Leybold Didactic GmbH
Lehr– und Didaktiksysteme

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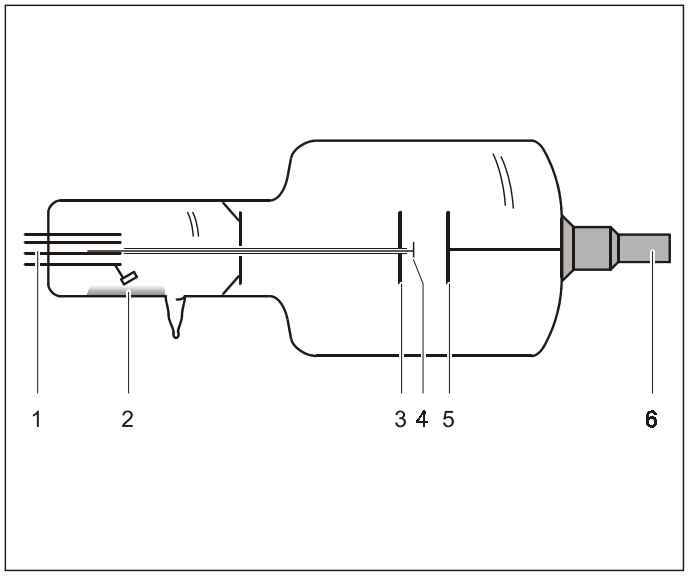


Instruction sheet 555 610

Demonstration diode (555 610)

1 Pin base (for cathode contacting)
2 Getter mirror (for maintaining the vacuum)
3 Cathode plate
4 Incandescent cathode
5 Anode
6 Anode connection

Safety notes

Danger of implosion: the demonstration diode is a high-vacuum tube made of thin-walled glass.

- Do not expose the demonstration diode to mechanical stress, and connect it only if it is mounted in the tube stand.
- Treat the contact pins in the pin base with care, do not bend them, and be careful when inserting them in the tube stand.
- Treat the anode connection with care.

During operation, hazardous contact voltages may be applied:

- Connect the demonstration diode with safety connection leads only.
- Establish connections only while power supplies are switched off.

During operation, the demonstration diode is heated by the cathode heating:

- If necessary, allow the demonstration diode to cool down before dismounting.

The demonstration diode may be destroyed by voltages or currents that are too high:

- Keep to the operating parameters given in the section on technical data.

1 Description

The demonstration diode enables basic experiments to be carried out relating to thermionic emission of electrons from hot cathodes (Edison effect), charge transport in the vacuum, diode characteristics, and the rectifying action of a diode.

During operation, electrons are emitted from the incandescent cathode. They form a space charge cloud in front of the cathode, which can be extracted towards the anode by applying a positive voltage between the cathode and the anode. In the so-called space charge region of the diode characteristic, the electron current towards the anode (anode current) clearly rises if the anode voltage is increased.

2 Technical data

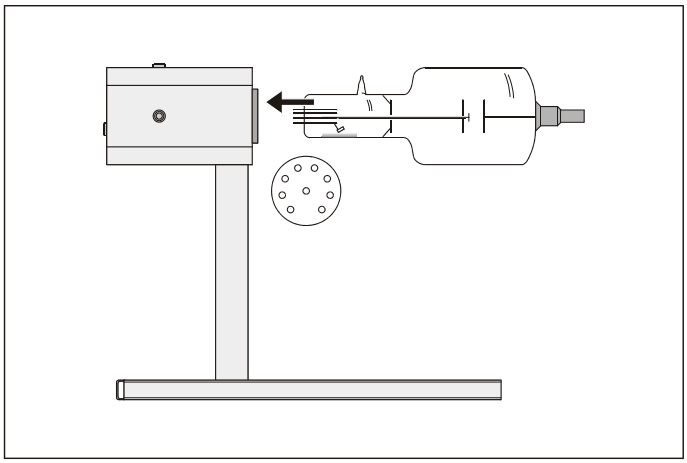
Heating voltage U_F:	0 ... 7.5 V (rec.: 6.3 V)
Heating current I_F:	approx. 2.5 A at 6.3 V
Anode voltage U_A:	-500 ... 500 V (-5 ... 5 kV if the cathode heating is switched off)
Anode current I_A:	approx. 6 mA at 300 V/ 6.3 V
Pressure:	$<10^{-6}$ hPa
Diameter:	90 mm
Total length:	270 mm
Mass:	250 g

