

PHYWE Systeme GmbH & Co. KG
Robert-Bosch-Breite 10
D-37079 Göttingen

Telefon +49 (0) 551 604-0
Fax +49 (0) 551 604-107
E-mail info@phywe.de

Operating instructions


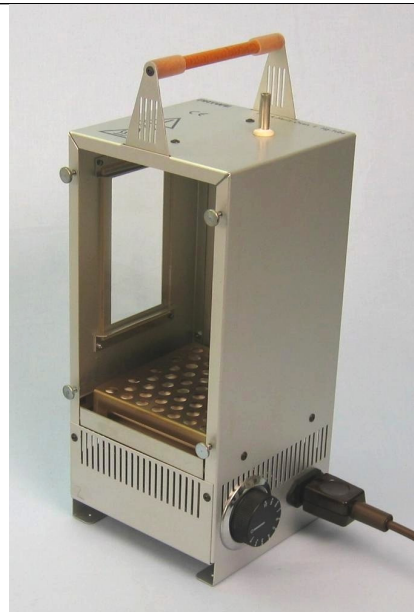
 The unit complies with the corresponding EC guidelines.



Fig. 1: 09105-10 Franck-Hertz Tube on a panel



09105-93 Franck-Hertz Oven

TABLE OF CONTENTS

- 1 SAEFTY PRECAUTIONS
- 2 PURPOSE AND CHARACTERISTICS
- 3 HANDLING
- 4 NOTES ON OPERATION
- 5 TECHNICAL SPECIFICATIONS (TYP. FOR 25 °C)
- 6 LIST OF EQUIPMENT
- 7 GUARANTEE
- 8 WASTE DISPOSAL

1 SAEFTY PRECAUTIONS



Important!

- The Hg-tube build-up has changed, therefore the old operation instructions are not valid any more. Please read these operating instruction carefully before putting the tube into operation, to protect yourself and to prevent damage to your tube or oven.



Caution!

- Check that your mains supply voltage corresponds to that given on the type plate fixed to the instrument.
- Install the instrument so that the on/off switch and the mains connecting plug are easily accessible.
- Do not cover the Control Unit ventilation slits.
- Only use the instrument in dry rooms in which there is no risk of explosion.
- Only use the experimental set-up for the purpose for which it is intended.

2 PURPOSE AND CHARACTERISTICS

The Franck-Hertz Hg-Tube and Franck-Hertz Oven (see Fig. 1) are instruments that have been developed specifically for use in demonstrations and practical work in the teaching of Physics in schools and colleges. The tube must be heated to obtain an adequate mercury vapour density for the experiment. To achieve this, it is placed in an oven.

The dependence of the anode current on the applied acceleration voltage proves the existence of discrete energy states of Hg atoms when free electrons collide with those atoms. The excitation energies of Hg atoms can be determined from the spectra recorded. The shell model of the atom postulated by Bohr was experimentally confirmed in 1913/14 by means of Franck-Hertz experiments (named after James Franck and Gustav Hertz).

3 HANDLING

3.1 Franck-Hertz Oven

The oven is connected to the AC mains supply voltage using the supplied equipment lead with its heat resistant plug; operation on direct voltage is not permissible. The device should be heated up on the highest setting for about 10 minutes when first used. This process fumes off volatile constituent parts. Breathing in the fumes should be avoided under all circumstances.

3.1.1 If Franck-Hertz Control Unit 09105-99 is used (see Fig. 2) then switch on the control knob fitted to the side of the oven to its maximum. The oven temperature is then controlled automatically by control unit.

3.1.2 Without Control Unit the oven temperature can be varied manually by rotating the control knob. If the bimetallic switch has not switched off the heater when the required temperature is exceeded by about 5 °C, then the control knob should be turned back anticlockwise until the bimetallic switch switches off the heater (a clicking sound is heard). This setting must, if necessary, be corrected a few times before the required temperature has stabilised (after about 15 min. heating period) about the specified mean value with a variation of about $\pm 15^\circ\text{C}$.



Caution!

- The oven housing and the screws on the front panel will heat the current set temperature during operation and may therefore be very hot. The carrying handle and the BNC socket on the front panel of the Franck-Hertz tube may be quite hot, particularly under extended operation under the oven.
- For safety reasons the temperature measurement should not be taken with a Thermocouple (13615-01 or 13615-02) and Franck-Hertz Control Unit (09105-99) or a Digital Temperature Meter (07050-00). The thermocouple is inserted through the opening at the top of the oven into the interior. The temperature measurement should be taken at about the centre of the oven.
- It is recommended that a heat-protective plate is placed under the oven.
- The oven is to use only under supervision.
- Don't put other devices in the surrounded area of the oven; Safety distance of 20 cm to the oven must be strictly adhered.
- After all measurements switch the oven off and leave it for at least 15 min. to cool down before further operation.



