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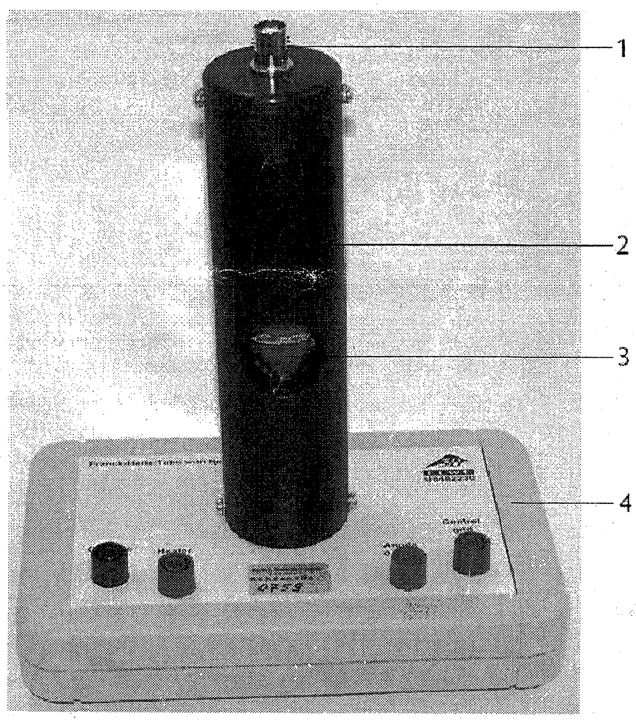
Franck-Hertz Tube with Ne Filling on Base

1000912 / U8482230

Instruction sheet

04/12 ALF



1 BNC connector
2 Screening cylinder with observation window
3 Franck-Hertz tube
4 Base with connector sockets

1. Safety instructions

- Do not subject the tube to any mechanical stress. Do not put kinks in any connecting leads. There is always a risk that glass can break and cause injury.

2. Description

The Franck-Hertz tube is a tetrode with an indirectly heated barium oxide cathode K, a mesh-type control grid G, a mesh-type anode A, and a collector electrode E (see Fig. 1). The electrodes are in a plane-parallel configuration. The distance between the control grid and the anode grid is about 5 mm, and the distances between the cathode and the control grid and between the anode and the collector electrode are both about 2 mm. The tube is supplied already filled with neon gas at a pressure chosen to give an optimum characteristic curve, which is in the region of several hPa.

The connecting sockets for the heater, control grid and anode grid voltages are on the base of the instrument. The collector current is taken off through the BNC socket at the top end of the screening cylinder. An internal 10 kΩ limiting resistor is permanently built in between the connector sockets for the accelerator (control grid) voltage and the anode voltage. This protects the tube in case there is a spark discharge caused by applying too high a voltage. The voltage loss in this resistor when making measurements is negligible, as the anode current in the tube is smaller than 5 pA. (Thus the voltage loss in the protecting resistor is 0.05 V.)

3. Technical data

Filament voltage:	4 – 12 V
Control voltage:	9 V
Accelerating voltage:	max. 80 V
Countervoltage:	1.2 – 10 V
Tube:	130 x 26 mm dia. approx.
Base with connector sockets:	190x115x115 mm^3 approx.
Weight:	450 g approx.

4. Basic principles

In the Franck-Hertz experiment neon atoms are excited by inelastic collision with electrons. The excited atoms emit visible light that can be viewed directly. Thus it is possible to detect zones where the light and therefore the excitation is more intense. The distribution of such zones between the cathode and the grid depends on the difference in potential between the two:

Electrons are emitted from the cathode and are accelerated by a voltage U towards the grid. Having passed through the grid they reach the target and thus contribute to a target current I if their kinetic energy is sufficient to overcome a decelerating voltage between the grid and the target.

The $I(U)$-characteristic (see Fig. 3) has a similar pattern to the original Franck-Hertz experiment using mercury gas but this time the intervals between minima where the current falls to almost zero for a specific voltage $U = U_1$ corresponding to the electrons reaching sufficient kinetic energy to excite a neon atom by inelastic collision just before reaching the grid are about 19 V. Simultaneously it is possible to observe a faint orange light close to the grid since the energy transition to the base state of a neon atom results in the emission of such light. The zone of illumination moves towards the cathode as the voltage U increases and the target current I rises once more.

