Lehr– und Didaktiksysteme
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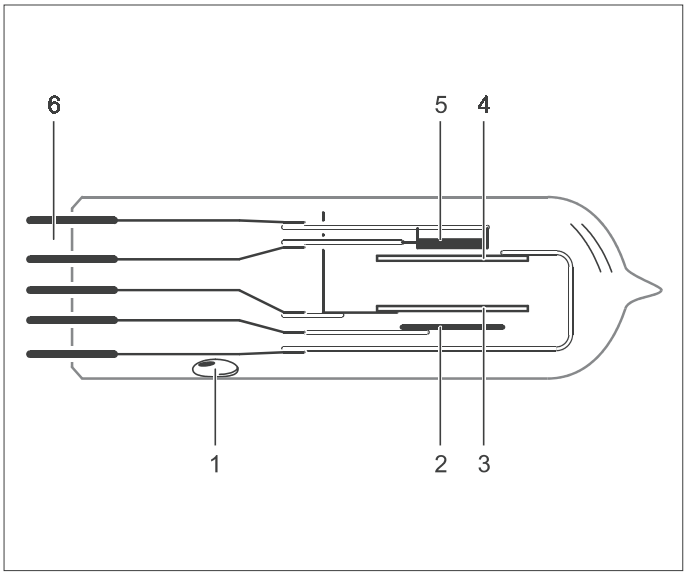


Instruction sheet 555 854

Hg Franck-Hertz tube (555 854)

1 Mercury filling
2 Collector
3 Accelerating grid
4 Emitting grid
5 Cathode
6 Pin base

Safety notes

Danger of implosion: The Hg Franck-Hertz tube is a high-vacuum tube made of thin-walled glass filled with approx. 5 g of mercury.

- Do not expose the Hg Franck-Hertz tube to mechanical stress, and connect it only mounted in the socket for Hg Franck-Hertz tube (555 864 or 555 865).
- Treat the contact pins in the pin base with care, do not bend them, and be careful when inserting them in the socket.

Mercury released when the glass breaks is poisonous if inhaled. There is danger of cumulative effects.

- Avoid contact with the released substance.
- Collect released substance, e.g. with the mercury adsorbent (306 83), and dispose of it according to applicable regulations. Must not be introduced into the sewerage system.
- Do not inhale vapour or aerosols, and air closed rooms.

The Hg Franck-Hertz tube is heated during operation:

- Allow the Hg Franck-Hertz tube to cool down before taking it out of the electric oven.
- Make sure that the maximum temperature is not exceeded by controlling the heating with the Franck-Hertz supply unit or another control instrument.

1 Description

The Hg Franck-Hertz tube is a vacuum tube with an indirectly heated cathode, an emitting grid, an anode grid, and a collector. It contains a drop of mercury, which evaporates when the tube is heated. This arrangement makes it possible to carry out the experiment of J. Franck and G. Hertz, which demonstrates the discrete energy transfer in collisions of free electrons with mercury atoms. It is also possible to determine the excitation energy of the atoms.

2 Technical data

Mercury filling:	approx. 5 g
Excitation energy of the Hg atoms:	4.9 eV
Hg vapour pressure:	12 hPa at 180°C
Operating temperature:	approx. 180°C
Maximum temperature:	200°C continuously 220°C for short periods
Cathode heating:	4 V* / 0.5 A (AC or DC) indirectly

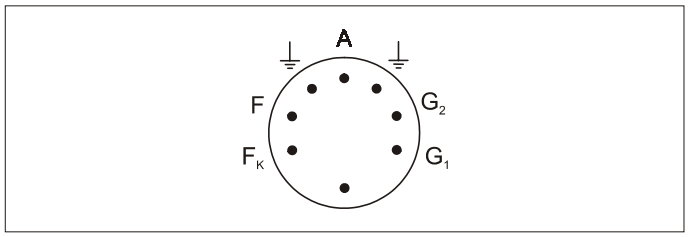
* A voltage of 6.3 V can be applied because of a series resistor in the socket (555 864 or 555 865)

Emitting grid voltage:	approx. 3 V DC
Accelerating voltage:	0 to 30 V DC
Countervoltage at collector:	approx. -1.5 V DC
Pin base:	9-pin
Dimensions:	10 cm x 2.8 cm dia.

