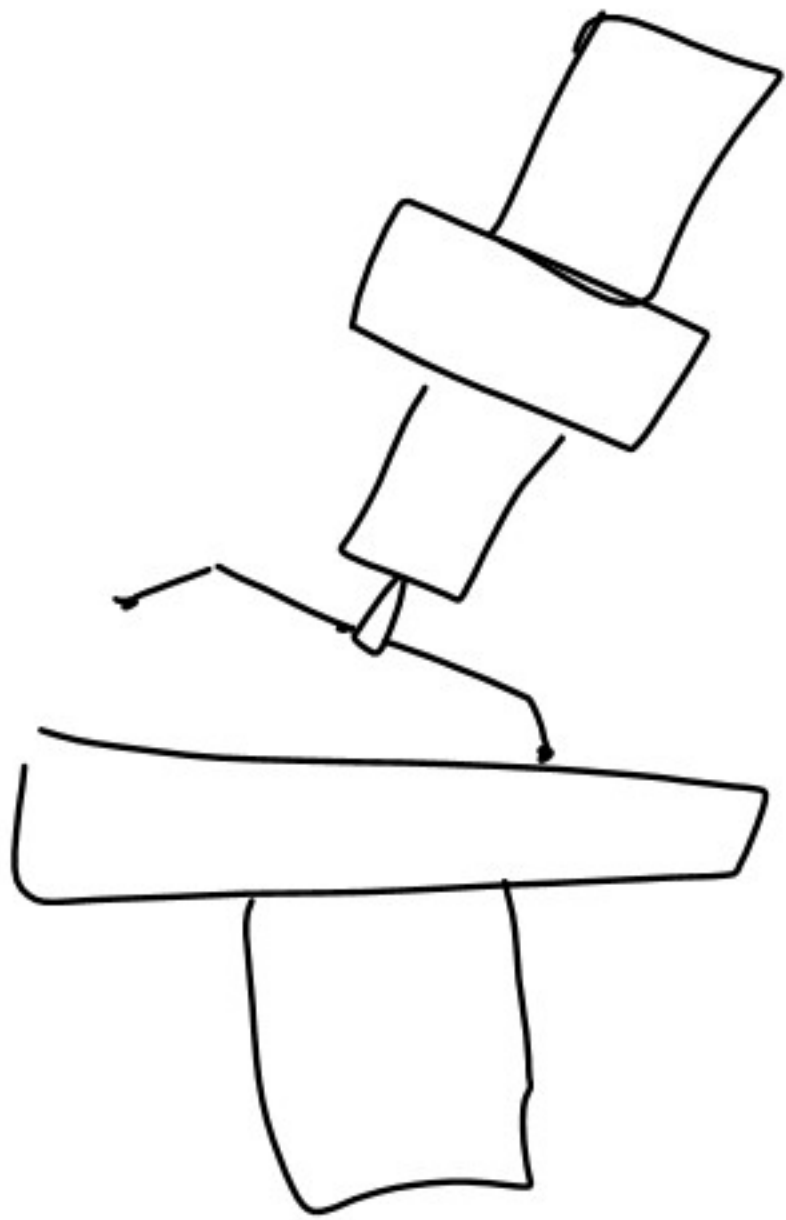
Pivot

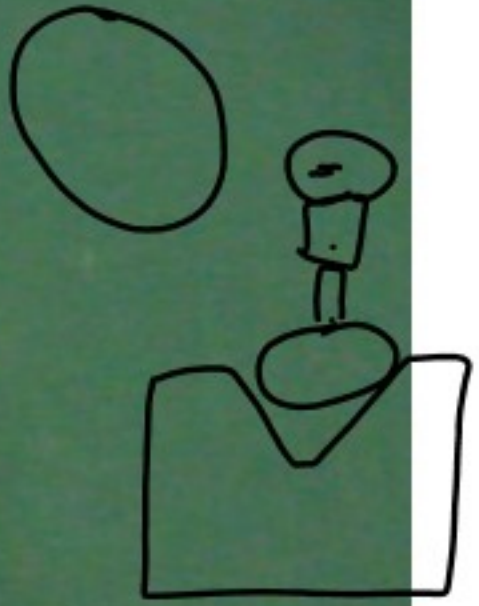