For a higher voltage $U = U_2$ the target current also drops drastically and it is possible to see two zones of illumination. The electrons can in this case retain enough energy after an initial collision to excite a second neon atom.

As the voltages are further increased, other minima in the target current along with further zones of illumination can be observed.

The $I(U)$-characteristic exhibits various maxima and minima and the interval between the minima is about ΔU = 19 V. This corresponds to excitation energy of the 3p energy level of a neon atom (see Fig. 4) so that it is highly likely that this level is being excited. Excitement of the 3s-level cannot be neglected entirely and gives rise to some fine detail in the structure of the $I(U)$-characteristic.

The zones of illumination are zones of greater excitation and correspond to drops in voltage in the $I(U)$-characteristic. One more zone of illumination is created every time U is increased by about 19 V.

Note

The first minimum is not at 19 V itself but is shifted by an amount corresponding to the so-called contact voltage between the cathode and grid.

The emission lines in the neon spectrum can easily be observed and measured using a spectroscope (1003184 / U21877) when the maximum voltage U is used.

5. Operation

The following equipment is also required to complete the experiment:

1 Power supply unit for F/H experiment (230 V, 50/60 Hz) 1012819

or

1 Power supply unit for F/H experiment (115 V, 50/60 Hz) 1012818

1 Analogue oscilloscope, 2x 30 MHz 1002727 / U11175

1 HF Patch cord, 1 m 1002746 / U11255

2 HF Patch cords, BNC/4 mm plug 1002748 / U11257

Safety leads for experiments

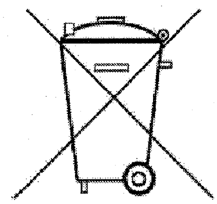
- Start with the voltage supply unit switched off, and with all the voltage setting knobs fully to the left.
- Connect up the experiment as shown in Fig. 2.
- Turn on the equipment. It will start in ramp mode.
- Set up the oscilloscope in XY mode with x = 1 V/div and y = 2 V/div.
- Gradually increase the heater voltage till the filament starts to faintly glow red. Then wait 30 seconds till it reaches its operating temperature.
- Set the accelerating voltage to 80 V and select a grid voltage of 9 V.

The ideal heater voltage should be between 4 and 12 V. This differs from tube to tube due to manufacturing tolerances.

- Gradually increase the heater voltage until an orange glow appears between the cathode and the grid. Then turn down the heater voltage till the glow disappears and only the filament is glowing.
- Gradually increase the decelerating voltage until the measured curve (of signal against accelerating voltage) is near horizontal.
- Increase the gain till the maxima of the Franck-Hertz curve can be seen on the oscilloscope screen.

6. Disposal

- The packaging should be disposed of at local recycling points.
- Should you need to dispose of the equipment itself, never throw it away in normal domestic waste. Local regulations for the disposal of electrical equipment will apply.



