

1  
Dial Indicators

Accuracy

0.001 in  
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  $\theta$  that should be kept low, preferably within  $15^\circ$ .

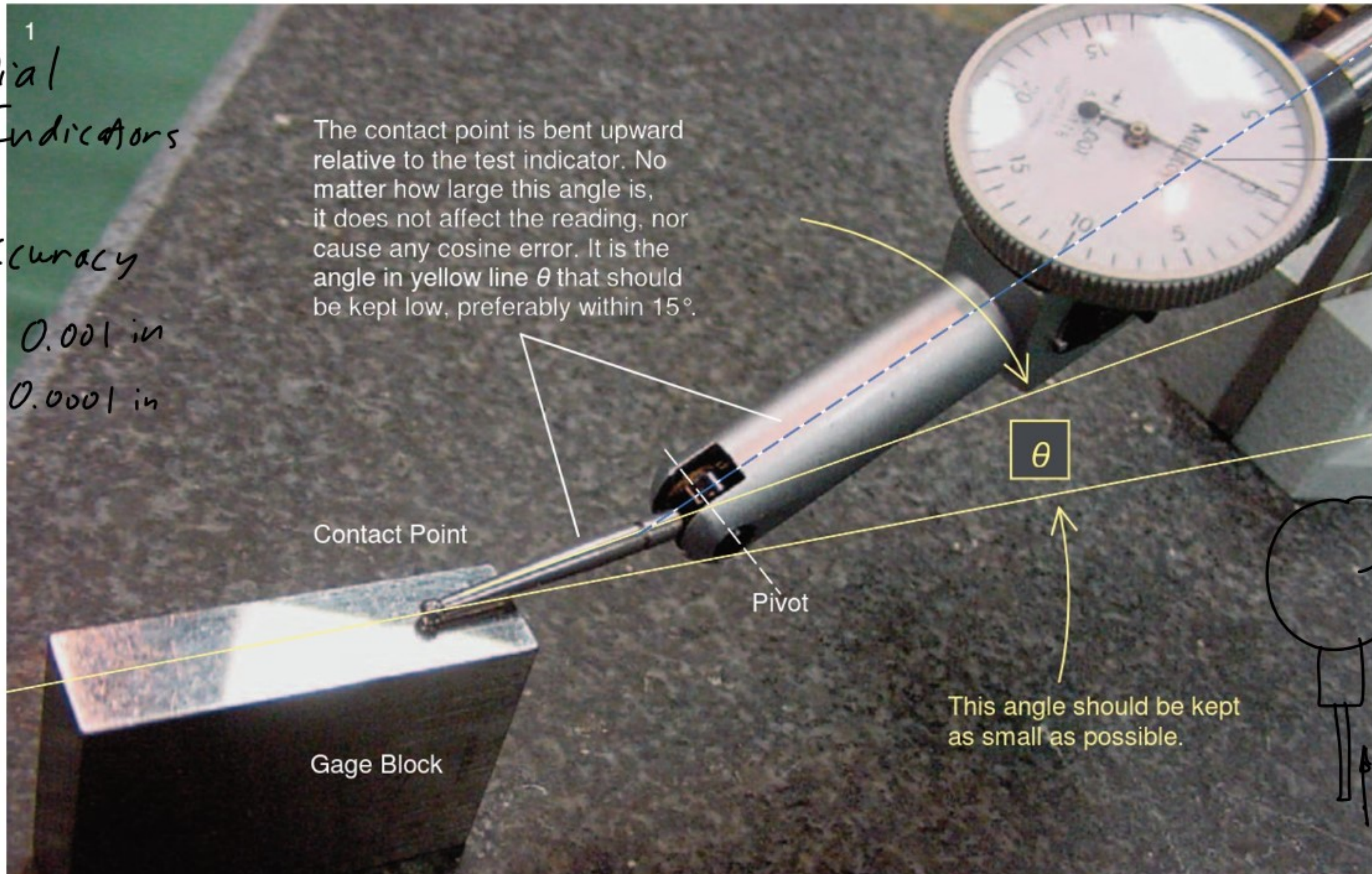
Contact Point

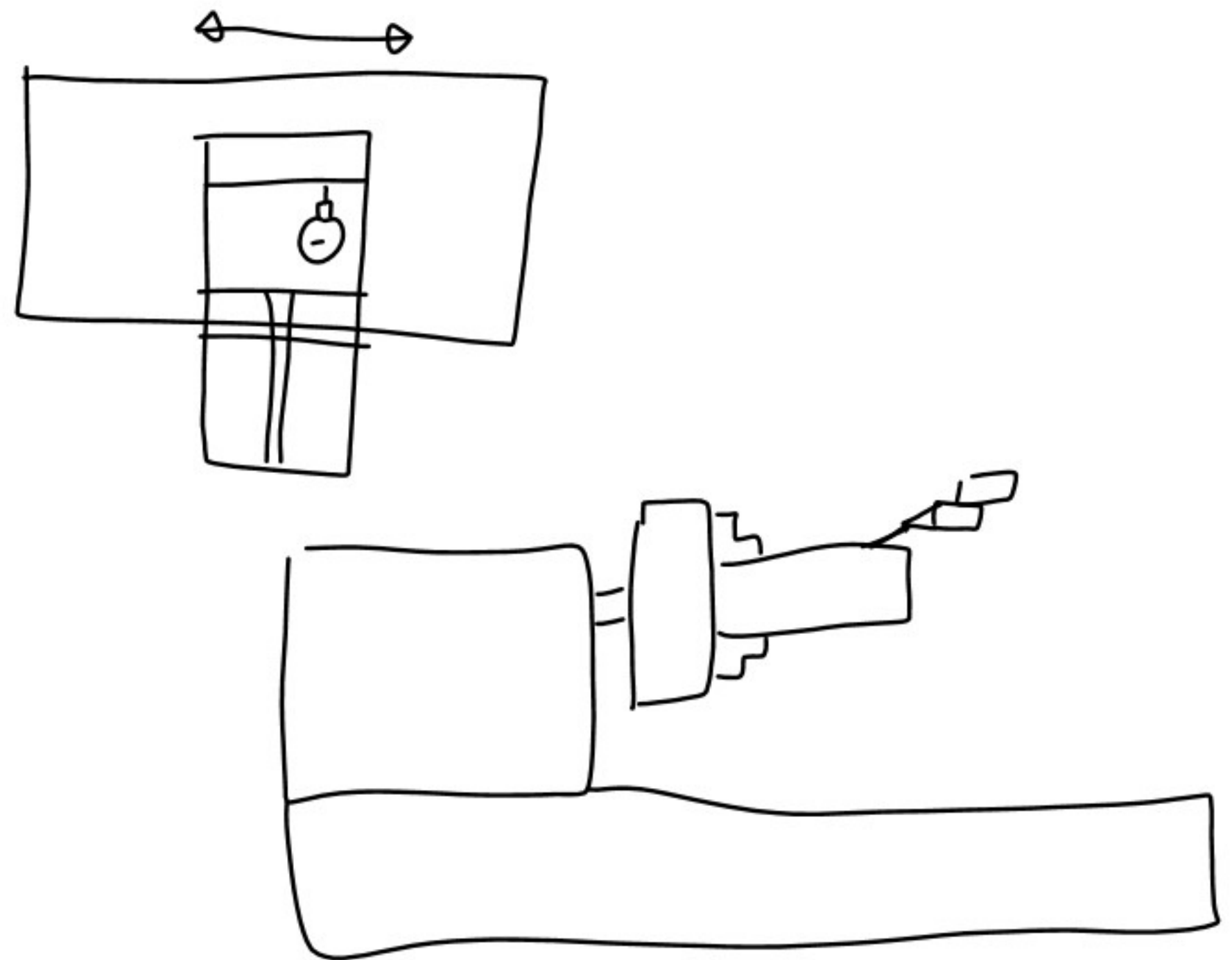
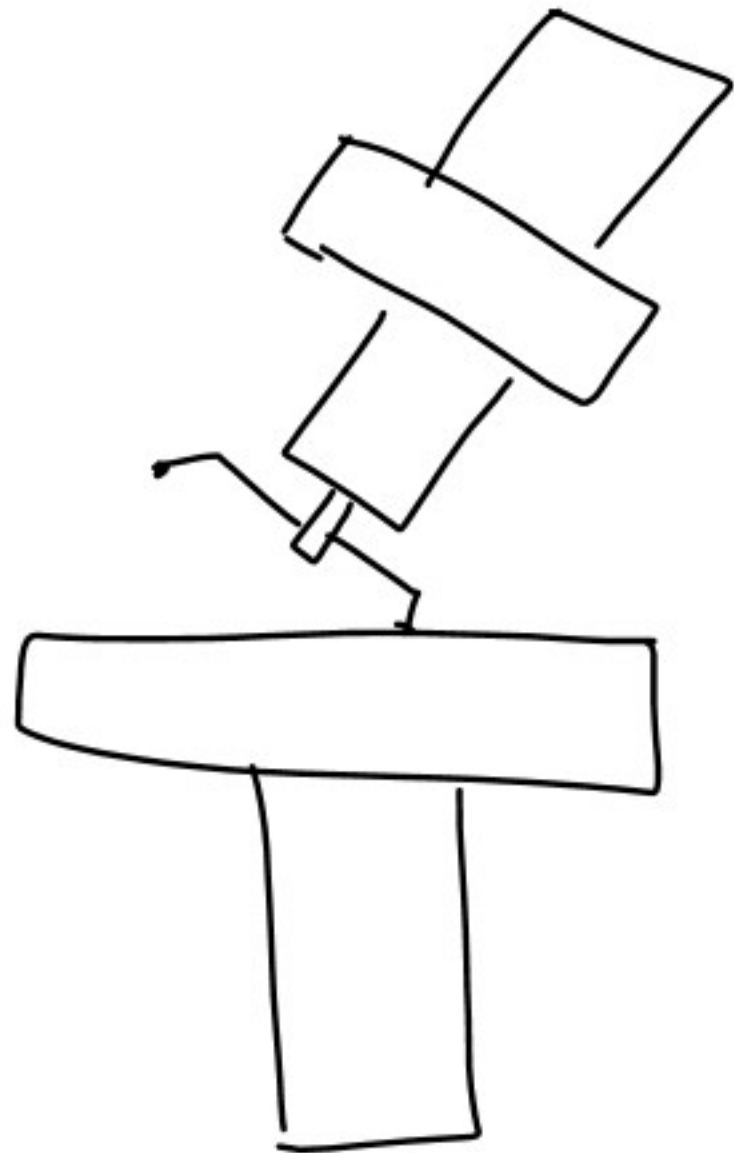
Pivot