Fig. 2: Franck-Hertz experiment with Hg-Tube and oven

3.2 Franck-Hertz tube on panel

The Franck-Hertz tube (electron collision tube) is a triode with plane, parallel electrodes (see Fig. 3): an indirectly heated oxide-coated cathode **C**, a grid-shaped accelerating electrode **A** and a collecting electrode **S**. The distance between the cathode and the grid is large compared with the mean free path of the electrons in Hg vapour at the operating temperature so that the impact probability is as high as possible. In contrast, the distance between the grid and the collecting electrode is short. A protective resistance is included in the grid lead.

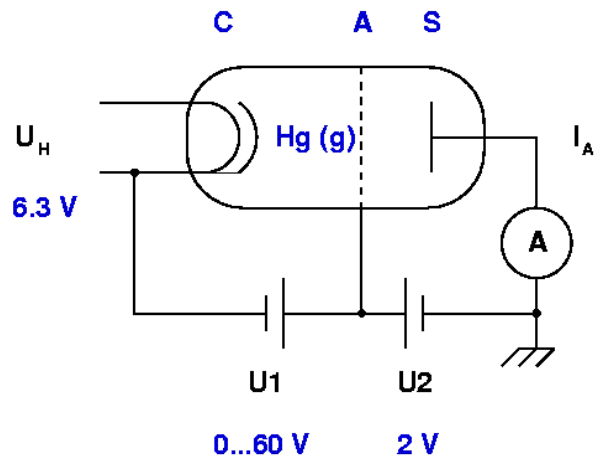


Fig. 3: Schematic view of a Hg-triode

As a consequence of the mercury ions produced during the operation of the Franck-Hertz tube ignition is observed in the form of a glow discharge at a critical acceleration voltage. The collection current then suddenly increases and can exceed the highest current measurement range on the amplifier. Therefore, when the discharge occurs, the acceleration voltage should be immediately reduced until the discharge disappears. If Franck-Hertz Control Unit is used then the tube power supply is switched off automatically after 7 sec. to avoid the discharges.

Fig. 4 Characteristic Franck-Hertz Spectrum for Hg-Tube

Following parameters are strictly recommended:

- T = $(175 \pm 10) ^\circ\text{C}$
- $U_H = (6.3 \pm 0.5) \text{ V}$; current of the heating supply < 150 mA
- $U_1 = 0 \dots 60 \text{ V}$;
- $U_2 = (2.0 \pm 0.5) \text{ V}$;

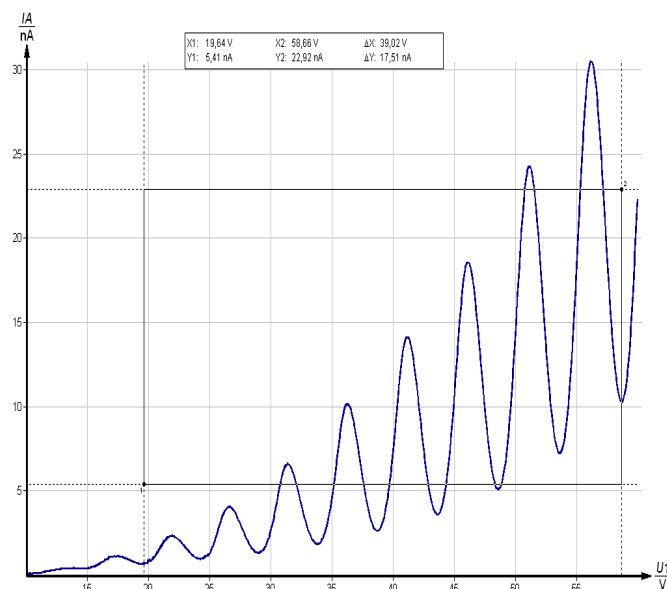
Don't set the heating voltage U_H too high to avoid the discharges and the damage of the Hg-tube.

If the discharge occurs at acceleration voltages which are too low, the oven temperature should be increased or the heating voltage U_H should be decreased. The higher the oven temperature, the higher the voltage at which the tube ignites. Also, the mean collection current and, correspondingly, the absolute value of its maxima decrease with increasing oven temperature. The first maxima on the current/voltage curve can be best found at low oven temperatures. Generally, oven temperatures of around $175 ^\circ\text{C}$ are used. However, in some circumstances better experimental results can be obtained at slightly lower temperatures (down to $160 ^\circ\text{C}$) or at higher temperatures (up to $190 ^\circ\text{C}$).

