FOUR GENERATIONS OF CALIPERS

The history of caliper

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Over 180 years, calipers are the most common professional measuring tool at every production facility.

Calipers are distinguished from rulers and measuring rulers by the presence of indicating devices, measuring jaws and movable frames.

Calipers have unique potential among another linear meter:

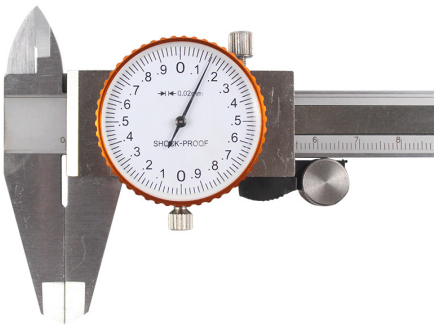
- "Colombics" measure four parameters of the tool (external and internal dimensions, depth and ledges);
- Precision calipers in the range of 0 ... 150 mm at the same time replace 6 micrometers;
- The extended calipers measure sizes up to 10000 mm with jaws up to 1000 mm

Old calipers were used in China
about 1100 ... 3400 years ago,
as a kind of measuring ruler with a movable frame
and two jaws / 1,2 /, see Pict. 1.
Old Calipers did not have special indicating devices,
due to which their error
(with transverse measuring jaws) exceeded the error
of conventional measuring rulers..

Pict.1 *Han Bronze Vernier Caliper [2]*

Calipers are classified by type of indicating devices [3], Pict. 2-5:

Pict.2 *Bar nonius (with Vernier scale)*



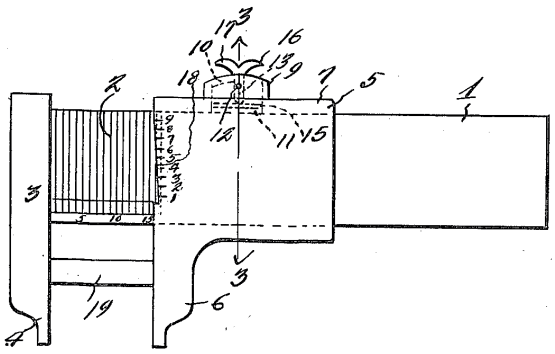
Pict.3 *With integrated dial (indicator)*

Pict.4 *Digital electronic (with incremental or photoelectronic scale)*

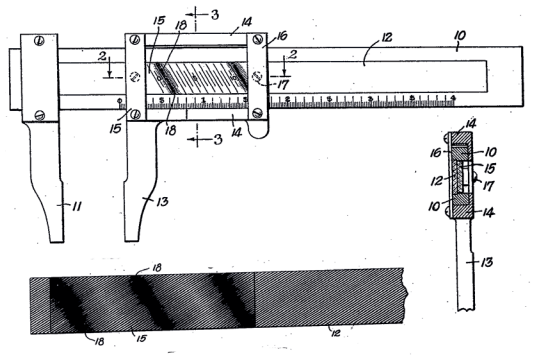
Pict.5 *Computerized (with integrated microcomputer)*

FOUR GENERATIONS OF CALIPERS

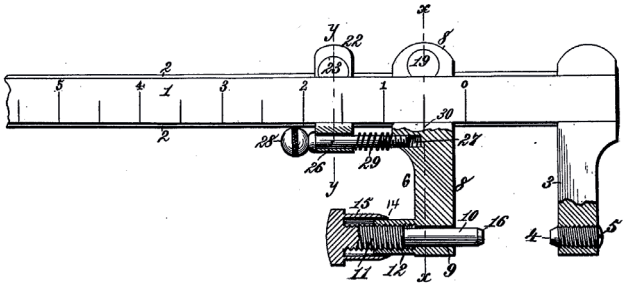
Caliper models are known that have not become an independent common gauge due to structural and metrological deficiencies, among which the following calipers are most interesting:



