Franck-Hertz Control Unit

09105.99

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CE The unit complies with the corresponding EC guidelines.

Operating Instructions

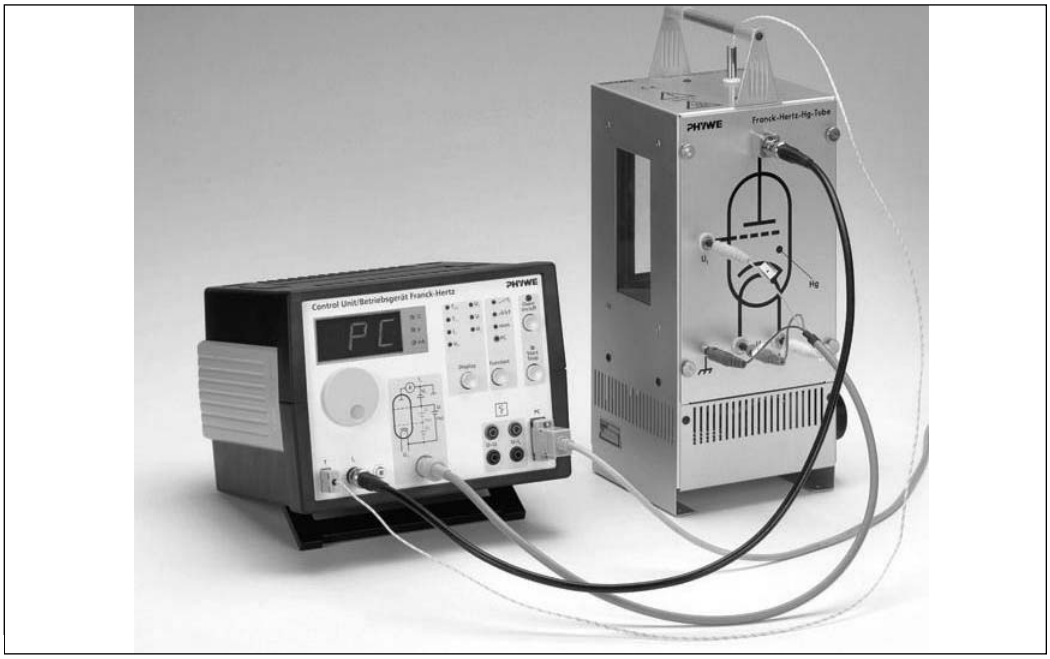

Fig. 1: Set-up for Franck-Hertz experiment with Hg-tube and oven.

1 SAFETY PRECAUTIONS

- Carefully read these operating instructions completly before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- 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 ventilation slots.
- Take care that no liquids or objects enter in through the ventilation slots.
- Only use the instrument in dry rooms in which there is no risk of explosion.
- Do not start up this instrument in case of visible signs of damage to it or to the line cord.
- Only use the instrument for the purpose for which it was designed.

2 PURPOSE AND DESCRIPTION

The Franck-Hertz Control Unit is an instrument that has been developed specifically for use in demonstrations and practical work in the teaching of Physics in schools and colleges. It serves to supply voltage to, and control, a connected Hg-tube or Ne-tube, as well as to measure temperature and anode current. The dependence of the anode current on the applied acceleration voltage proofs the existence of discrete energy states of Hg or Ne atoms when free electrons collide with those atoms. The excitation energies of these 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 Franz-Hertz experiments (named after James Franck and Gustav Hertz).

The Franck-Hertz Control Unit must be supplied with a steady operating voltage of 115 V or 230 V (+/- tolerance). Connection via an adjusting transformer is not permissible.
The instrument produces the accelerating voltage U1, the counter voltage U2, the control voltage U3 (only for the Ne-tube) and the heating voltage U_H from this supply voltage. None of these voltages are dangerous to touch. They are applied to the tube via the 5-pin connecting cable. The cables are coded so that the Control Unit recognizes which type of tube is connected and undertakes the basic settings.
All adjustable and measurable observables can be displayed by a 3-digit LED display. The presentation and evaluation of the measured values can be carried out in alternate ways, either manually, or with the help of an oscilloscope or a XYt recorder, or via an RS 232 interface using Franck-Hertz Measure software.

