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Operating instructions

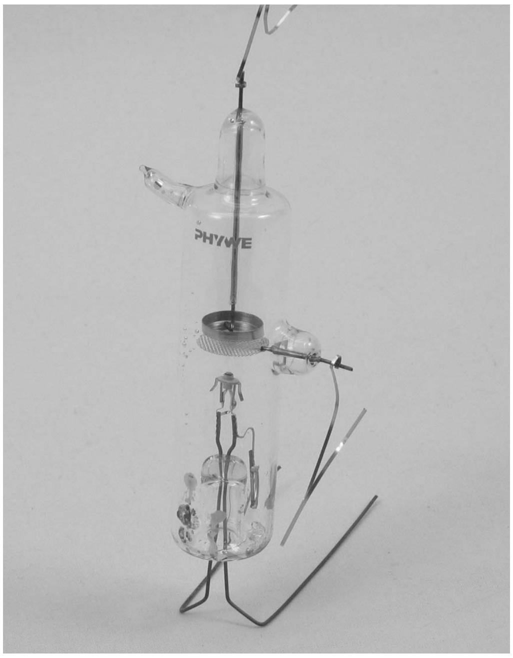

Fig. 1a: Franck-Hertz-Hg-Tube.

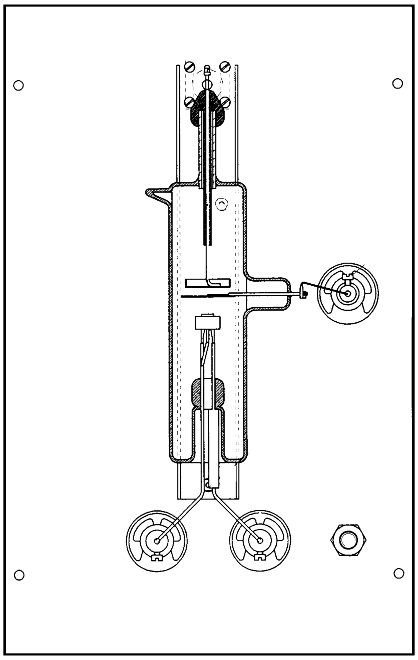

Fig. 1b: Franck-Hertz-Hg-Tube on panel.

1 SAFETY PRECAUTIONS

Caution!

- **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.**
- Only use the instrument in dry rooms in which there is no risk of explosion.
- Only use the instrument for the purpose for which it was designed.

Following parameters are strictly recommended:

- T = (175 ±10)°C
- U_H = (6.3 ±0.5) V; current of the heating supply < 150 mA
- U_1 = 0... 60 V;
- U_2 = (2.0 ±0.5) V;

Don't set the heating voltage U_H too high to avoid the discharges and the damage of the Hg-tube. The characteristic Franck-Hertz spectrum (see Fig. 3): 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 then 1 µA, i.e. the Hg-tube should nearly never ignite!

2 PURPOSE AND DESCRIPTION

The Franck-Hertz tube is used for verifying the excitation of Hg atoms due to electron collision. 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).

3 HANDLING

3.1 Franck-Hertz tube on panel

The Franck-Hertz tube (electron collision tube) is a triode with plane, parallel electrodes (see Fig. 2): an indirectly heated oxidecoated 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 wavelength of the electrodes 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.

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 oven power supply is switched of automatically to avoid the discharges.

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°C are used. However, in some circumstances better experimental results can be obtained at slightly lower temperatures (down to 160°C) or at higher temperatures (up to 190°C).

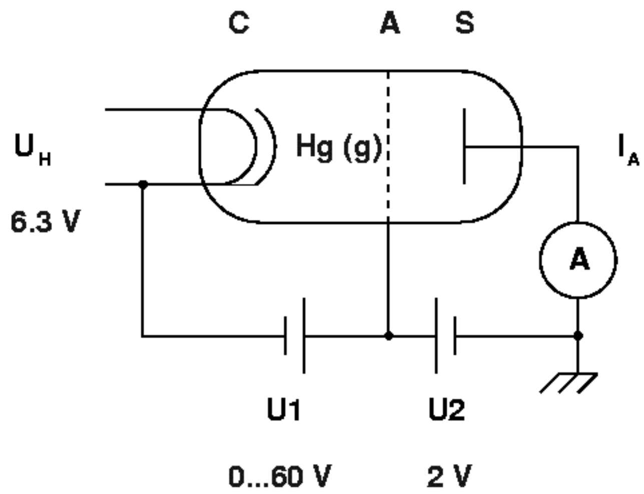

Fig. 2: Schematic view of a Hg-triode.