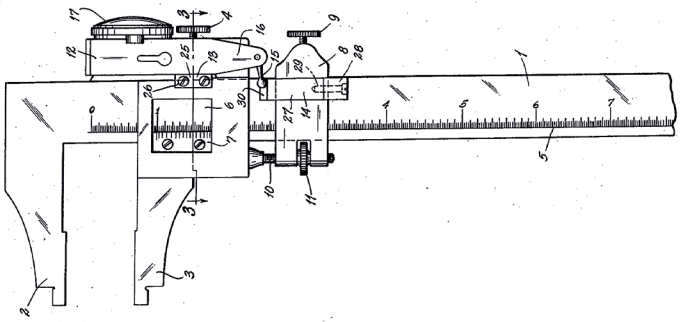
Pict.6 *With a diagonal scale [4]*
Патент H.Packet 1,231,934 1917 г.



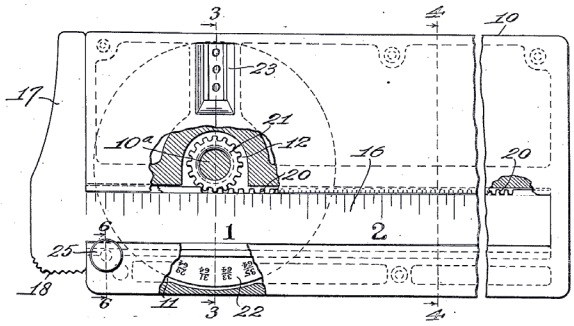
Pict.7 *With moire scale [5]*
Патент G.E.Giambiasi 1,415,627 1922 г.



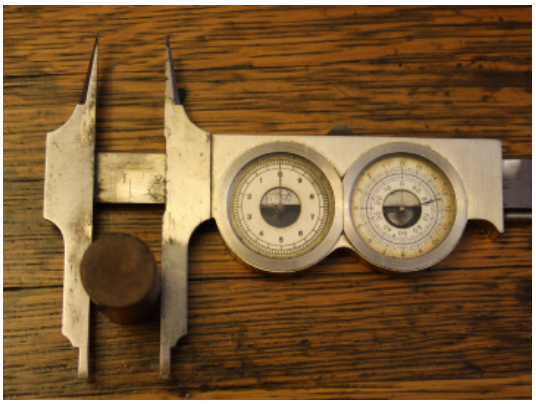
Pict.8 *With a micrometer head on a movable sponge [6]*
Patent S.H.Bellows 403,726 1889 г.



Pict.9 *With indicator on a movable frame [7]*
Patent L.H.Dowe 2,447,612 1948 г.

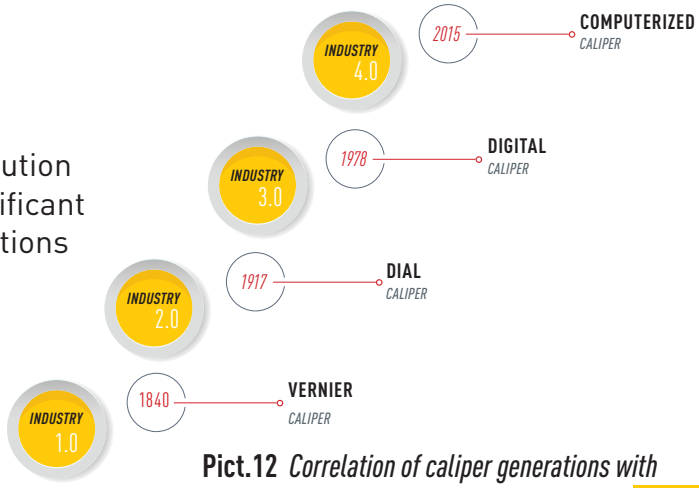


Pict.10 *Digital mechanical calipers with ring decades [8]*
Patent F.M.Gamroth 2,034,804 1936 г.



Pict.11 *Double indicator caliper SHCK London meter [8]*

Four main types of indicating devices (Vernier, dial, digital, computerized) correspond to the four main generations of the 180-year evolution of the calipers, we have established a highly significant correlation in time with the four Industrial revolutions (from «1.0 Industry» to «Industry 4.0»). Pict. 12.



