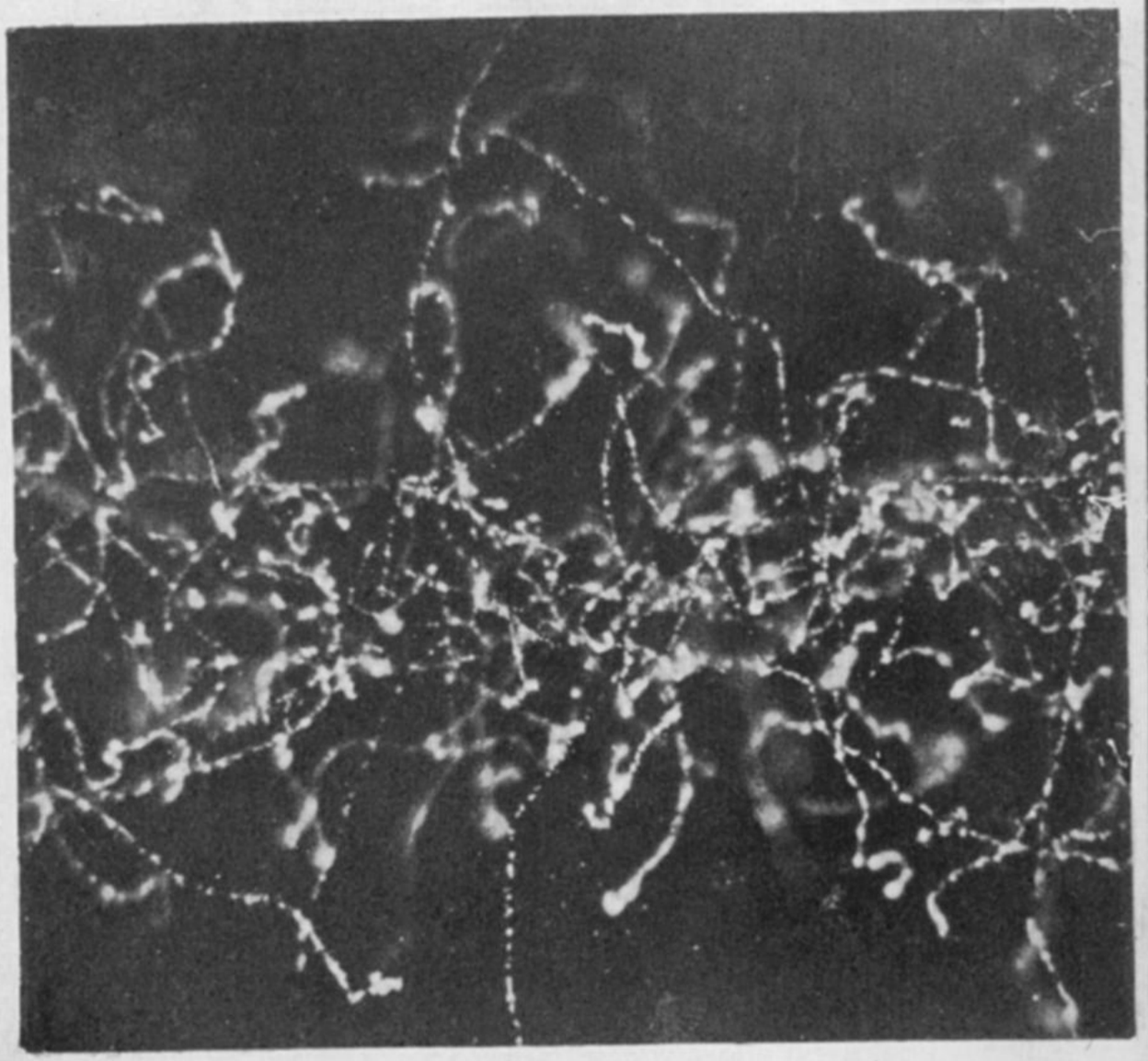
Experimental Particle Physics Detectors and Experiments



