High-voltage tests of UCN storage chamber model with sitall isolators

Preliminary laboratory researches of samples of sitalls, have shown, that these materials are the most perspective for manufacturing from them cylindrical isolators and electrodes of storage chambers and also - high-voltage feedthroughs. Polycrystalline glass of system SiO_2 – Al_2 O_3 -MgO alongside with high mechanical and electric strength, absence of times and water absorptions possess high thermostability (~150°C) and high temperature strength (700°C).
It will allow to avoid destruction and deformation of storage chambers at annealing procedure, necessary after BeO covering, and also at vacuum warming up in a spectrometer. A measurement of resistance of several sitall samples the specified system with various phase structure and a crystallization degree have been lead. The measured specific volumetric electric resistance exceeds 10^{16} Ohm cm that meets the requirements to limiting size of leakage currents on isolators of the UCN storage chamber.
For check of electric characteristics of sitall in vacuum, in an electric field of a high tension, the sitall cylinder with 137 mm in diameter, thickness of a wall of 10 mm and height of 60 mm, and also two aluminium high-voltage electrodes, thickness of 30 mm with deepening for sitall cylinder, depth of 5 mm have been made. The surface of the cylinder before crystallization has been pickled in a fluoric acid for removal of a layer with the microcracks formed at machining. Collected and carefully washed the model of the storage chamber with distance between electrodes of 50 mm has been placed inside of the vacuum chamber and connected to high-voltage feedthroughs. The vacuum was provided with the help of vacuum system on base TMN 500 and cryogenic adsorption pump SSNA 1500. The control of vacuum was carried out with the help vacuum measuring instrument of the Edwards Company - Penning 8. For measurements of leakage currents the device has been developed and made allowing measuring a current of any polarity with accuracy 1 nA in a range 1 nA – 10 μA. The device has an independent feed from accumulators and effective protection against overvoltage at breakdowns.

For comparison tests of the similar chamber with quartz isolator have been lead. Results of tests of uncovered chambers:

1. In some minutes after switching on 14 kV/cm for sitall, and 10 kV/cm for quartz it was received.
2. In some hours of conditioning (training) of chambers by discharges and currents 5 – 10 μA, 20 kV/cm for sitall and15 kV/cm for quartz it was received.
3. In day it was received 25 - 26 kV/cm for sitall (with currents 0.5 - 1 μA at vacuum 3,6 10^{-5}), for quartz – 19 kV/cm (at increase of high voltage the current increased up to 10 μA), additional conditioning within day has not given increase of electric field intensity.
4. At addition of ^{4}He up to pressure of 10^{-3} mmHg at once have received 28 kV/cm – a leakage current was about ~0 μA – but occasionally there were discharges. Through 5 minutes - +/-30 kV/cm (~0 μA) & rare discharges. Through 15 minutes – +/-31 kV/cm, within an hour it was not observed discharges. The leakage current changed close 25 nA.
5. Porosity of quartz is experimentally confirmed: impregnation by its helium at pressure of 10^{-1} mmHg with simultaneous adsorption other gases by pump SSNA has enabled to receive 30 kV/cm at optimum pressure of helium (after pumping of surplus of helium).

Then were tested the BeO covered sitall and quartz cylinders prepared under the scheme:

1. boiling in water of double distillation

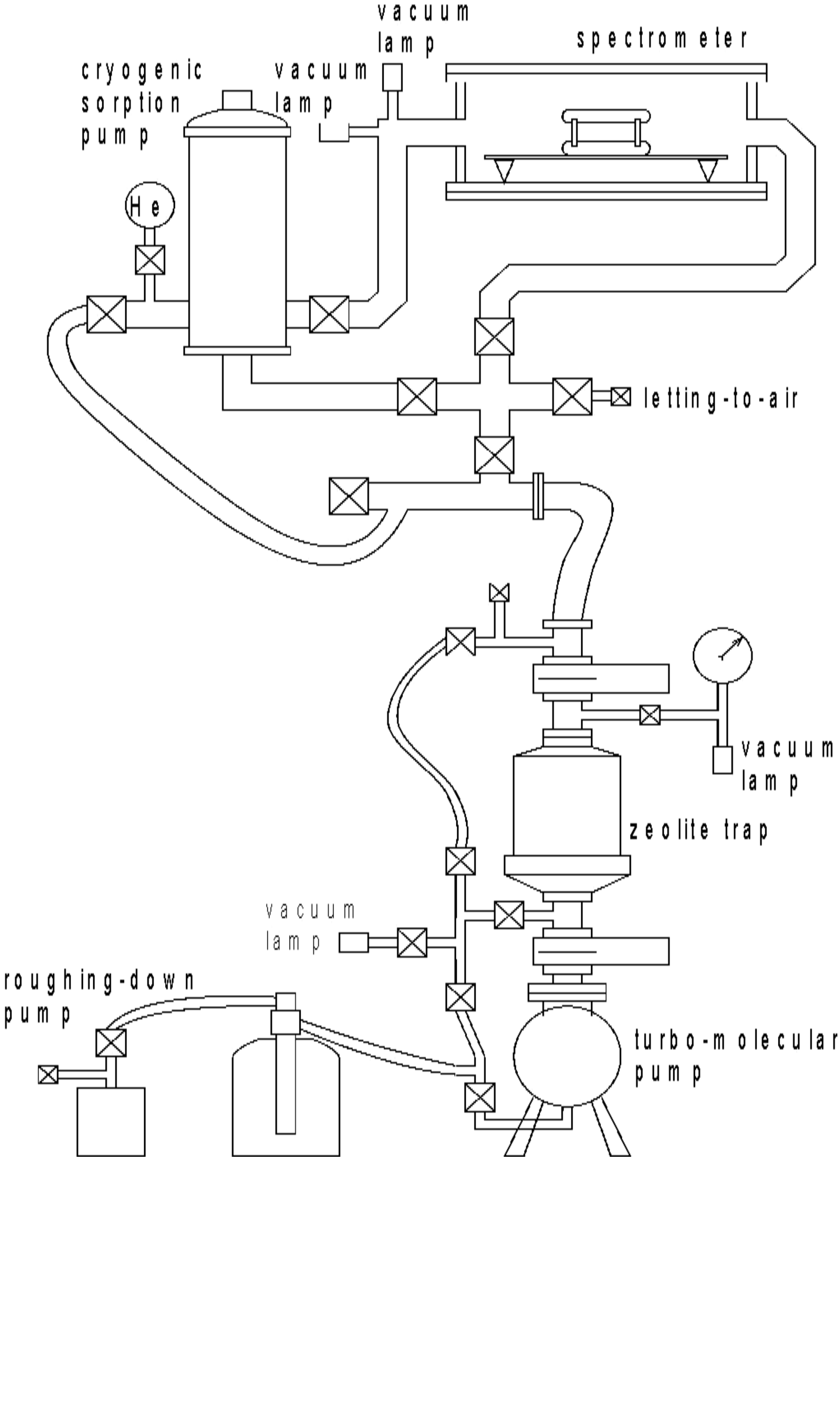
2. annealing at 600 ^{0}C with the subsequent loading still hot in covering installation.
3. pumping with a new vacuum post without oil.
4. cleaning of surfaces by discharge ("Radical").
5. BeO covering.
6. annealing at 600 ^{0}C again.

Rise of a high voltage on storage chambers with BeO coating it became possible to make faster, than was without BeO, - probably, due to annealing. Through 15 minutes of training of sitall 26 kV/cm (without helium) it was achieved. For quartz: 11 kV/cm through 15 minutes, and 17 kV/cm in 4 hours. With helium it was achieved on sitall 32 kV/cm for half an hour of training. Impregnation by helium quartz has allowed receiving 30 kV/cm for half an hour of training.

Conclusions:

- in PNPI EDM-experiment E=14 kV/cm (it was reached for two weeks), in last ILL EDM-experiment E=4.5 kV/cm (E_{max}~ 8 kV/cm). Experiment has shown an opportunity of a significant prize in intensity of an electric field up to 32 kV/cm due to decreasing of distance between electrodes (root dependence) and due to application of a new material of sitall;
- process of training (conditioning) stall isolators proceeds much faster due to smaller outgasing under influence high voltage on sitall. It is necessary to take into account, that at closed shutters in storage time of UCN in EDM measurements a pumping of storage chambers practically is absent (with leaking of UCN it is necessary to struggle). Gas evolution under influence of a high voltage can result to systematic effects;
- porosity of quartz which except for influence on electric strength can lead to additional losses of UCN at storage in chambers;
- it is required to carry out a full-scale test experiment with sitall with data recording on a computer;
- as at discharges small gas evolution from sitall was observed, it is necessary BeO covering to carry out with preliminary warming of chambers inside covering installations and to use annealing up to 700 ^{0}C after covering;

