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A Continuously Sensitive Cloud Chamber

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A particularly simple cloud chamber is described that is continuously sensitive to ion tracks. The chamber operates on the principle of vapor diffusion from a hot to a cold surface. The sensitive region is a shallow horizontal layer near the cold surface. The chamber has been placed in a magnetic field and curved tracks of β-particles from a radioactive source have been photographed. Pictures of such electron tracks are shown.

EXPANSION chambers as invented by C. T. R. Wilson have always suffered from the essential intermittency of their expansion-recompression mechanism. One would like a chamber that maintains a continuously supersaturated region in which tracks form and fall out to be replaced by tracks from the next event with no insensitive period or dead time ever intervening. A notable attempt in this direction was made by Langsdorf[1] but his rather complex apparatus has never come into use. We have been studying this problem and recently we have set up a particularly simple device. We have used the principle of vapor diffusion from a hot to a cold surface employed by Langsdorf. This diffusion mechanism produces a shallow region between these two surfaces that remains continuously supersaturated.

The chamber we have set up consists of a glass beaker that sits on a cake of dry ice (cold surface) and is covered with a cardboard wet with alcohol that stays at room temperature (hot surface). The wet cardboard provides the vapor, which can be either ethanol or propanol, or mixtures of either of these with water. Ion tracks of excellent quality are observed in a shallow layer near the cold bottom of the beaker. Sharp tracks of both electrons and protons are seen in air.

Our experience with this simple beaker chamber has been that best operation is obtained when a clearing field is placed across the sensitive region. Both horizontal and vertical fields have been tried and a vertical field works best. Here, of course, the clearing field cannot sweep old ions away as in a Wilson chamber but, instead, it forces additional tracks from above and below into the permanently sensitive region. This adds more ionizing events to those occurring originally in this thin layer. The additional ion load helps keep the supersaturation from increasing to the fog limit and makes chamber operation much more satisfactory. We have used fields of about 50 to 100 volts/cm with equal results.

For better seeing from above (through a 4-in. diameter hole cut in the cardboard and covered with a glass plate) we have put a piece of black velvet cloth in the bottom of the beaker; and to keep any white frost from forming on top of the velvet we have added alcohol sufficient to cover the velvet. This arrangement provides a very satisfactory black background that stays black at dry ice temperatures. Incidentally, the thickness of the cold alcohol layer can be varied so as to vary the temperature attainable at its upper surface. This in turn determines the maximum supersaturation attained in the sensitive region, giving some control of the optimum track load. Reducing the maximum supersaturation, however, also

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[1] A. Langsdorf, Rev. Sci. Inst. **10**, 91 (1939).

makes the sensitive layer thinner; and this may or may not be an advantage in a particular experiment.

After one first puts the beaker on the dry ice cake, a thin fog forms near the cold bottom and the fog particles grow and gradually fall out *in a very few minutes*. This fog is due to the dust, present in ordinary air, that must be removed before one can see ion tracks. Tracks begin to show usually about five to ten minutes after the beaker is first put on the dry ice. Those who have operated Wilson cloud chambers, and have struggled with making the air dust-free by tedious repeated slow expansions, will recognize here another remarkable property (besides the simplicity) of this type of chamber. Tracks continue to be visible after this short dust-clearing period as long as one keeps the cardboard wet and the dry ice supply adequate. We find that if the dry ice block covers less than about two-thirds of the beaker bottom, operation begins to deteriorate and the tracks become fragmentary and diffuse.

We have put this chamber with its horizontal ion tracks into a vertical magnetic field (air core coils, $H \simeq 1000$ oersted) and observed the characteristic circular paths of electrons and positrons of energies up to a few Mev. (See Fig. 1.) With a γ-ray source we have enjoyed watching the development in the chamber gas of ion clusters and longer range recoil electrons from the Compton process, and some events that look like electron-positron pairs. With a 5 mc Po-Be neutron source outside the beaker at the level of the sensitive region we have observed many sharp bright straight tracks of proton recoils and an occasional nuclear reaction occurring in the chamber gas. A proton recoil frequently shows its characteristic sharp small angle bend near the end of its range. The nuclear reactions are distinguished from the protons by the appearance of a short bright track that has a large angle bend near one end. In this case the apex of the bend always faces the neutron source.