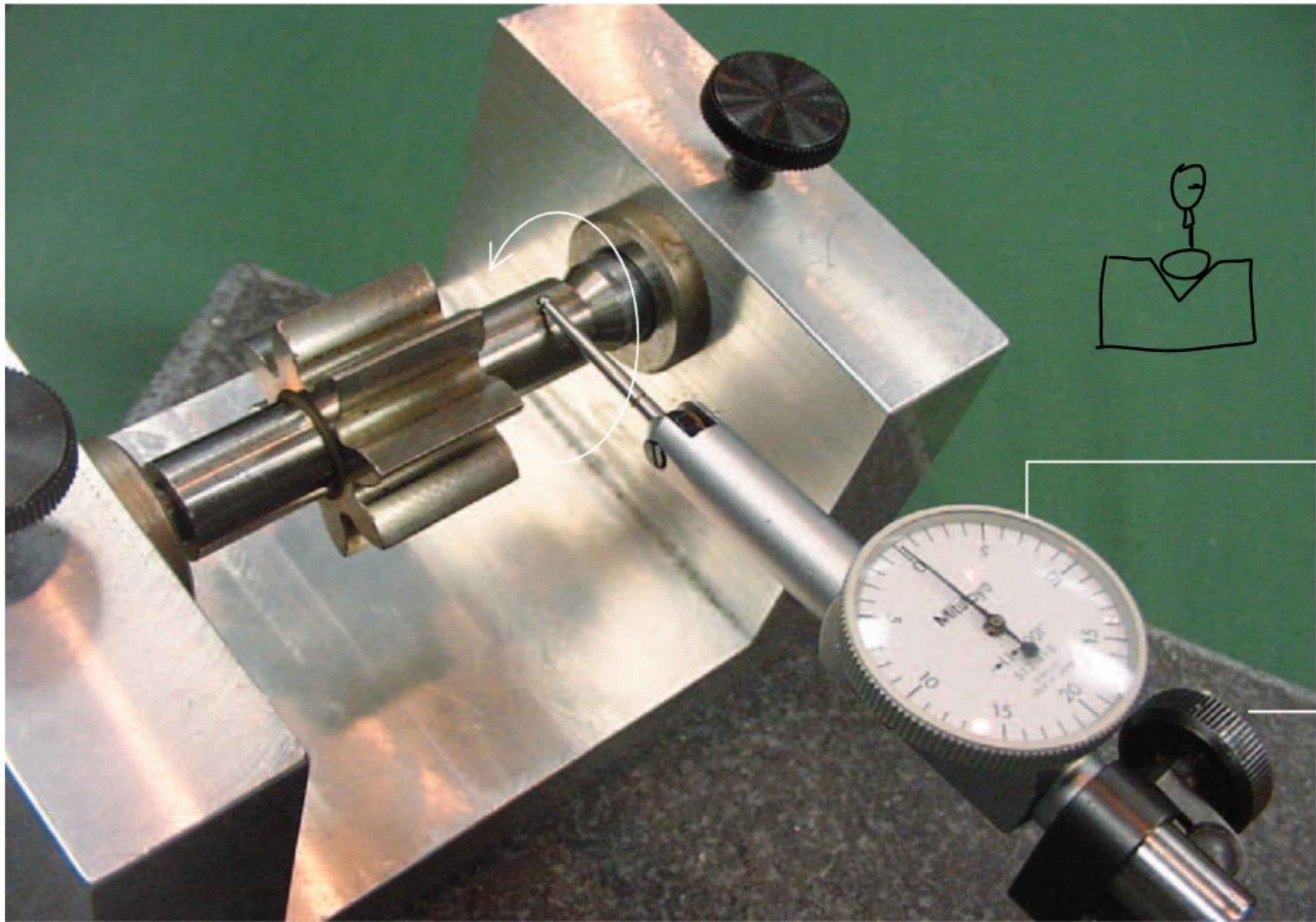
Gage Block

$\theta$

This angle should be kept as small as possible.