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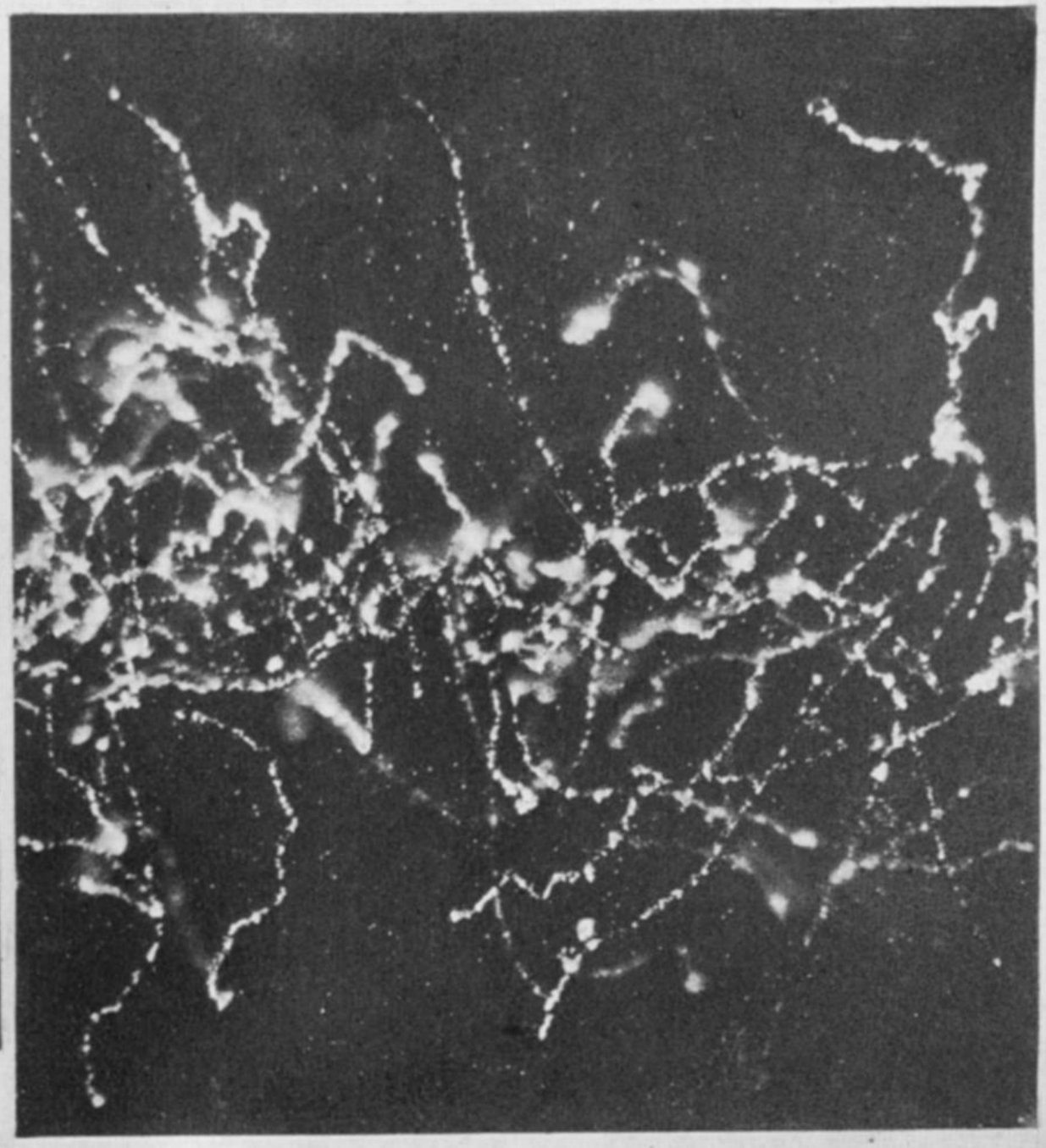


2

Ryan Nichol

Outline

- Last ~15 minutes of each weeks lecture devoted to discussing a particular experimental technique
- Topics covered may include
  - The cloud chamber
  - Emulsion detectors
  - Scintillator
  - Cherenkov detectors
  - Bubble chambers
  - Drift chambers
  - Time projection chambers
  - ...

Wilson's Cloud Chamber

- In 1912 C. T. R. Wilson published a paper describing his development of an "Expansion Apparatus"

On an Expansion Apparatus for making Visible the Tracks of Ionising Particles in Gases and some Results obtained by its Use.

By C. T. R. Wilson, M.A., F.R.S.

(Received June 7,—Read June 13, 1912.)

- For the first time this allowed scientists to actually 'see' fundamental particles

No one will deny the extraordinary interest and importance of this method which showed for the first time and in such minute detail the effects of the passage of ionizing radiations through a gas… I am personally of the opinion that the researches of Mr Wilson in this field represent one of the most striking and important of the advances in atomic physics made in the last twenty years… It may be argued that this new method of Mr Wilson's has in the main only confirmed the deductions of the properties of the radiations made by other more indirect methods. While this is of course in some respects true, I would emphasize the importance to science of the gain in confidence of the accuracy of these deductions that followed from the publication of his beautiful photographs.

Ernest Rutherford, 1927[1]

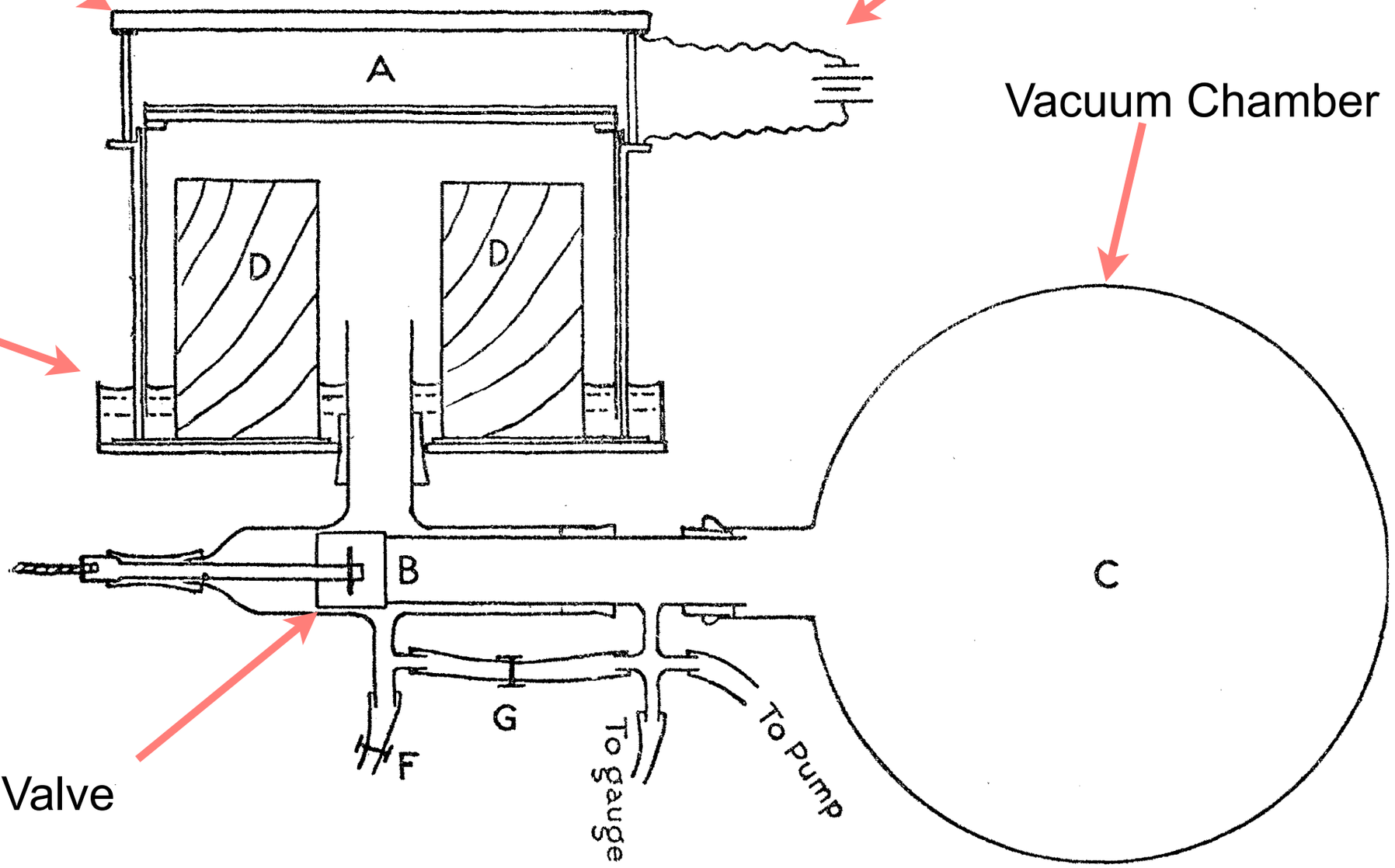
How does it work?