We have found this beaker chamber to be useful for looking at samples of very weak radioactive isotopes made in the cyclotron. The weak sample spread thin behind a zapon film is merely lowered on a string through the hole in the top cardboard all the way to the level of the sensitive region. Any electrons, positrons or γ-rays from the sample make themselves immediately evident. We have put also a bit of uranium oxide into a tiny zapon bag, lowered it on a string into the sensitive layer, and watched the α-particles shoot out from the bag.

The different radiations produced by a β^+-emitter that emits also x-rays from K-capture may readily be distinguished because the positrons describe circular arcs in the magnetic field which originate at the *surface* of the sample whereas any γ's or x-rays form Compton recoils at random distances from the sample. It is interesting to note that the sensitive region is sensitive to ions very close to the sample surface. As far as we can tell, the visible tracks of β-particles start at most about 1 mm from the sample. Moreover, the observation of what is coming from a radioactive sample is continuous because we have found that it disturbs nothing to leave an incandescent light source focused on the sensitive region all the time. Thus the detection by the continuous cloud chamber of just what radiations are being emitted from radioactive substances becomes especially simple and satisfying.

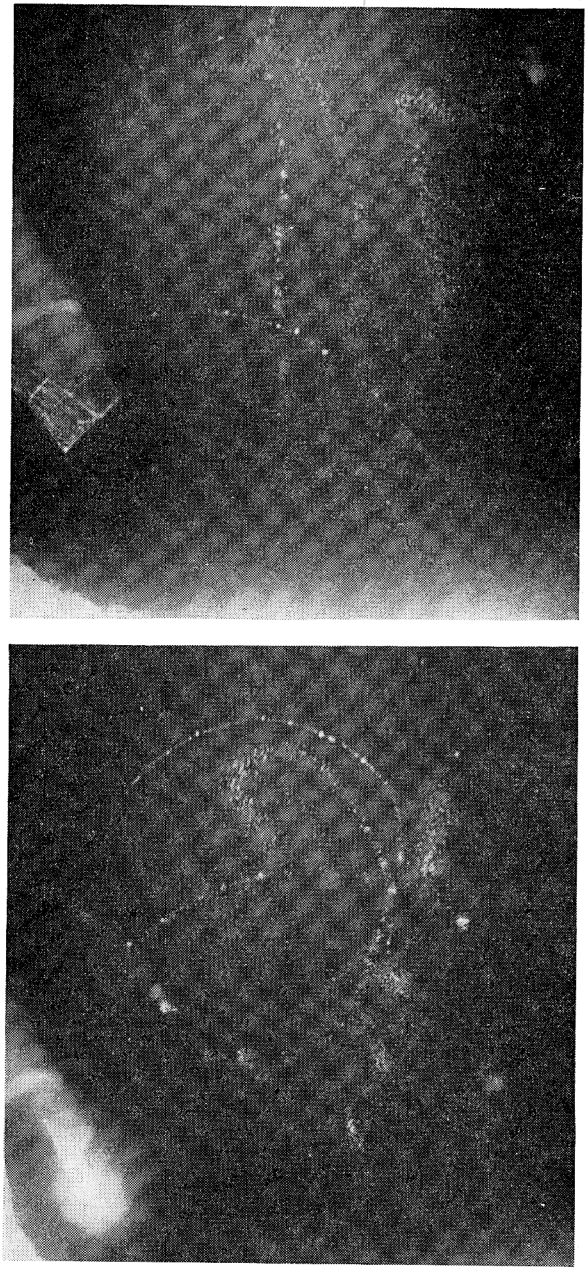

FIG. 1. Two photographs of β-particles from $Sr^{90}+Y^{90}$. The active material is evaporated on zapon film and placed at the level of the sensitive region. The active source is the diffuse object at the left in each photograph. In addition to the β-particles, there are present stray diffuse tracks of electrons from cosmic ray background. In most of the pictures we have obtained, these stray electrons can be distinguished easily from the β-electrons.