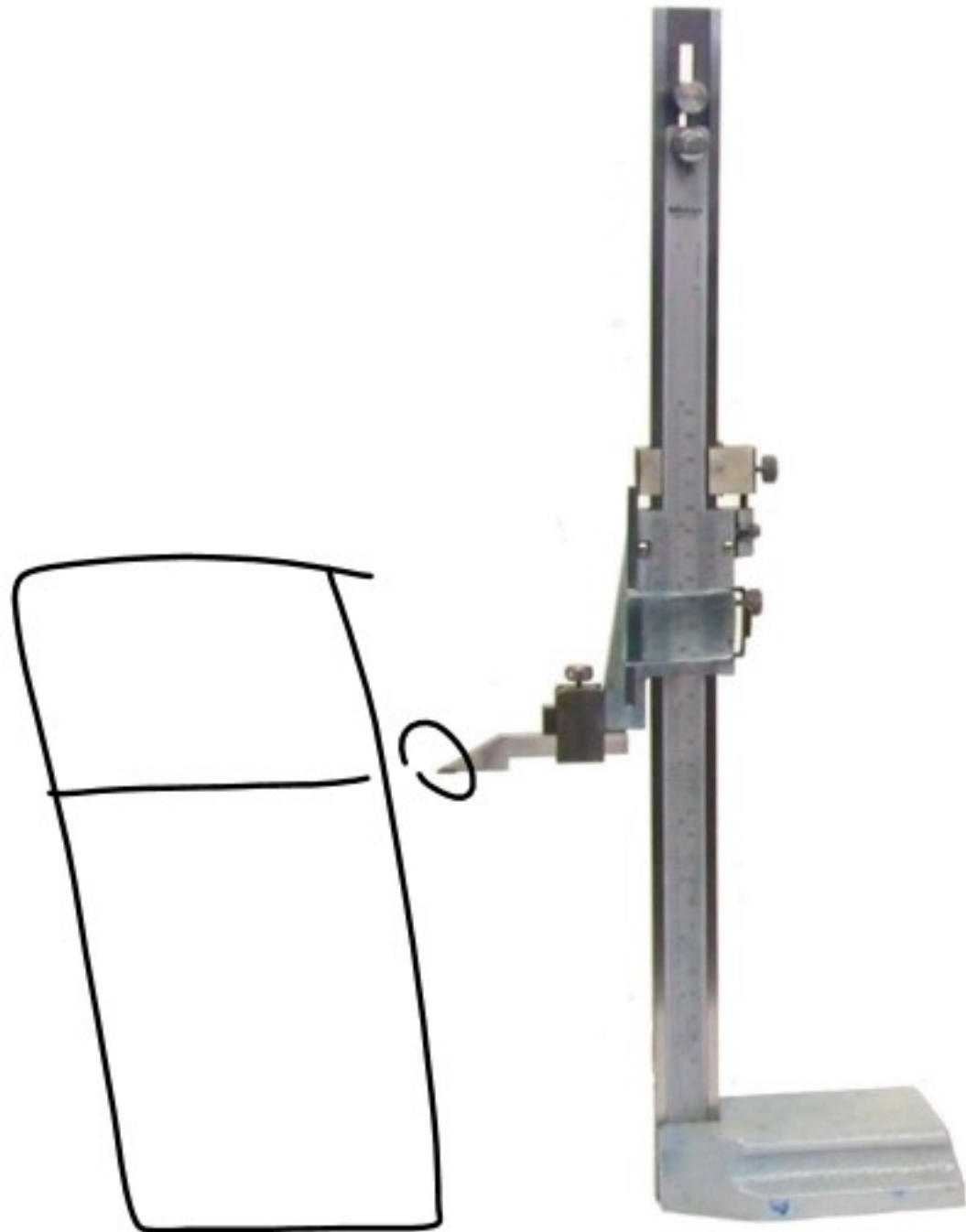




Hight Gauge



Accuracy 0.0001 in



$$\frac{1}{64} \text{ in} = 0.015625 \text{ in}$$

go / no-go gauge

The "Go" ball will go into the bore much easier and smoother than the "Go" plug gage of the same size.