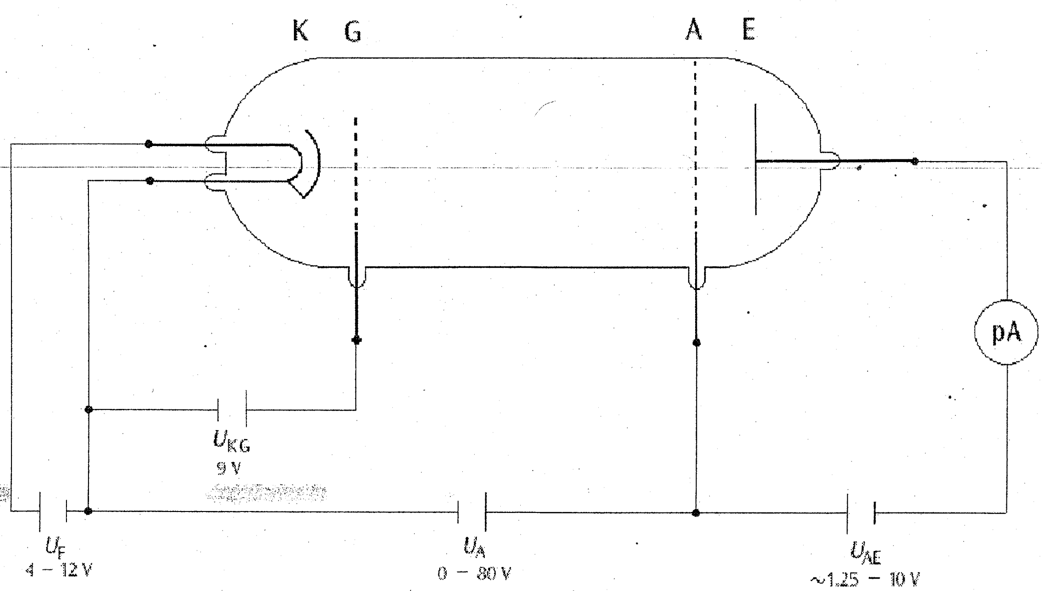


Fig. 1 Schematic of set up for measuring the Franck-Hertz curve for neon (K cathode, G control grid, A anode, E collector electrode)

