

Lawrence Berkeley National Laboratory

Recent Work

Title

A 36-ATMOSPHERE DIFFUSION CLOUD CHAMBER

Permalink

<https://escholarship.org/uc/item/1hq9g8x5>

Authors

Elliott, John B.
Maenchen, George
Moulthrop, Peter H.
et al.

Publication Date

1955-02-18

UCRL 2865
UNCLASSIFIED

UNIVERSITY OF
CALIFORNIA

*Radiation
Laboratory*

TWO-WEEK LOAN COPY

*This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 5545*

BERKELEY, CALIFORNIA

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

UNIVERSITY OF CALIFORNIA

Radiation Laboratory
Berkeley, California

Contract No. W-7405-eng-48

A 36-ATMOSPHERE DIFFUSION CLOUD CHAMBER

John B. Elliott, George Maenchen, Peter H. Moulthrop,
Larry O. Oswald, Wilson M. Powell, and Robert W. Wright

February 18, 1955

A 36-ATMOSPHERE DIFFUSION CLOUD CHAMBER

John B. Elliott, George Maenchen, Peter H. Moulthrop,
Larry O. Oswald, Wilson M. Powell, and Robert W. Wright

Radiation Laboratory, Department of Physics,
University of California, Berkeley, California

February 18, 1955

ABSTRACT

A 36-atmosphere diffusion cloud chamber has been constructed for use with the 184-inch cyclotron and with the bevatron. Minimum-ionizing particles leave dense, sharp tracks of good contrast with hydrogen filling at design pressure. In the operation described, one event is obtained every 15 minutes for a reaction cross section of 30 mb for negative pions on hydrogen.

Among the unique features of the chamber are (a) the high pressure; (b) the high magnetic field; (c) the simple unit preassembly of the chamber and the upper pole piece; (d) the distortion-free photography afforded by the small camera windows of good optical quality directly in front of the camera lenses, and the absence of a large top glass near the sensitive region; (e) the thin window for collimated beams; (f) the supported cast Astrolite windows for illumination; and (g) the satisfactory sensitive layer obtained despite the large height-diameter ratio of the pressure vessel.

A 36-ATMOSPHERE DIFFUSION CLOUD CHAMBER *

John B. Elliott, George Maenchen, Peter H. Moulthrop,
Larry O. Oswald, Wilson M. Powell, and Robert W. Wright

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

February 18, 1955

INTRODUCTION

A theory of diffusion cloud chambers giving explicit predictions as to operation at elevated pressures has been given by Shutt.¹ High-pressure diffusion chambers built by Shutt and by others² have been operated in cyclotron and cosmotron beams, yielding valuable data on elementary particle interactions. This is a description of a chamber constructed at the University of California Radiation Laboratory. Although development work on the chamber is still in progress, it is believed that the chamber incorporates several unique features that will be retained in future modifications. Some results obtained with this chamber have already been reported.³

