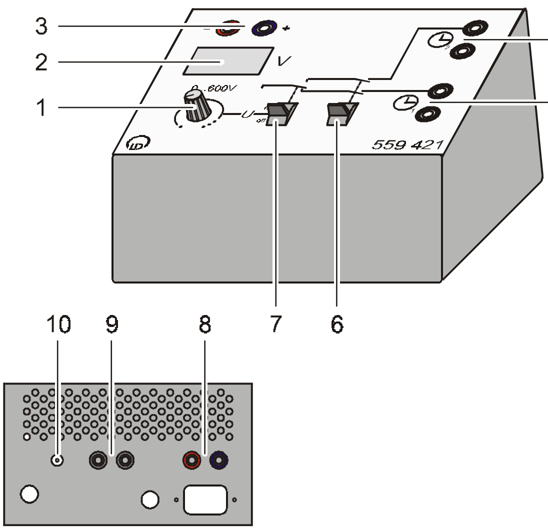
Lehr– und Didaktiksysteme
LD Didactic GmbH
Leyboldstrasse 1 · D-50354 Huerth

06/05-W97-Kem



Instruction sheet 559 421

Millikan supply unit (559 421)

1 Voltage adjusting knob
2 Voltage display
3 Connector for plate capacitor
4 Time measurement output 2 (rise time)
5 Time measurement output 1 (fall time)
6 Switch t
7 Switch U
8 Output for voltage measurement
9 Connector for illumination device
10 Hollow socket

1 Description

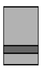
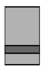
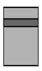
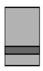
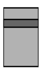
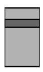
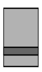
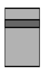
The Millikan supply unit supplies the voltage needed for the plate capacitor and the illumination device of the Millikan apparatus (559 411) and makes available the outputs for connecting time measurement instruments in order to carry out the Millikan experiment.

2 Scope of delivery

1 Millikan supply unit

1 Plug-in power supply unit 230 V / 12 V (562 791)
or
1 Plug-in power supply unit 115 V / 12 V (562 792)

3 Function of switch U and t

Switch U	Switch t	Voltage	Time measurement output 1 (fall time)	Time measurement output 2 (rise time)
		Off	Open	Open
		On	Open	Open
		On	Open	Short circuited
		Off	Short circuited	Open

4 Technical Data

Voltage for plate capacitor:

Voltage:	0 ... 600 V, continuously variable
Display :	digital, 3-digit, 14 mm figure height
Connection:	4-mm safety socket

Output for voltage measuring/*/:

Voltage graduation:	1 / 1000
Connection:	4-mm safety socket

/*/ e.g. with Sensor-CASSY (524 010)

Ilumination device:

Voltage:	12 V
Connection:	4-mm safety sockets

Time measurement outputs:

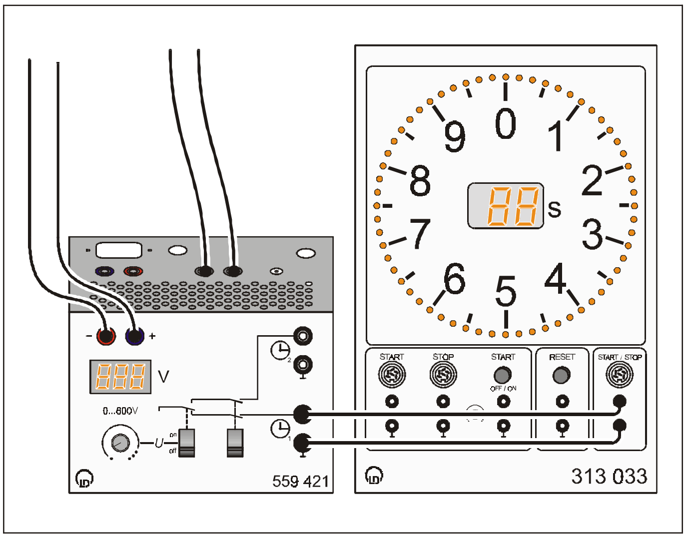
Connections:	4-mm safety socket

General data:

Supply voltage:	12 V~ from plug-in power supply unit
Connection:	Hollow socket
Dimensions:	19 cm × 15 cm × 11 cm
Weight:	1 kg