Pict.12 *Correlation of caliper generations with Industrial Revolutions*

The first type of indicating devices for calipers was the vernier reading in calipers, which corresponds to the time of the First Industrial Revolution «In-dustry 4.0» (the emergence of steam engines and mechanical production) in the period of 1760 ... 1840th [10].

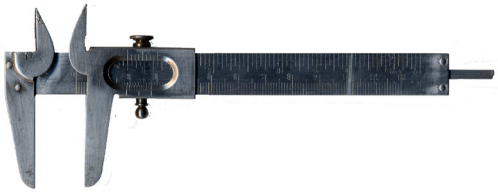
Vernier calipers use the Vernier indicating principle, which was discovered two centuries earlier.

The first vernier caliper appeared in France in 1837 ... 1840 at the royal factory, while the first caliper had a measuring range of 0 ... 530 mm, a division price of 0.100 mm and an error of 0.250 mm [1], **Pict.13.**

Pict.13 *First nonius caliper*

Error of Vernier calipers an order of magnitude smaller errors in measuring tapes and rulers, however, could not be better 0,030 mm [3].

Vernier calipers are widely used for over 180 years and have good perspectives in reliability and availability. **Pict.14.**



Pict.14 *Nonuis caliper*
Photo Of The «Museum. Tool «MICROTECH»

70 years after the appearance of Vernier calipers appeared calipers dial, it coincided with the Second industrial revolution «Industry 2.0» (the advent of electricity and mass production in the late 19th century to early 20th century [10]).

The use of analog calipers is hampered by the need for high intensity, high skill and absolute view of the users to ensure the passport indicators analog calipers.

Pict.15 *Indicator caliper Mauser*
https://www.worthpoint.com/worthopedia/vintage-

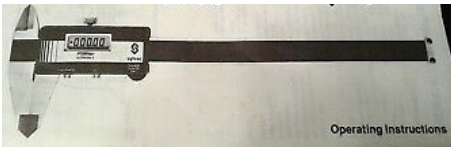
These disadvantages are absent from the calipers with a digital readout, the appearance of which coincided with the Third industrial revolution «Industry 3.0» (digital and computer) in the period from 1960 to 2011.

Calipers with digital indication developed and patented almost simultaneously Hans Ulrich Mayer (the first President of the Swiss «Sylvac» in 1972 /11/) and Ingvar Andermo (a renowned expert of the Swedish Royal Institute /12/, which in the future are quite productive in the American division of the Japanese company Mitutoyo /13/).

The first production models of digital electronic calipers has released a Swiss firm Tesa /1/, see Pict.16. These calipers was a glass scale and a photoelectric reading device which, after the incremental scales have ceased to apply in the calipers.

Digital electronic calipers modern Incremental scales developed and began to produce in 1980, the Swiss firm «Sylvac» [1], **Pict. 17**

Pict.16 *Digital caliper TESA*
Photo Of The «Museum. Tool «MICROTECH»



Pict.17 *Photo of the old type Sylvac caliper*

The measuring world largest Japanese firm Mitutoyo in the early 80-ies of the purchased licenses, and successfully used the technology to other developers [1]:

In 1981 had a common range and a common catalog by the innovative Swiss firm «Sylvac» [13];

- In 1983, it acquired a license and technology for the production of incremental caliper scales from the Royal Swedish Institute [1];

In August 1984, it was able to produce and sell 100 thousand digital calipers[1].

Japanese specialists of the company «Mitutoyo» in 1983 patented wired digital calipers with external PC [15], watch **pict.18**.

In 1987, another Japanese firm «Man Design» patented side transmitter for digital electronic Vernier caliper [16].

In 37 years, there have been virtually no changes in design or functionality

The appearance of calipers with computer reporting devices in 2015 coincided with the Fourth Industrial Revolution «Industry 4.0» (synthesis of digital, physical and biological technologies), which was announced at the Hannover Fair in 2011 by Klaus Schwab [10].

