Operation Manual

Rad-1-Cloud_Precipitation-v1

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Preface

Rad-1-Cloud_Precipitation-v1 is an educational equipment for demonstrating (i) the generation of ionization tracks by radiation particles, and (ii) the formation mechanism of precipitation.

The first function is based on the principle of cloud (Wilson) chamber, with the equipment powered electrically to prevent the inconvenience of the need of dry ice as required by a conventional cloud chamber.

The second function is achieved by overturning the setup to generate a temperature gradient, such that the vapor of a volatile solvent generated at the bottom of the chamber is condensed at the top surface to give precipitation.

The equipment is particularly useful in teaching students at high school levels, for those who take a Physics course including a component of radioactivity. One example is the Physics course of the Hong Kong Senior Secondary Curriculum which includes a compulsory unit of "Radioactivity and Nuclear Energy". It is also suitable to be used for teaching students at all levels, for those who take courses associated with general science, weather, meteorology, environmental science and geography.

More information on the working principles and procedures are described in the following two parts of this manual.

April, 2013

Part 1 Cloud chamber

Principle

A conventional diffusion cloud chamber uses dry ice (−78.5°C) to cool down the base plate of the chamber (Fig. 1-a). Alcohol vapor introduced into the chamber diffuses from upper part of the chamber towards the base. It becomes supersaturated, such that when particles from a radioactive source pass through, some vapour molecules are ionized to become condensation nuclei. Visible tracks are formed and seen as a consequence.

To prevent the inconvenience of using dry ice, Rad-1-Cloud_Precipitation-v1 is designed to powered electrically, by using Peltier cooler to cool down the base of the chamber at ≈ -40^{o}C (Fig.1-b). The equipment is conveniently used in a classroom for demonstrating radioactive ionization phenomena caused by cosmic ray, radon or other radioactive isotopes. Fig.1-c shows a snap of the tracks.

Demonstrative videos: http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/Radiation

Fig. 1-a

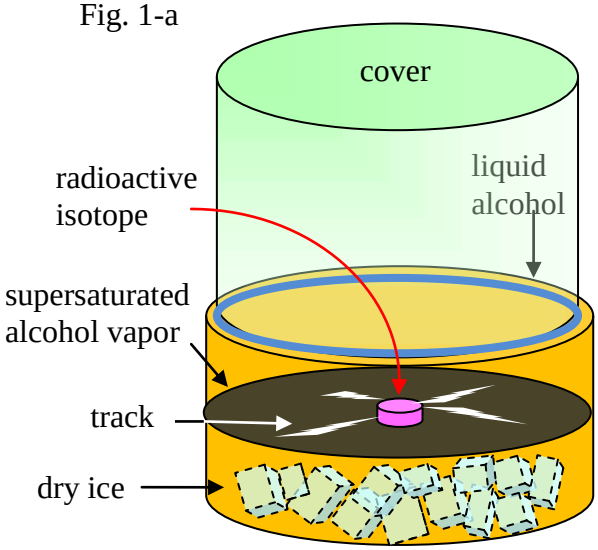
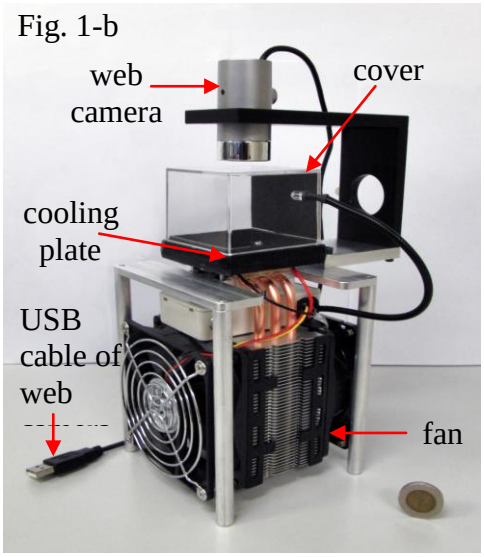
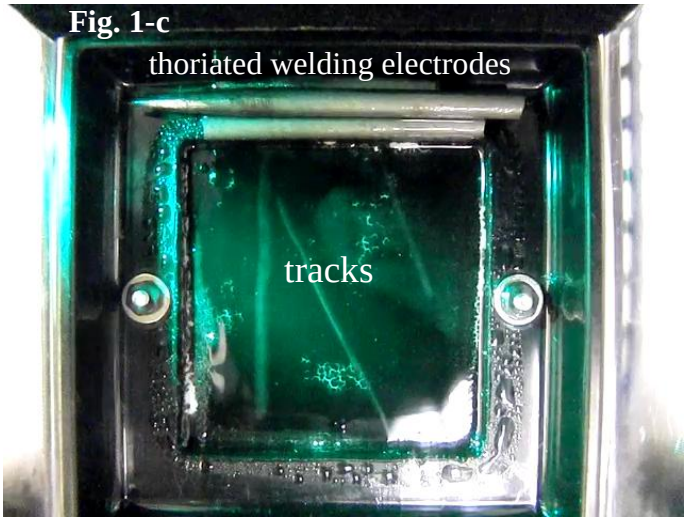


