10 CHARGED BALLOON

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When an air filled balloon is rubbed with wool or dry paper electrization takes place. In this case we can consider several ways of electrization. One of the ways is the ruin of balloon structure and electron loses. In this case balloon is charged in positive charge.

It's more realistic to consider electrization case, which depends only on friction. In this case we assume that there is neither dust nor humidity layer on the balloon surface, so electrization happens only because of friction, in another words triboelecrization takes place.

It's clear that some definite surface is heated by friction. Here we consider two cases of heating: I - is the whole surface heating and II - is the heating of some surface inequalities. Both cases are depended on the surface structure characteristics. It's clear that for some solid bodies, which can have high temperature for inequalities, it's possible thermo emission, after which the heated surface is charged in positive charge. Albeit this case isn't inevitable. If both structures have freely connected ions, than we can determine the number of those ions that can shift from one structure into another by Boltzman distribution:

$$N = N_0 e^{-A/kT}$$

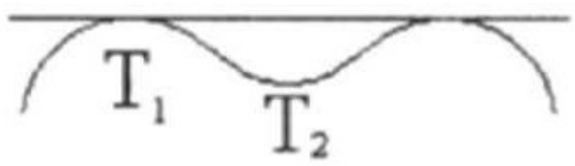
Where N_0 is the initial number of ions and A is the ion binding energy. In this case a big number of ions will shift from the heated surface to relatively cold and this will lead to electrization.

On picture 1 (a) is shown the difference of temperatures on the surface with inequalities (that leads to surface electrization) and picture 1 (b) shows us the electrization process between two rubbing bodies.

But if A (ion binding energy) is sufficiently big, than by the surface heating one of the surfaces reaches the sufficient value of temperature for the charge to shift by the above mentioned way.

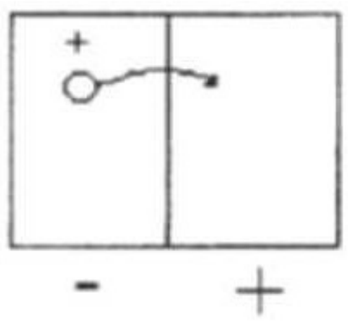
Pic. 1

(a)

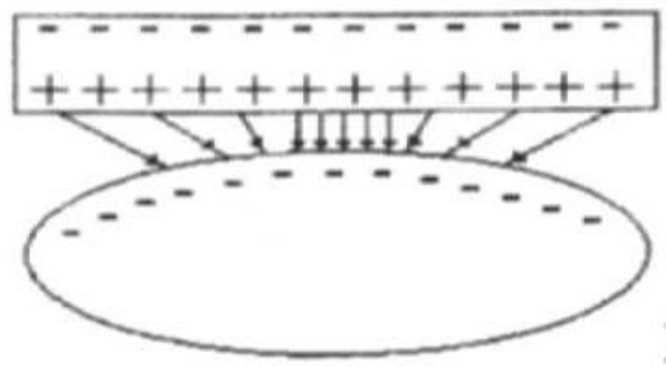


$T_1 > T_2$

(b)