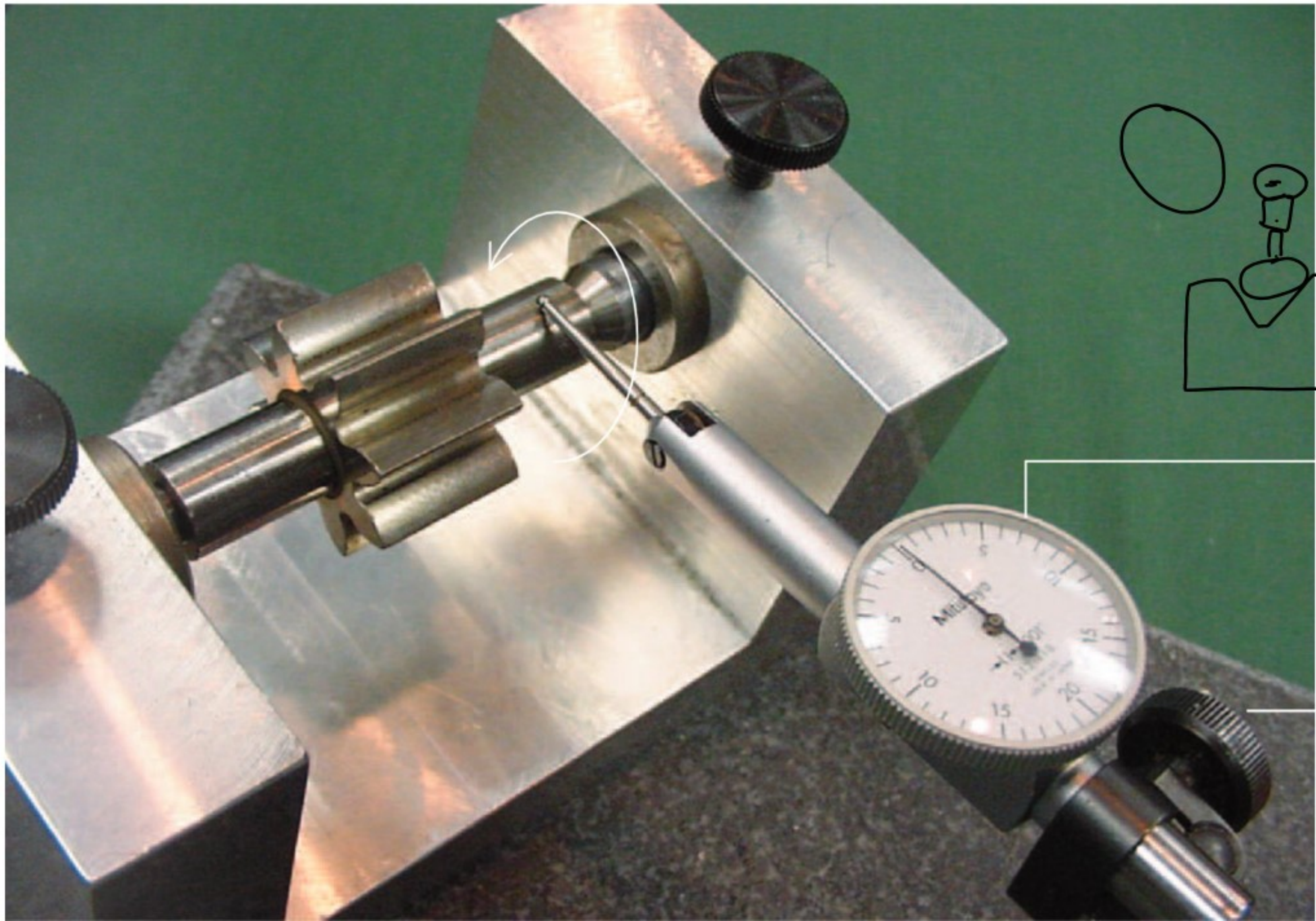
Gage Block

θ

This angle should be kept as small as possible.



