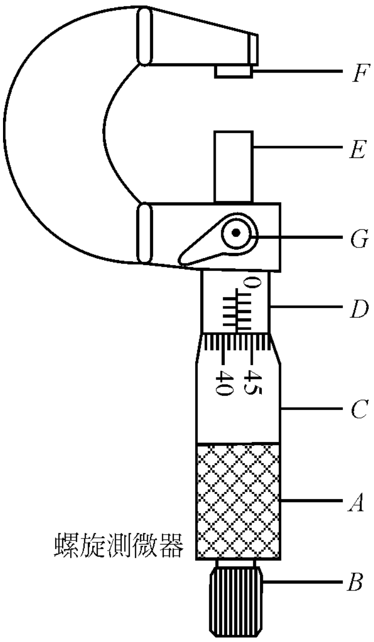
Exp. 4 Micrometer Caliper

1. Section Purpose

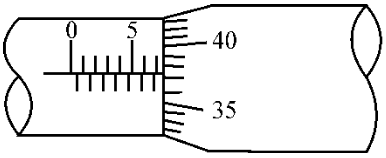
To comprehensively understand the structure, theory and uses of micrometer calipers and put it into practical use

2. Theory

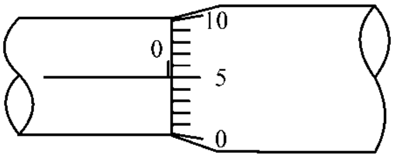


圖一

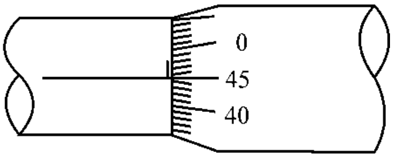
Shown in illustration 1 is the structure of a micrometer caliper, whose F is to fix an object in place, and D is served as its main body, with C being a round ruler and BE being its central axis. G is a twistable latch to clench objects. which can be loosened when turned counterclockwise, and can hold objects in place when turned clockwise. Please leave G loosened when the instrument is not in use as indicated in Illustration 1. When the round ruler is turned for a round (50 graduations in a round), the main ruler will move for one degree (graduation), which also means 1/2 mm, namely, every graduation on C represents 0.01mm. Handle B is connected with a spring and should be held tight to prevent objects clenched between EF from being too tight or loose. Please refer to illustration 2 for details. (B is also referred to as pressure fixing knob) In illustration 3, graduation zero of C is five graduations more than 0.0, or can be presented as + 5.0. D, the actual length of the objects to be measured, is the reading *a plus the reading b*/100 minus reading *c*/100. In illustration 4, the length of zero point to C is five graduations less than 0.0, which is also presented as -5.0. Therefore, the actual length of the object to be measured is the reading *a plus the reading b*/100 on round ruler minus reading *c*/100. This method brings extra convenience when the graduation numbers of c and b greatly vary; however, when they are close, it is advised to adopt approach 2 to judge in prevention of mistakes.



圖二



圖三



圖四

3. Instruments or Materials Required

a micrometer caliper, a piece of glass, 9 identical coins and some metal wires

4. Steps to the Experiment

1. Loosen the knob fixed and measure the zero point of the main body before measuring any objects, twisting C until it touches EF, and then turning B until hearing clacking sounds for 3 times. Jot down graduation c of round ruler c, including an estimate, for the purpose of correcting the zero point.
2. Then, put the object to be measured between EF. According to step 1, jot down the readings acquired from the main ruler (body), graduation b (including an estimate). When the corrected graduation of the zero point is c, x, the actual length of the object to be measured, is

$$x = a + \frac{b}{100} + \frac{50U(c-b)-c}{100} \tag{1}$$

where $\frac{50U(c-b)-c}{100}$ is zero point correction

; $U(c-b)=\begin{cases}1, & 若 c > b \\ 0, & 若 c \le b\end{cases}$

; $U(c-b)$ is step function (See Illustration 5.)

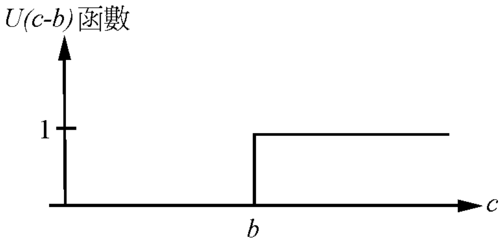


Illustration 5

Example：(1) as shown in Illustration 3, the zero point graduation c is 5, and the actual length in illustration 2 is

$$\begin{aligned} x &= 7 + \frac{37.5}{100} + \frac{50U(5-37.5)-5}{100} \\ &= 7 + \frac{37.5}{100} + \frac{-5}{100} \end{aligned}$$

(2) namely, when it is 45, then the actual length indicated in illustration 2 will be

$$x = 7 + \frac{37.5}{100} + \frac{50U(45 - 37.5) - 45}{100}$$
$$= 7 + \frac{37.5}{100} + \frac{5}{100}$$

thereby proving that all the micrometer calipers have been designed to be directly readable.

(3) Pick one of the coins from the prepared 9 identical ones.

(4) Correct the zero point first and then jot down value C and observe main ruler a, the graduation of it, b, to acquire the thickness of the coin, x_1.

(5) Measure the first coin's thickness from different spots and repeat step 4 for 2 times to respectively acquire the graduations a_0, a, b.

(6) Use t_1 to represent the average thickness of the first measured coin, and acquire it..

(7) Measure the second coin by repeating step 4 to 6 and use to represent the 3 measured values as x_4, x_5, x_6 and represent the average thickness of it as t_2 and repeat the same method to acquire t_3, t_4,⋯t_9.

(8) From t_1, t_2,⋯t_9， the error values of the 9 coins prepared can be acquired.

(9) Mark the observation value of the coin thickness as $t = (a.m. \pm \text{ error})mm$

(10) Utilize the 27 values that are previously acquired, x_1, x_2,⋯,x_{27}, to make a curve chart for error distribution as the instruction below:

1. Find the maximum of x_i, x_{max} and minimum, x_{min}, and you'll have the interval, $S = x_{max} - x_{min}$.
2. Divide the values acquired into 5 groups and set the group interval as 0.2 S according to the following instruction:
   (1) Set the first group as $x_{min} \sim x_{min} + 0.2\ S$.
   (2) Set the second group as $x_{min} + 0.2\ S \sim x_{min} + 0.4\ S$, ⋯
   (3) Set the fifth group as $x_{min} + 0.8\ S \sim x_{max}$ and fill it into Table 2
3. Calculate the times and organize the data acquired by specifying how many of the above-acquired 27 values falling between the data acquired in previous 5 groups and fill them into Table 2
4. Use the group number as the horizontal coordinate, and set the measured times of each group as the vertical coordinate and draw it on a sheet of graph (squared) paper and it'll be the curve chart for the measured values' error distribution.

5. Questions:

(1)How accurate it is when we measure with a micrometer caliper? Which decimal place can it be accurate to?

(2) When marked as 1/50 mm on a micrometer caliper and evenly divide the round ruler into 50 sections, how much will the main ruler move when the round ruler is turned for one round?

(3) When marked as 1/50 mm on a micrometer caliper and evenly divide the round ruler into 25 sections, how much will the main ruler move when the round ruler is turned for one round?