Cylindrical Cloud Chamber

Voltage Source

Vacuum Chamber

Water



Opening Valve

FIG. 1.

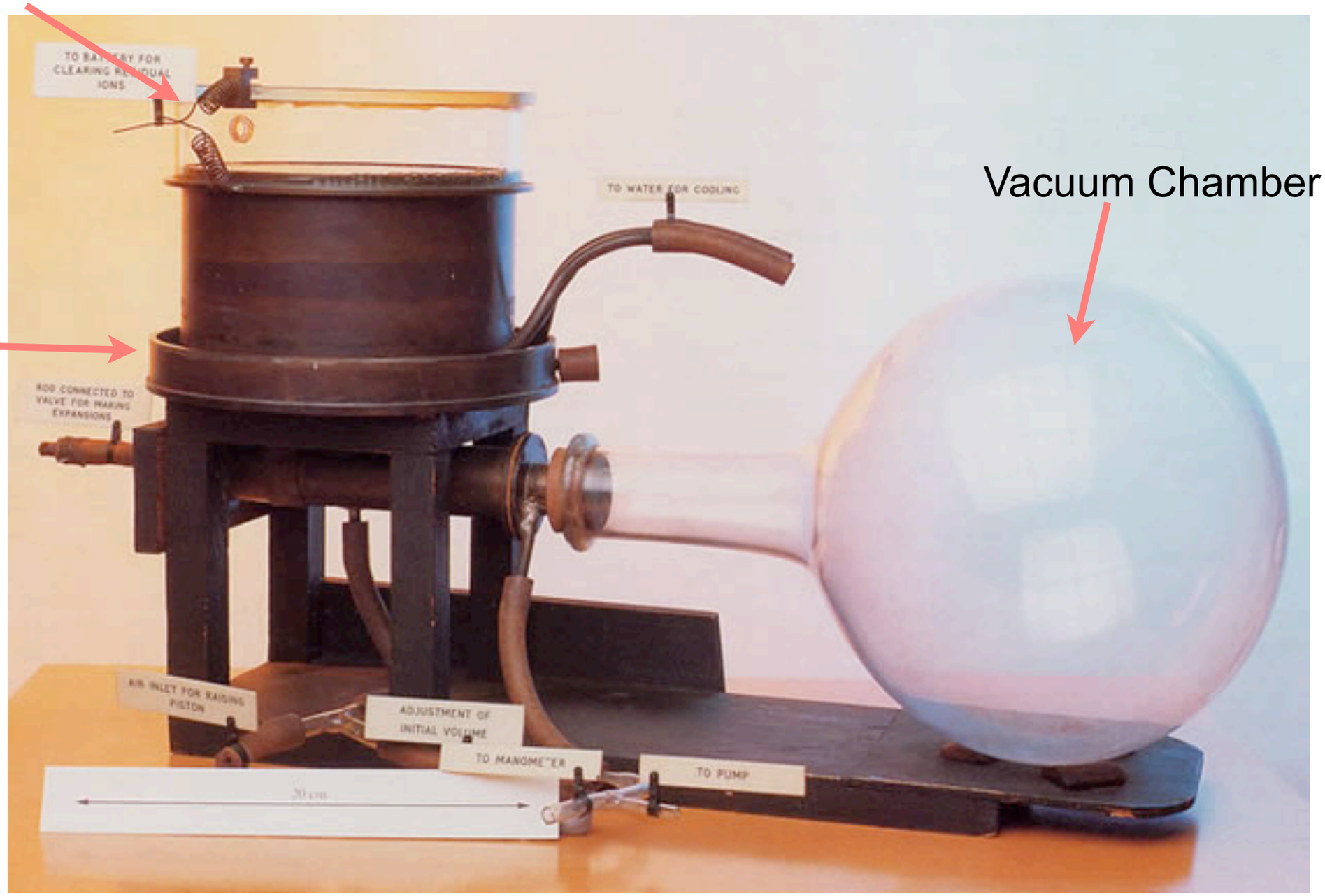
Roy. Soc. Proc., A, vol. 87,

How does it work?