ring  
gauge



Coordinate  
Measurement  
Machine

CMM

Accuracy 0.00005 in



Optical  
Comparator



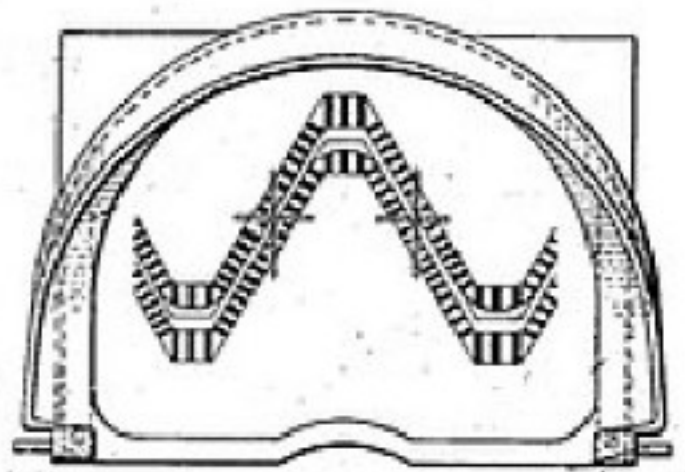
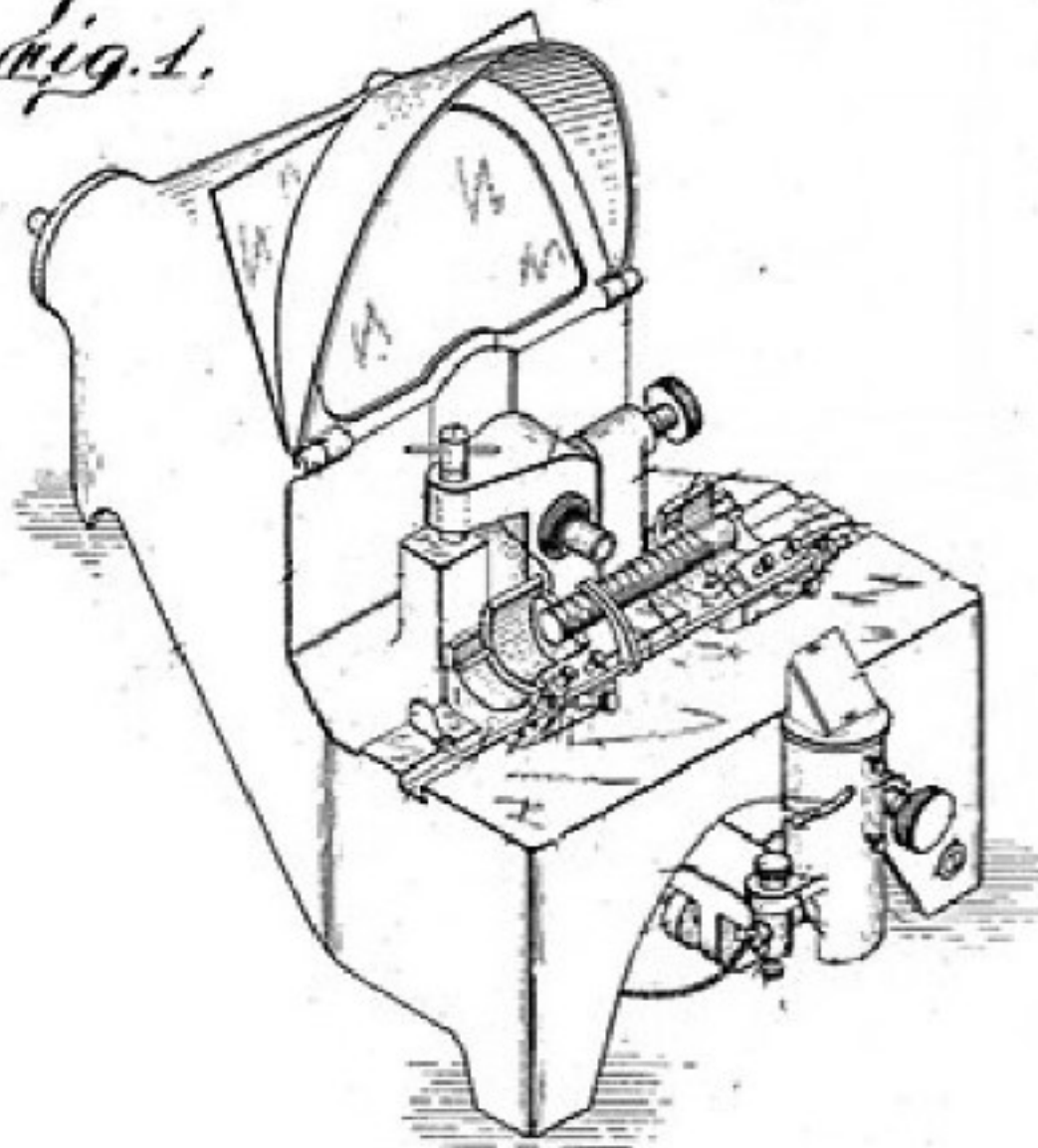


Mar. 5, 1929.