5 Experimental setup

5.1 Float method, manual measurement

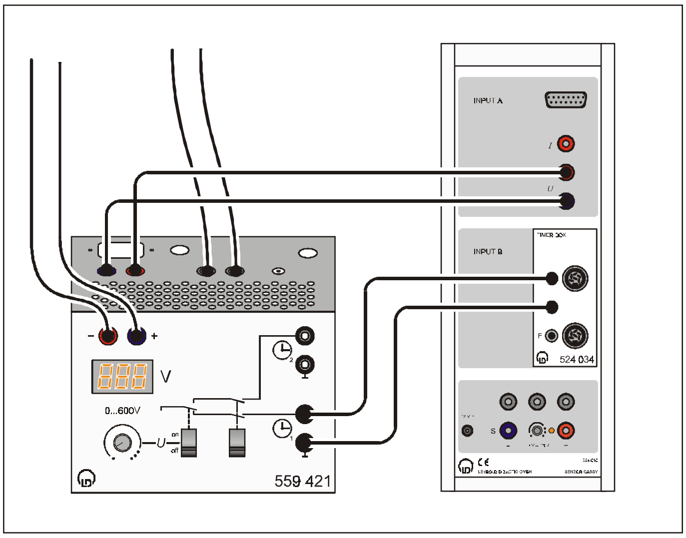


Recommended time measurement instrument for fall time

1 Electronic stop-clock P	313 033
1 Digital counter	575 48
1 Counter P	575 451

- To measure the fall time, connect time measurement output 1 to the time measurement instrument and measure the short circuit time.
- Read capacitor voltage on the voltage display.

5.2 Float method, measurement with Sensor Cassy

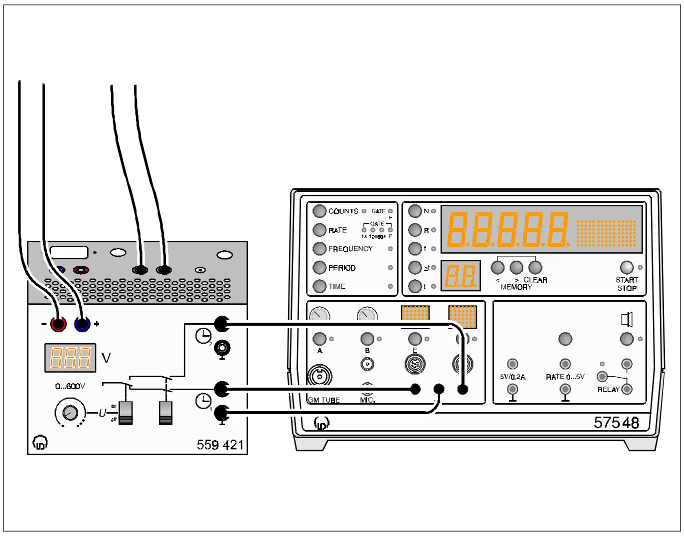


Additional equipment required:

1 Sensor CASSY	524 010
1 Timer Box	524 34

- To measure the capacitor voltage, connect the voltage measurement output to input A and observe the graduation factor 100.
- To measure the fall time, plug the Timer Box to input B of the Sensor Cassy, then connect time measurement output 1 and measure the short circuit Time.

5.3 Fall/rise method, manual measurement

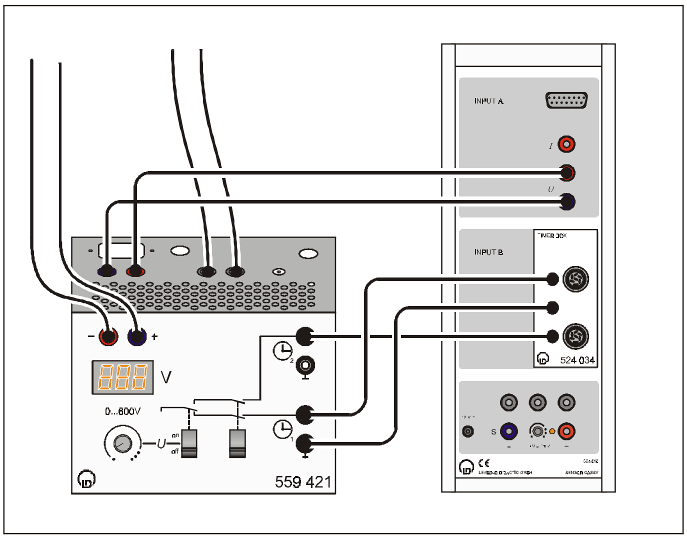


Recommended time measurement instrument for fall and rise time:

2 Electronic stop-clocks P	313 033
1 Digital counter	575 48
1 Counter P	575 451

- To measure the fall time and rise time, connect time measurement outputs 1 and 2 to the time measurement instrument(s) and measure the short circuit times, respectively.
- Read capacitor voltage on the voltage display.

5.4 Fall/rise method, measurement with Sensor CASSY



Additional equipment required:

1 Sensor CASSY	524 010
1 Timer Box	524 34

- To measure fall time and rise time, plug the Timer Box to input A of the Sensor Cassy, connect time measurement outputs 1 and 2 and, then, measure the short circuit times.
- To measure the capacitor voltage, connect the voltage measurement output to input B and observe graduation factor 100.

6 Carrying out the experiment

6.1 Float method:

The float potential U and the fall speed v are determined from the fall time t for a pre-selected distance *s*. The following applies for the radius *r* and the charge q of the droplet:

$$r = \sqrt{\frac{9}{2} \cdot \frac{\eta \cdot v}{(\rho_2 - \rho_1) \cdot g}}, \quad q = 9 \cdot \pi \cdot \frac{d}{U} \cdot \sqrt{\frac{2 \cdot \eta^3 \cdot v^3}{(\rho_2 - \rho_1) \cdot g}}$$

(*d*: plate spacing, η: viscosity of air, ρ_2: density of oil, ρ_1. density of air, *g*: gravitational acceleration)

- First turn switch U and switch t downward.
- Use switch U to turn on capacitor voltage, then adjust it using a rotary potentiometer so that a selected oil droplet floats.
- Use switch U to turn off the capacitor voltage.