Calipers the previous three levels had many differences from the system of «Industry 4.0», in contrast to the calipers accounting-computer devices «Caliper 4.0».

The caliper «Caliper 4.0» for use in «Industry 4.0» have the following functions:

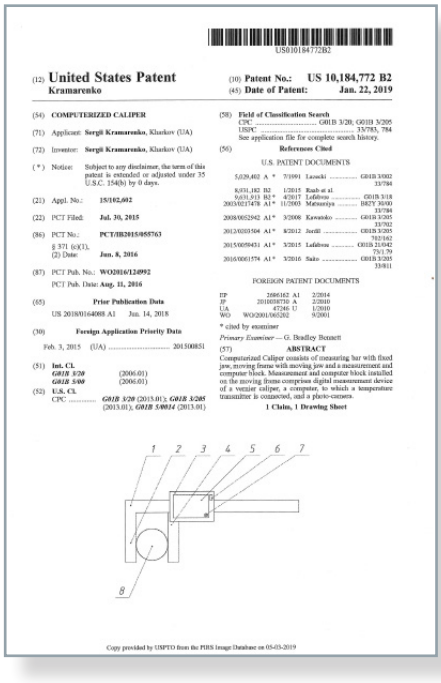
A two-way exchange of information of the caliper «Caliper 4.0» with all composite systems «Industry 4.0» («Factory 4.0», «Machine 4.0», «4.0 Metrology», servers, PCs, and smart backgrounds, with different meritele 4.0);

- Operation of calipers «Caliper 4.0» in automatic mode (mathematical processing of measurement results, logging and archiving, current and adjusted communication with external component systems «Industry 4.0»)

- Adaptive condition monitoring of the caliper «Caliper 4.0» (compensation of temperature expansion of the measured part, mathematical compensation of error in the measuring range, self-calibration and calculation of misalignment, saving the results of the previous calibration, date of the subsequent calibration).

-Innovative calipers «Caliper 4.0» with reporting-computer devices were the first in the world to be patented by specialists of «MICROTECH» /17, 18/, since 2016 computer calipers (models «Tablet» and «Intelligent») are serially produced in Ukraine and exported to 45 countries.

Pict.18 *Caliper Mitutoyo with data transfering cabel*



(12) **United States Patent**
Kramarenko

(10) **Patent No.: US 10,184,772 B2**
(45) **Date of Patent: Jan. 22, 2019**

(54) **COMPUTERIZED CALIPER**

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(72) Inventor: **Sergii Kramarenko**, Kharkov (UA)

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PCT Pub. Date: **Aug. 11, 2016**

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G01B 5/00 (2006.01)

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(58) **Field of Classification Search**
CPC G01B 3/20; G01B 3/205
USPC 33/783, 784
See application file for complete search history.

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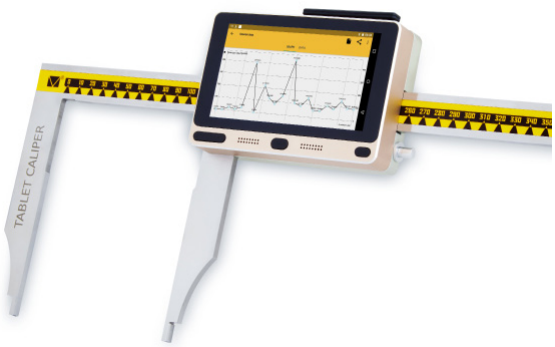
Primary Examiner — G. Bradley Bennett

(57) **ABSTRACT**

Computerized Caliper consists of measuring bar with fixed jaw, moving frame with moving jaw and a measurement and computer block. Measurement and computer block installed on the moving frame comprises digital measurement device of a vernier caliper, a computer, to which a temperature transmitter is connected, and a photo-camera.

1 Claim, 1 Drawing Sheet

Pict.19 *Patent US 10184772 Computerized caliper [17]*



Pict.20 *Computerized caliper MICROTECH Tablet 4.0 [3]*

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16.Pat. UAN°128692 «Caliper «Intelligent Caliper»