THE CLOUD CHAMBER

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•The role of the Wilson Cloud Chamber is often forgotten in the modern annals of the development of particle physics.

•Up until 1952, when the Bubble Chamber was invented by Donald Glaser, scientists relied on the the Cloud Chamber for the photographic investigations of fundamental processes.

•Rutherford describe the cloud chamber as "the most original and wonderful instrument in the scientific history"

"Seeing is believing"

Aerosol Science and Technology 32:243-248 (2000), " Historical Review of Coulier, Aitken"
Rev. Mod. Phys. 18, 225 - 290 (1946)
Phys. Rev. 51, 818 - 825 (1937), "Alpha Particles from Uranium"

Cloud Formation and Airborne Dust - the fog

- Airborne Dust known ca.1869, by optical techniques. Tyndall, Brownian
- Pioneers, Coulier(ca. 1875), Aitken (ca. 1880) showed the importance of airborne dust particles in the air in the formation of clouds.
- " Fine solid particles suspended in the air are necessary for the production of fogs". Coulier
- More than 200 tons of sulfur was burned with coal every winter in London in the 1880's -> "London Fog".
- Lord Kelvin and JJ Thompson (ionization) made important contributions to the theory.

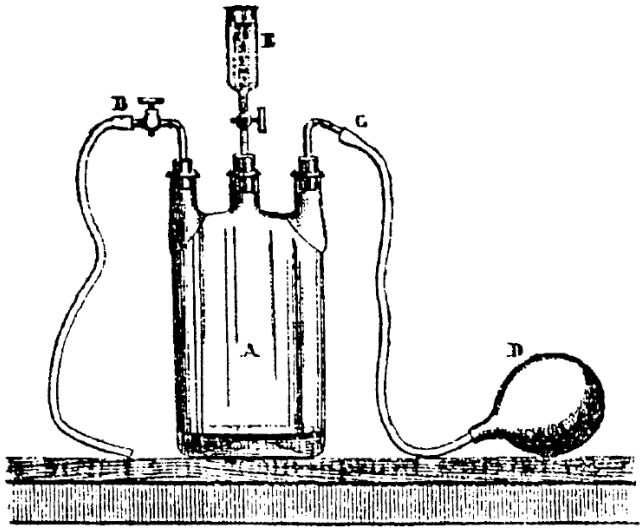
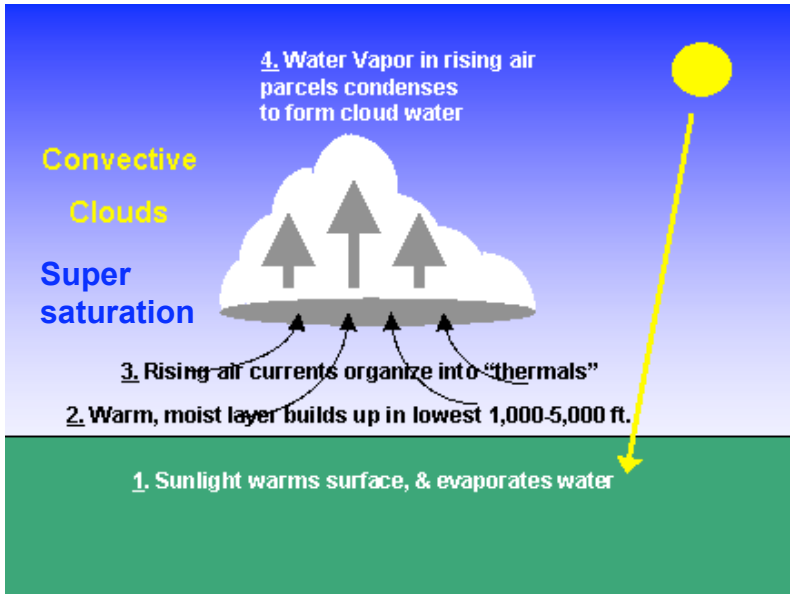


FIGURE 1. The apparatus used by P. J. Coulier for the studies on water vapor condensation (Coulier, 1875a).



Rev. Mod. Phys. 18, 225 - 290 (1946)

WILSON CLOUD CHAMBER

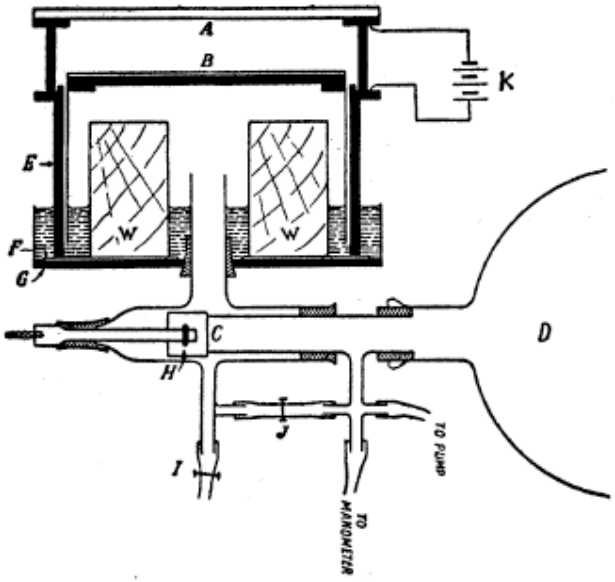


FIG. II-1. Wilson's original cloud chamber.

AB = expansion chamber, cylindrical in shape and completely closed,
B = movable base which slides inside cylinder E and serves as piston,
F = rubber sheet resting on a brass disk G to arrest downward motion of B,
D = highly evacuated vessel which may be put in communication with the space below B by opening the valve C,
WW = wooden blocks reducing the air space within the chamber,
I = stopcock on opening which space below B is connected with the atmosphere and the piston brought back to the original position,
J = pinch cock for adjusting the initial position of the piston and hence the expansion ratio,
K = battery providing the electric field to remove stray ions just before a fresh expansion.

- In Wilson's original design ca. 1911 a diaphragm expanded to rarify and bring the vapor+air mixture into a supersaturated state.
- Wilson's original chamber acted very slowly and more advanced designed soon followed.
- For rare nuclear or cosmic events triggered or rapidly cycled chambers were developed.
- Rudiments of stereo photography was developed.
  - Some continually sensitive chambers based on **diffusion** were developed ca. 1940.
  - A saturated vapor diffused between a warm to cold plate in the chamber.
  - The sharpness of the tracks suffered in such devices.

Rev. Mod. Phys. 18, 225 - 290 (1946)

BLACKLETT/OCCHIALINI CLOUD CHAMBER ca. 1933

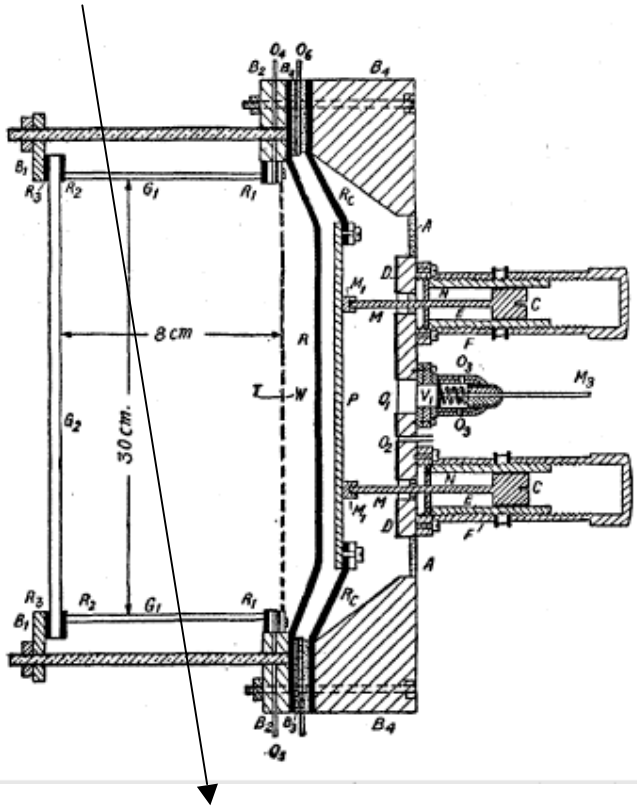


FIG. II-2. The diagram shows a vertical section of the cloud chamber through the axis of the cylinder.

G_1—section of the glass cylinder taken from the sides.
G_2—thick glass plate covering G_1, through which the picture is taken.
R_1, R_2, R_3—rubber gaskets for making the chamber air tight.
R—rubber diaphragm whose motion produces compression and expansion.
W—wire netting in front of R to reduce turbulence inside chamber.
T—a piece of black velvet soaked with alcohol water mixture to produce a perfectly dark background and also to reduce turbulence.
P—brass plate serving as piston and fixed on annular rubber cloth.
M_1—rod screwed on to P which slides inside the brass tube E when the piston works.
N—stop fixed rigidly with the brass tube E which limits the maximum forward motion of the screw head C on the compression stroke.
E—brass tube with screws on the outer surface which may be moved towards or away from P by screwing it in or out of tube F. The position of E thus controls the expansion ratio.
O_2—inlet for air into the back chamber. This is permanently connected with the compressor unit through a regulative valve V_2 shown in the following figure.
O_1—outlet for air from the back chamber. This is closed when valve is in its most forward position.
V_1—valve controlling escape of air. When V_1 is pushed back, air escapes through O_1 and O_3.
O_4—inlet for alcohol-water mixture. This is closed during the operation of the chamber.
O_3—inlet for gas into the front chamber. This also remains closed after gas mixture has been introduced.
O_6—a hole in brass piece B_3 which connects the space between the rubber diaphragm and the piston with atmospheric air. This facilitates quick forward and backward motion of the piston.

The Blacklett/Occhialini chamber could be triggered upon the passage of a cosmic ray.

Phys. Rev. 51, 818 - 825 (1937)

Alpha Particles from Uranium - UI and UII

TABLE I. *Summary of most important range determinations.*

METHOD	RANGE IN AIR @ 15°C 760 mm		INVESTIGATOR	DATE
	U I	U II		
Ionization	2.53 cm	2.91 cm	Geiger-Nuttall[1]	1912
Pleochroic Haloes	2.82	2.91	Gudden[2]	1924
Wilson Chamber	2.73	3.28	Laurence[3]	1927
Scintillations	—	3.23	Rutherford[4]	1927
Wilson Chamber	2.72	3.28	Kurie[5]	1932

[1] H. Geiger, J. Nuttall, Phil. Mag. **23**, 439 (1912).
[2] Gudden, Zeits. f. Physik **26**, 110 (1924).
[3] G. C. Laurence, Phil. Mag. **27**, 690 (1914).
[4] E. Rutherford, Phil. Mag. **4**, 580 (1927).
[5] F. Kurie, Phys. Rev. **41**, 701 (1932).

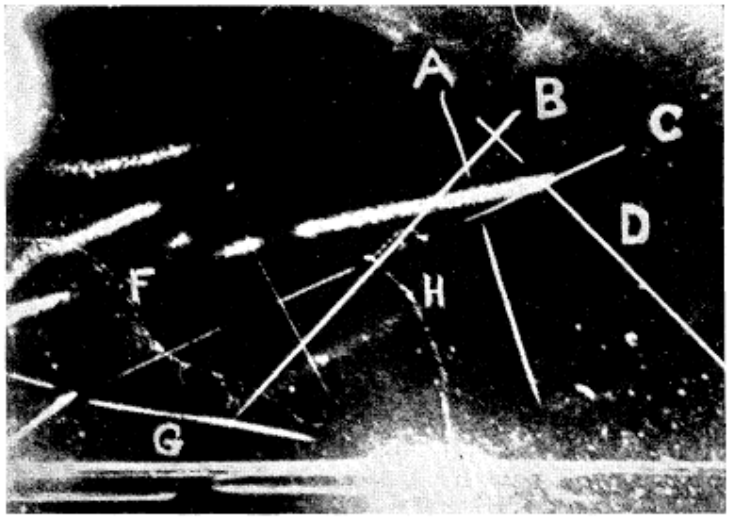


FIG. 1. Reproduction of typical chamber photograph, showing tracks of various types and ages.

$$U_{92}^{238} \rightarrow Th_{90}^{234} + \alpha_2^4 \ (4.2MeV, \mathbf{UI})$$
$$\rightarrow X_{91}^{234} + \beta_{-1}^0 + \bar{\nu}$$
$$\rightarrow U_{92}^{234} + \beta_{-1}^0 + \bar{\nu}$$
$$\rightarrow Th_{90}^{230} + \alpha_2^4 (\sim 4.7MeV, \mathbf{UII})$$

$$U_{92}^{235} \rightarrow Th_{90}^{231} + \alpha_2^4 \ (4.5MeV)$$

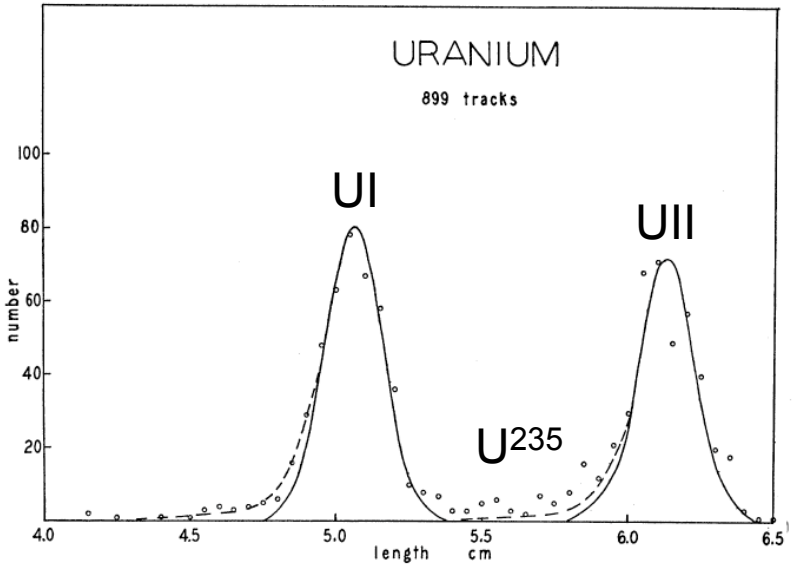
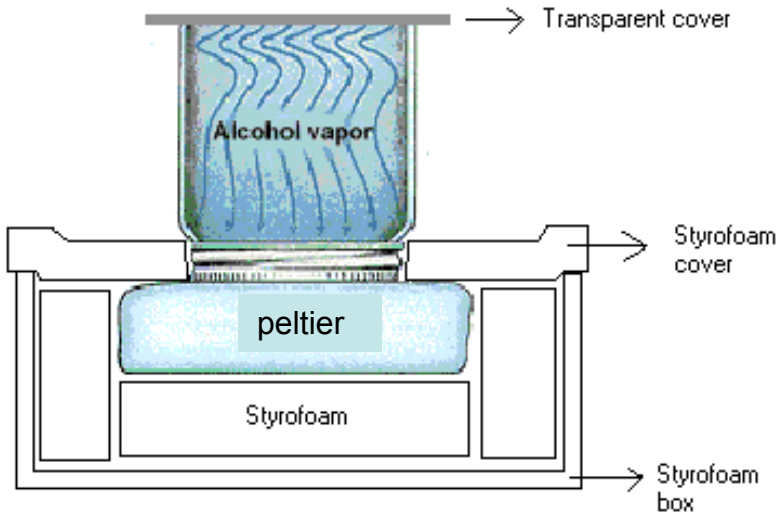
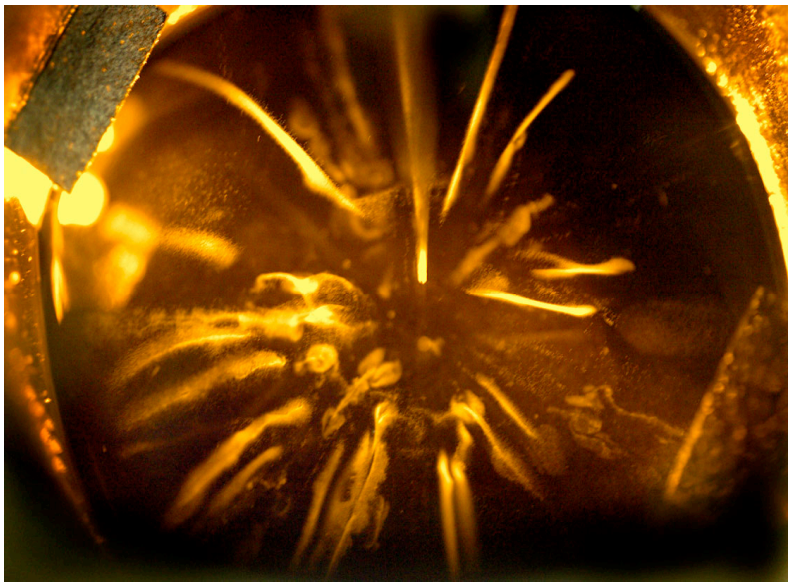


FIG. 2. Track length distribution for uranium alpha-particles.

THE DIFFUSION CLOUD CHAMBER

•The diffusion cloud chamber was developed in 1936 by Alexander Langsdorf.
• Alcohol wicks up to the top and then diffuses down to a cold base plate.
• A supersaturated layer forms near the bottom - sensitive to ionization.





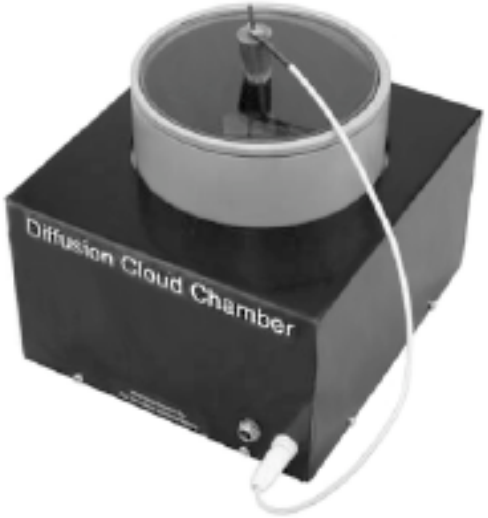
http://www.andrews.edu/services/physicsenterprises/products/diff_cloud_cham.html

THE CLOUD CHAMBER DEMO

http:-.andrews.edu/services/physicsenterprises/products/product_demos.html

Diffusion Cloud Chamber Manual

(Model 500 and 600)



Includes the following:

Cloud Chamber
12V DC Power Supply and Cable
Water Circulation Pump
2 Rubber Hoses
Extraction Pipette
Source Holder and Stopper
High Voltage Connecting Cable
Coupon for Pb 210 Source Needle
redeemable from Spectech™

- Cold water must flow when Peltier Device powered on.
- Alcohol should be removed from the chamber after use - opened and aired.