The characteristic Franck-Hertz spectrum (see Fig. 4): The Dependence of the collection current I_A on the acceleration voltage U_1 must be recorded at constant heating voltage U_H (heating current < 150 mA) by increasing the acceleration voltage U_1 from 0 V to 60 V. The collection current I_A must be smaller than $1 \mu\text{A}$, i.e. the Hg-tube should nearly never ignite!

Notes:

- Due to oven temperature variations slightly different levels of collection current may be obtained for repeated measurements at the same acceleration voltage. However, the position of the maxima remains unaffected.
- The position of the maxima for the collection current remains unchanged when the reverse bias changes, but the position of the minima are displaced a little. The level of the mean collection current decreases with increasing reverse bias.
- If the Franck-Hertz Control Unit is not used in the experiment then it is recommended that on reaching the optimum oven temperature (this depends on the Franck-Hertz tube used) the heater is switched off and recording of the curve is started immediately.
- When the bimetallic switch switches the oven on and off, there is a change of load on the AC mains, causing a small change in the set acceleration voltage. This should be noted if the switching takes place just when the curve is being recorded.



4 NOTES ON OPERATION

This high-quality instrument fulfills all of the technical requirements that are compiled in current EC guidelines. The characteristics of this product qualify it for the CE mark. This instrument is only to be put into operation under specialist supervision in a controlled electromagnetic environment in research, educational and training facilities (schools, universities, institutes and laboratories). This means that in such an environment, no mobile phones etc. are to be used in the immediate vicinity. The individual connecting leads are each not to be longer than 2 m.

The instrument can be so influenced by electrostatic charges and other electromagnetic phenomena that it no longer functions within the given technical specifications. The following measures reduce or do away with disturbances:

Avoid fitted carpets; ensure potential equalization; carry out experiments on a conductive, earthed surface, use screened cables, do not operate high-frequency emitters (radios, mobile phones) in the immediate vicinity. Following a blackout failure, operate the on/off switch for a reset.

5 TECHNICAL SPECIFICATIONS (TYP. FOR $25 ^\circ\text{C}$)

Operating temperature range $5 \dots 40 ^\circ\text{C}$,
Relative humidity < 80 %

Franck-Hertz tube

Temperature	$(175 \pm 10) ^\circ\text{C}$
Voltage U_1	$0 \dots 60 \text{ V}$
Voltage U_2	$0 \dots 3 \text{ V}$
Voltage U_H	$0 \dots 7 \text{ V}$; heating current < 150 mA

Franck-Hertz-oven

Protection class	I
Connecting voltage (+6% / -10%)	see type plate
Mains frequency	50/60 Hz
Power consumption	approx. 600 W
Max. Temperature	$300 ^\circ\text{C}$
Housing dimensions (mm)	153 x 153 x 325
Weight approx.	2 kg

6 LIST OF EQUIPMENT

A. For Franck-Hertz experiments with Hg-tube, without a PC

Franck-Hertz Control Unit	09105-99
Franck-Hertz Hg-tube	09105-10
Franck-Hertz oven	09105-93 or 09105-90
Thermocouple NiCr-Ni, sheathed	13615-01 or 13615-02
5-pin connecting cable for Hg-tube	09105-30
Shielded BNC cable, $l = 750 \text{ mm}$	07542-11

B. For Franck-Hertz experiments with a PC

As in A. above and additionally:

RS 232 Data cable	14602-00
Franck-Hertz Measure software	14522-61

7 GUARANTEE

We guarantee the instrument supplied by us for a period of 24 months within the EU, or for 12 months outside of the EU. Excepted from the guarantee are damages that result from disregarding the Operating Instructions, from improper handling of the instrument or from natural wear.

The manufacturer can only be held responsible for the function and technical safety characteristics of the instrument, when maintenance, repairs and alterations to the instrument are only carried out by the manufacturer or by personnel who have been explicitly authorized by him to do so.

8 WASTE DISPOSAL

The packaging consists predominately of environmentally compatible materials that can be passed on for disposal by the local recycling service.



Should you no longer require this product, do not dispose of it with the household refuse.

Please return it to the address below for proper waste disposal.

PHYWE Systeme GmbH & Co. KG
Abteilung Kundendienst (Customer Service)
Robert-Bosch-Breite 10
D-37079 Göttingen

Phone +49 (0) 551 604-274
Fax +49 (0) 551 604-246