南京邮电大学
Nanjing University of Post & Telecom

物理实验教学中心

Physics Expeiment Center

Measuring low-resistances using double bridge

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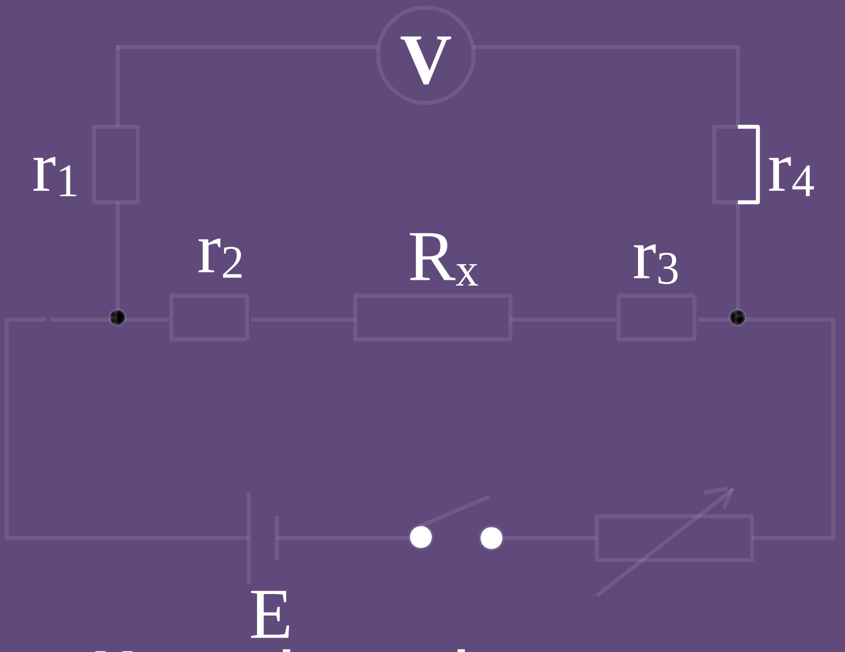
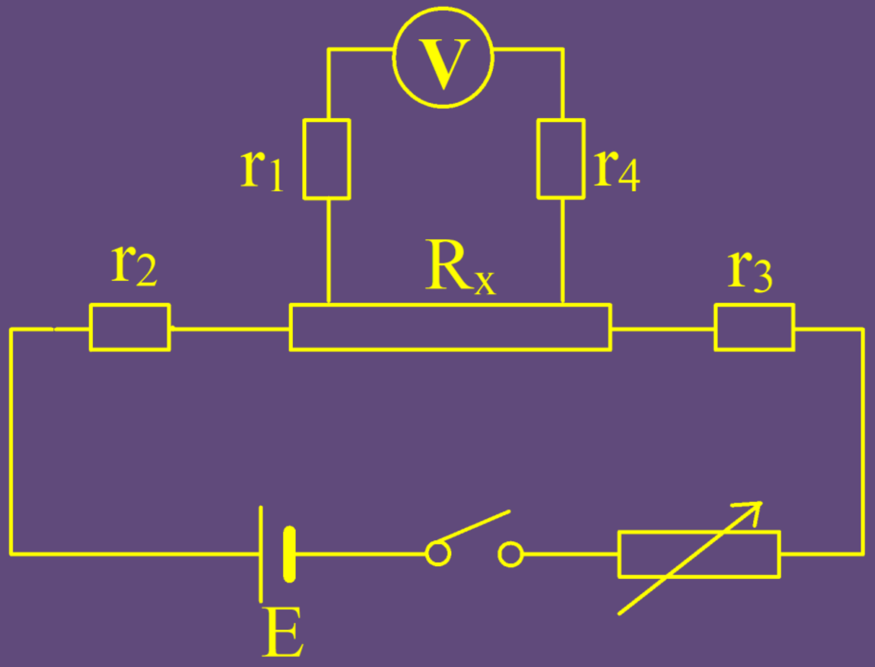
Experiment purposes

- Know the meaning of four probe method and structure of double bridge；
- Learn to use double bridge to measure **low resistance**；
- Learn to measure resistivity of conductor

Principles

- Four Probe Method





- **Measuring resistance using Voltammetry,** contact resistance, conductor resistance, If **r_2 and r_3>=R_X,** we can not use this circuit to measure **R_X。**

low resistance R_X->two Current contact C-C, two Voltage contact P-P.