3 Putting into operation

additionally required:

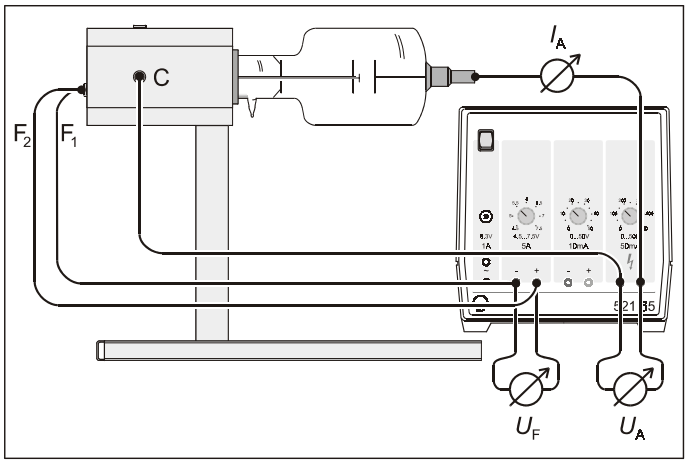
1 tube stand	555 600
1 DC power supply	521 65

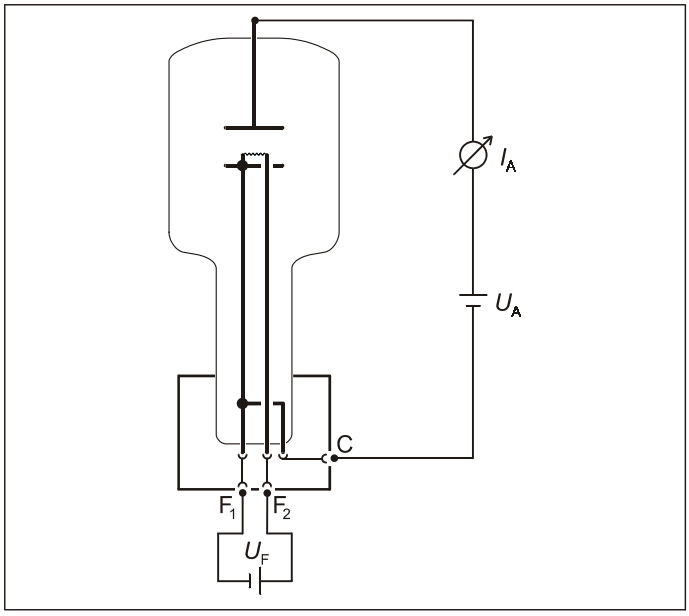
3.1 Mounting in the tube stand:



- Hold the demonstration diode horizontally, and turn it so that the two pins with the greatest distance in the pin base point downwards.
- Carefully insert the pin base in the socket of the tube stand until it stops.

3.2 Connection to the DC power supply:





additionally recommended:

1 amperemeter 1 µA ... 30 mA	for anode current I_A
1 voltmeter 0 ... 500 V	for anode voltage U_A
1 voltmeter 0 ... 10 V	for heating voltage U_F

- Connect the socket F_1 of the tube stand to the negative pole and the socket F_2 to the positive pole of the 4.5...7.5 V output to get a positive heating voltage U_F (see sketched circuit diagram).
- Connect the socket C of the tube stand to the negative pole and the anode to the positive pole of the 0...500 V output to get a positive anode voltage U_A (see sketched circuit diagram).