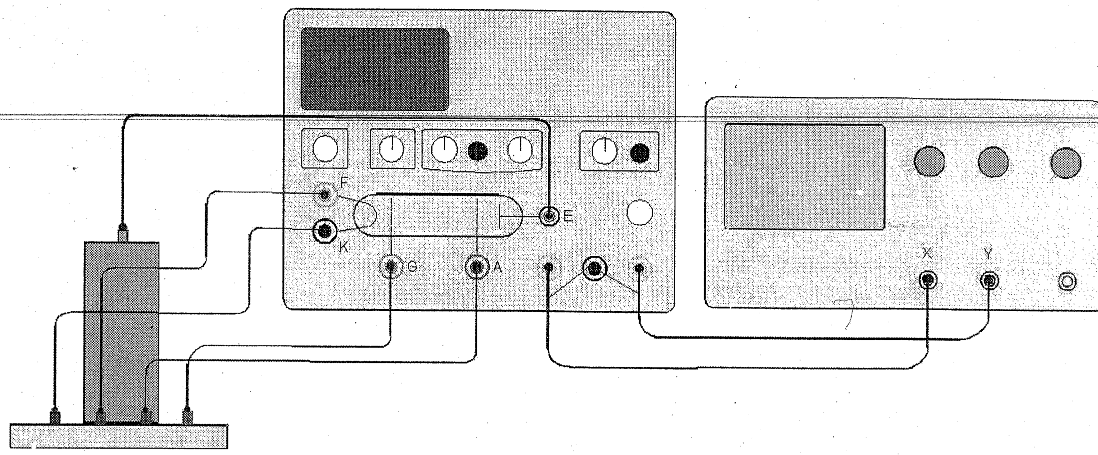


Fig. 2 Experiment set-up - Franck-Hertz tube filled with neon

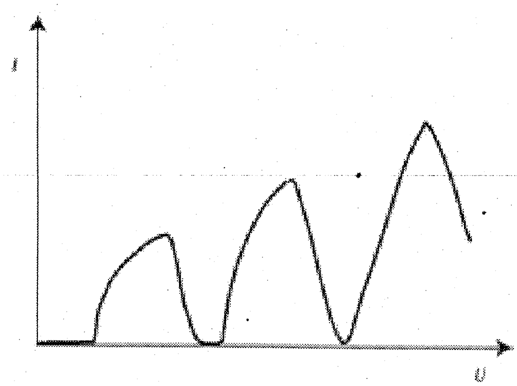


Fig. 3 Target current I as a function of the accelerating voltage U

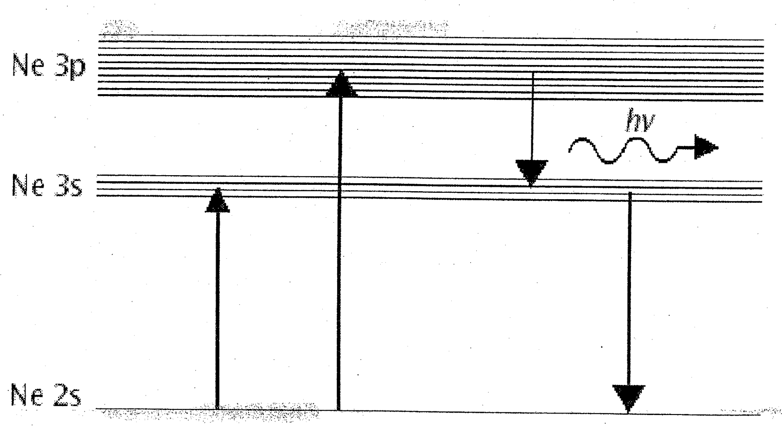


Fig. 4 Energy levels in neon atoms

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KA6045

Franck-Hertz tube control unit

Instruction sheet

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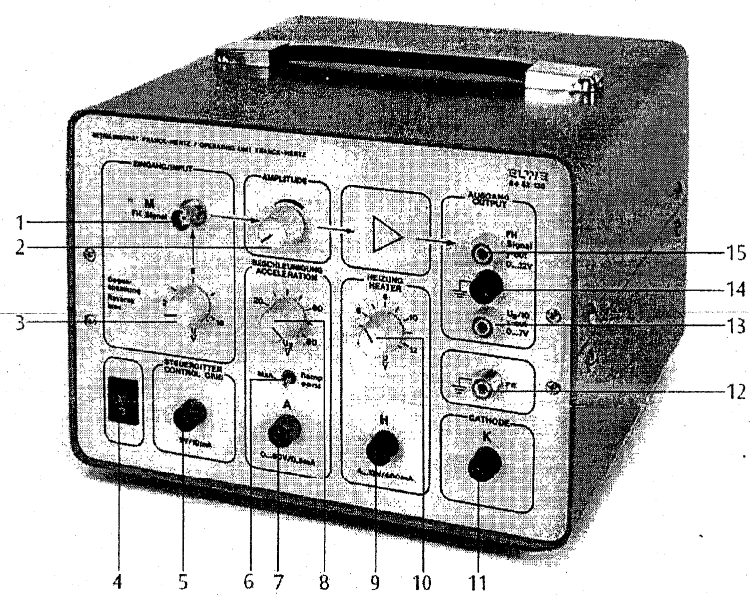

1 FH signal input
2 Rotary knob for FH signal amplitude
3 Rotary knob for reverse bias
4 Power switch
5 Control grid output
6 Toggle switch manual/ramp
7 Accelerating voltage output
8 Rotary knob for accelerating voltage
9 Heater voltage output
10 Rotary knob for heater voltage
11 Cathode output
12 Chassis ground for neon tube
13 Accelerating voltage output/10
14 Ground socket
15 FH signal output

1. Safety instructions

The apparatus conforms to the safety requirements for electrical equipment for measurement, control and laboratory use of DIN EN 61010 part 1 and is classified as belonging to protection class I. It is intended for operation in dry rooms that are suitable for electrical equipment or installations.

Safe operation of the apparatus is guaranteed with correct handling. However, safety is not guaranteed if the apparatus is handled improperly or carelessly. If it is to be expected that safe operation is impossible (e.g., in case of visible damage), the apparatus is to be rendered inoperative immediately and to be safeguarded from unintentional use.

In schools and training institutions, operation of the apparatus is to be responsibly supervised by trained personnel.

- Before first use, check if the apparatus is designed for local line voltage.
- Before start of the experiment, check the apparatus for damage.
- In case of visible damage or functional anomalies, render the apparatus inoperative immediately.
- Plug apparatus only into grounded power outlets.
- Allow only trained electronics specialists to open the apparatus.

2. Description

The Franck-Hertz control unit can be used to conduct the Franck-Hertz experiment with mercury vapour or with neon gas. It provides all of the operating voltages required to conduct the Franck-Hertz experiment, and contains a highly sensitive DC amplifier to measure the current at the collector electrode.

1. Accelerating voltage U_B:
Options are a regulated DC voltage of 0 ... 80 V (toggle switch: "Man") or a sawtooth voltage 0 ... 80 V_{ss}, 50/60 Hz (toggle switch: Ramp). At the oscilloscope output U_B/10, this voltage is divided by 10.

2. Heater voltage U_H:
DC voltage 4 ... 12 V for the heater filament of the indirectly heated oxide cathode.

3. Retarding voltage U_G:
DC voltage of 1, 2 ... 10 V for reverse bias between grid and collector electrode.

4. Control voltage:
DC voltage of 9 V for the control grid in the neon-filled Franck-Hertz tube

5. DC amplifier:
The DC amplifier provides a voltage proportional to the collector current, rated up to 10 mA. At the lowest amplification 1 V of voltage measured corresponds to an electron current of 10 µA approx. and at the highest amplification to an electron current of 10 nA approx.