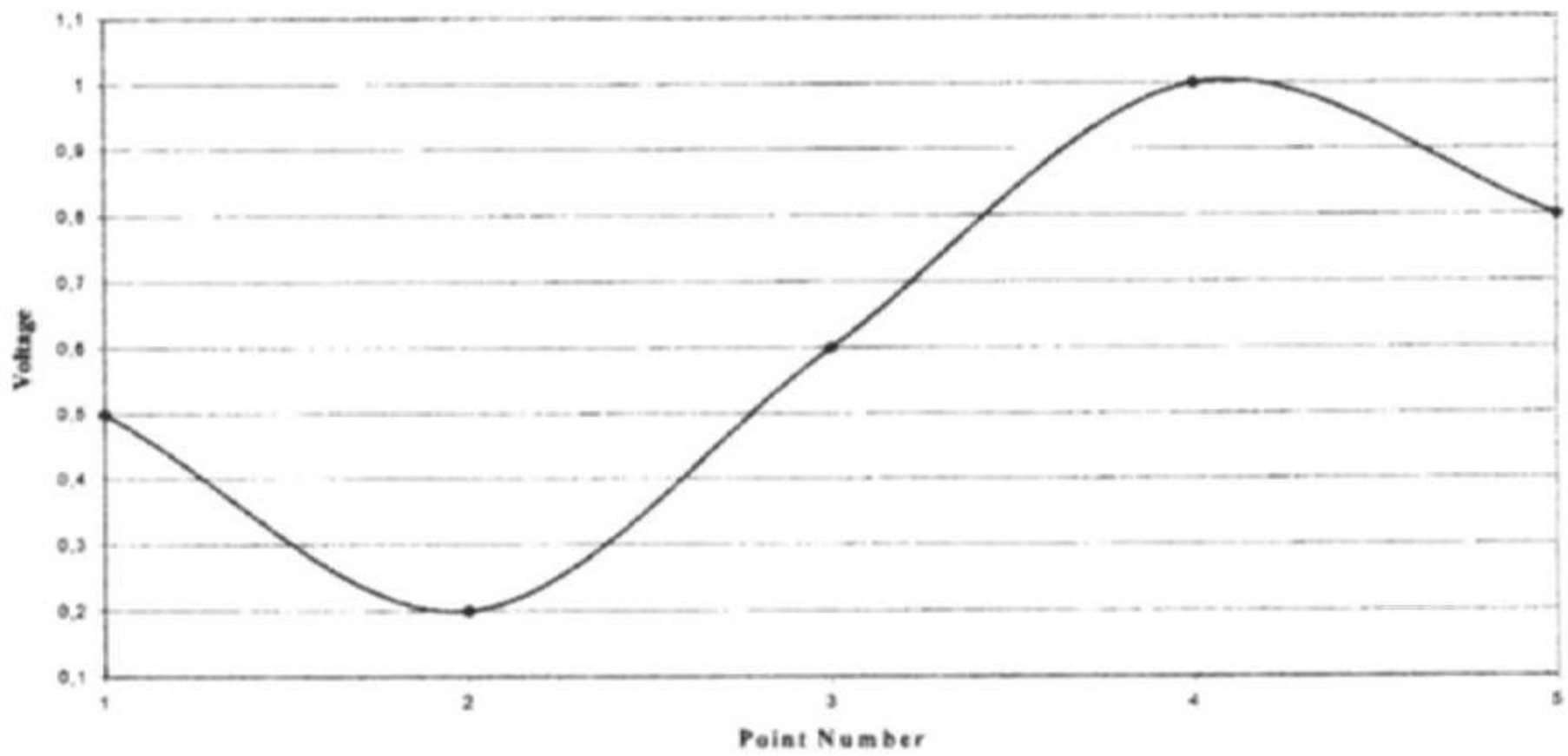
As we know charged balloon may stick to the ceiling and stay there. The explanation of this phenomenon is the following: as the charged balloon has an electric field round it, when it's approached to the ceiling, ceiling dipoles are polarized and interaction force is emerged (picture 2). If the interaction force is more than the balloon gravity force, than balloon may stick to the ceiling and stay there.