4 Experiment examples

4.1 Thermionic emission:

a) unheated cathode:

U_F = 0 V, U_A = ±300 V: I_A = ±0.01 µA

From the cold (unheated) cathode no charge carriers are emitted. Therefore no charge transport can occur at the anode. The current that actually flows is due to leakage currents through the glass bulb or on its surface.

b) heated cathode, without anode voltage:

U_F = -6.3 V, U_A = 0 V: $I_A \approx$ 95 µA

If the cathode heating voltage is negative, the anode potential with respect to the incandescent cathode is positive. A current flows towards the anode which can be attributed to electrons emitted from the cathode (Edison effect).

U_F = +6.3 V, U_A = 0 V: $I_A \approx$ 0.15 µA

If the cathode heating voltage is positive, the anode potential with respect to the incandescent cathode is negative. A small current flows towards the anode as some electrons emitted form the cathode have sufficient kinetic energy to overcome the potential difference.

c)heated cathode, with anode voltage:

U_F = 6.3 V, U_A = +300 V: $I_A \approx$ 6 mA

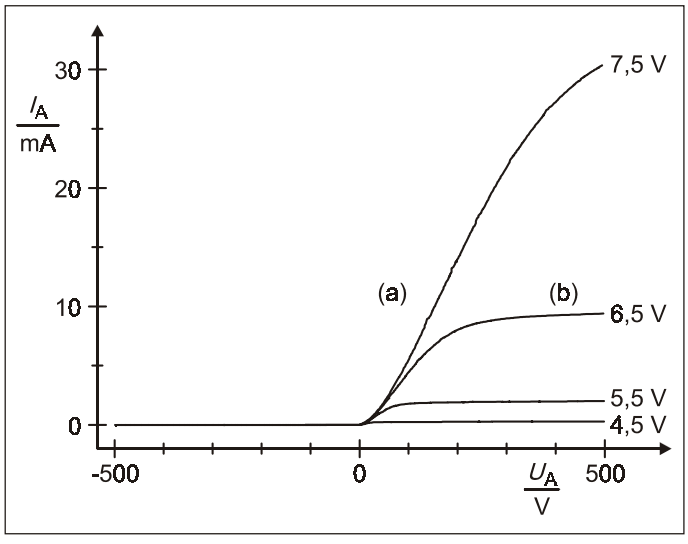
A positive anode voltage draws the electrons that are emitted from the cathode to the anode. A current flows towards the anode.

U_F = 6.3 V, U_A = -300 V: $I_A \approx$ -0.02 µA

If the anode voltage is negative, the current is negligible. The diode works as a (thermionic) valve.

4.2 Diode characteristic:

Characteristic $I_A(U_A)$ for heating voltages U_F = 4.5-7.5 V



(a) Space charge region:

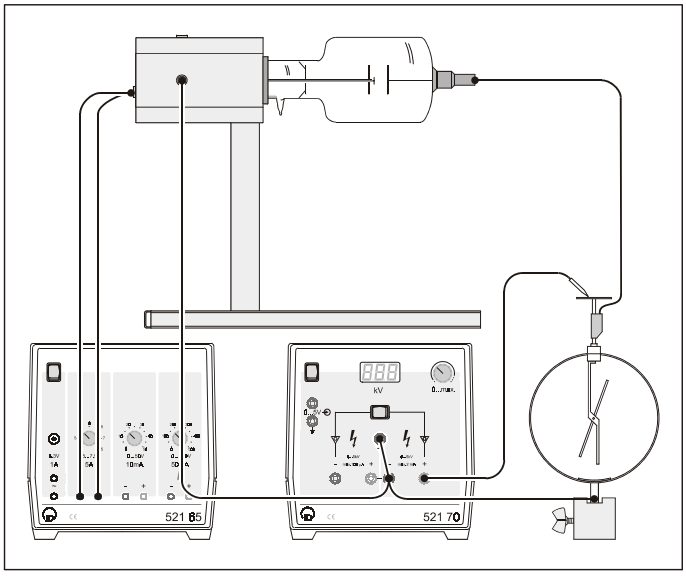
The Schottky-Langmuir law applies:

$I_A = k \cdot U_A^{\frac{3}{2}}$ with k being a constant that depends on the geometry

(b) Saturation region:

The saturation current increases with the temperature T of the incandescent cathode and thus with the heating voltage U_F.