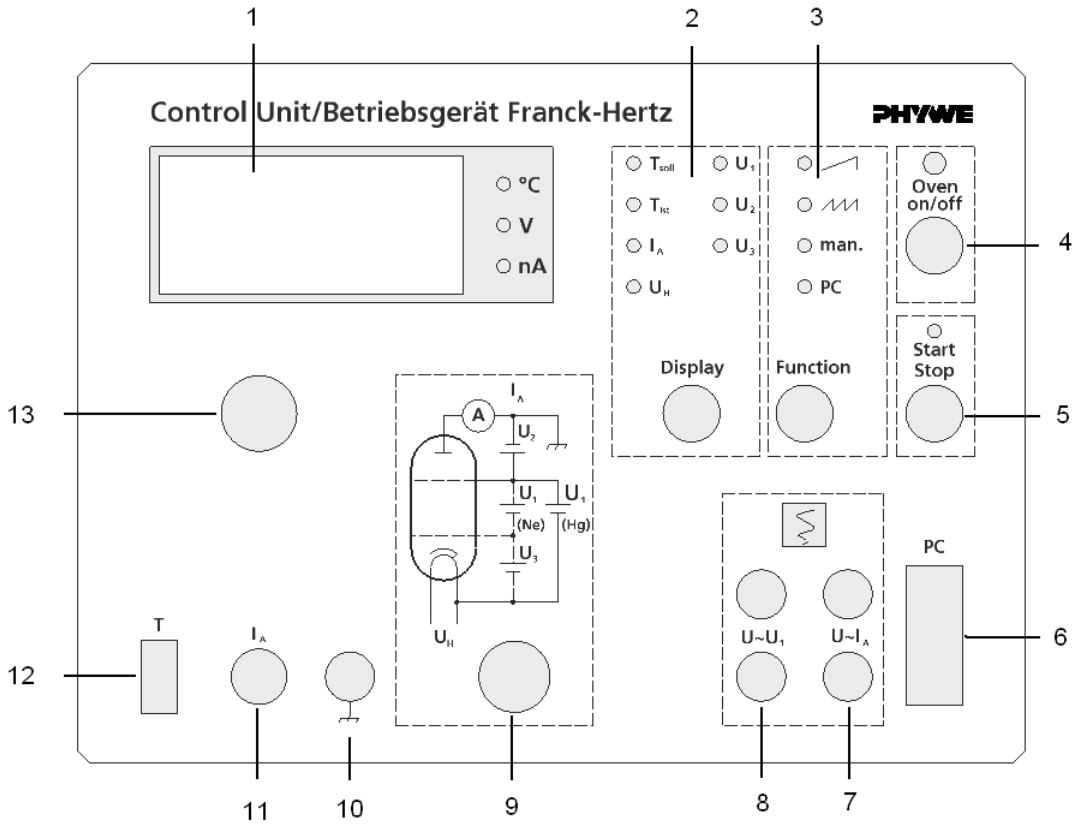

Fig. 2: Function and operating elements of Franck-Hertz Control Unit.

3 HANDLING

3.1 Function and operating elements (see Fig. 2)

1 *Three digit digital display*
with optional display of either temperature T, anode current I_A or voltage U_H, U1, U2 or U3.

2 *"Display" pushbutton*
for selection of the quantity to be displayed

3 *"Function" pushbutton*
for selection of a function from "ramp", "saw tooth", "manual control" or "PC control".

4 *"Oven on/off" pushbutton*
for activation of the Hg oven heating.

5 *"Start/Stop" pushbutton*
for initiating or stopping measurement.

6 *9-pin D-SUB socket RS 232*
for connection of the Control Unit to the serial interface of a computer.

7 *Pair of 4 mm sockets "U~IA"*
Analog output (Y): Voltage proportional to the anode current.

8 *Pair of 4 mm sockets "U~U1"*
Analog output (X): Voltage proportional to the accelerating voltage U1.

9 *DIN socket*
for supplying voltage (U_H, U1, U2 and U3) to the tube connected.

10 *GND connector*

11 *BNC socket "I_A"*
Input for anode current measurement.

12 *Temperature input T*
Thermocouple socket, to which a NiCr-Ni thermocouple with DIN plug (type K) can be connected.

13 *Rotary switch*
for adjustment of temperature (T_{nom}) and voltages (U_H, U1, U2 and U3).

14 *At the back of the instrument:*
Grounded socket for the plug that supplies voltage to the temperature-regulating Franck-Hertz oven for the Hg-tube

3.2 Starting up the instrument

Use the connecting cord supplied with the instrument to connect it to the AC mains supply (115 or 230 V), then operate the mains switch at the back of the instrument to switch it on.

Connect the Hg-tube or Ne-tube to the control unit with the 5-pin connecting cable and the BNC cable [connections (9) and (11)]. When doing this, make sure that the 4 mm plug labelling matches the socket labelling on the plate.

A temperature sensor (12) must be additionally connected when the Hg-tube is to be used. Do this by leading the tip of the probe through the opening in the Franck-Hertz oven and positioning it at the height of the cathode of the tube. Checking that the connecting voltage of the oven matches the local line voltage, then plug the oven connecting cable with the grounded plug into the grounded socket at the back of the Control Unit. **Turn the rotary switch on the oven to its maximum.** This ensures that the bimetallic switch in the oven is first activated to switch off the oven at a very high temperature, and so will not disturb the regulating process. When measured values are to be acquired and presented, connect outputs (7) and (8) to a XYt recorder or to an oscilloscope. To use a computer for the measurement, connect the Control Unit to its serial interface with a RS 232 cable (if necessary, use a USB - RS 232 adapter, 14602.10).

3.2.1 Manual experimental procedure

The values given in [ ] are typical values with which it should be possible to successfully record a measurement curve. **If the collection current is too high then the measurement will be interrupted automatically by control unit after 7 sec. to protect the tube from being damaged. To avoid the discharges adjust the parameters U2, U3 and U_H as follows: decrease the heating voltage U_H and decrease the voltage U3.**

Experiment with the Hg-tube

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch. This causes the instrument to activate predefined values according the type of tube connected. As examples of this, the heating voltage U_H is preset at 6.3 V and the range of the accelerating voltage U1 limited to 60 V.