Cylindrical Cloud Chamber

Water

Vacuum Chamber

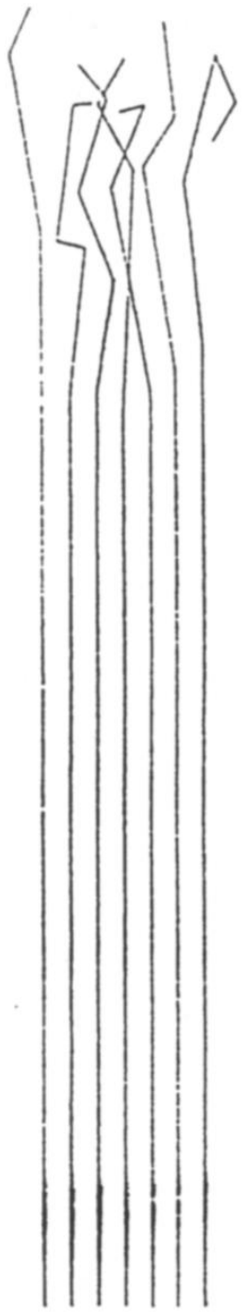


http://www-outreach.phy.cam.ac.uk/camphy/cloudchamber/cloudchamber10_2.htm

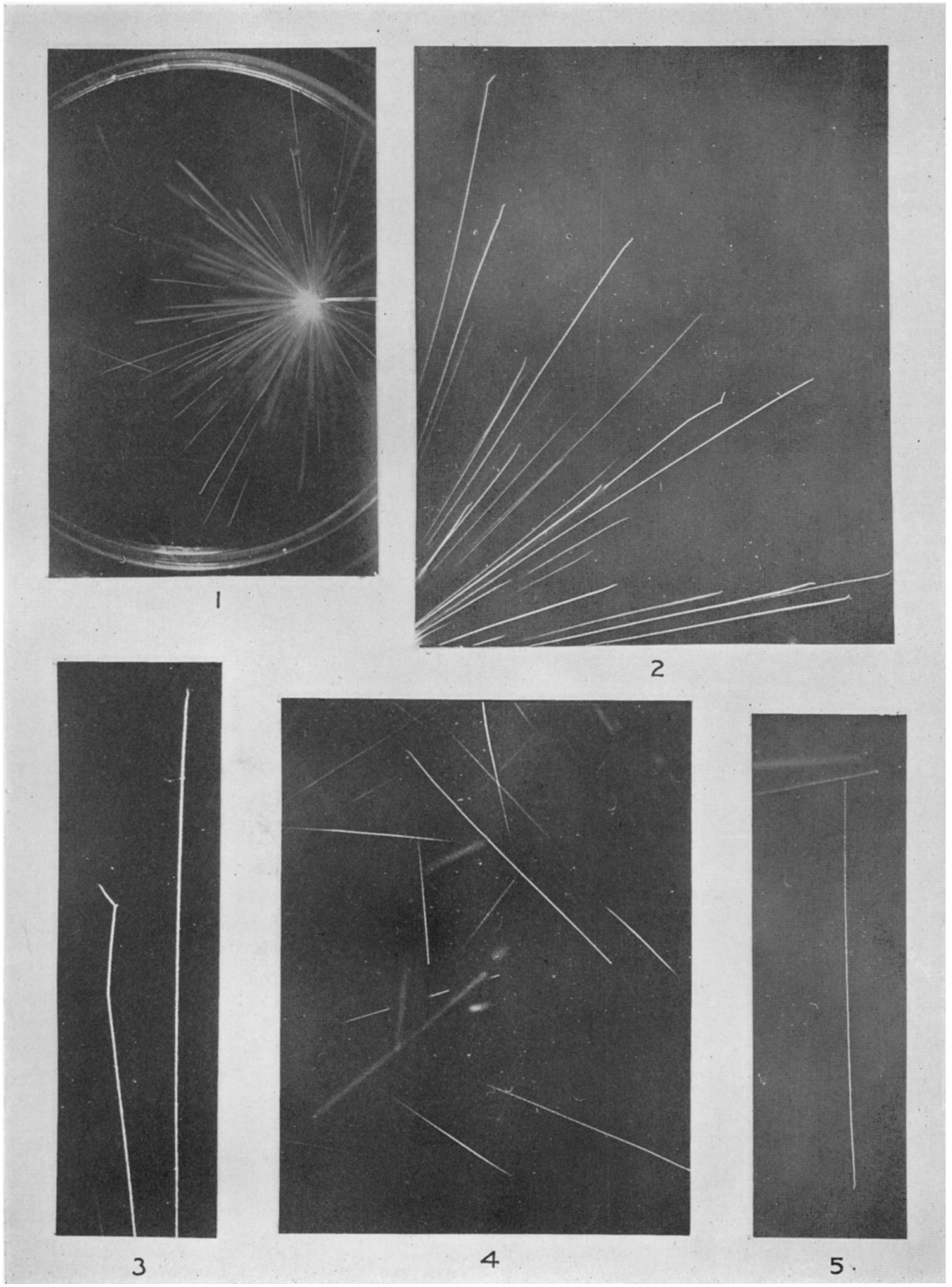
The build your own version

- These days it is easy to build your own cloud chamber using dry ice and alcohol