Vacuum system



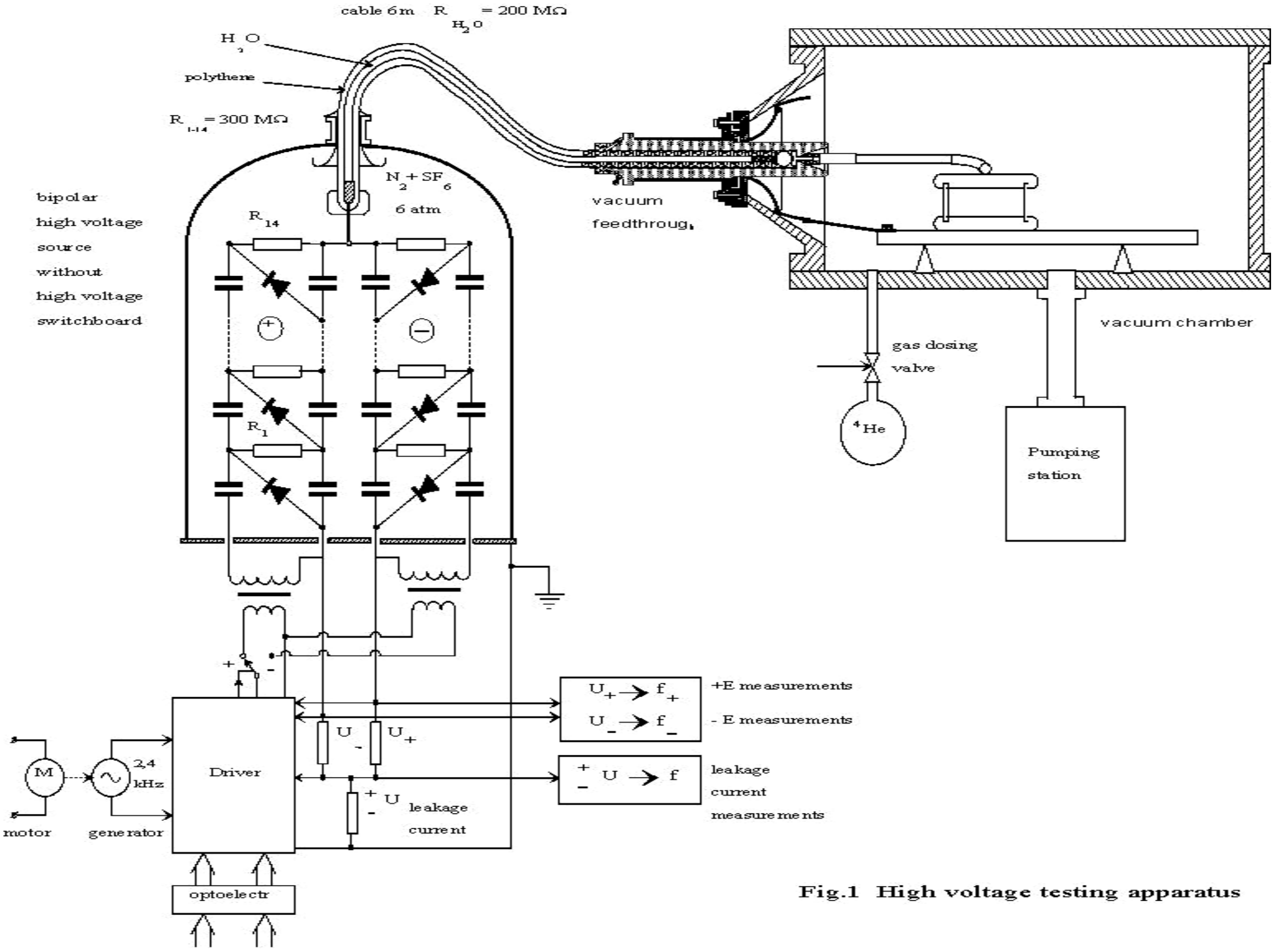


Fig.1 High voltage testing apparatus