B) Set the following parameters with pushbutton (2) and rotary switch (13).
- Target temperature $T_{nom.}$ [175 ± 10°C];
- U_H [6.3 ± 0.5 V];
- U1 [0…60 V];
- U2 [2.0 ± 0.5 V];
- U3 is not necessary for the Hg-tube.

C) Use pushbutton (4) to switch the oven on. The red LED above pushbutton (4) does not stop flashing until the actual temperature "$T_{act.}$" has reached the target temperature (with a tolerance of approx. +/- 2°C).

D) Set to "manual" with pushbutton (3). Start measurement with pushbutton (5).

Experiment with the Ne-tube

Heating is not required in this case.

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch.

B) Set the following parameters with pushbutton (2) and rotary switch (13).
- A target temperature is not required here;
- U_H [7.5 ± 0.5 V];
- U1 [0…99.9 V];
- U2 [8 ± 1 V];
- U3 [2 ± 1 V].

C) Set to "manual" with pushbutton (3). Start measurement with pushbutton (5).

The luminous layers shown in Fig. 3 are typical for the Ne-tube. These visible luminous layers (wavelength approx. 640 nm, corresponding to about 2 eV) are generated when Ne atoms that have been excited by collisions with electrons pass over from the 3p level (approx. 19 eV) via the 3s level (approx. 17 eV) back to the ground state.

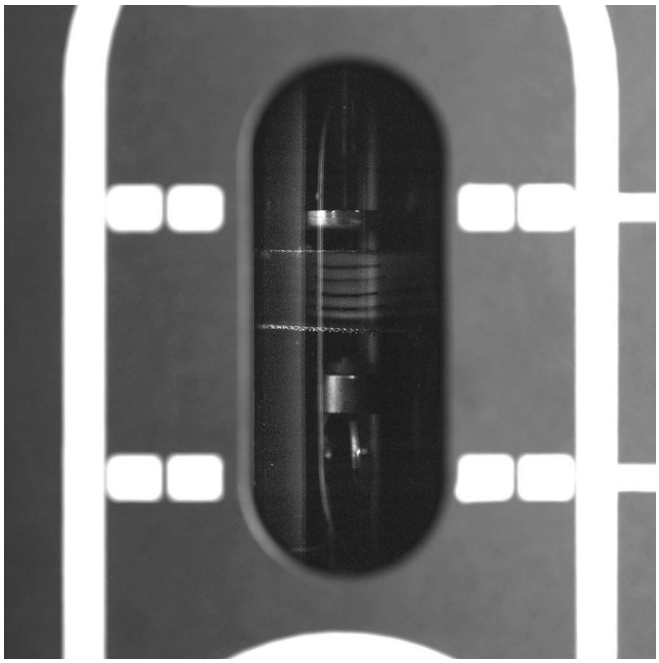

Fig. 3: Franck-Hertz experiment with the Ne-tube: Five typical luminous layers.

3.2.2 Experimental procedure using an oscilloscope

Experiment with the Hg-tube

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch.

B) Set the following parameters with pushbutton (2) and rotary switch (13).
- Target temperature $T_{nom.}$ [175 ± 10°C];
- U_H [6.3 ± 0.5 V];
- U1 [0…60 V];
- U2 [2.0 ± 0.5 V];
- U3 is not necessary for the Hg-tube.

C) Switch on the oven with pushbutton (4). The red LED above pushbutton (4) continues to flash until the target temperature is reached.

D) Set to "saw tooth" with pushbutton (3). Connect outputs (7) and (8) to the oscilloscope, then select the XY operating mode for the oscilloscope. Start measurement with pushbutton (5). In this "saw tooth" mode, the voltages set for U1 and U2 are applied to the Hg-tube with a frequency of 28 Hz. The typical Franck-Hertz curve that results is shown in Fig. 4.

Experiment with the Ne-tube

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch.

B) Set the following parameters with pushbutton (2) and rotary switch (13).
- A target temperature is not required here;
- U_H [7.5 ± 0.5 V];
- U1 [0…99.9 V];
- U2 [8 ± 1 V];
- U3 [3 ± 1 V].

C) Set to "saw tooth" with pushbutton (3). Connect outputs (7) and (8) to the oscilloscope, then select the XY operating mode for the oscilloscope. Start measurement with pushbutton (5). If the current is too high then the measurement will be interrupted automatically by control unit after 7 sec. to protect the tube from being damaged. Adjust the settings in B) and use pushbutton (5) to repeat the measurement any time required.