3. Technical data

Mains voltage:	See back of chassis
Heater voltage:	4 ... 12 V
Heater current:	180 ... 400 mA
Accelerating voltage:	0 ... 80 V,
Retarding voltage:	1, 2 ...up to 10 V
Control voltage:	9 V
FH signal input:	BNC connector
Outputs:	4-mm safety sockets
Dimensions:	160 x 132 x 210 mm
Weight:	2.4 kg

4. Operation

4.1 Franck-Hertz tube with Hg filling

Additionally required:

1 Franck-Hertz tube filled with mercury plus vaporising furnace
1 Digital thermometer, 1 channel
1 Immersion sensor NiCr-Ni Type K
1 Analog oscilloscope, 2 x 35 MHz
1 HF lead, 1 m
2 HF leads, BNC / 4-mm plug
Safety leads for experiments

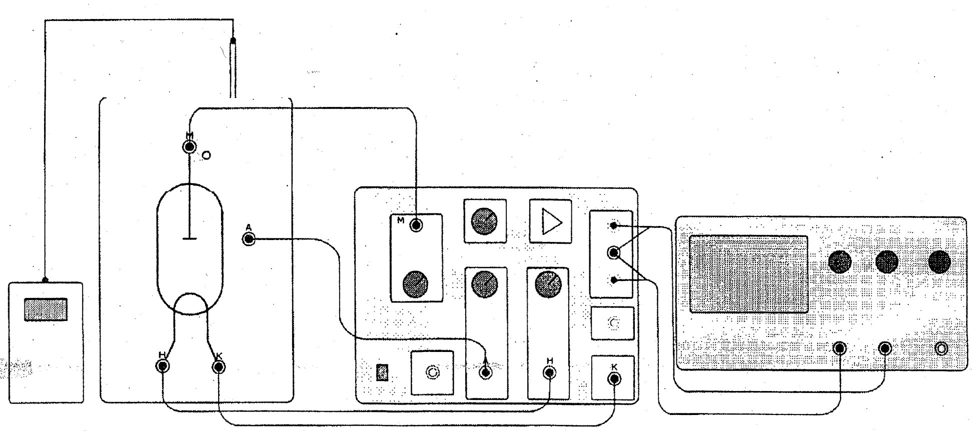

Fig. 1 Experiment set-up - Franck-Hertz tube filled with mercury

4.2 Franck-Hertz tube filled with neon

Additionally required:

1 Franck-Hertz tube filled with neon in chassis with connectors
1 Analog oscilloscope, 2 x 35 MHz
1 HF lead, 1 m
2 HF leads, BNC / 4-mm plug
Safety leads for experiments

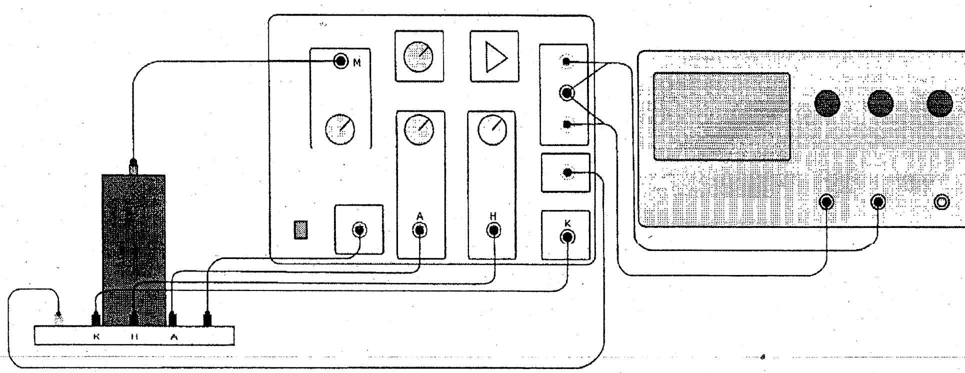

Fig. 2 Experiment set-up - Franck-Hertz tube filled with neon