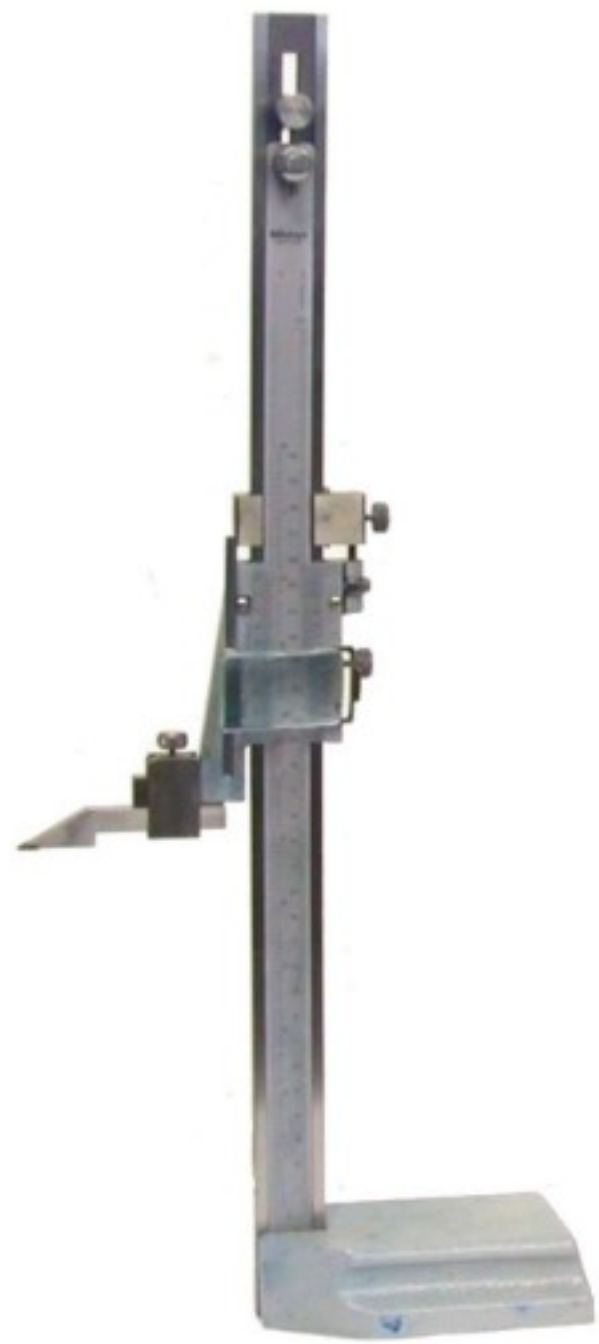




Height Gauge

Accuracy 0.0001 in

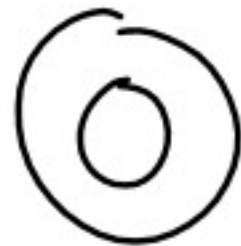




Go / no-go gauge



Ring Gauges



Coordinate
Measurement
Machine

CMM



Accuracy $50 \mu\text{m}$

Optical
Comparator



Mar. 5, 1929.

J. HARTNESS ET AL
OPTICAL COMPARATOR

1,703,933

Fig. 1.