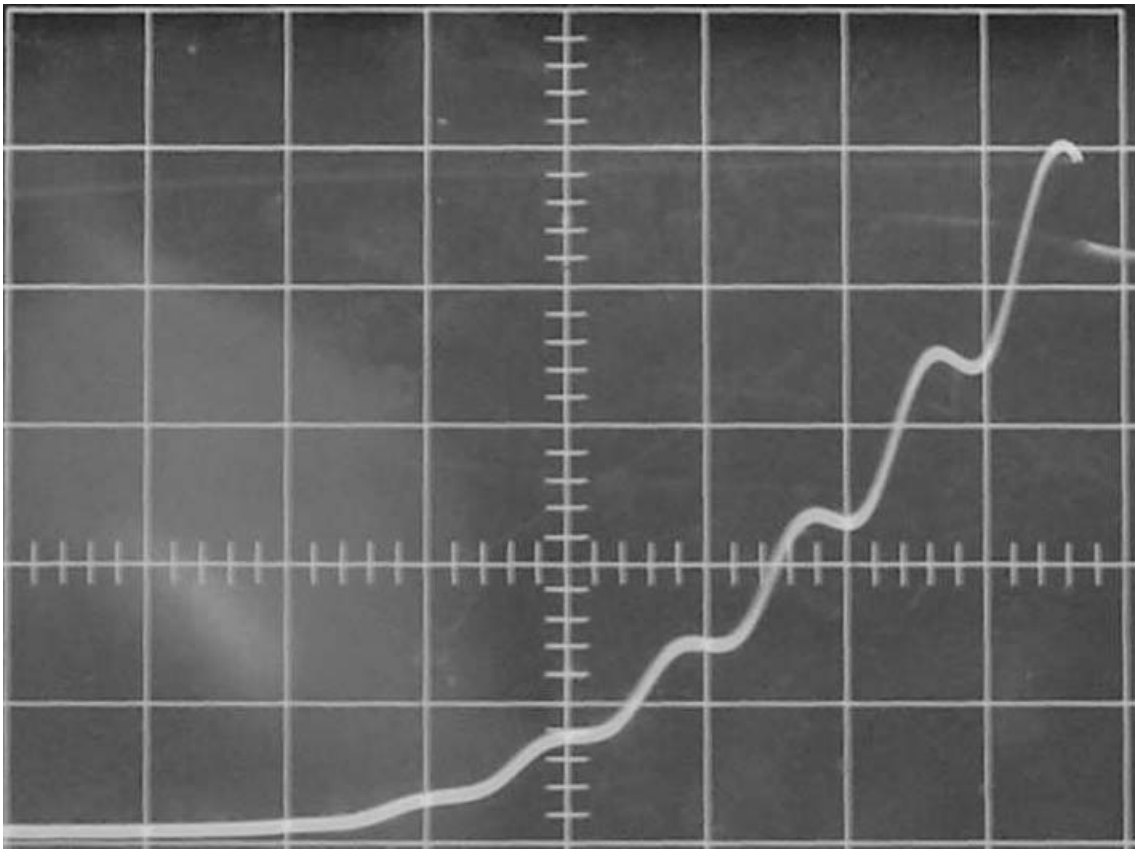

Fig. 4: Franck-Hertz-Experiments with the Hg-tube: Saw tooth measurement displayed by an Oscilloscope.

3.2.3 Experimental procedure with a XYt recorder

Experiment with the Hg-tube

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch.

B) Set the following parameters with pushbutton (2) and rotary switch (13).
- Target temperature $T_{nom.}$ [175 ± 10°C];
- U_H [6.3 ± 0.5 V];
- U1 [0…60 V];
- U2 [2.0 ± 0.5 V];
- U3 is not necessary for the Hg-tube.

C) Switch on the oven with pushbutton (4). The red LED above pushbutton (4) does not stop flashing until the target temperature has been reached.

D) Set to "ramp" with pushbutton (3).

E) Connect output (7) to the Y-input of the recorder, and (8) to the X-input.

F) Start measurement with pushbutton (5).
In "ramp" mode, the accelerating voltage is automatically increased from 0 V to U1_max within 20 seconds. The green LED above pushbutton (5) starts flashing when the maximum value of the accelerating voltage has been reached.

In manual operation, select U1 with pushbutton (2) and use pushbutton (13) to increase from 0 V to U1_max. In this operating mode, parameters can still be changed after starting measurement with pushbutton (5).