4.3 Charge carriers (free electrons):

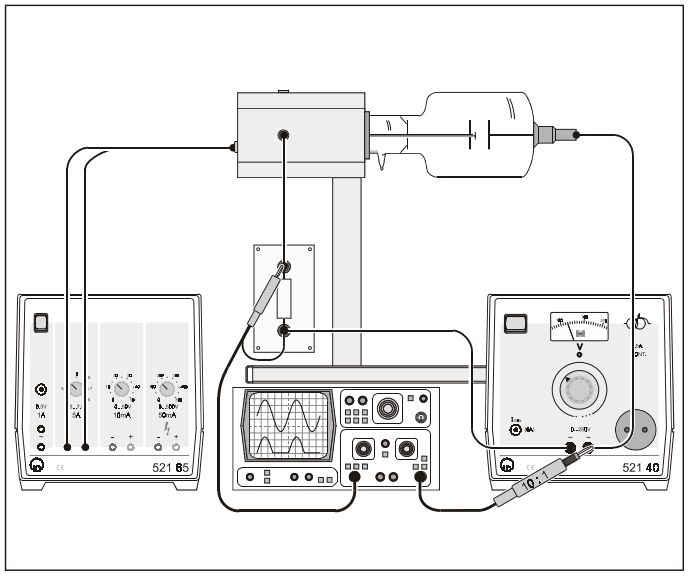


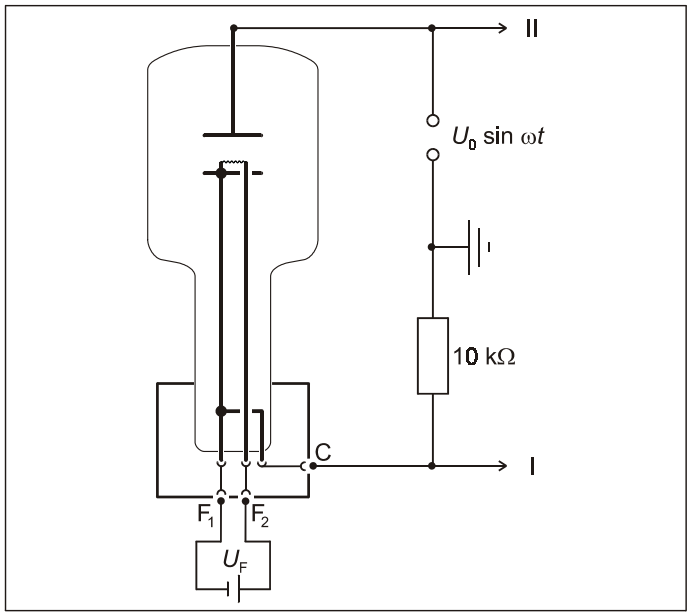
additionally required:

1 electroscope	540 091
1 high-voltage power supply 10 kV or friction rods	521 70

- Connect the anode to the electroscope.
- The cathode heating being switched off, charge the electroscope and the anode positively, e.g. with the high voltage U = 2.5 kV or with a friction rod.
- Switch the cathode heating on (U_F = 4.5 V), and observe the quick discharge of the positively charged electroscope.
- The cathode heating being switched off, charge the electroscope and the anode negatively, e.g. with the high voltage U = -2.5 kV or with a friction rod.
- Switch the cathode heating on (U_F = 4.5 V), and observe the constant deflection (or the considerably slower discharge via leakage currents) of the negatively charged electroscope.

4.4 Diode as a one-way rectifier:





Additionally required:

1 two-channel oscilloscope	e.g.	575 211
1 measuring resistor 10 kΩ		536 251
1 AC voltage supply 0 ... 30 V	e.g.	521 40

- Switch the cathode heating on (U_F = 6,3 V), and apply an AC voltage U_A < 16 V to the anode.
- Observe the rectified signal and the applied AC voltage simultaneously in channel I and II of a two-channel oscilloscope.

Remark: Here the ground potential is defined by the protective ground of the two-channel oscilloscope.

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