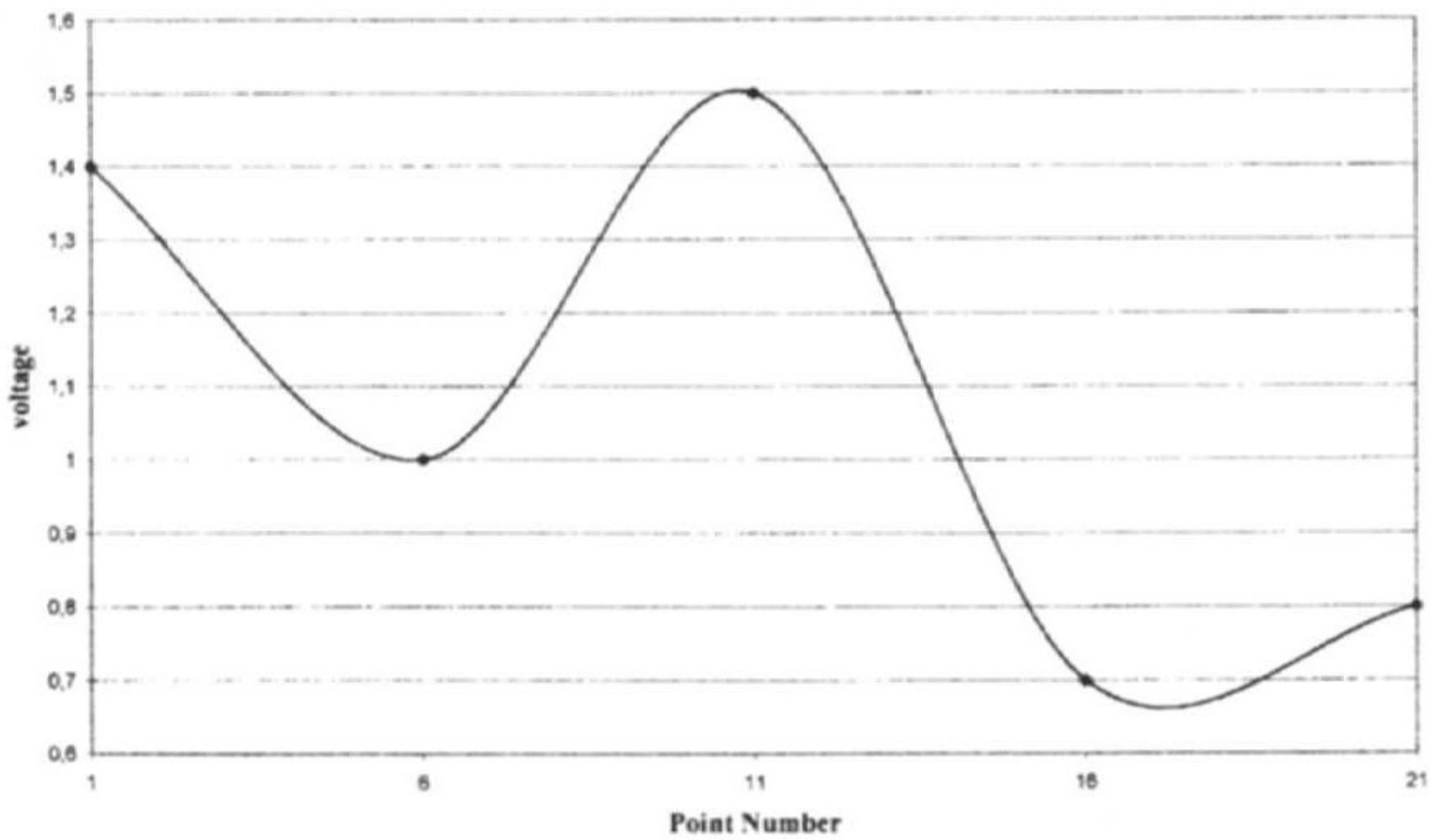
Pic. 2

The charge of the balloon and its ability to stick to the ceiling is greatly influenced by air humidity. We constructed several graphs of charge distribution on the surface for different air humilities, here are some of them:

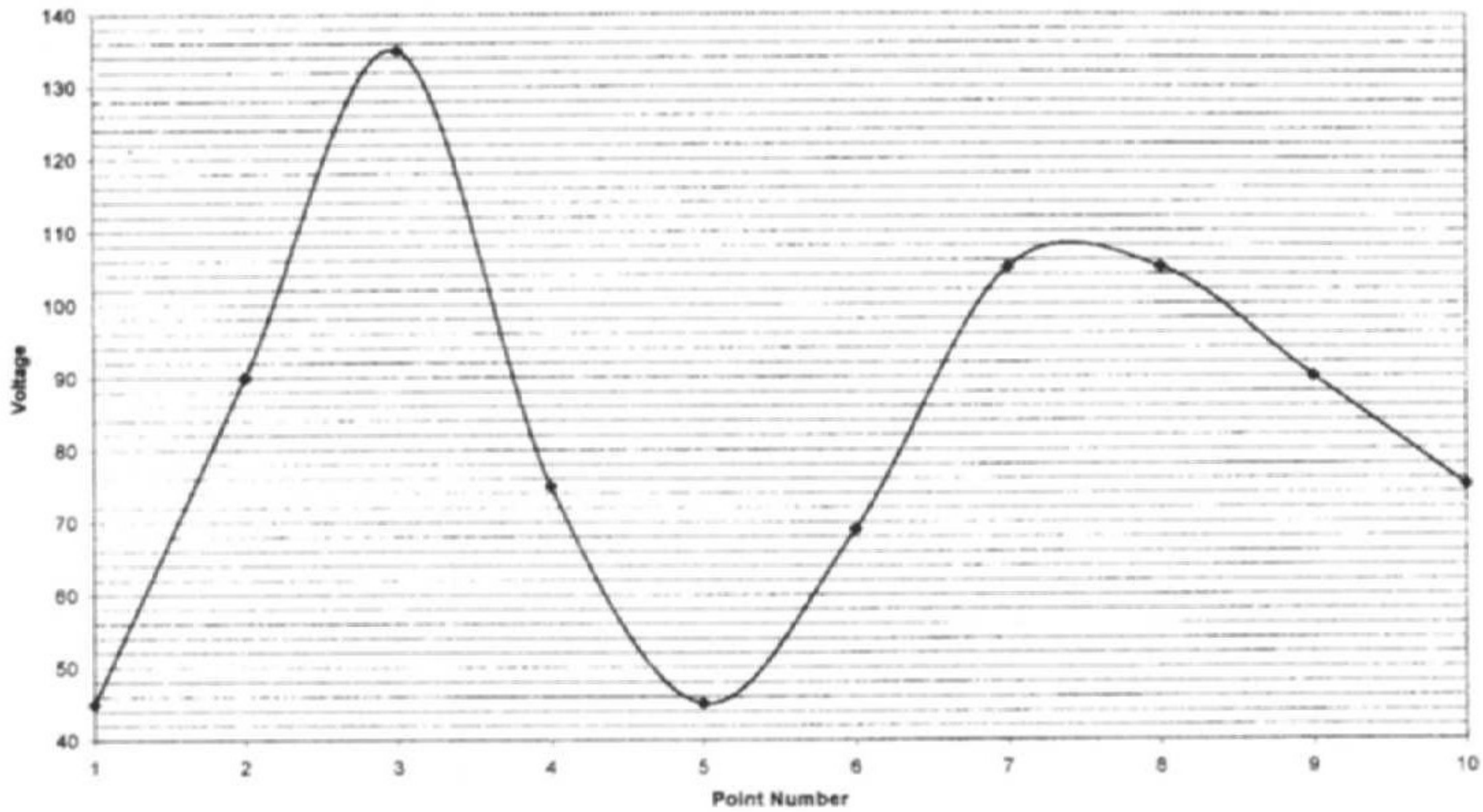
Charge distribution for φ=78%



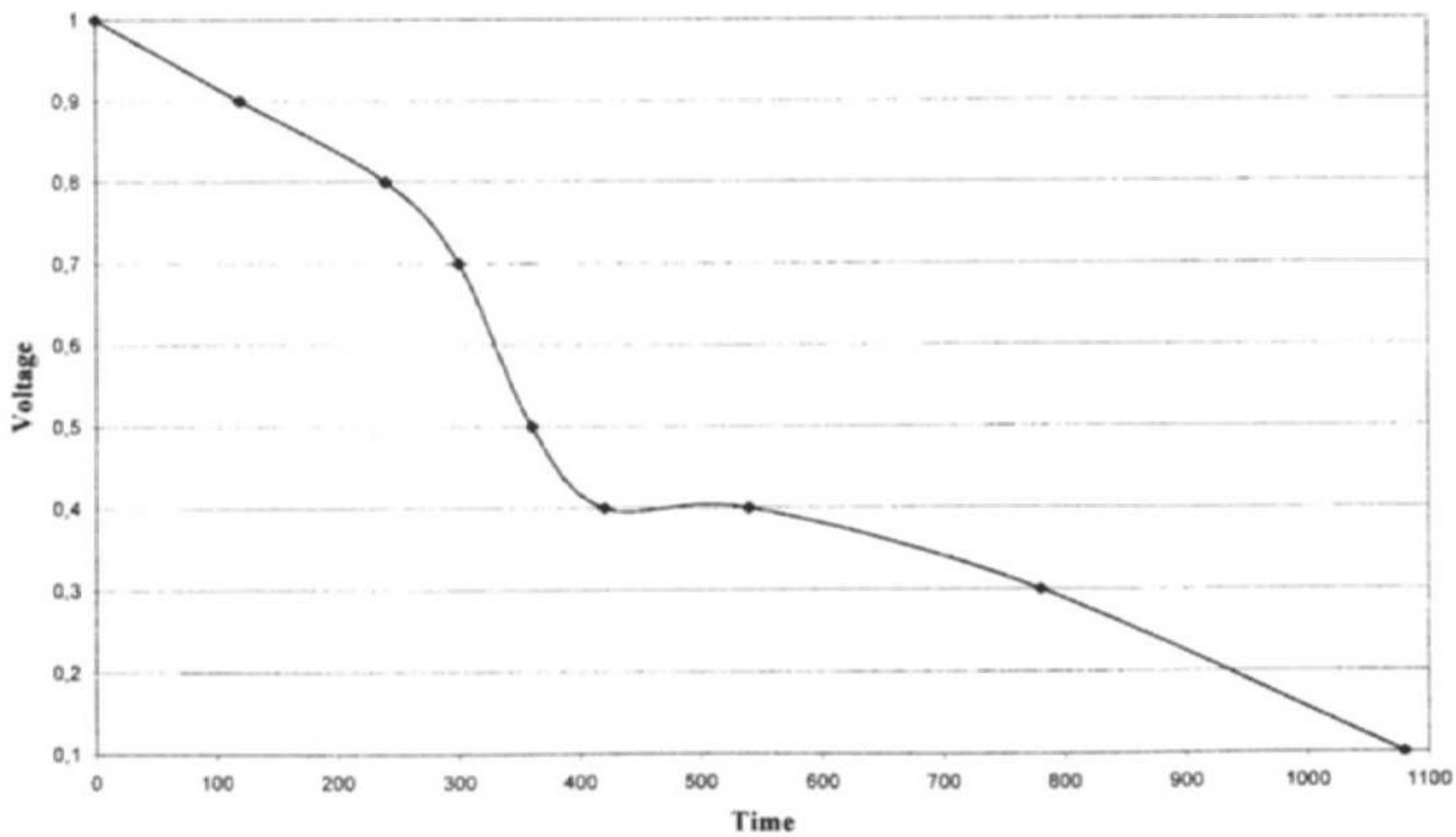
Charge distribution for φ=78%



Charge distribution for φ=83%



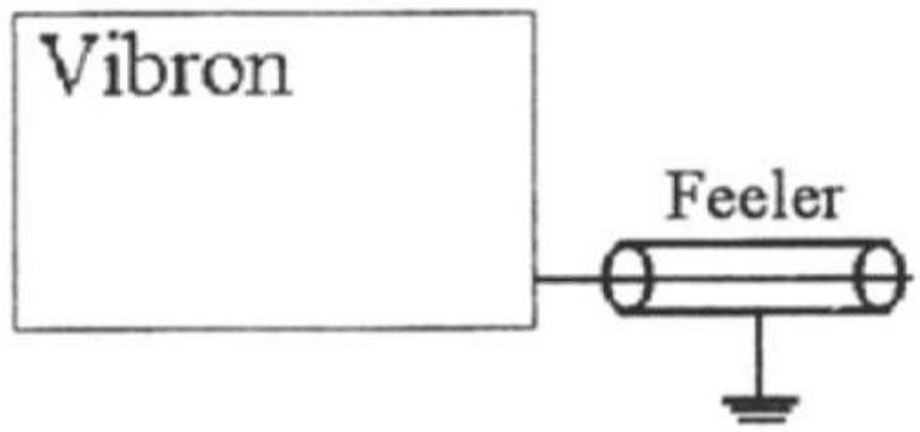
Charge lose in time for φ=83%



These graphs are made from the following experiment:

We constructed "feeler" (see picture 3) that is a conductor, which is connected to special "Vibron" voltmeter. We rubbed the balloon with the paper and then measured potential difference between feeler and points taken on the balloon surface. The distance between points is 1 sm. and the result of experiment is shown on above given graphs.