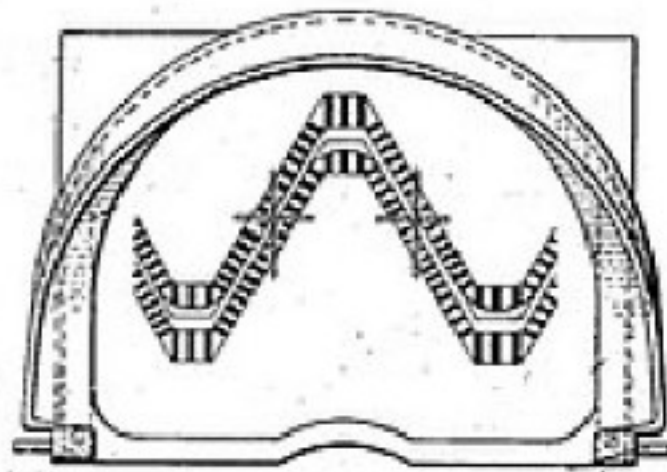
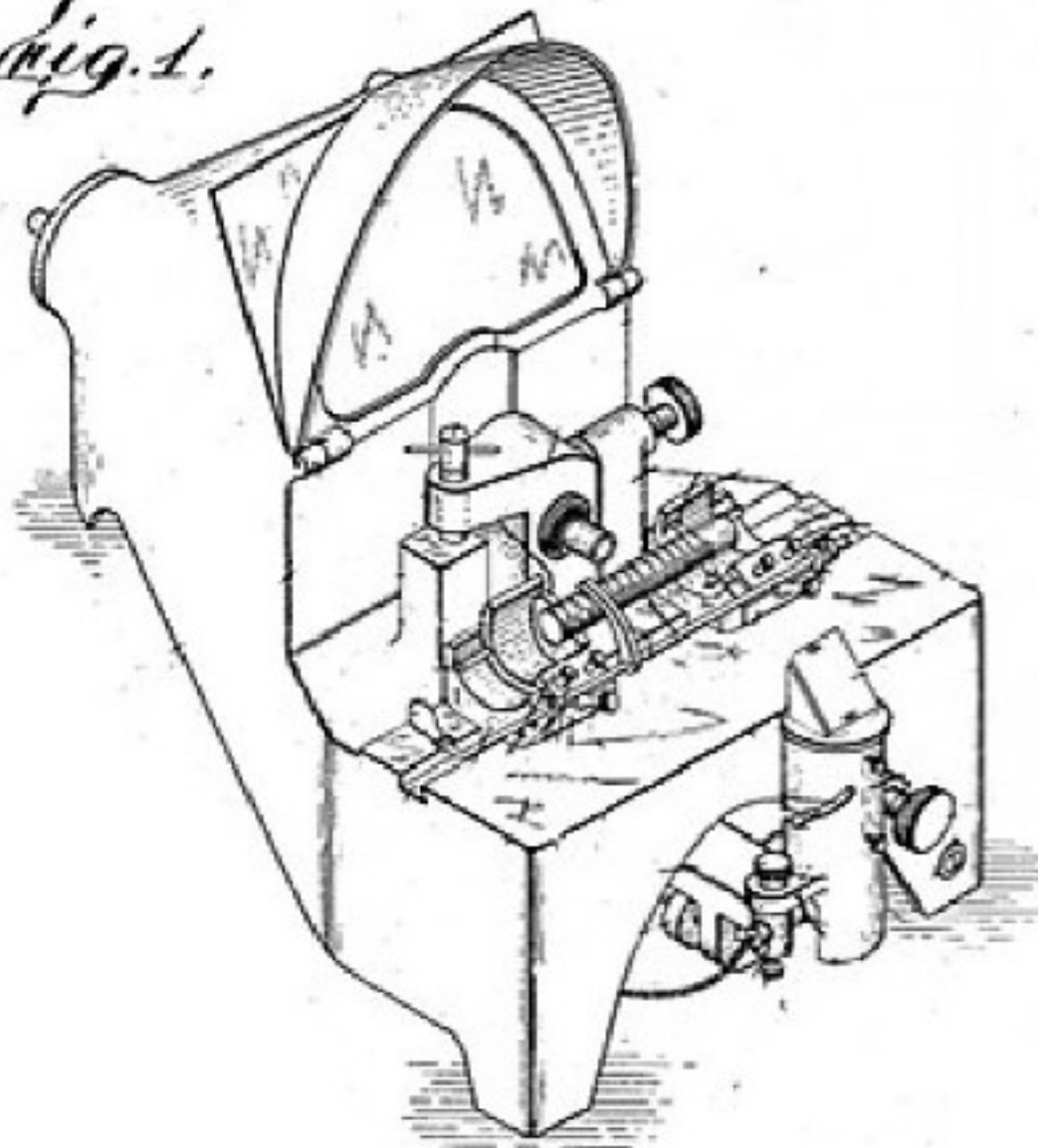