3 Accessories

1 socket for Hg Franck-Hertz tube, with DIN connector (555 864)
or
1 socket for Hg Franck-Hertz tube, with 4 mm plug (555 865)

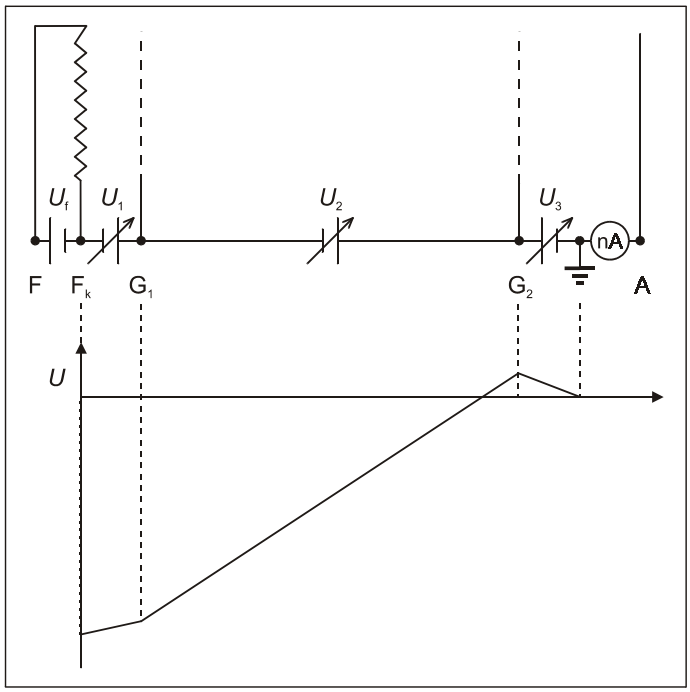
4 Pin configuration



View on pin base

G1 Emitting grid
G2 Accelerating grid
⏚ Reference pins, grounded when the tube is connected to the Frank-Hertz supply unit (555 880)
A Collector
F, Fk Cathode

5 Principle of measurement

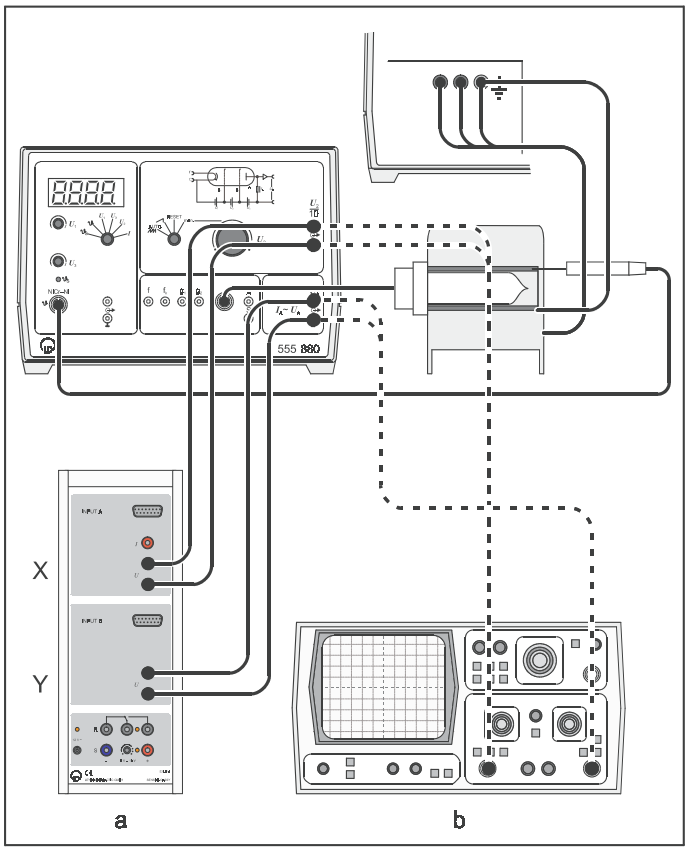


Cathode heating: U_f = 6.3 V AC/ DC, floating
Emitting grid voltage: U_1 = 0 ... 5.0 V DC, floating
Accelerating voltage: U_2 = 0 ... 30.0 V DC, floating
Countervoltage: U_3 = 0 ... 5.0 V DC, floating

For a sufficient mercury vapour pressure, the Hg Franck-Hertz tube has to be heated to approx. 180° C.

The collector current *I* is measured as a function of the accelerating voltage U_2 at optimized voltages U_1 and U_3.

6 Operation



additionally recommended:

1 Franck-Hertz supply unit	555 880
1 socket for Hg Franck-Hertz tube, with DIN connector	555 864
1 temperature sensor NiCr-Ni	666 193
1 electric oven, 200 W, 230 V	555 81
or	
1 electric oven, 200 W, 115 V	555 82
1 two-channel oscilloscope	575 211
or	
1 Sensor-CASSY	524 010
1 CASSY Lab	524 200

Working as a temperature measuring and control device, the Franck-Hertz supply unit controls the electric oven. It also supplies the required voltages, namely the cathode heating voltage, the emitting grid voltage, the accelerating voltage, and the countervoltage, and it contains a nanoammeter for measuring the collector current.

Remark:

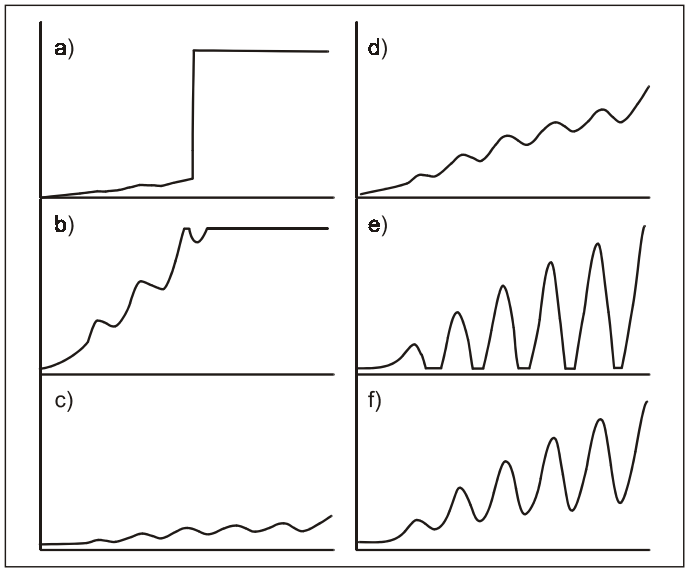
In the cold Hg Franck-Hertz tube, metallic mercury can cause a short between the electrodes:

- Apply voltages to the Hg Franck-Hertz tube only when the operating temperature has been reached.

Recording the Hertz curve:

- Adjust the emitting grid voltage U_1 = 3 V and the counter-voltage U_3 = 1.5 V, and record the Franck-Hertz curve.

Optimizing the Franck-Hertz curve:



a) Optimizing ϑ

If the Franck-Hertz curve exhibits a step-like rise (a) and a bright blue luminescence is observed in the Franck-Hertz tube through the insert opening of the electric oven:

- Switch the voltages at the Hg Franck-Hertz tube off immediately, and wait until the operating temperature is reached.
- If necessary, enhance the operating temperature (e.g. by 5 °C), and wait some minutes until the new thermal equilibrium is established.

b) Optimizing U_1 (a higher voltage U_1 leads to a higher emission current of the electrons).

If the Franck-Hertz curve rises too steeply and is cut off at the top already below U_2 = 30 V (b):

- Reduce U_1 until the slope of the curve corresponds to (d).

If the Franck-Hertz curve is too flat, i.e. the collector current I_A remains below 5 nA in the entire range (c):

- Increase U_1 (max. 4.8 V) until the slope of the curve corresponds to (d).

If the Franck-Hertz curve remains flat despite an increase of U_1:

- Reduce the setpoint ϑ_S for the oven temperature.

c) Optimizing U_3 (a higher counter voltage U_3 leads to more pronounced maxima and minima of the Franck-Hertz curve; at the same time the overall collector current is reduced):

If the maxima and minima of the Franck-Hertz curve are weakly pronounced (d):

- alternately increase the counter voltage U_3 (maximally 4.5 V) and then the emitting grid voltage U_1 until the shape (f) is reached.

If the minima of the Franck-Hertz curve are “cut off” at the bottom (e):

- alternately decrease the counter voltage U_3 (maximally 4.5 V) and then the emitting grid voltage U_1 until the shape (f) is reached.