Pic. 3

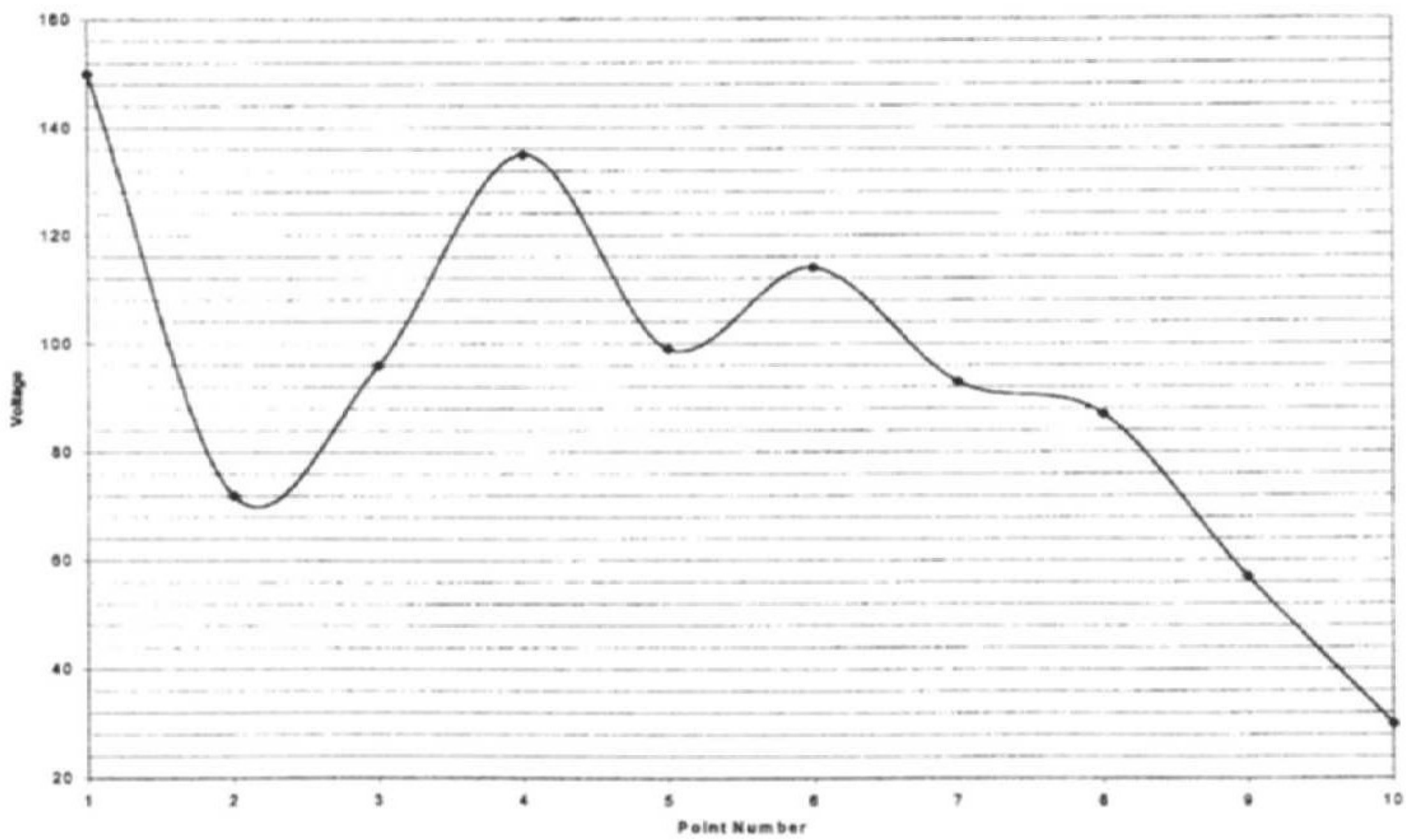


Feeler measures the potential difference on the 3 mm. diameter

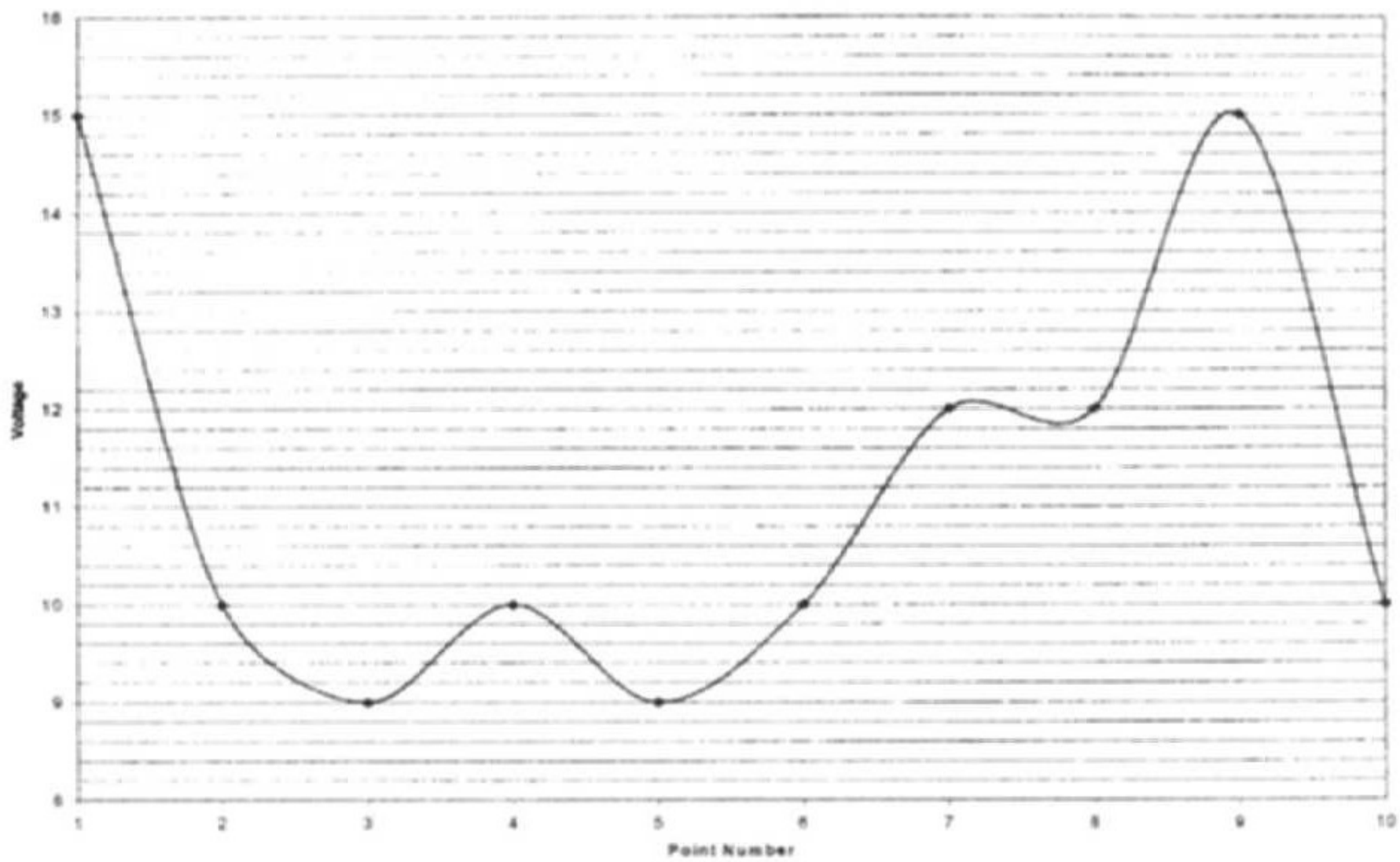
We also conducted another experiment:

We put Xerox powder and little iron ball in the plastic bottle. With the bottle shaking, iron ball breaks powder particles and powder dust is produced. Then we poured this dust on the charged balloon surface and got very nice and interesting picture. Before the dust pouring we measured the charge of the balloon and it was negative. We have also constructed the graphs of charge distribution before dust pouring and after and they are given below:

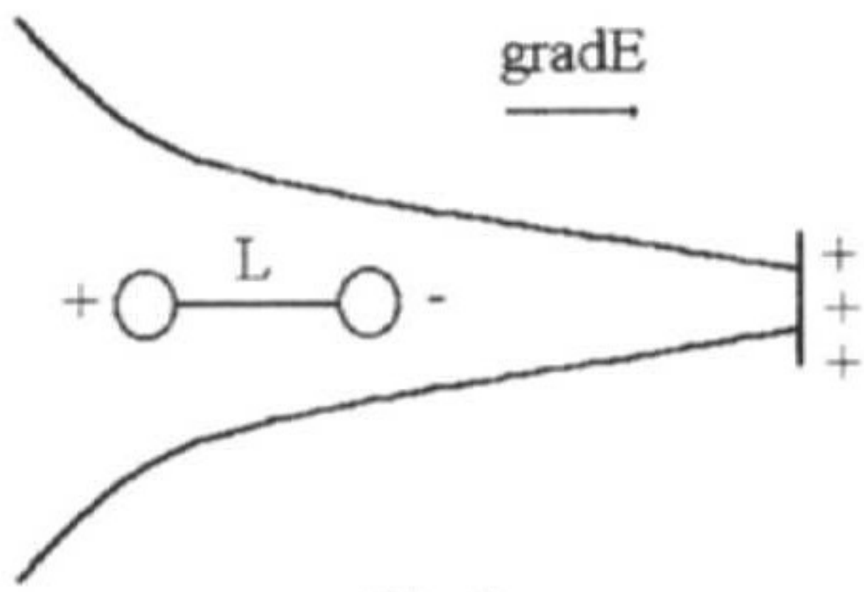
Charge distribution before pouring for φ=83%



Charge distribution after pouring for φ=83%

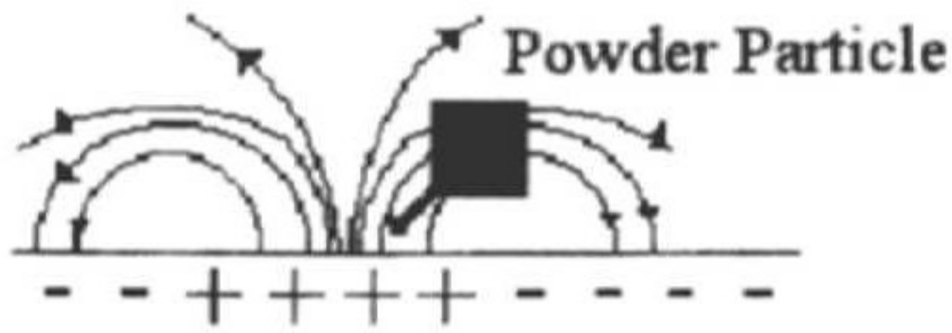


Now let's consider what happens when we pour powder on the charged (in our experiment negatively charged) balloon surface. Powder particles are dielectrics and they are polarized (see picture 4).