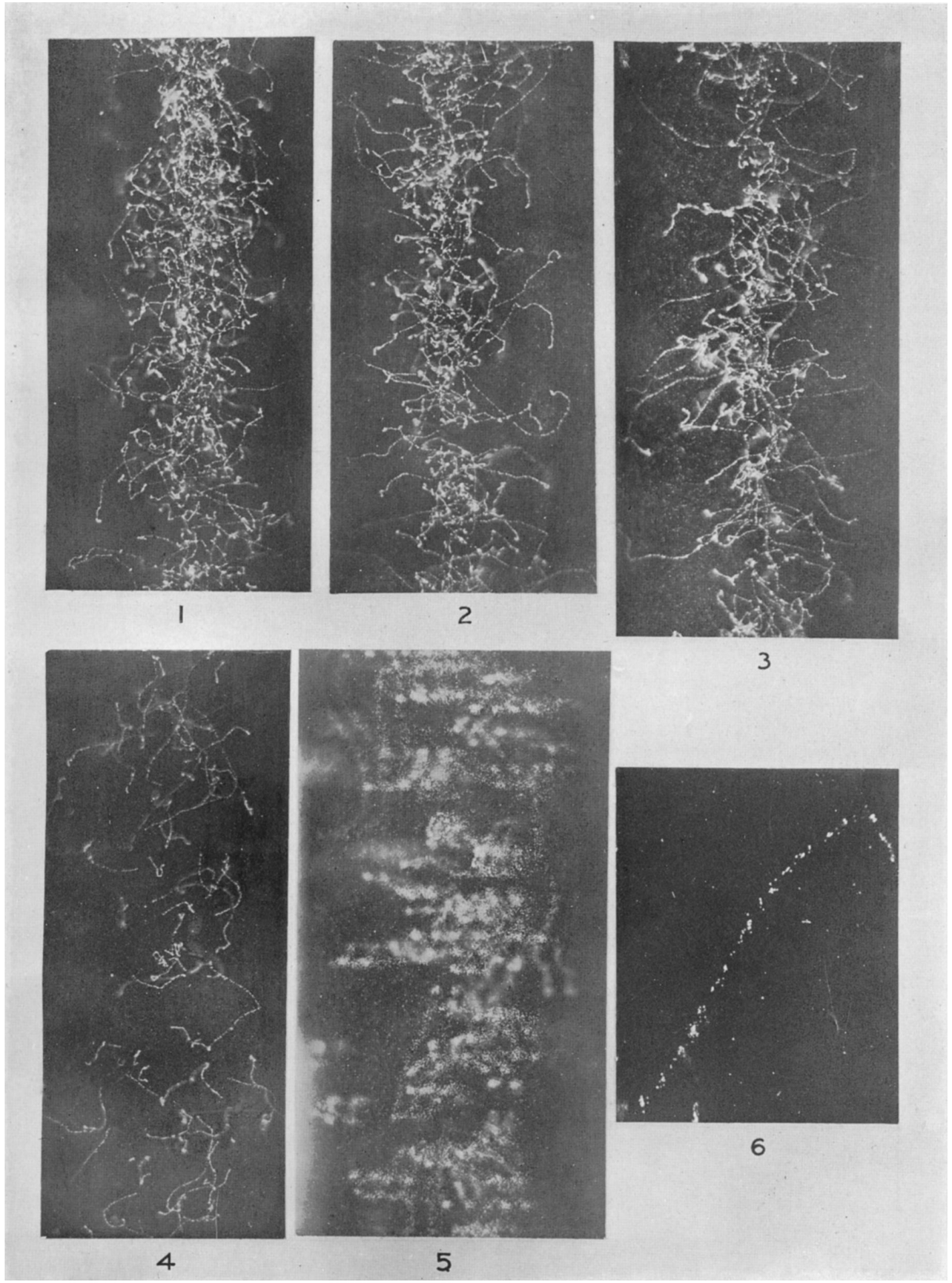
Alpha Particles



Bragg's 1911 prediction



X-Rays



The Positive Electron

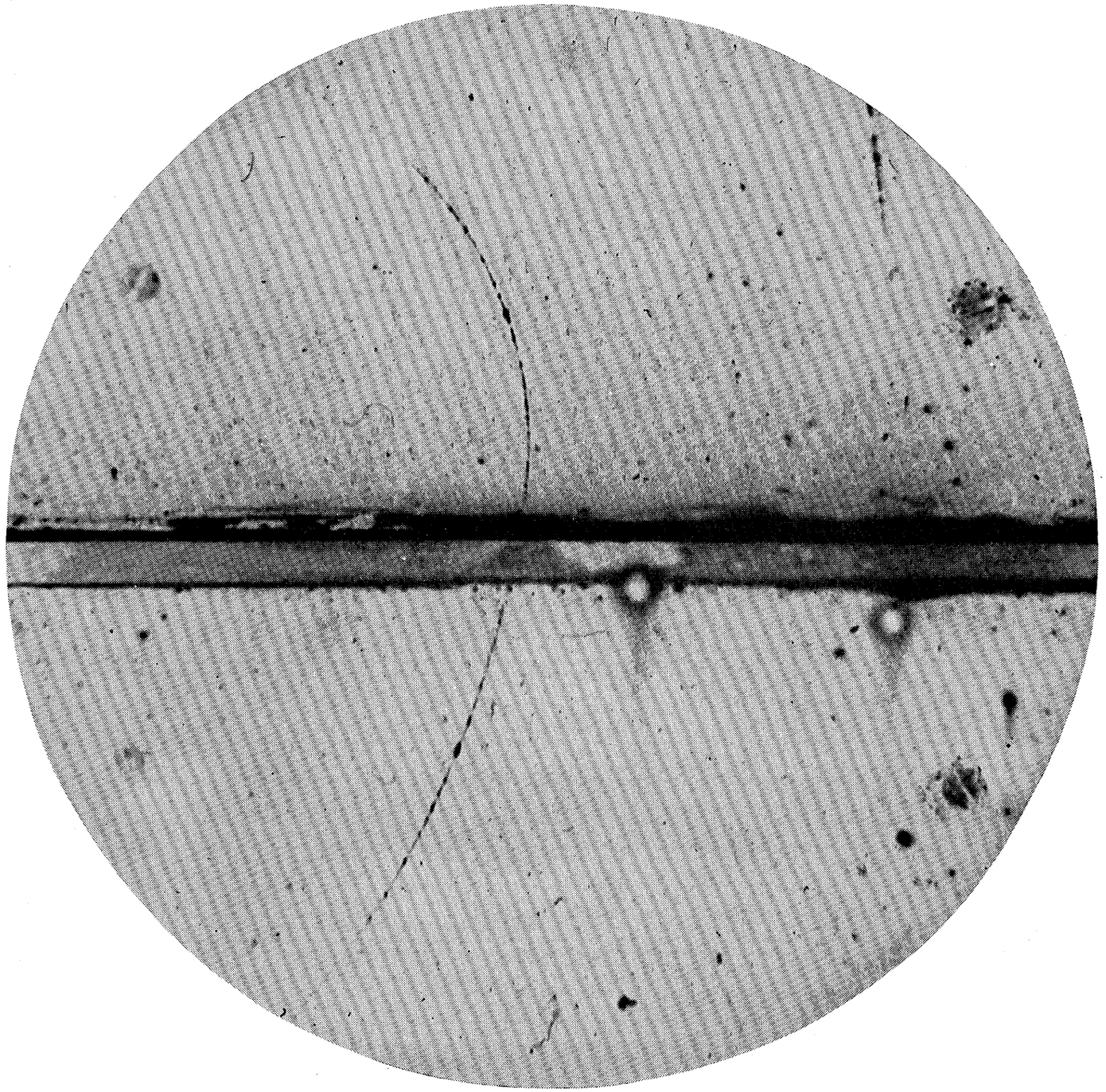
MARCH 15, 1933 PHYSICAL REVIEW VOLUME 43