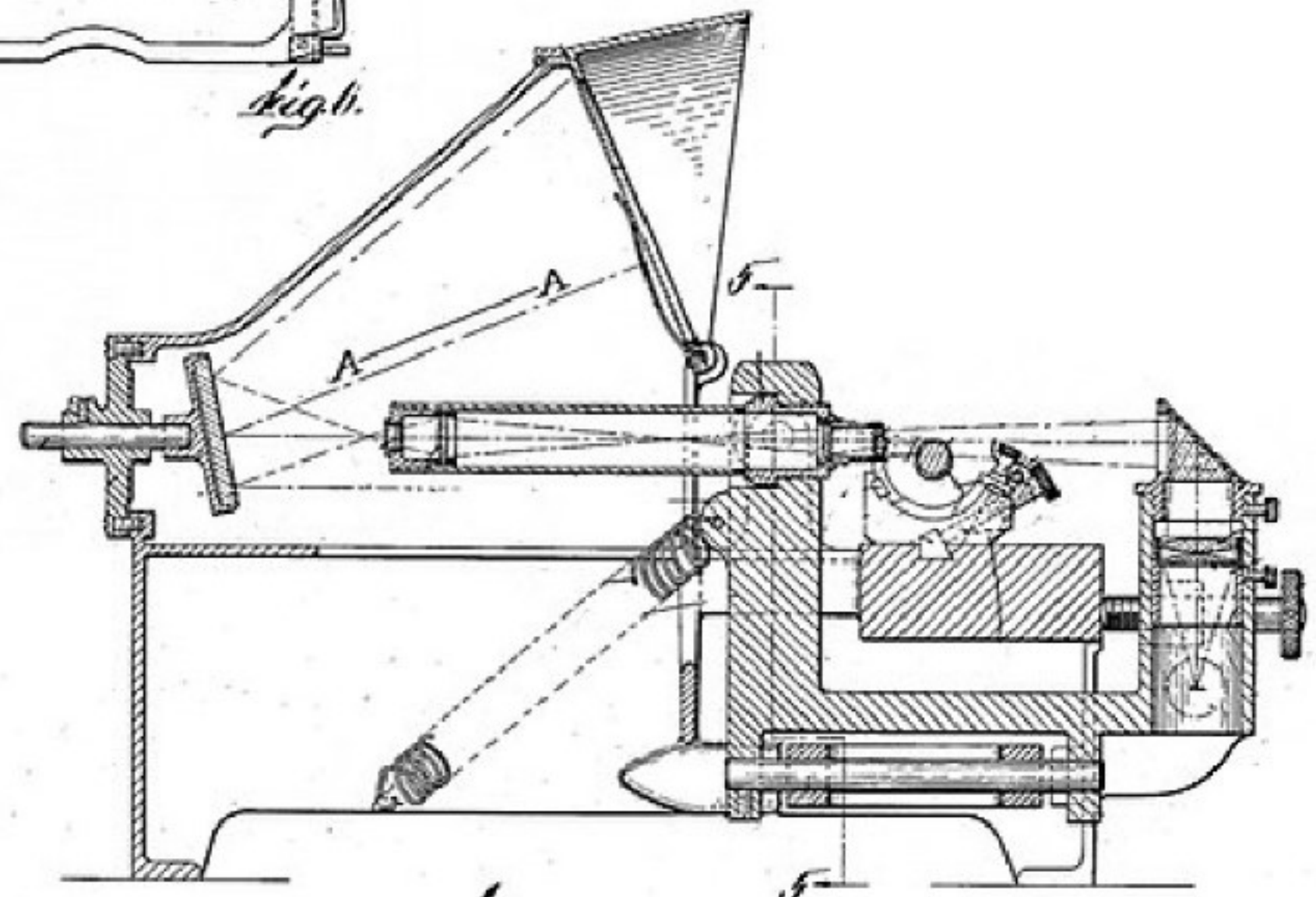
J. HARTNESS ET AL  
OPTICAL COMPARATOR

1,703,933

*Fig. 1.*



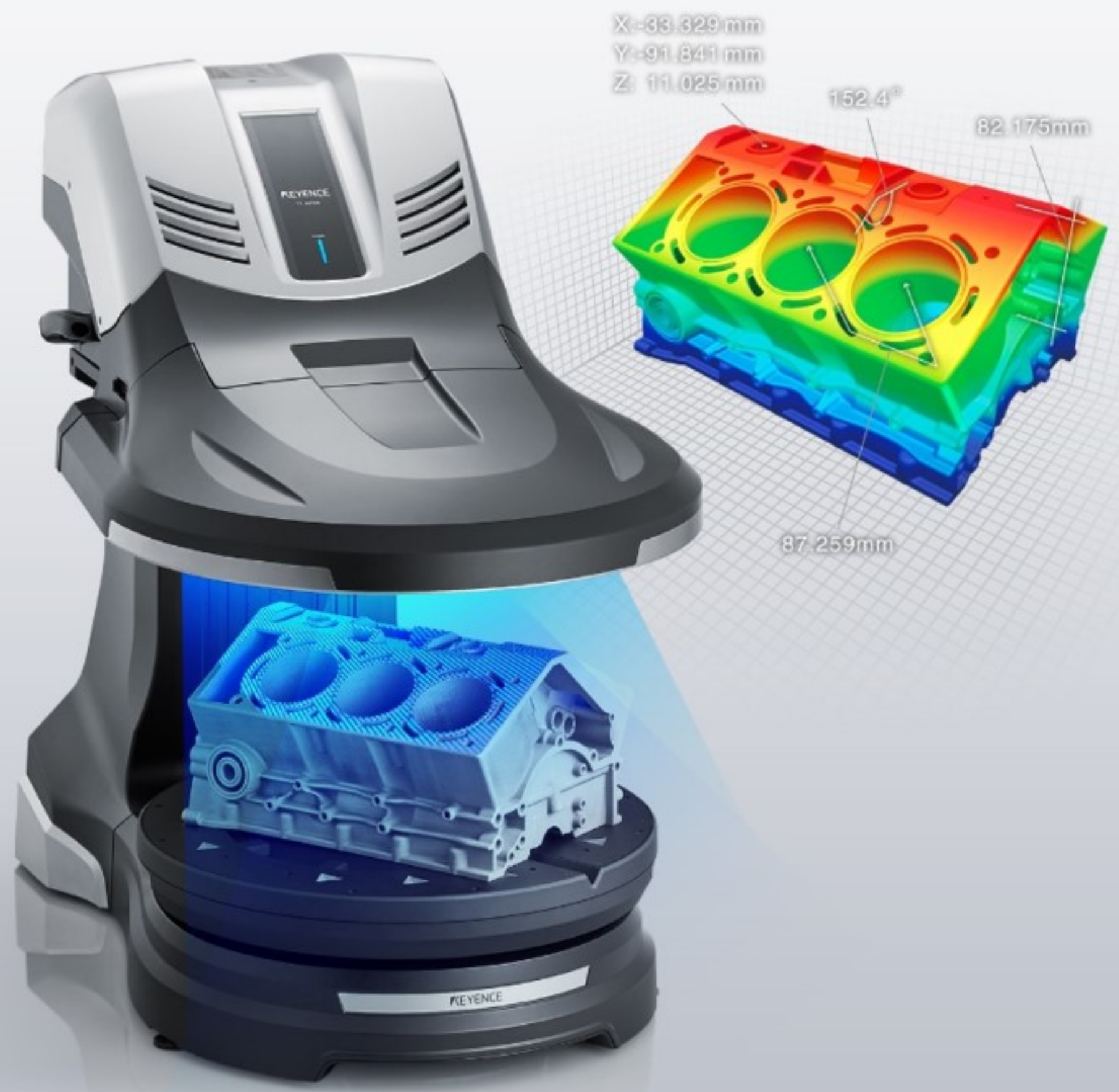
*Fig. 2.*