Pic. 4

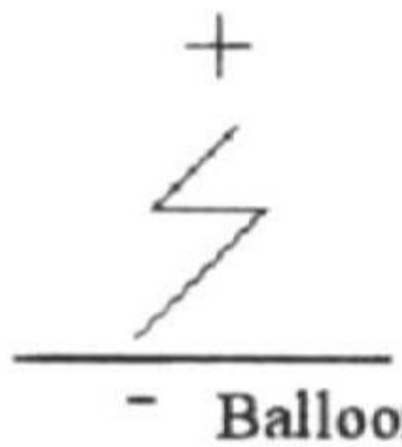
When balloon is being rubbed with the paper some electron groups may shift across the surface leaving behind positively charged lines. These lines are surrounded by negatively charged surface. If the powder particle is situated near the positively charged line, it is attracted to the line, because of the big electric field produced by the line, because of the Kulon force and we can also determine the main force applied to the particle (see picture 5).



Pic. 5

$$F = q\mathrm{L}\, gradE$$

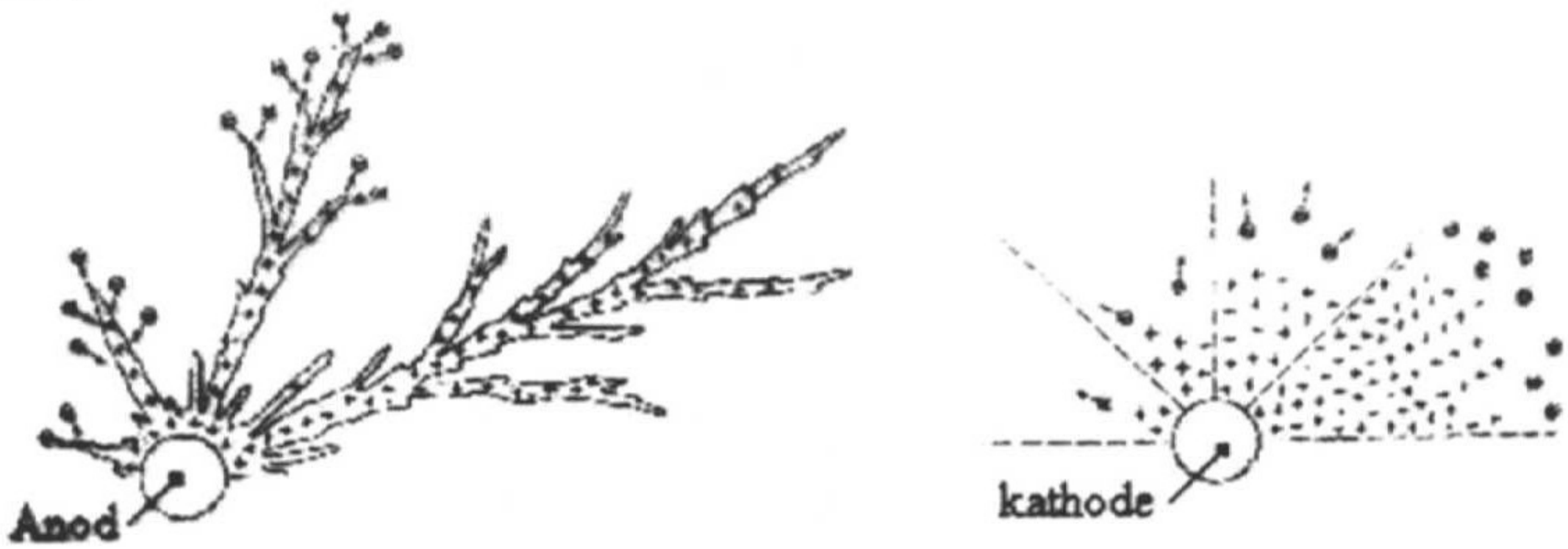
As the result we get that positively charged lines and surrounding negatively charged balloon surface are covered by powder and we get Lixtenberg pictures (scientist who found these pictures). But within the air humidity more then 85% Lixtenberg pictures aren't taken because in this case discharge takes place between balloon surface and air (see picture 6).



Pic. 6

If anode is approached to the negatively charged balloon surface (in our experiment paper plays anode role) electrons from the whole surface gather in the point under anode (leaving behind positively charged lines) and then happens discharge (sparkle). Picture 7 (a) shows the result we get after this process.

Pic. 7



(a) (b)

Another picture occurs if cathode is approached to the negatively charged balloon surface. Electrons are repulsed from the place under cathode and leave behind positively charged areas. These areas attract electrons from the cathode and electrons are shifted from the cathode to the

surface. Then the same process happens until cathode is removed from the surface and finally we get the picture 7 (b).

Below are given some Lichtenberg pictures taken by us after different experiments: