

3. Structure

A schematic diagram of the apparatus is shown in Fig. 4. The apparatus consists of a light source, a light receiving phototube, a DC amplifier, and five color filters. The light source and the receiving unit are installed on the base rail, the distance between them can be adjusted and read from the scale.

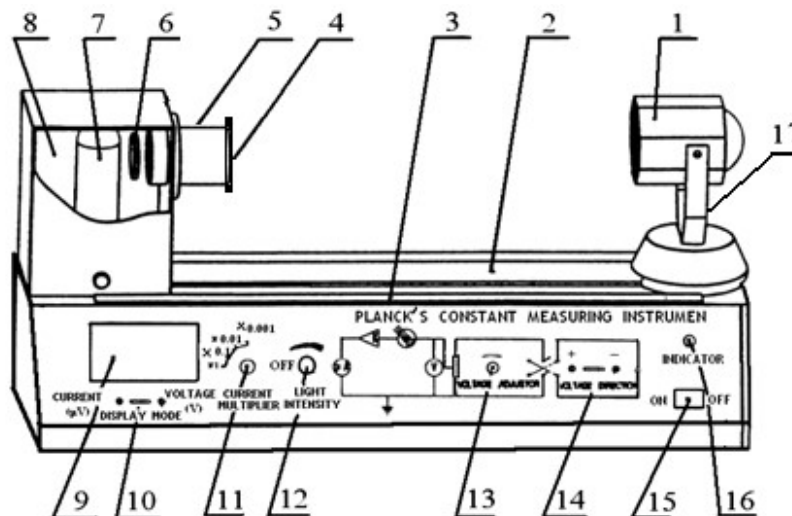


Figure 4 Schematic diagram of apparatus

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|---------------------------------|----------------------------|---------------------------|
| 1—Light source | 2—Base rail | 3—Scale (length=400 mm) |
| 4—Receiver cover (or filter) | 5—Receiver tube | 6—Focusing lens |
| 7—Vacuum phototube | 8—Receiver box | 9—Digital meter (V or I) |
| 10—Display mode switch (V or I) | 11—Current multiplier | 12—Light intensity adjust |
| 13—Accelerating voltage adjust | 14—Voltage polarity switch | 15—Power switch |
| 16—Power indicator | 17—Lock screw | |

4. Installation

Because the phototube and the lamp bulb are fragile, they are normally shipped as uninstalled items. Upon receipt of the apparatus, user needs to install the phototube and the bulb. Unscrew the top plate of receiver box (8) and insert the pins of the phototube into themount. Make sure the phototube is fully mounted and re-screw the top plate. Insert the pins of the bulb into the mount base in the light source housing. Use the spring retaining ring to secure the bulb in the housing. Make sure the bulb is fully mounted in the mount, as the bulb may slip off the mount.

Warning: Please handle the phototube and the bulb with care, as they are very fragile!

5. Setup and Adjustment

1) Setup

- Place the instrument on a secure table,make sure receiver tube (5) is blocked with cover (4), turn on the power, set light intensity adjustor (12) at moderate light level,slide light source (1) to 250mm position,and tighten the lock screw (17). If the lamp is not turned on, check if the lamp bulb slips off the mount.

- b. Adjust the tilt of the light source to let light illuminate directly onto the phototube.
- 2) Electrical adjustment
- a. Set display mode switch (10) to voltage display and adjust accelerating voltage adjustor (13) to get a stable voltage reading of $\pm 15\text{V}$.
 - b. Set display mode switch (10) to current display and keep the phototube covered while adjusting current multiplier (11) to choose among “ $\times 1$ ”, “ $\times 0.1$ ”, “ $\times 0.01$ ”, or “ $\times 0.001$ ” to ensure the dark current is less than $0.003\ \mu\text{A}$.
 - c. Change light intensity adjustor (12) to view different light intensity levels among strong, moderate, weak, or off.
 - d. Optimal conditions: light should shine on the central area of the phototube’s cathode plate rather than the anode, and maximum current should be observed. These conditions have been achieved in factory. If alignment is needed, open the top plate of receiver box (8) when the lamp is on, the image of the lamp can be seen on the cathode plate, adjust lamp location and tilt to bring the image to the central area of the plate (this should be performed by an experienced technician or instructor).

6. Experimental Procedure

- 1) Slide light source (1) to 250mm position, turn on the power, pre-heat the system for 5 minutes, and set current multiplier (11) at “ $\times 1$ ” position.
- 2) Place the red color filter (635 nm) onto receiver tube (5), set light intensity adjustor (12) at moderate light level, voltage polarity switch (14) at “+”, current multiplier (11) at “ $\times 1$ ” or “ $\times 0.1$ ”, and turn accelerating voltage adjustor (13) to gradually increase the photocurrent to saturation, and record the corresponding voltage. Use display mode switch (10) to toggle between current or voltage display.
- 3) Block the receiver tube by hand, the photocurrent should disappear at once; remove the hand, the photocurrent should reappear again, indicating that the photocurrent is formed very quickly (not exceeding 10^{-9} s).
- 4) Change the distance (R) between light source (1) and vacuum phototube (7), record the distance value (R) with corresponding photocurrent (I), and draw the $I-1/R^2$ curve. A straight line should be obtained.
- 5) Set light intensity adjustor (12) at strong light level, slide the light source to 300 mm position, voltage polarity switch (14) at “-”, display mode switch (10) at current display, accelerating voltage to 0V, and set current multiplier (11) at “ $\times 0.001$ ”. Adjust the accelerating voltage to decrease the photocurrent to zero, write down the accelerating voltage value for 635nm wavelength.
- 6) Repeat step 5) for each of the filters, and record the voltage value for each wavelength.
- 7) Convert the five wavelengths into frequencies ($\nu=c/\lambda$ where $c=3\times 10^8$ m/s, is the speed of light), plot accelerating voltage versus frequency, calculate the slope of the plotted line by means of least-square curve fitting, and derive Planck’s constant using Eq. (5).

- Note:**
1. To minimize measurement error, avoid or minimize stray light to the sensor.
 2. To minimize the effect of dark current, the relationship curve between accelerating voltage and dark current should be acquired initially by measuring accelerating voltage with corresponding photo current with the receiver tube being blocked. Then, the acquired dark current should be used as the “zero” photo current when measuring the cutoff voltage in the experiment. For example, in the experiment, if

the cutoff voltage of a specific filter is pre-determined at -0.5 V corresponding to real zero current output, and the dark current at this voltage is found 0.001 μA as previously measured, the accelerating voltage should be slightly adjusted until the photo current changes to 0.001 μA from 0 μA . In other words, the accelerating voltage corresponding to 0.001 μA should be taken as the cutoff voltage, rather than the accelerating voltage corresponding to zero current.

Warning: the Halogen Tungsten lamp can become very hot if turned on over a few minutes, so avoid touching the lamp or the lamp housing with bare hands!