As soon as the oil droplet is next to a selected scale graduation mark:

- Use switch t to start time measurement.

As soon as the oil droplet has fallen over a pre-selected distance:

- Use switch U to turn the capacitor voltage back on and thus stop time measurement.
- Read fall time *t* and capacitor voltage *U* and record with fall or rise distance *s*.

6.2 Fall/rise method:

The fall velocity v_1 and the rise velocity v_2 are determined from the fall time t_1 and rise time t_2 for a pre-selected distance *s*. The following applies for the radius *r* and the charge *q* of the droplet

$$r = \sqrt{\frac{9}{2} \cdot \frac{\eta \cdot v_1}{(\rho_2 - \rho_1) \cdot g}}, \quad q = 9 \cdot \pi \cdot \frac{d}{U} \cdot (v_1 + v_2) \cdot \sqrt{\frac{2 \cdot \eta^3 \cdot v_1}{(\rho_2 - \rho_1) \cdot g}}$$

- First turn switch U and switch t downward.
- Use switch U to turn on the capacitor voltage and adjust it using a rotary potentiometer so that a selected oil droplet rises.

As soon as the oil droplet is in the upper area of the capacitor:

- Use switch U to turn off the capacitor voltage.

As soon as the oil droplet is next to a pre-selected graduation scale mark:

- Use switch t to start measuring the fall time.

As soon as the oil droplet has fallen over a pre-selected distance:

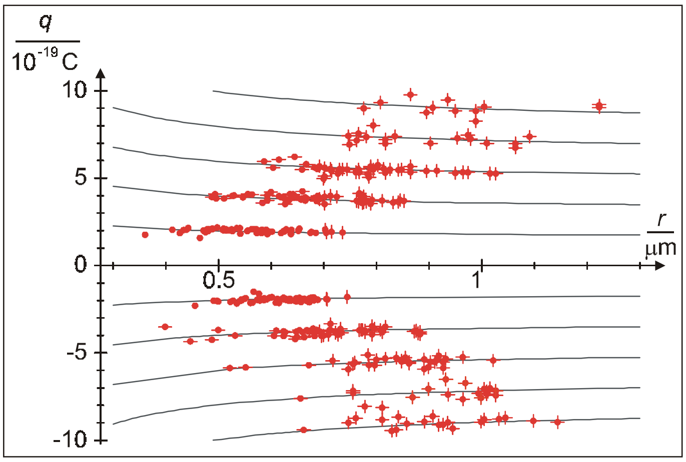
- Use switch U to turn on the capacitor voltage, to end measurement of the fall time and start measurement of the rise time.

As soon as the oil droplet has risen over the same pre-selected distance *s* :

- Use switch t to end time measurement.
- Read fall time t_1, rise time t_2 and capacitor voltage *U* and record with fall or rise distance *s*.

7 Result

7.1 Result without charge correction:



Observed droplet charges *q* as a function of droplet radius *r* (measured result from 400 individual measurements according to the fall/rise method)

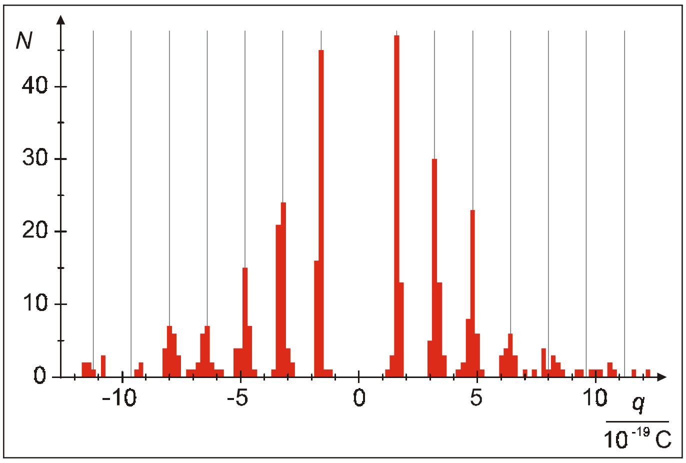
7.2 Charge correction:

Cunningham formula for considering the deviation from Stoke's friction for small droplet radii *r*:

$$q_c = \frac{q}{\sqrt{\left(1 + \frac{A}{r}\right)^3}}$$

(the friction of the oil droplet in air at standard pressure and 25°C is *A* = 0.07776 µm)

7.3 Result with charge correction:



Frequency distribution of the observed corrected droplet charges *q*

LD Didactic GmbH · Leyboldstrasse 1 · D-50354 Huerth / Germany · Phone (02233) 604-0 · Fax (02233) 604-222 · e-mail: info@ld-didactic.de