Fig. 2.

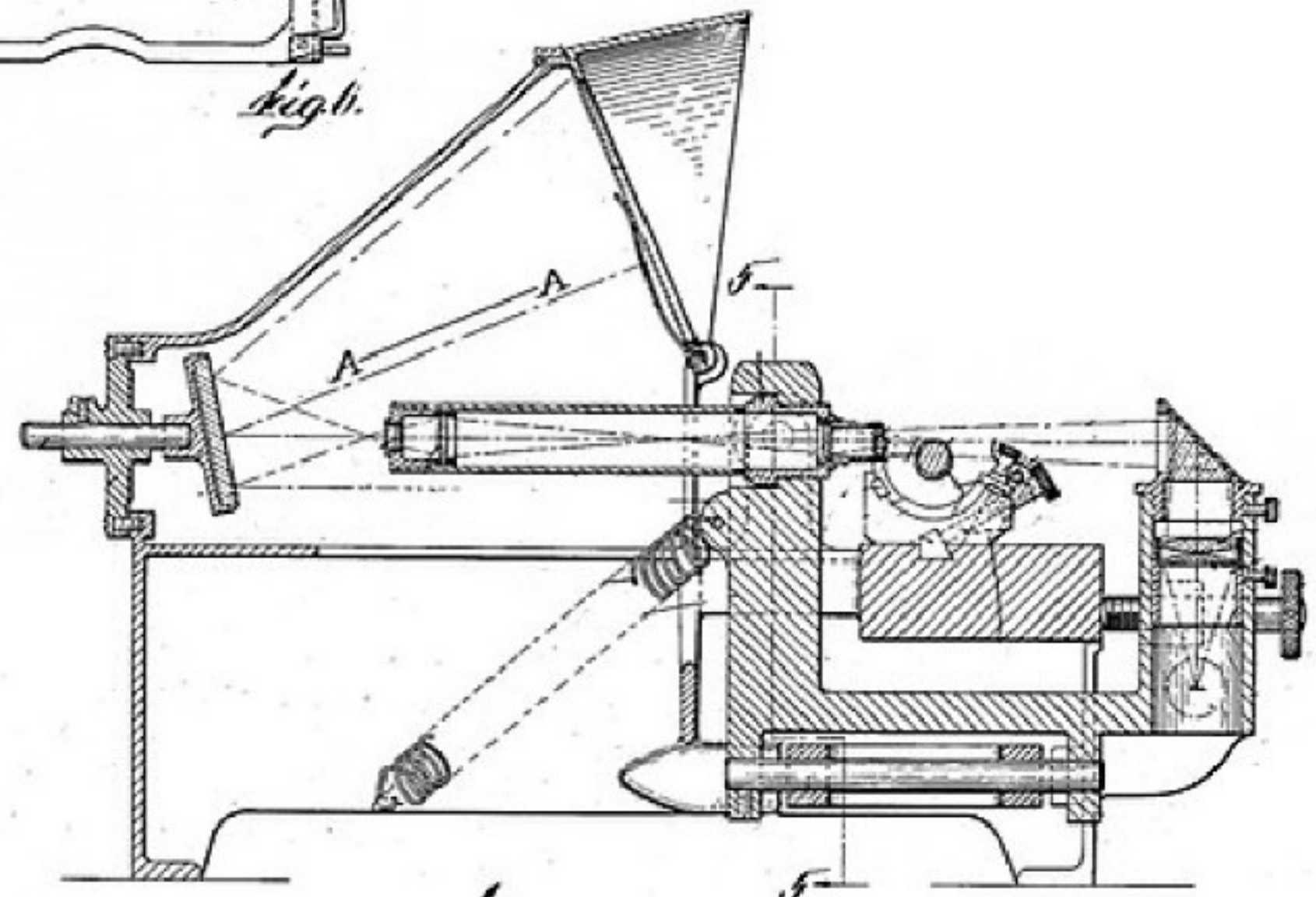


Fig. 3.

Inventors
James Hartness
Russell W. Porter
by
Lee H. Brown, Clerk
Attys.