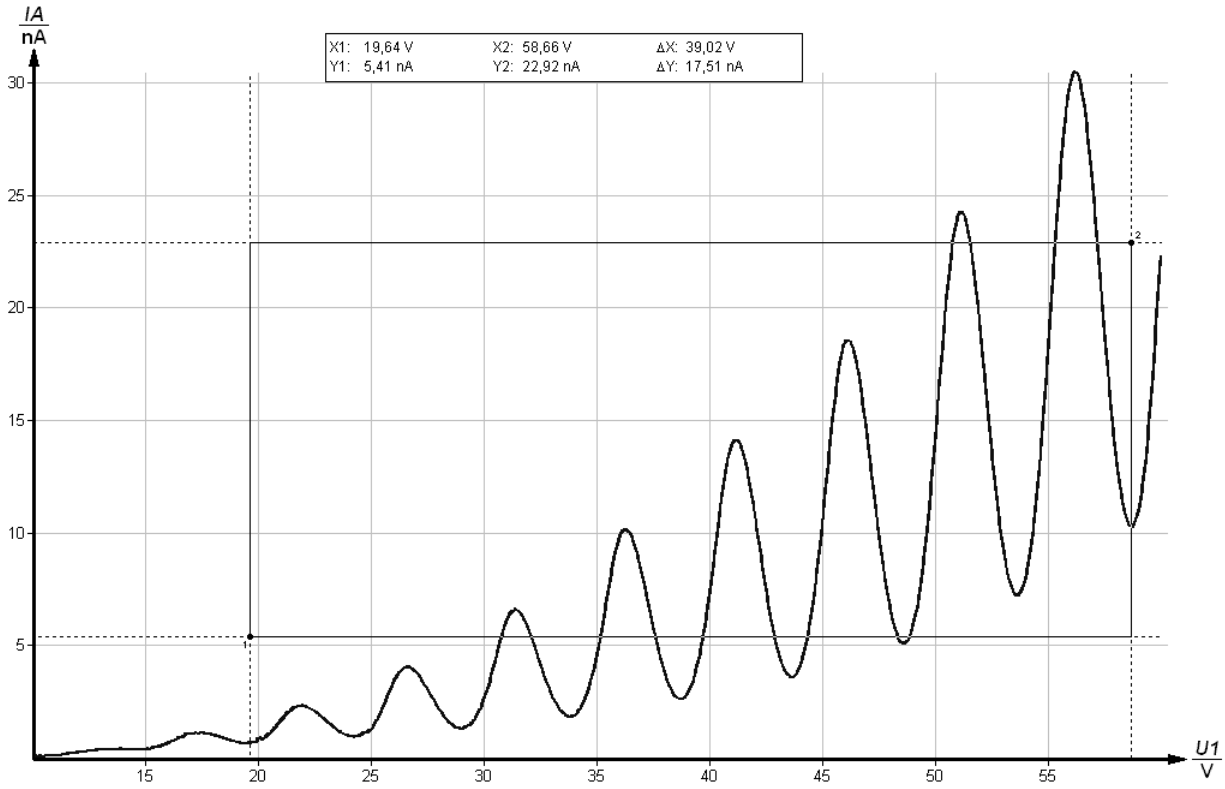

Fig. 5: Franck-Hertz curve for Hg.

Experiment with the Ne-tube

A) Connect the components as described in section 3.2. Turn on the Control Unit at the on/off switch.

B) Set the following parameters with pushbutton (2) and rotary switch (13).
- A target temperature is not required here;
- U_H [7.5 ± 0.5 V];
- U1 [0…99.9 V];
- U2 [8 ± 1 V];
- U3 [2 ± 1 V].

C) Set to "ramp" with pushbutton (3).

D) Connect output (7) to the Y-input of the recorder, and (8) to the X-input.

E) Start measurement with pushbutton (5).
In "ramp" mode, the accelerating voltage is automatically increased from 0 V to U1_max within 20 seconds. The green LED above pushbutton (5) starts flashing when the maximum value of the accelerating voltage has been reached.

In manual operation, select U1 with pushbutton (2) and use pushbutton (13) to increase from 0 V to U1_max. In this operating mode, parameters can still be changed after starting measurement with pushbutton (5).