<u>Four-Probe Method</u>

Van der Pauw Method

- Measure low resolution using double bridge

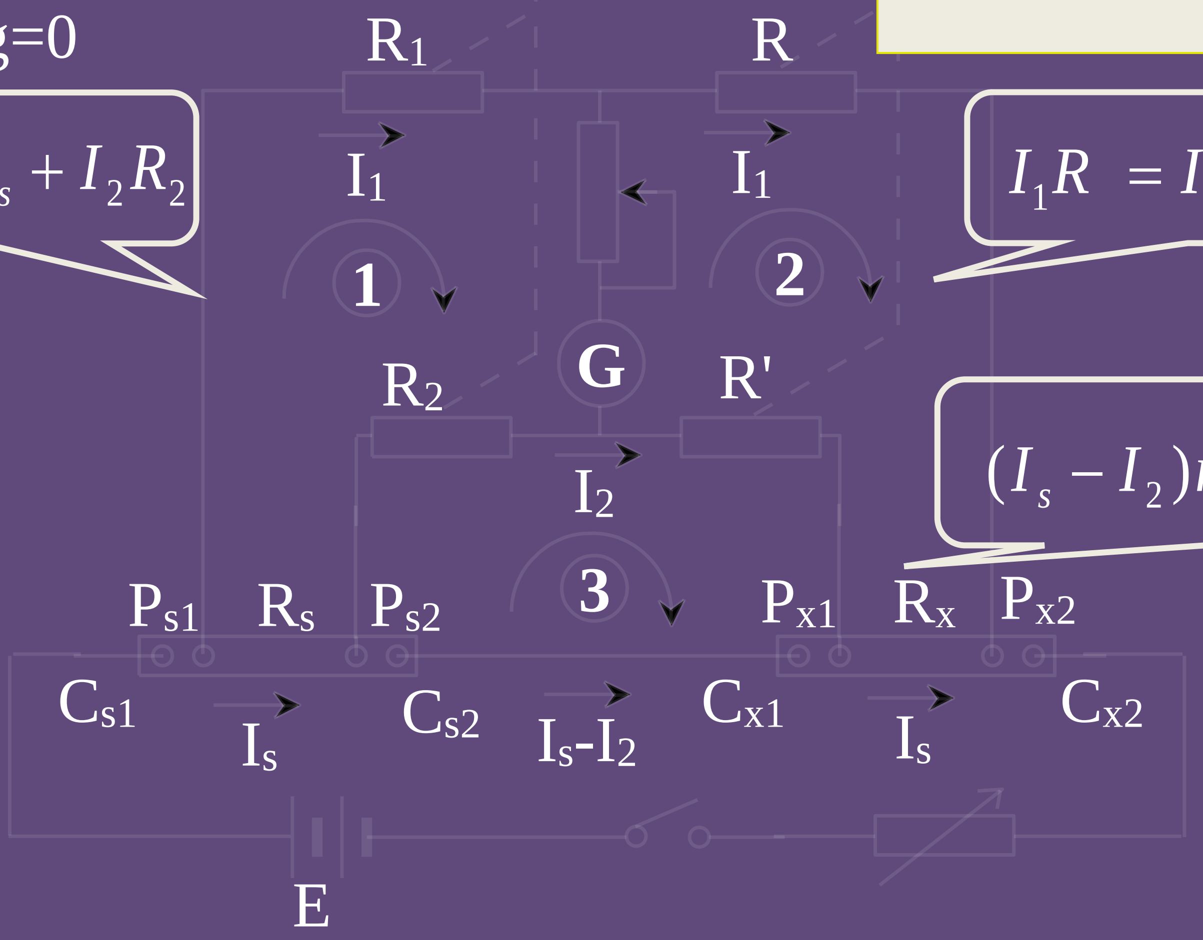
If R/R1=R′/R2 , $R_x = \frac{R}{R_1} R_s$

If Ig=0

$$I_1 R_1 = I_s \cdot R_s + I_2 R_2$$

$$I_1 R = I_s \cdot R_x + I_2 R'$$

$$(I_s - I_2) r = I_2 (R_2 + R')$$

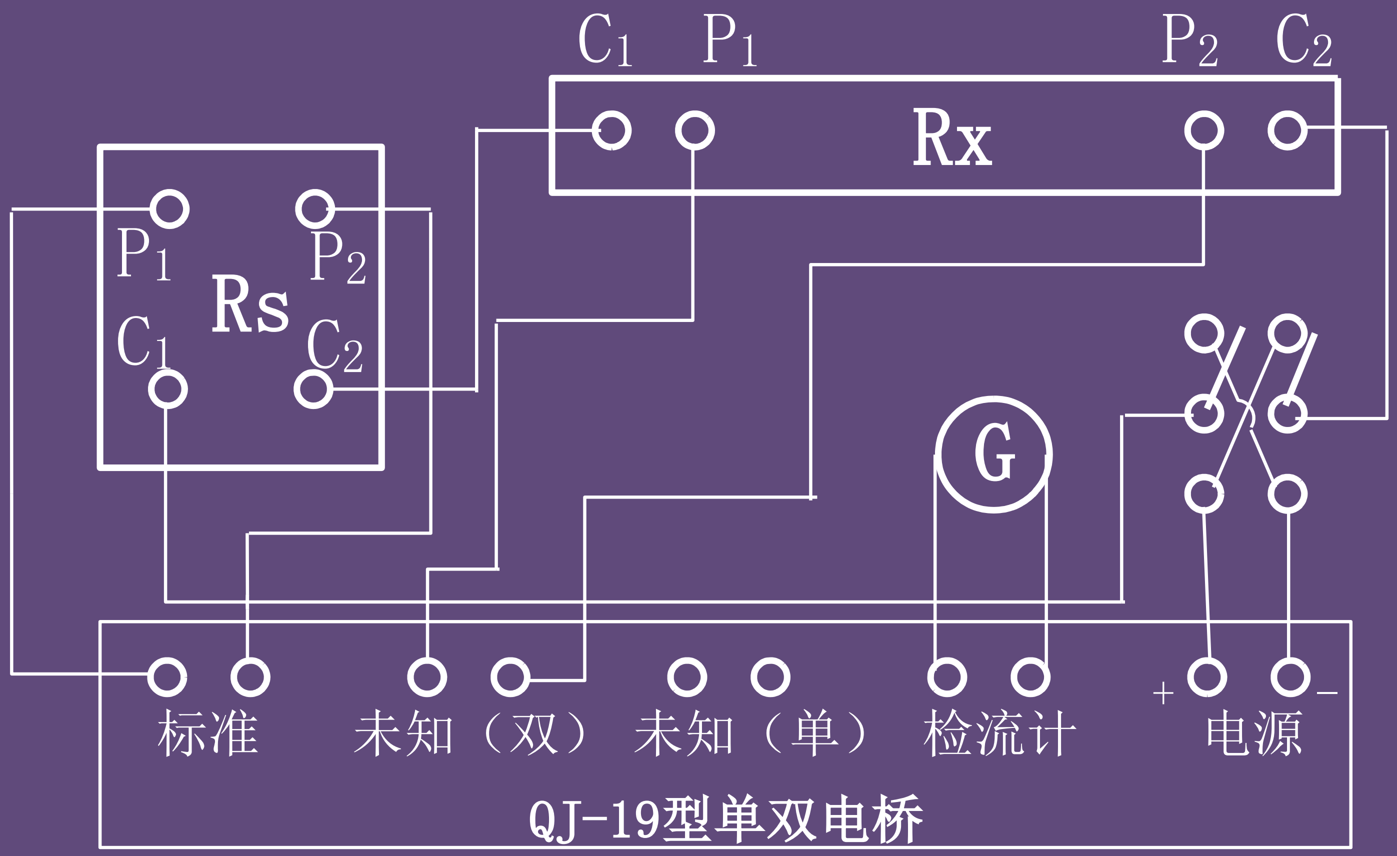


$$R_x = \frac{R}{R_1} R_s + \frac{r \cdot R_2}{r + R' + R_2}\left(\frac{R}{R_1} - \frac{R'}{R_2}\right)$$

➢ Experimental apparatus

➢ Operation

1. Circuit diagram



2. Initial adjustment

◆ **adjustment of double bridge**

R

R1， R2—>$10^4\Omega$

Press fine adjustment button（细调）

Switch to “**double bridge**” （双桥）

◆ adjustment of galvanometer

Galvanometer switch gear-> “zero-adjustment（调零） ” ,turn the zero-adjustment knob to adjust

After zero-adjustment, switch gear-> maximum range “30mV”

◆ Adjustment of standard resistance

Generally, standard resistance -> “0.1Ω ”， According to the actual situation to make corresponding adjustments during measurement. The selected principle： double bridge: 5 effective number, no more than the measurement range of double bridge.

◆ Adjustment of resistance

By adjusting the slider to select resistance's length to be measured， choose two lengths (200mm，400mm) to measure.

<u>**Notes: to ensure good contact with metal rods， tightening knobs during experiment.**</u>

3. Measurements (take 200mm copper rod as an example)

① insert copper bar at four terminal resistance box, adjusting the sliding side to 200mm.

② After zero-adjustment, switch gear-> maximum range “30mV”

③ Turn off reversing switch, adjust double bridge, Make the galvanometer indicated as ***zero***, adjust double bridge.

④ Adjust the galvanometer to “3mV” ， adjust double bridge once more， make the galvanometer indicated as zero. Adjust gradually until galvanometer-> “30μV” , Balance indicator->0. Record R resistance of double bridge .

⑤ Turn the reversing switch to the other side， backward current, adjust bridge balance once more according to ③ 、 ④, record R.

Table I: Diameters of the copper rod

NO.	1	2	3	4	5	Average d
d (mm)						

Table II: Resistance and resistivity

R1=R2=10000 Ω

	L (mm)	R_S	R		$\bar{R}$	R_X	ρ	$\bar{\rho}$
			+	-				
Copper rod	200	0.01						
	400	0.1						

$R_x = \frac{R}{R_1} R_s, R1 = 100000$;

$\rho = \pi d^2 R_x / 4L, d$: diameter of copper rod,L:length of rod(200mm,400mm);

$U_\rho = \rho . \sqrt{(\frac{U_{R_x}}{R_x})^2 + 4(\frac{U_d}{\bar{d}})^2 + (\frac{U_L}{L})^2}; \frac{U_{R_x}}{R_x} = 0.005, U_L = 1mm,$

$U_d = \sqrt{{U_A}^2 + {U_B}^2}, U_A = s.\frac{t}{\sqrt{n}}, U_B = 0.004mm, (\frac{t}{\sqrt{n}} = 1.24, s = \sqrt{\frac{\sum(d_i - \bar{d})^2}{n-1}}, n = 5)$

Here is the weblink to download this slide:
https://github.com/bliseu/phylab/
Some useful links:
https://www.elprocus.com/what-is-a-kelvin-double-bridge-and-its-working/
https://circuitglobe.com/kelvin-bridge.html
https://www.sciencedirect.com/science/article/abs/pii/004060909490863X#:~:text=The%20Van%20der%20Pauw%20method%20is%20one%20of,the%20given%20graph%20was%20confirmed%20by%20numerical%20calculations.

1. Please calculate and finish the tables in the slide, compare the calculated resistivity of copper with the theoretical value.
2. A 500-word description of the "Double-Bridge Method" and "Van der Pauw Method" should be given in the report.
The DEADLINE is May 30, 2024.

END