The Positive Electron

CARL D. ANDERSON, *California Institute of Technology, Pasadena, California*
(Received February 28, 1933)

- In 1929 Dirac identified negative energy electron solutions to his equation as equally corresponding to positive energy positively charges particles
- In 1933 Anderson measured one of these particles using a cloud chamber
  - How de we know this isn't an electron?
  - How do we know this isn't a proton?

CARL D. ANDERSON



The Discovery of the Muon

NOVEMBER 1, 1937 PHYSICAL REVIEW VOLUME 52

New Evidence for the Existence of a Particle of Mass Intermediate Between the Proton and Electron

J. C. STREET
E. C. STEVENSON

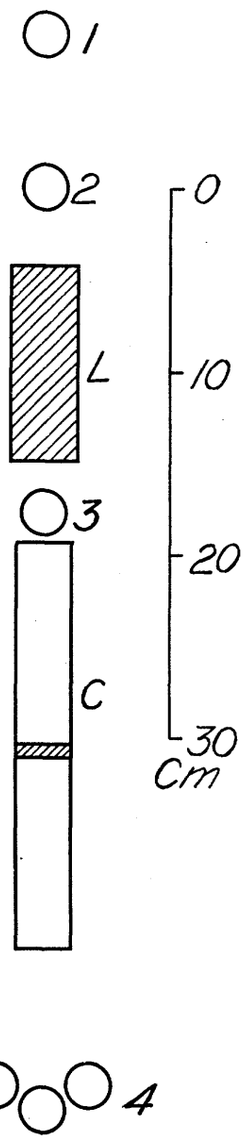


FIG. 1. Geometrical arrangement of apparatus.

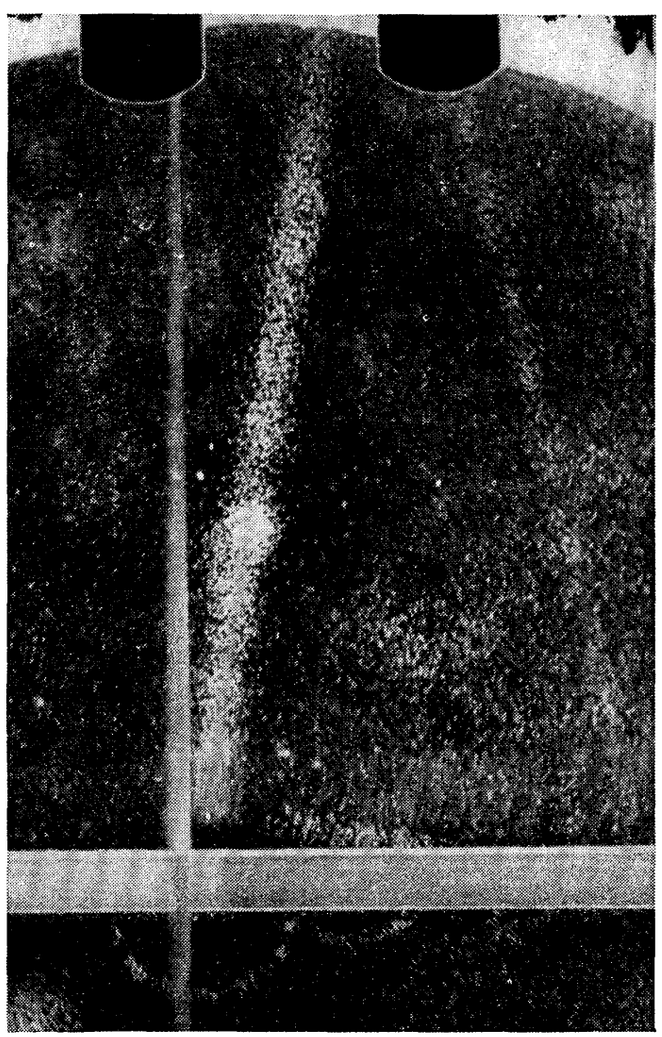


FIG. 2. Track *A*.