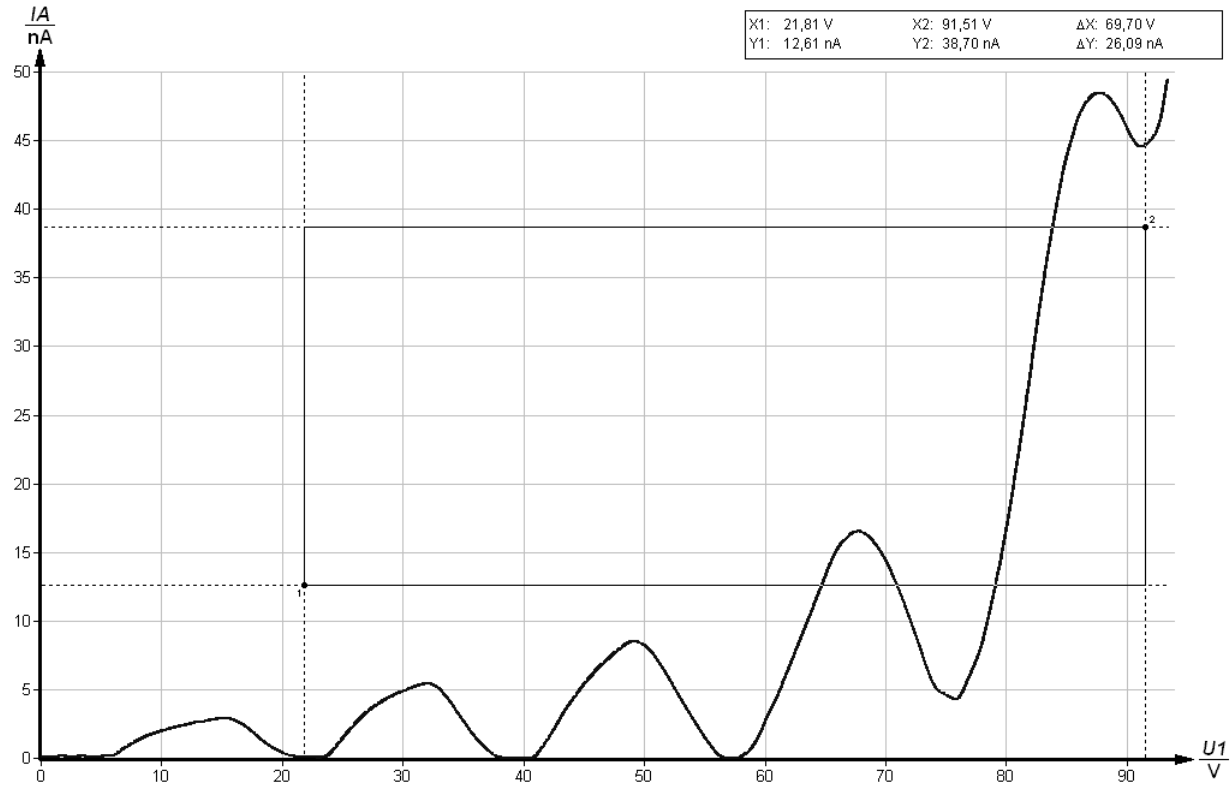

Fig. 6: Franck-Hertz curve for Ne.

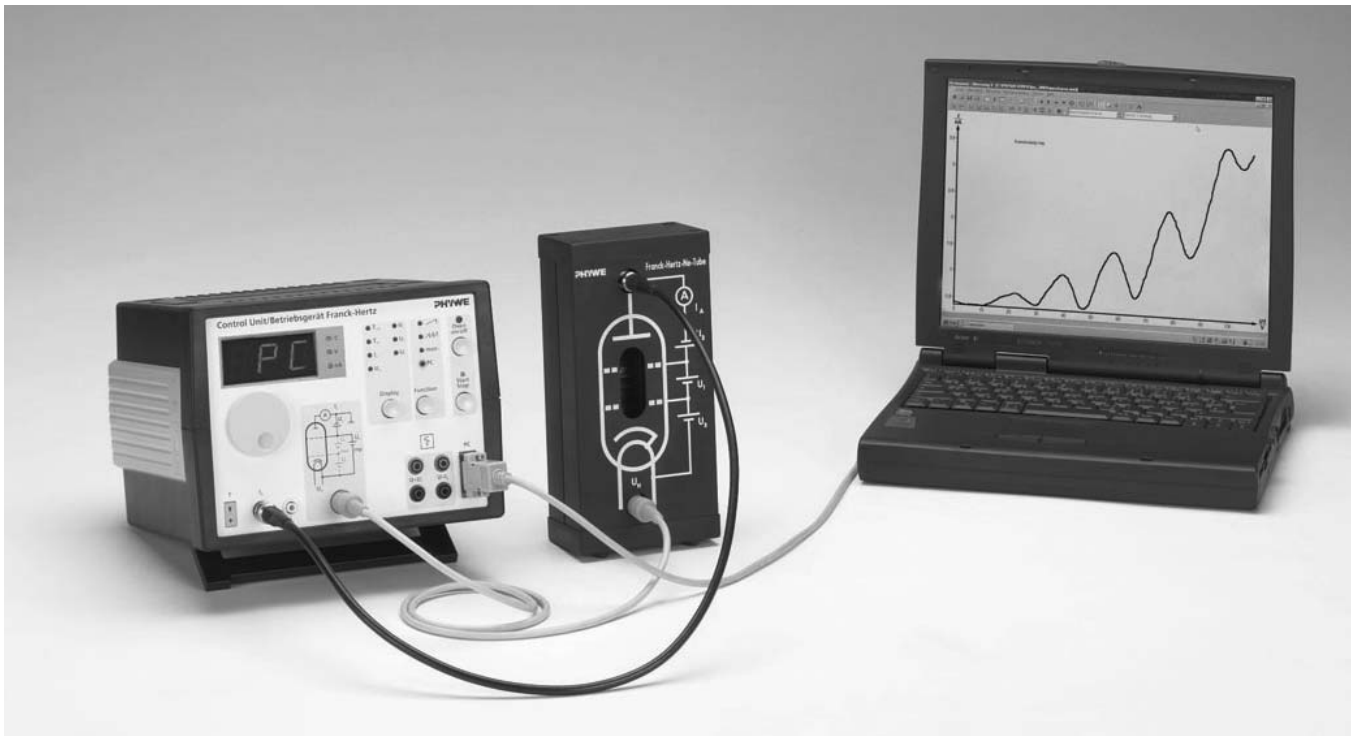

Fig. 7: Complete set-up for Franck-Hertz experiment with the neon tube and a PC.

3.2.4 Experimental procedure using a computer

Connect the Control Unit to the computer with an RS 232 cable. Franck-Hertz Measure software carries out the steering of the Control Unit and the acquisition, presentation and evaluation of all measured values. No other external measuring equipment is required

A) Connect the components as described in section 3.2 (see Fig. 7). Turn on the Control Unit at the on/off switch. Set to "PC" with pushbutton (3).