Optical
CMM

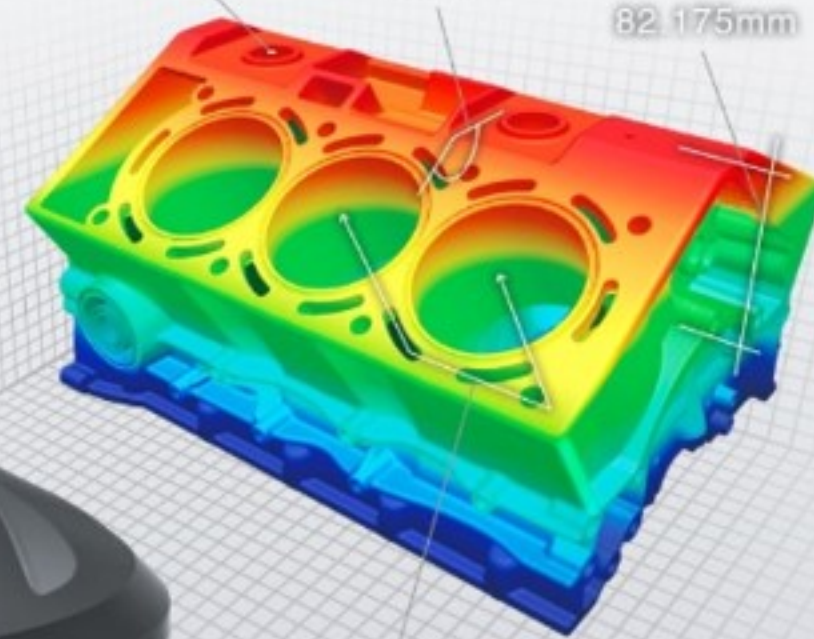


X: 83.329 mm
Y: 91.841 mm
Z: 11.025 mm

152.4°

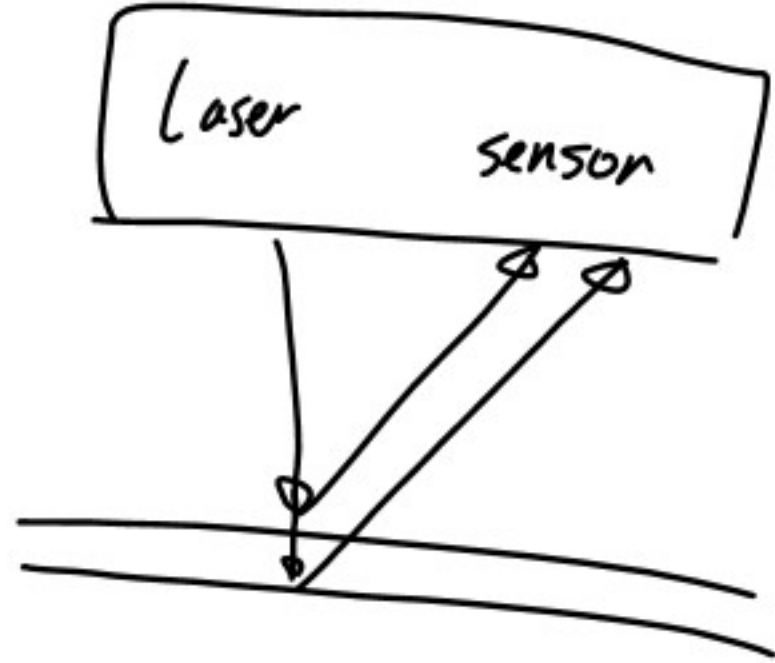
82.175 mm

87.259 mm



Laser

Profilier

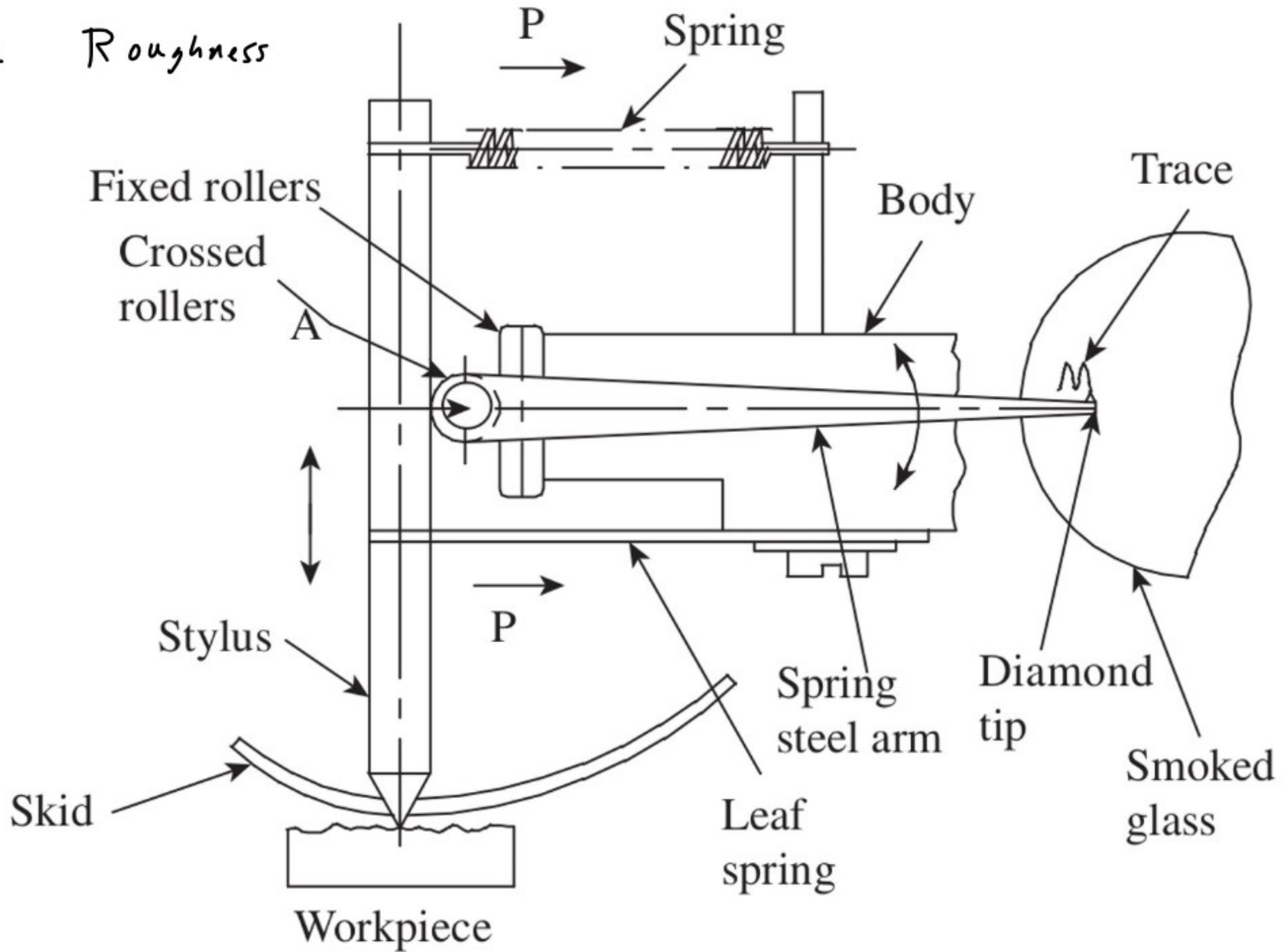


repeatability

10 - 40 min

Surface

Roughness



Hardness tests

Vickers
Brinell
Knoop
Rockwell
Shore



Scale	Abbreviation [§]	Major Load* (kgf)	Indenter	Use	N	h
A	HRA	60	spheroconical diamond [†]	Cemented carbides, thin steel, shallow case-hardened steel	100	500
B	HRB	100	$\frac{1}{16}$ in (1.59 mm) ball	Copper alloys, soft steels, aluminum alloys, malleable iron	130	500
C	HRC	150	spheroconical diamond [†]	Steel, hard cast irons, pearlitic malleable iron, titanium, deep case-hardened steel, other materials harder than 100 HRB	100	500
D	HRD	100	spheroconical diamond [†]	Thin steel and medium case-hardened steel and pearlitic malleable iron	100	500
E	HRE	100	$\frac{1}{8}$ in (3.18 mm) ball	Cast iron, aluminum and magnesium alloys, bearing metals, thermoset plastics	130	500
F	HRF	60	$\frac{1}{16}$ in (1.59 mm) ball	Annealed copper alloy, thin soft sheet metals	130	500
G	HRG	150	$\frac{1}{16}$ in (1.59 mm) ball	Phosphor bronze, beryllium copper, malleable irons.	130	500
H	HRH	60	$\frac{1}{8}$ in (3.18 mm) ball	Aluminum, Zinc, Lead ^[20]	130	500
K	HRK	150	$\frac{1}{8}$ in (3.18 mm) ball	Bearing alloy, tin, hard plastic materials ^[20]	130	500
L	HRL	60	$\frac{1}{4}$ in (6.35 mm) ball	Bearing metals and other very soft or thin materials.	130	500
M	HRM	100	$\frac{1}{4}$ in (6.35 mm) ball	Thermoplastics, bearing metals and other very soft or thin materials	130	500
P	HRP	150	$\frac{1}{4}$ in (6.35 mm) ball	Bearing metals and other very soft or thin materials	130	500
R	HRR	60	$\frac{1}{2}$ in (12.70 mm) ball	Thermoplastics, bearing metals, and other very soft or thin materials	130	500
S	HRS	100	$\frac{1}{2}$ in (12.70 mm) ball	Bearing metals and other very soft or thin materials	130	500
V	HRV	150	$\frac{1}{2}$ in (12.70 mm) ball	Bearing metals and other very soft or thin materials	130	500
15T, 30T, 45T		15, 30, 45	$\frac{1}{16}$ in (1.59 mm) ball	Superficial: for soft coatings	100	1000
15N, 30N, 45N		15, 30, 45	spheroconical diamond [†]	Superficial: for case-hardened materials	100	1000

* Except for the superficial scales where it is 3 kgf, the minor load is 10 kgf.

[†] Also called a *Brale indenter*, is made with a conical diamond of $120^\circ \pm 0.35^\circ$ included angle and a tip radius of 0.200 ± 0.010 mm.

[§] The Rockwell number precedes the scale abbreviations (e.g., 60 HRC), except for the "Superficial scales" where they follow the abbreviations, separated by a '-' (e.g., 30N-25).

- ▶ CMM (<https://youtu.be/4vs5lJtZcFU>)
- ▶ Optical Comparator (<https://youtu.be/ptV8bFXIHJE>)