Proton

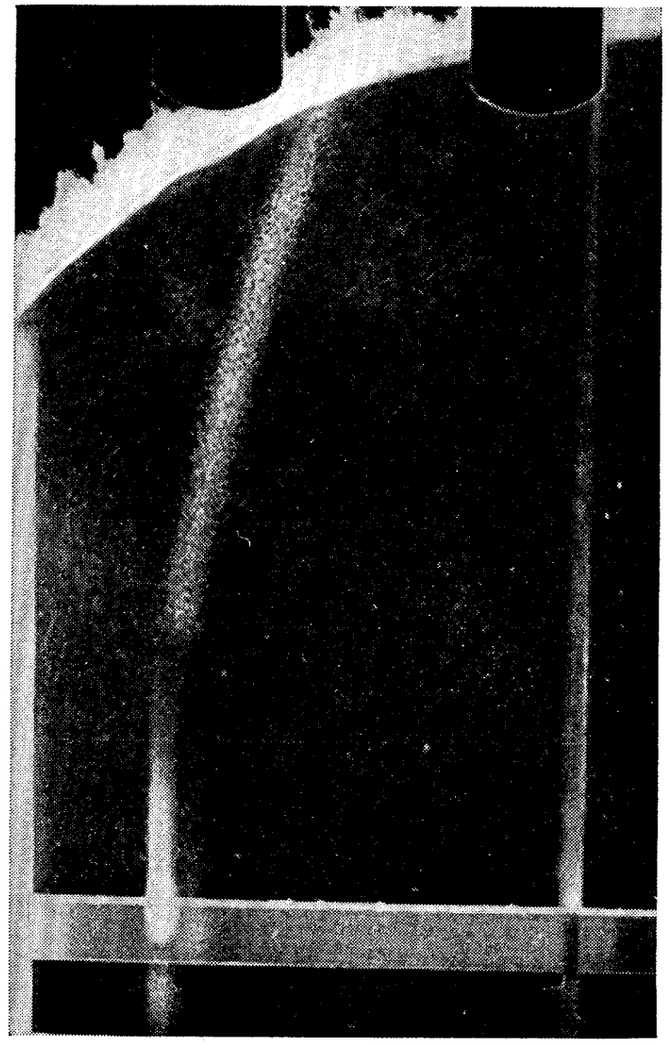


FIG. 3. Track *B*.

Muon

The Kaon?

- Use kinematics to determine the mass of the particle

MARS 1946.

EXISTENCE PROBABLE D'UNE PARTICULE DE MASSE $(990 \pm 12$ pour $100)\, m_0$ DANS LE RAYONNEMENT COSMIQUE

Par L. LEPRINCE-RINGUET et M. LHÉRITIER.

$$\sqrt{M^2c^4+P^2c^2} = \sqrt{m_1{}^2c^4+p_1{}^2c^2} + \sqrt{m_2{}^2c^4+p_2{}^2c^2} \quad (1)$$

$$P = p_1 \cos\theta + p_2 \cos\varphi \quad (2)$$

$$p_1 \sin\theta = p_2 \sin\varphi. \quad (3)$$

No. 4077 December 20, 1947 NATURE

EVIDENCE FOR THE EXISTENCE OF NEW UNSTABLE ELEMENTARY PARTICLES

By DR. G. D. ROCHESTER
AND
DR. C. C. BUTLER
Physical Laboratories, University, Manchester