B) Start the Measure software and call the Franck-Hertz measurement programme. This automatically recognizes if the Hg tube or the Ne-tube is connected. The parameters required are predefined (see Fig. 8). The values given in Fig. 8 are typical values with which it should be possible to successfully record a measurement curve. **If the collection current is too high then the measurement will be interrupted automatically by control unit after 7 sec. to protect the tube from being damaged. To avoid the discharges adjust the parameters U2, U3 and U_H as follows: decrease the heating voltage U_H and decrease the voltage U3.**

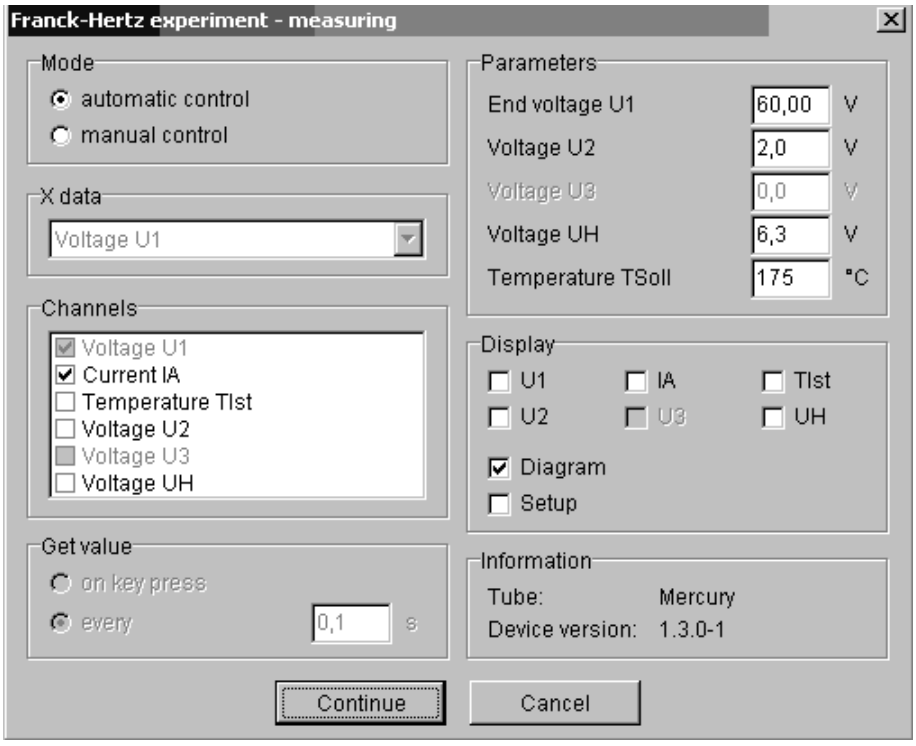

Fig. 8: Measurement parameters of the Franck-Hertz programme for the Hg-tube.