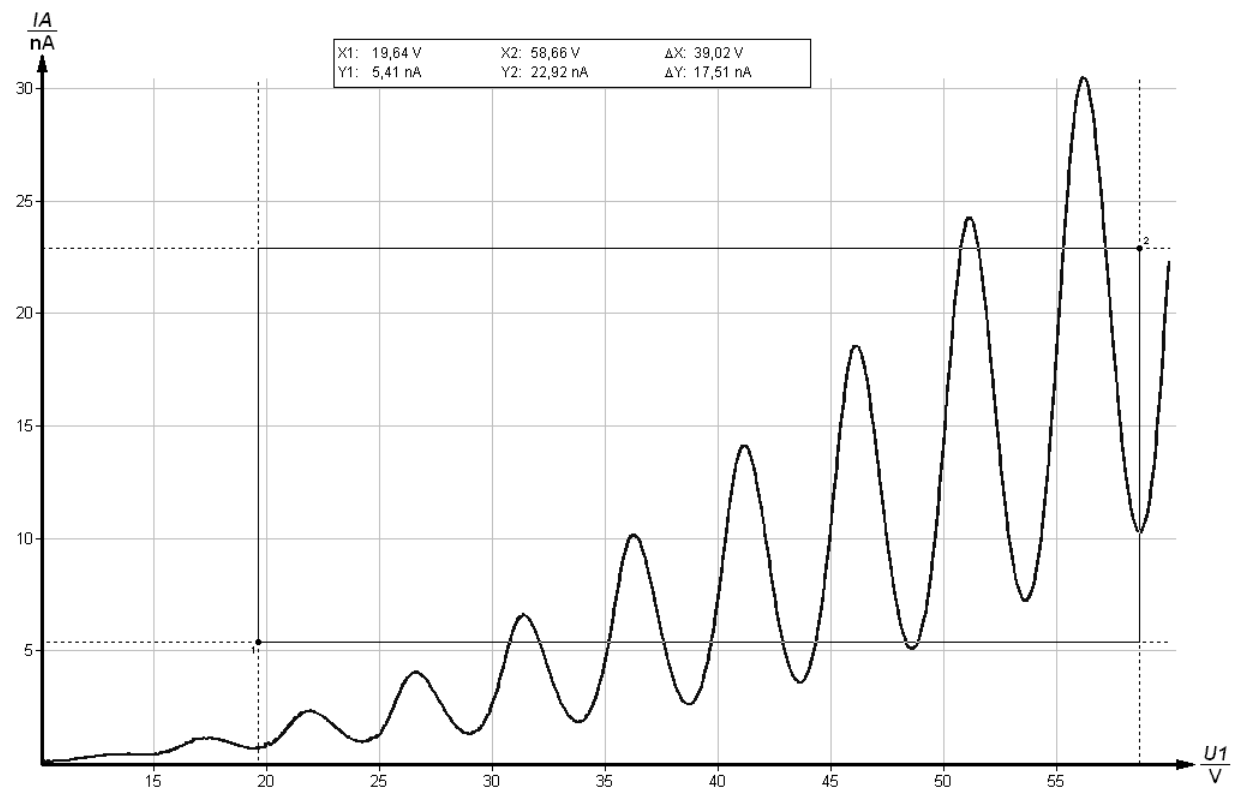

Fig. 3: Characteristic Franck-Hertz Spectrum for Hg-tube:

3.2 Fitting the tube in the PHYWE front plate

The aluminium rack on the back of the front plate serves to hold the tube. Pull the aluminium rack slightly apart and insert the tube so that the two connecting wires which lead to the cathode are below, and their bent ends point towards the front plate. Avoid damaging the fused nipple of the tube while positioning it. Loosen the grub screws of the feed socket coming from the front plate and insert the ends of the wires from the cathode in the corresponding holes in the socket. Retighten the grub screws. Take care not to bend the wires leading to the cathode too much, and be sure not to cross them, otherwise tube damage and short-circuiting could result.

Connect the wire connection coming from the grid via a strip of connectors to the resistance which is connected to the lead through the socket labelled with a grid symbol. Shorten the wire if necessary with cutting pliers. Finally, screw the collecting electrode to the lead through the top of the front plate, again with a strip of connectors. Shorten the wire if necessary. When the front plate is installed in the oven, avoid short-circuiting by ensuring that no wire connections touch the walls of the oven or the aluminium rack. The middle lead wire to the cathode must be connected to the socket lead-through which is labelled with the cathode symbol in the wiring diagram which is printed on the front of the front plate (the socket on the right, looking at the wiring diagram from the front!).

3.3 Fitting the tube in other front plates

Hold the tube so that the hot wire lead, which is connected to the middle lead wire of the cathode, is on the side of that socket lead-through which is labelled with the cathode symbol in the wiring diagram printed on the front of the front plate. Insert and fix the hot wire ends coming from the cathode in the corresponding holes in the socket. Take care not to bend the wires leading to the cathode too much, and be sure not to cross them, otherwise tube damage and short-circuiting could result. When the wires from the cathode must be bent, hold the appropriate wire on the tube side with combination pliers and bend the wire with a second pair of pliers. This avoids any mechanical stress on the glass holding of the wire. Shorten wires which are too long with cutting pliers. Connect the wire connection coming from the grid via a strip of connectors to the resistance which is connected to the lead through the socket labelled with a grid symbol. With some front plates, in which the socket leading through the plate is exactly on the opposite side to the grid connection of the tube, the connecting wire
is to be led round the tube. Finally, screw the collecting electrode to the lead through the top of the front plate, again with a strip of connectors. Shorten the wire if necessary. When the front plate is installed in the oven, avoid short-circuiting by ensuring that no wire connections touch the walls of the oven.

4 TECHNICAL SPECIFICATIONS

Franck-Hertz tube

Temperature	(175 ±10) °C
Voltage U_1	0... 60 V
Voltage U_2	0... 3 V
Voltage U_H	(6.3 ±0.5) V; heating current max. 150 mA

5 LIST OF EQUIPMENT

A. 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 mm	07542.11

Length of the tube	130 mm
Diameter of the tube	28 mm
Weight	approx. 0.22 kg

B. Franck-Hertz experiments with a PC

As in A. above and additionally:

RS 232 data cable	14602.00
Franck-Hertz Measure software	14522.61

6 NOTES ON THE 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. 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.

7 WASTE DISPOSAL

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

Please contact your municipal administration for information on the disposal of instruments.