Fig. 1-b



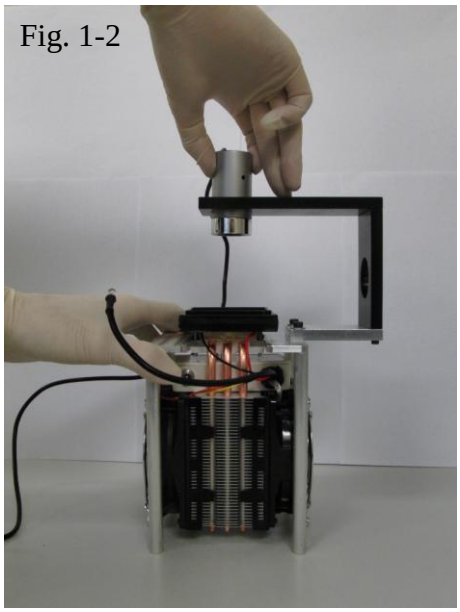


Operation procedures

1-1 Screw the 4 legs to the flange, with the cooing unit at the lower position (Fig. 1-1).
1-2 Fix the web camera at the top position of the holder (Fig. 1-2).

Fig. 1-1

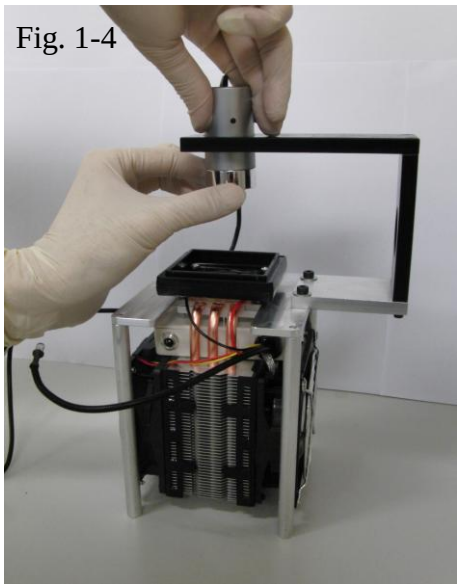
Fig. 1-2



1-3 Connect the camera's USB plug to the computer, and activate the driver to see the image (Fig. 1-3).
1-4 Adjust the position of the camera to get the best image (Fig. 1-4).