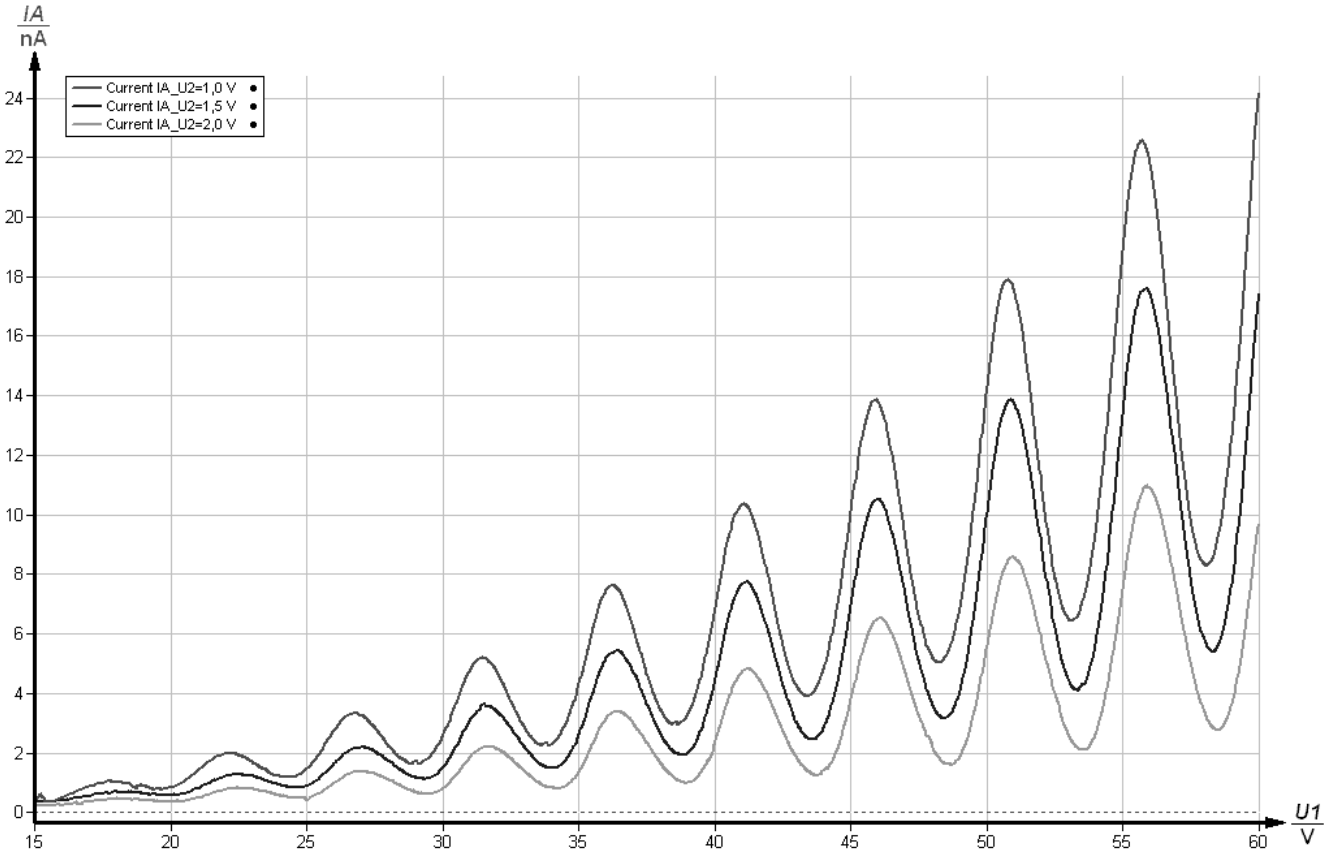

Fig. 9: Franck-Hertz-curve for Hg-tube and different counter voltages U2.

C) The programme allows manual or automatical increase of the accelerating voltage. Fig. 9 shows three curves that were plotted at different counter voltages U2 (= 1 V; 1.5 V; 2 V).

D) The excitation energies of mercury or neon atoms can be determined from the distance between minimum values. Typical results obtained are 4.9 V for Hg atoms and 12 V for Ne atoms.

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 electromagneric 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.

This instrument corresponds to Class A, Group 1 of the EN 55011 Standard and can only be operated without limitation outside of residential areas. Should electromagnetic disturbances occur in surrounding residential areas although operation is limited to the technical room of a school or other training facility, then it can be demanded of the operator that he carries out adequate measures (e.g. screening, greater distance, reduction in the operating time) at his own cost.

The Operating Instructions for the Franck-Hertz Oven 091005.93/.90 are to be carefully followed whenever this piece of equipment is put into operation.

Caution! A change of safety fuse is only to be carried out when the instrument is dead (unplug the mains plug), whereby it must be ensured that fuses (see the type plate for values) are allotted to the appropriate fuse holder FU1 or FU2. They must under no circumstances be inserted in the wrong holder. Remove a blown fuse by undoing the safety cap (with a slight turn anti-clockwise) and replace it with a new one.

5 TECHNICAL SPECIFICATIONS (typ. for 25 °C)

Operating temperature range 5...40°C,
Relative humidity < 80 %

Inputs

Temperature T

NiCr-Ni-DIN-socket (Typ K)	
Measurement range	0°C...999°C
Resolution	1°C

Current I_A

BNC-socket	
Measurement range	0...50 nA
Resolution	0.1 nA

Outputs

Analog output U~U1

Pair of 4 mm sockets	
Output voltage	0...10 V (10 V == 100 V)
Output current	max. 10 mA

Analog output U~I_A

Pair of 4 mm sockets	
Output voltage	0...10 V (10 V == 50 nA)
Output current	max. 10 mA

Tube supply

DIN socket	
Voltage U1	0...99.9 V
Resolution	0.1 V
Voltage U2	0...12 V
Resolution	0.1 V
Voltage U3	0...6 V
Resolution	0.1 V
Voltage U_H	0...10 V
Resolution	0.1 V
Output current	max. 400 mA

Oven supply

Grounded plug	Back of instrument
Voltage	Corresponds to the mains voltage, see below
Power output	max. 600 VA

Data output

D-SUB-9 socket	
RS 232C	up to 115200 Baud

Digital display

Type of display	7 segment LED
Character height	20 mm

Mains supply

Protection class	I
Connecting voltage (+6% / -10%)	115 V/230 V
Mains frequency	50/60 Hz
Power consumption with oven	approx. 625 VA
Power consumption with Ne-tube	ca. 40 VA
Mains fuse (5 mm x 20 mm)	see type plate
Housing dimensions (mm)	230 x 236 x 168 (W, H, D)
Weight	approx. 3.3 kg

6 LIST OF EQUIPMENTL

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, 75 cm	07542.11

B. For Franck-Hertz experiments with Ne-tube, without a PC

Franck-Hertz Control Unit	09105.99
Franck-Hertz Ne-tube	09105.40
5-pin connecting cable for Ne-tube	09105.50
Shielded BNC cable, 75 cm	07542.11

C. For Franck-Hertz experiments with a PC

As in A. oder B. above and additionally:	
Data Cable with 2 Ferrites, 9 pole	14602.05
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 EC. This guarantee does not cover natural wear nor damage resulting from improper handling.
The manufacturer can only be held responsible for the function and technical safety characteristics of the instrument, when maintenance, repairs and changes 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 environmental 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.

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