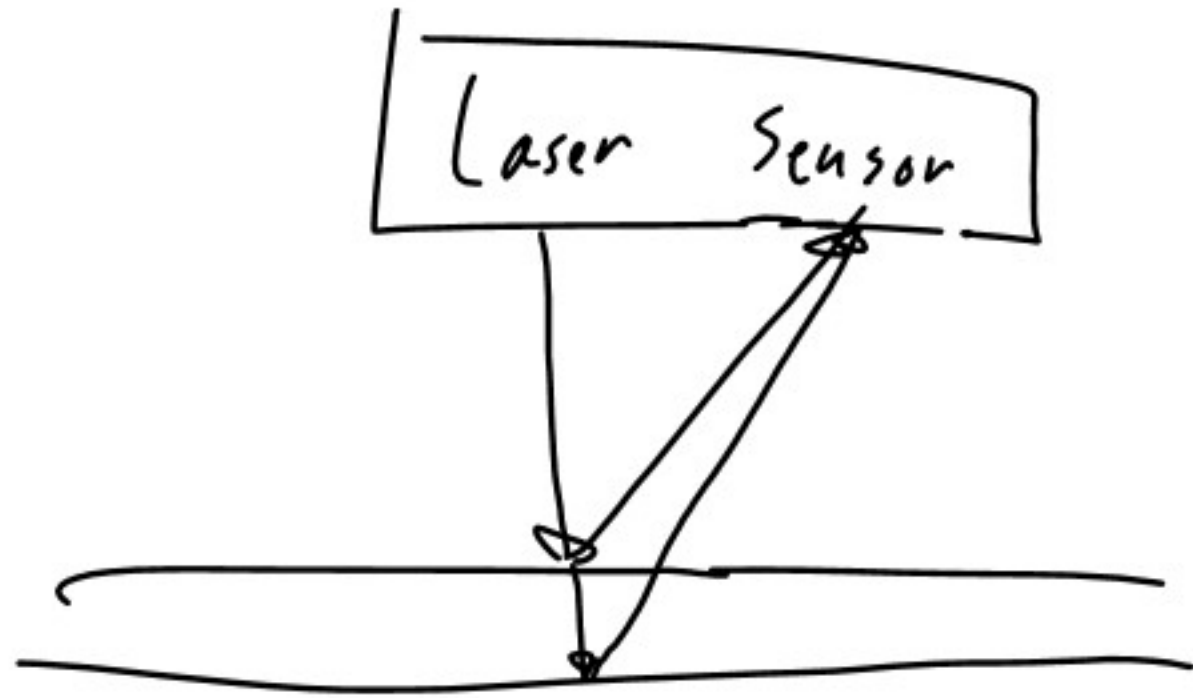
*Fig. 3.*

*Inventors*  
*James Hartness*  
*Russell W. Porter*  
*by*  
*Charles Brown Derby Day*  
*Attys.*