Fig. 1-3

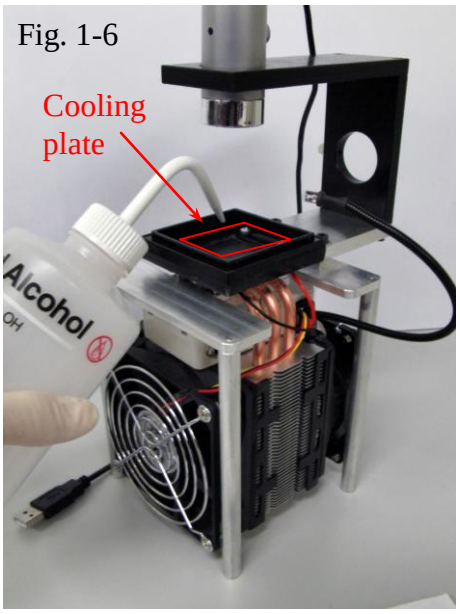
Fig. 1-4



1-5 Remove the cover of the chamber (Fig. 1-5).
1-6 Drop a thin alcohol layer on cooling plate (Fig. 1-6).

Fig. 1-5

Fig. 1-6



Important note: Always use a lifting tool to hold a radioactive source. Do not touch any source with bare hand. After the experiment, put the radioactive source back in the safety storage and wash your hands thoroughly. For a sample containing detachable radioactive material (like thorium in lantern mantle), the sample must be sealed in a plastic bag all the time to prevent direct contact with human skin.

1-7 Place the radioactive source on one side of the cooling plate (Fig. 1-7).
1-8 Wet the black felt, which is attached to one side of the cover (Fig. 1-8).

Fig. 1-7

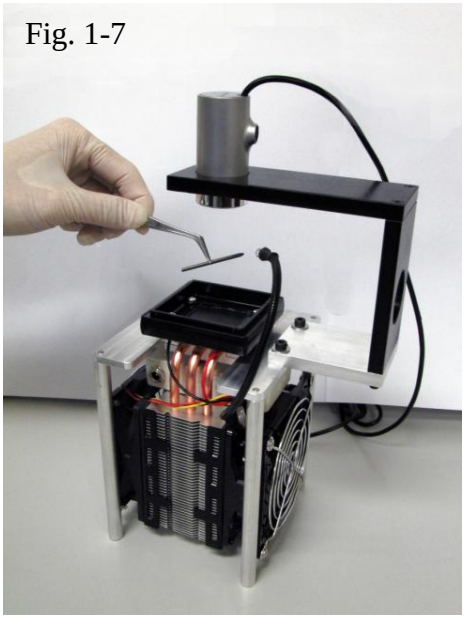


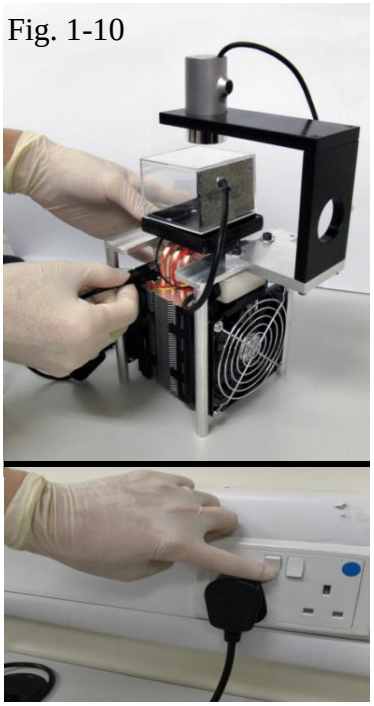
Fig. 1-8

1-9 Replace the cover with the side of a black felt positioned farther away from the observer (Fig. 1-9).

1-10 Connect the equipment to an AC adapter, and switch on the mains (Fig. 1-10).

Fig. 1-9

Fig. 1-10



1-11 Wait for the cooling plate to reach the desired temperature (≈ 0.5 min). Direct the LED light to see the ionization tracks (Fig. 1-11).

1-12 To end the experiment, switch off the mains and disconnect the wires (Fig. 1-12).

Fig. 1-11

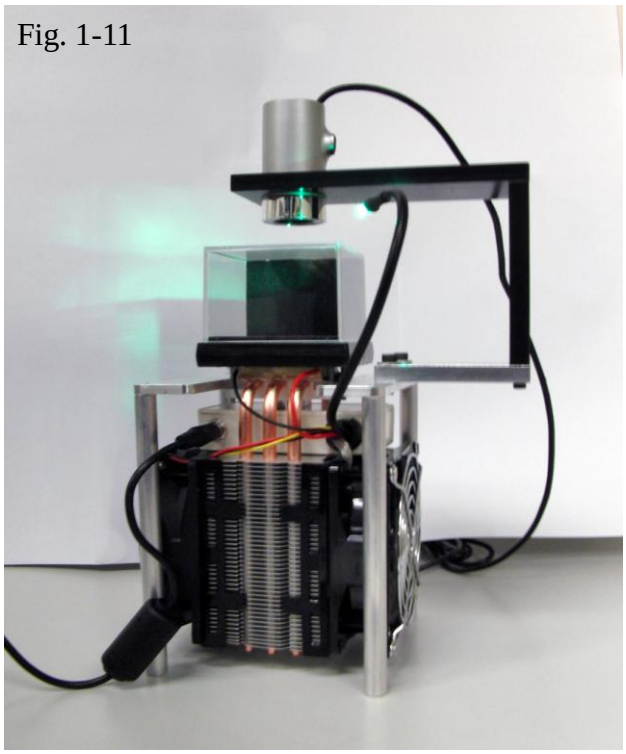
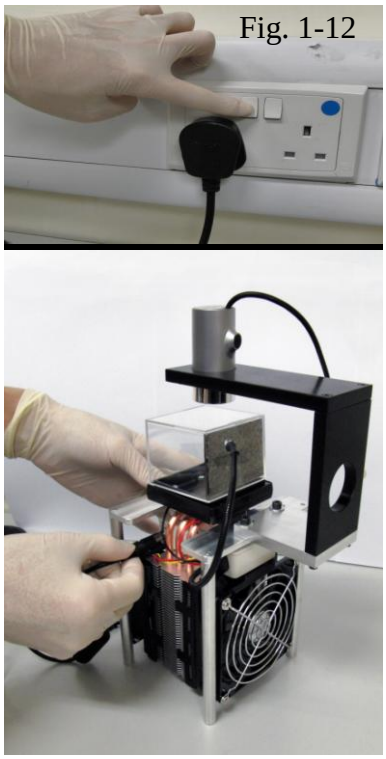


Fig. 1-12



1-13 Remove the plastic cover (Fig. 1-13).
1-14 Remove the radioactive source (Fig. 1-14).

Fig. 1-13

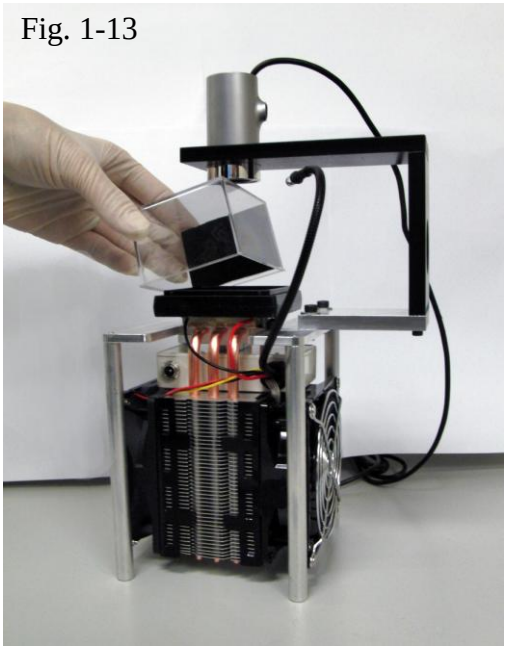
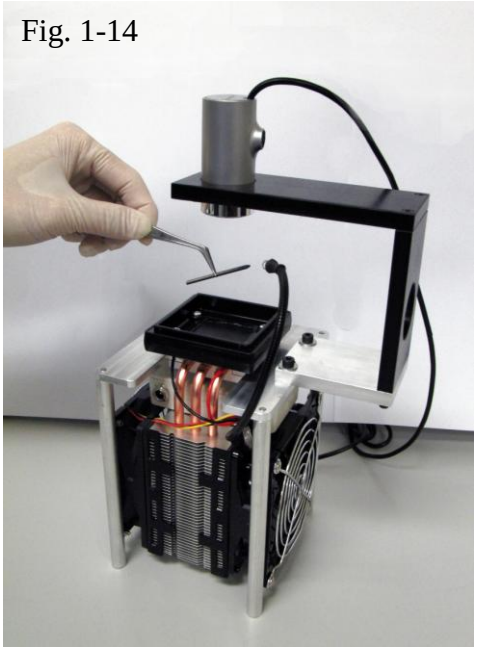


Fig. 1-14



1-15 Clean up the cooling plate softly and prevent the paint to be smeared. Let the chamber to be dried in air, and finally replace the cover (Figs. 1-15 to 1-17).

Fig. 1-15

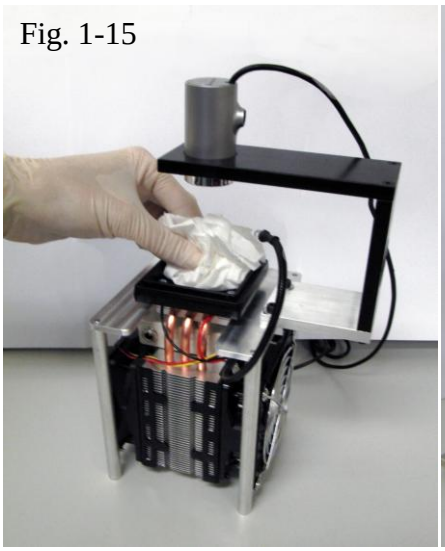


Fig. 1-16

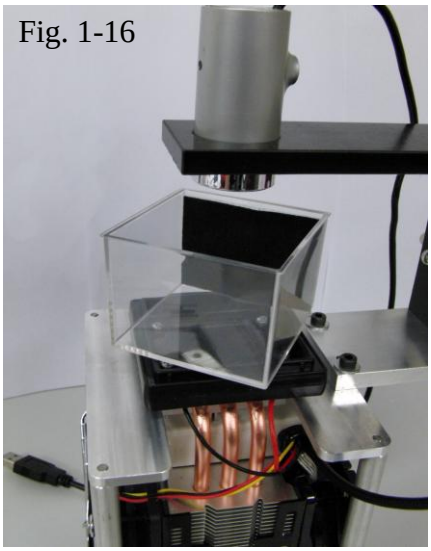
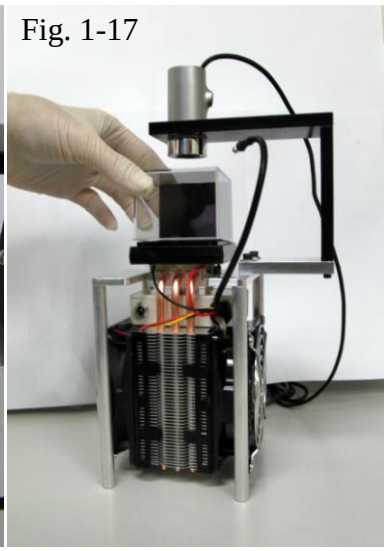


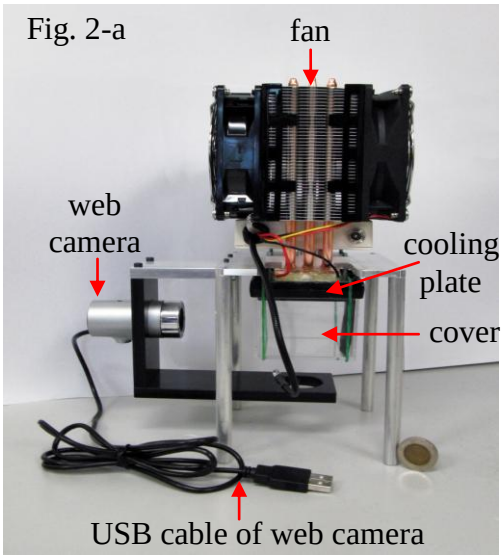
Fig. 1-17

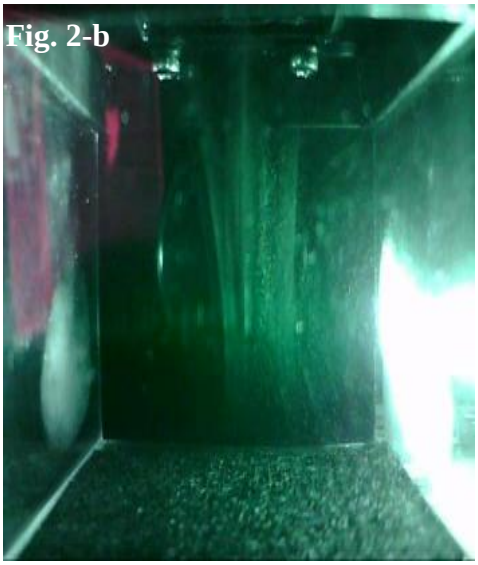


Part 2

Another function of Rad-1-Cloud_Precipitation-v1 is to illustrate the physical mechanism of the generation of precipitation. The configuration of the setup is shown in Fig. 2-a. A snap of "alcohol rain" is shown in Fig. 2.b.

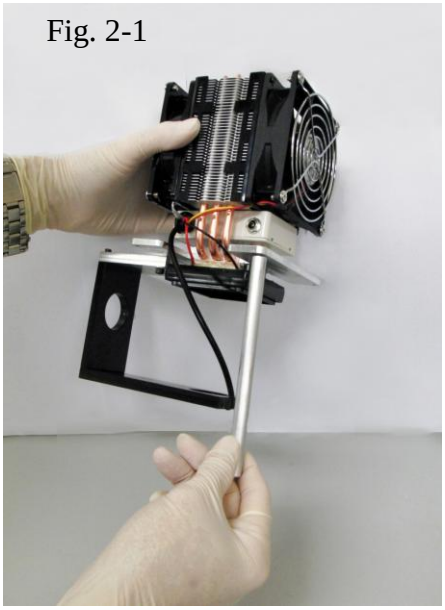
Demonstrative videos: http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/Radiation

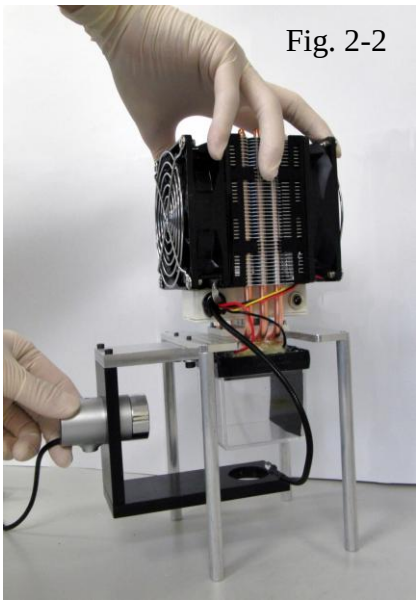




Operation procedures

2-1 Screw the 4 legs to the flange with the cooling unit at the upper position (Fig. 2-1).
2-2 Fix the web camera at the side of the holder (Fig. 2-2).





2.3 Connect the camera's USB plug to the computer, and activate the driver to see the image (Fig. 2-3).

2.4 Adjust the position of the camera to get the best image (Fig. 2-4).

Fig. 2-3

Fig. 2-4

2-5 Remove the cover of the chamber (Fig. 2-5).

2-6 Put an additional black felt at the bottom of the cover (Fig. 2-6).

2-7 Wet the added black felt with alcohol (Fig. 2-7)

Fig. 2-5

Fig. 2-6

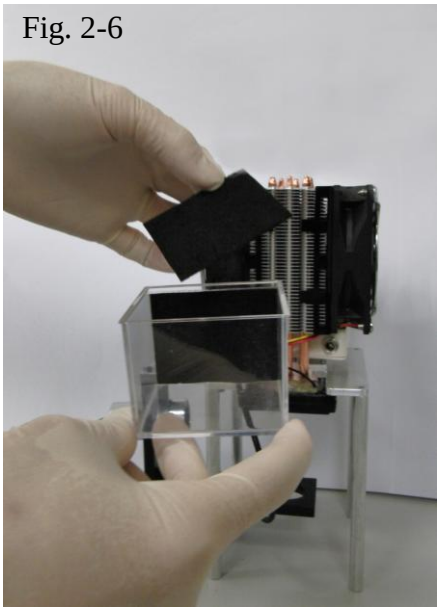


Fig. 2-7

2-8 Use rubber bands to hold the cover (Fig. 2-8).
2-9 Connect the setup to the AC adapter and switch on the mains (Fig. 2-9).

Fig. 2-8

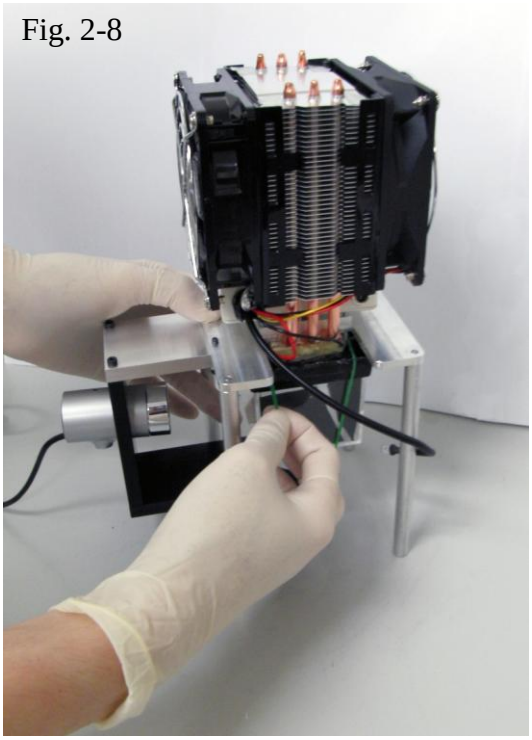
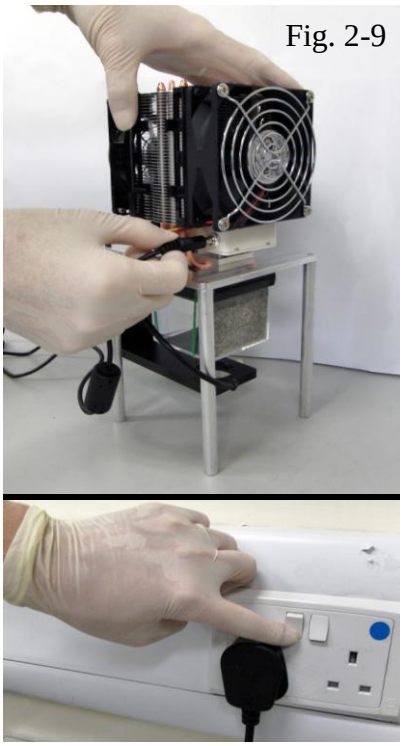


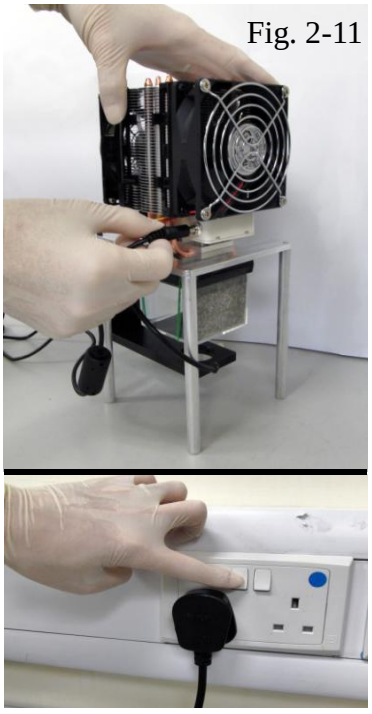
Fig. 2-9



2-10 Wait for the cooling plate to cool down (≈ 0.5 min). Direct the LED light to see precipitation (Fig. 2-10). It would be clearer by turning off the background light.
2-11 To end experiment, switch off the mains and disconnect the wire (Fig. 2-11).

Fig. 2-10

Fig. 2-11



2-12 Remove the cover (Fig. 2-12).
2-13 Clean up the base plate softly. Prevent the paint to be smeared. Dry the chamber in air (Fig. 2-13).
2-14 Replace the cover to the chamber (Fig. 2-14).

Fig. 2-12

Fig. 2-13

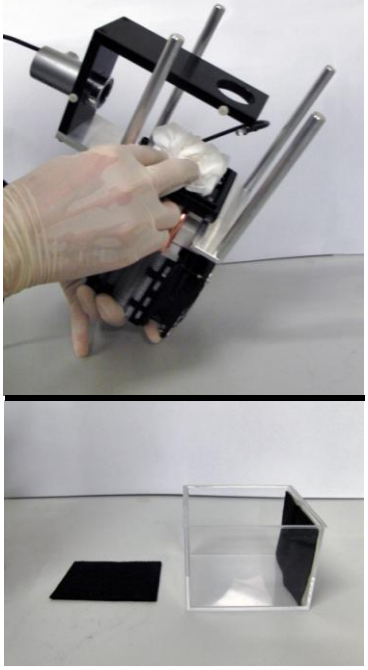
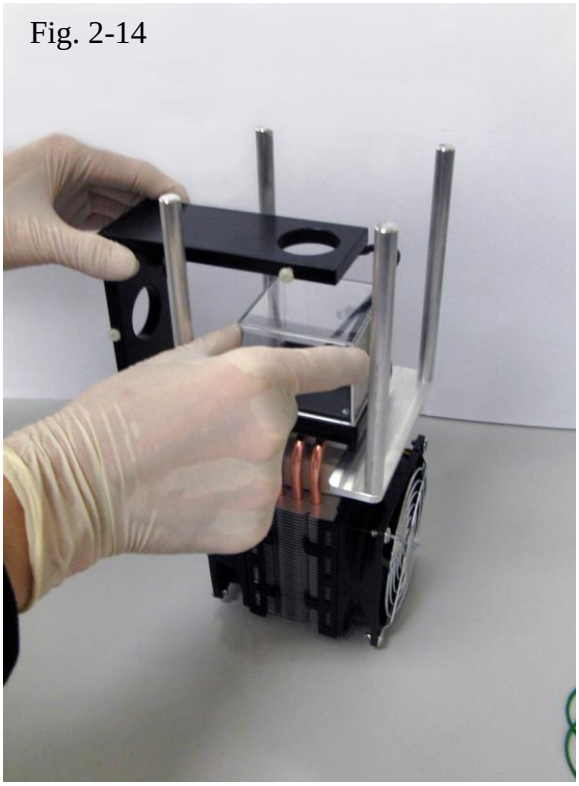


Fig. 2-14



- End -