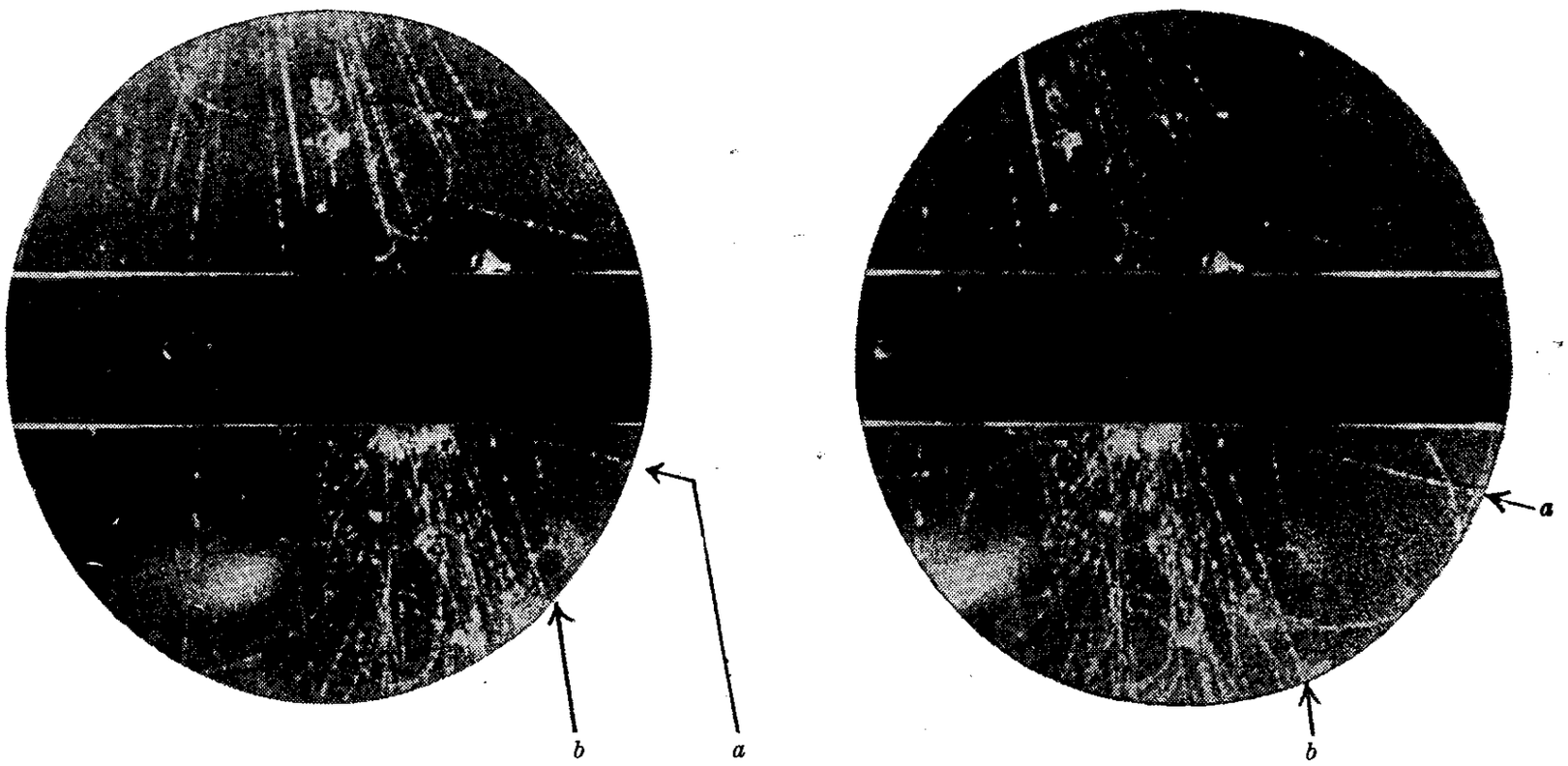
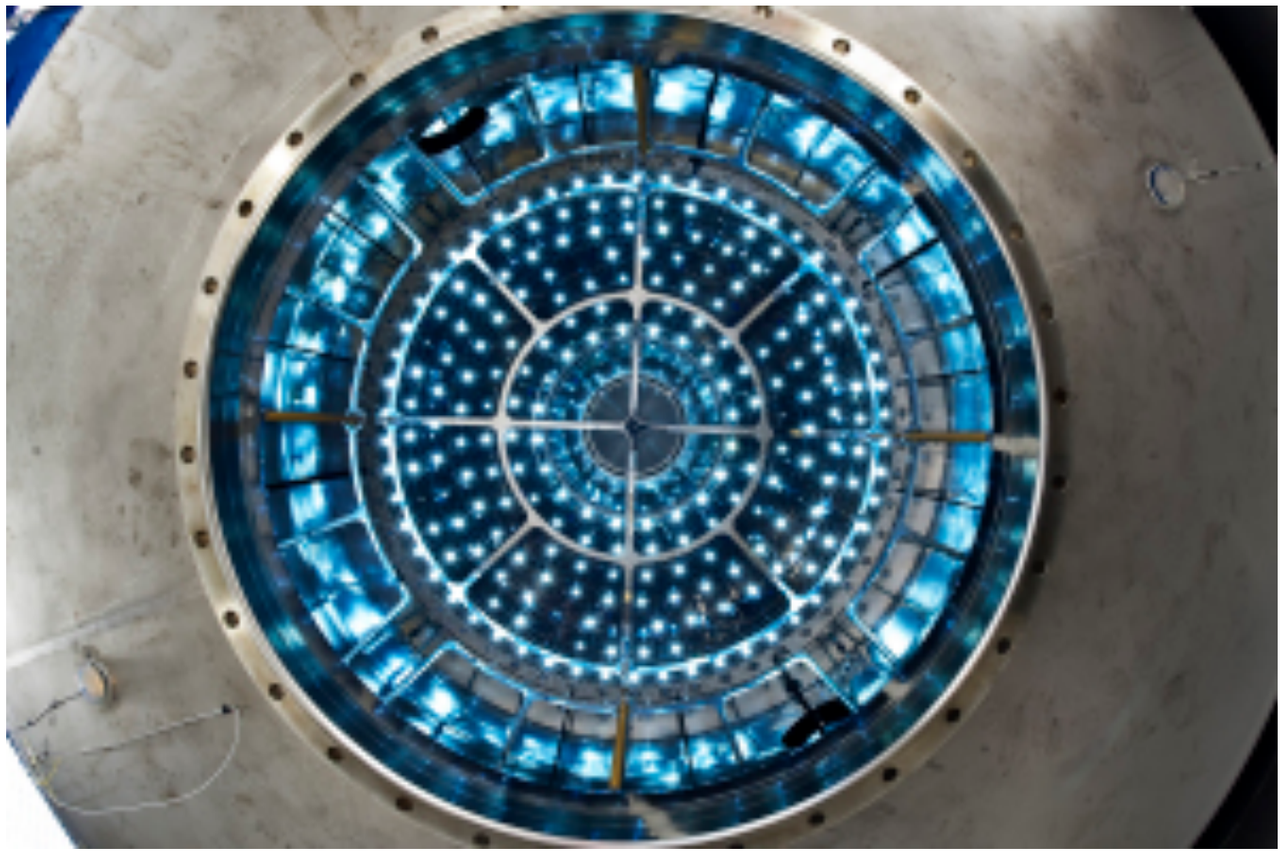


Fig. 1. STEREOSCOPIC PHOTOGRAPHS SHOWING AN UNUSUAL FORK (*a b*) IN THE GAS. THE DIRECTION OF THE MAGNETIC FIELD IS SUCH THAT A POSITIVE PARTICLE COMING DOWNWARDS IS DEVIATED IN AN ANTICLOCKWISE DIRECTION

CLOUD - Cosmics Leaving OUtdoor Droplets

UCL

- CLOUD is an active experiment at CERN which is investigating the link between galactic cosmic rays and cloud formation
- Utilises a gigantic cloud chamber in a beam of particles from the CERN PS (proton synchrotron)



References

- C. T. R. Wilson, “On an Expansion Apparatus for Making Visible the Tracks of Ionising Particles in Gases and Some Results Obtained by Its Use”, Proc. R. Soc. Lond. A, 87, 595, 277-292 (1912),
- P. A. M. Dirac, “A theory of electrons and protons”, Proc. R. Soc. Lond. A, 126, 360-365 (1930)
- Carl. D. Anderson, “The Positive Electron”, Phys. Rev. 43, 491–494 (1933)
- J. C. Street and E. C. Stevenson, “New Evidence for the Existence of a Particle of Mass Intermediate Between the Proton and Electron”, Phys. Rev. 52, 1003–1004 (1937)