Optical  
CMM



# Laser Profilometer



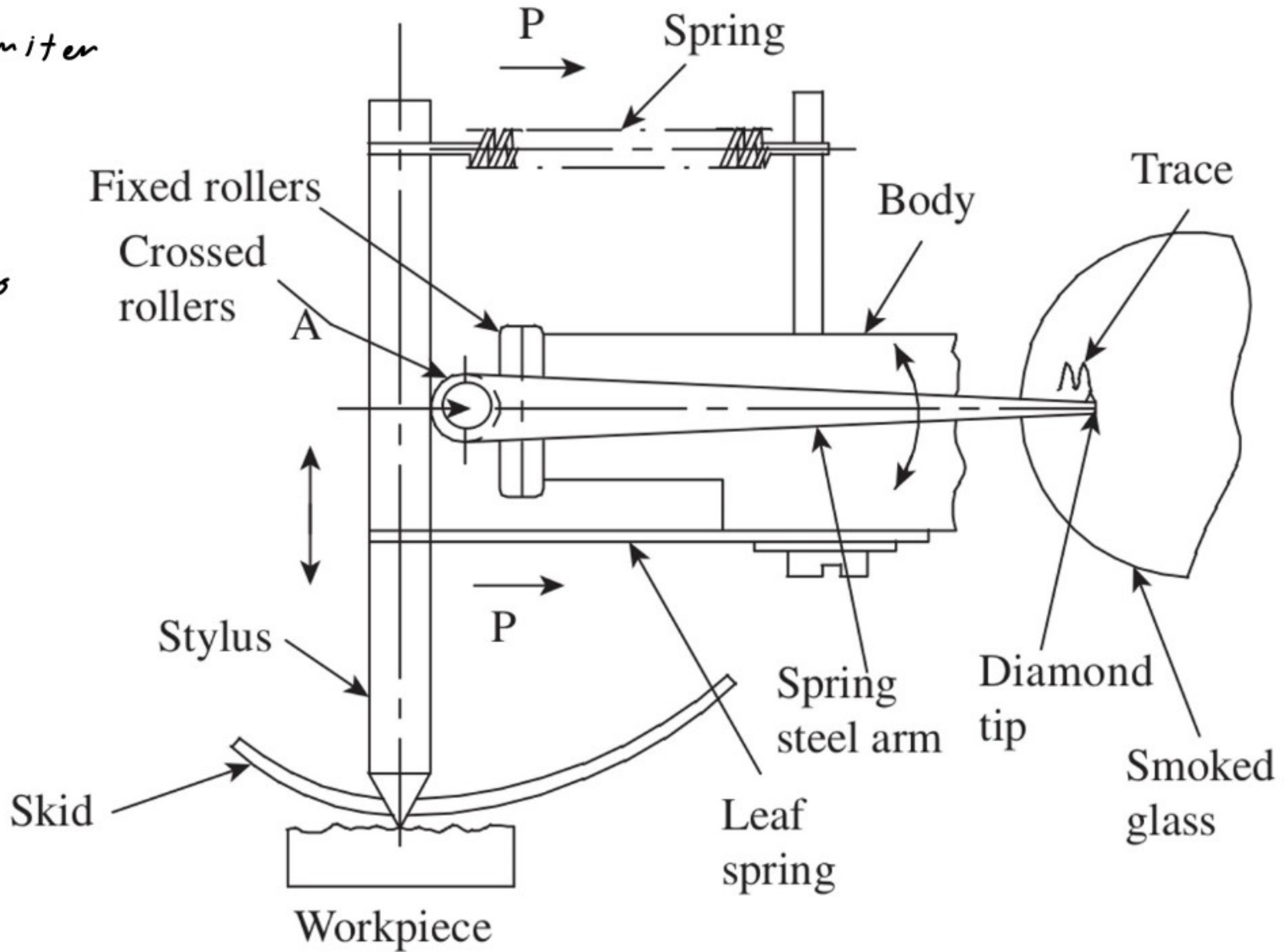
3200 points

$\frac{1}{9}$  to  $1\frac{3}{8}$  wide

$\frac{3}{9}$  to 3 range

# Profilimeter

Surface  
Roughness



# Hardness tester

Vickers

Brinell

Knoop

Rockwell

Shore

etc.





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

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

<sup>†</sup> 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  $0.200 \pm 0.010$  mm.

<sup>§</sup> 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>)