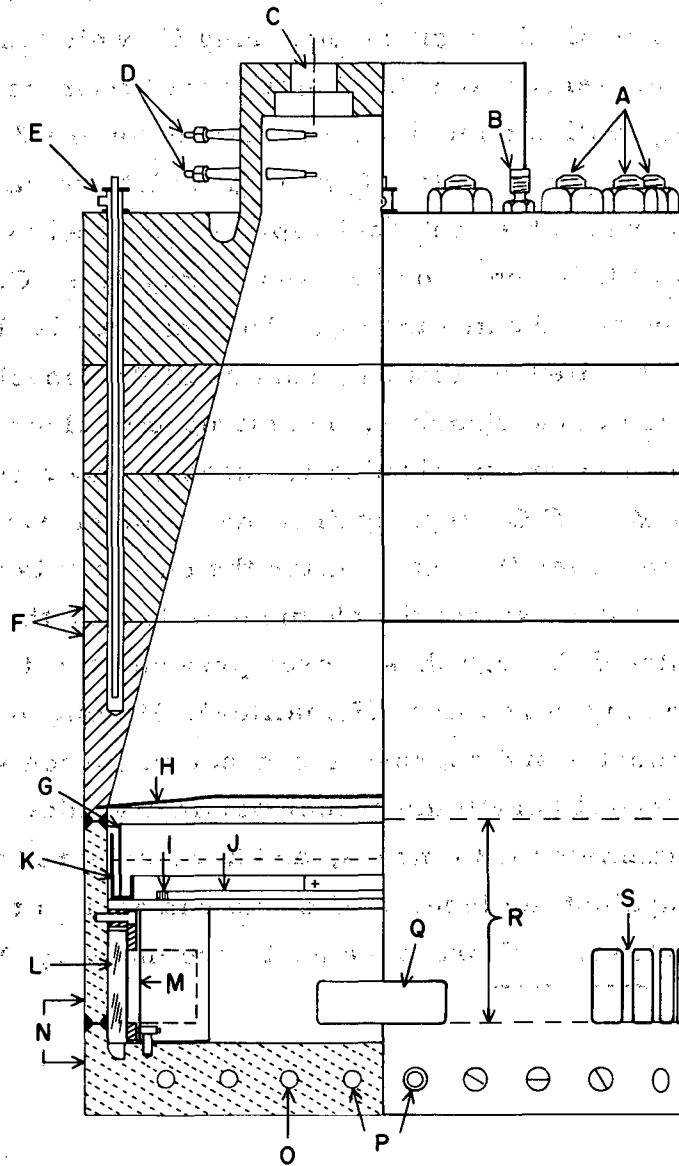
DESIGN AND CONSTRUCTION

Figure 1 is a cutaway view of the cloud chamber. The 19.23-inch outside diameter of the chamber was dictated by the 19.25-inch hole in the upper yoke of the existing UCRL cloud chamber magnet,⁴ through which the chamber is lowered into the magnet. The hot-rolled steel upper portion of the chamber duplicates the upper pole piece employed when other chambers are used in the same magnet. Recently installed electronic magnet-current control equipment, an enlarged heat exchanger, and improved connections between the leads and the coils now permit pulsing the magnet to 4,000 amps (21,000 gauss) on an 11-second cycle, with a duration of the full field of about 0.2 second. The base of the chamber is thermally insulated from the lower pole face of the magnet by 3/32 inch of Bakelite. The 2.25-inch-thick chamber bottom has 8 half-inch holes, O, P, drilled on through on chords, with interconnections for circulating acetone at dry ice temperature. Temperature control of the upper pole assembly is provided by circulating water, thermostatically controlled at $32.0 \pm 0.5^{\circ}\text{C}$, through four squirt tubes E. The heating, the higher thermal conductivity, and the greater mass of the hot-rolled

*Work performed under the auspices of the U. S. Atomic Energy Commission.

Fig. 1. Cutaway view of the cloud chamber.

- A Stressproof steel main bolts, 1 by 16 inches (16)
- B Pressure line to interior of chamber for gas or alcohol (3)
- C Viewing and camera ports (4)
- D Spark plugs for clearing field and thermocouples (8); no electric heating is used with this chamber at present.
- E Squirt tubes (4)
- F Upper pole assembly
- G Wick
- H Black bakelite ring
- I Bakelite clearing-field support
- J Clearing-field wires (5)
- K Copper alcohol tray
- L Cast Astrolite windows (2)
- M Homalite heat shield, 1/16 inch
- N Nonmagnetic stainless steel
- O Acetone channel
- P Acetone inlets (2)
- Q Beryllium-copper windows, 0.012 x 1.25 x 3 inches (details not shown)
- R Welds
- S Ribs, 3/4 x 1 inch, to support windows L (7 ribs on each side)



MU-8911

Fig. 1

steel portion of the chamber, as compared to the nonmagnetic stainless steel wall below the weld, allows the upper pole assembly to be held at a fairly uniform temperature, and thus control the gradient on the lower portion of the chamber.

Gas circulation from the upper volume of the pressure vessel is impeded by a 1/16-inch-thick black bakelite ring H, which also serves as a mask to prevent light scattered from the chamber wall from reaching the camera. In steady-state operation no moisture condenses on the 3/4-inch-thick borosilicate crown glass parallel flats C through which the camera views the chamber. The condensable methanol vapor is supplied by a well-washed sewed assembly of 1.5-inch-wide kerosene-lamp wicks G, which is 3 layers thick and is fed by an unheated tray K. The chamber is illuminated through 5/8-inch-thick Astrolite* windows L, cast at UCRL, machined to the exact inside radius of the cloud chamber, and clamped in place by stainless steel frames. The windows are mechanically supported by ribs S, and sealed by low-temperature Kell-F O-rings against the chamber wall; elevated pressure in the chamber improves the seal. After the chamber is in place, 5-sided lucite boxes are sealed against the chamber wall over the windows. Nitrogen gas slowly circulated through these boxes prevents frost from forming. A 4-3/16-inch-high ring of 1/16-inch Homalite**, M, improves the azimuthal temperature symmetry and suppresses convection currents in the gas near the walls. The 12-mil beryllium-copper particle window foil is bent into a half cylinder of diameter 1.25 inches, and hard-soldered to a brass frame which is sealed against the inner wall of the chamber in the same manner as the Astrolite windows. All pressure seals are made by O-rings.

* Astrolite, R-250 improved, is a transparent alcohol-resistant thermosetting plastic obtained from Industrial Plastics Service, 4435 Linden Street, Oakland, California.

** Homalite, C. R. 39, is a transparent alcohol-resistant thermosetting plastic obtained from The Homalite Corporation, 11-13 Brookside Drive, Wilmington, Delaware.

OPERATION

Reagent-grade methanol is added to the tray under gravity feed every four hours of operation, and the bottom level is adjusted through a drain. A 1/16-inch-deep layer of alcohol mixed with black dye on the bottom of the chamber provides an excellent photographic background. The usable sensitive volume, during normal operation with accelerators, extends to within 0.5 inch of the bottom, and is from 2 to 2.5 inches in height and 10 inches in diameter. It is estimated that the average temperature in the sensitive volume is -40°C . The clearing-field wires are maintained at 900 volts negative potential, and are grounded about 4 seconds (the approximate fall-out time for a track) before the beam pulse. A microammeter in series with the clearing field batteries has been found useful in monitoring chamber conditions, a reading of more than 10 μamp being often associated with poor operation. Several arrangements of alcohol trays and wicks were tried. The presence of an additional tray above the bakelite mask H seemed to increase the sensitive depth slightly but caused a rather large background of single drops and reduced the chamber's resistance to radiation. The present arrangement consists of an unheated single tray and wick at a temperature of about 0°C . The design pressure of the chamber is 525 psi gauge pressure, and in practice with hydrogen and helium filling, no marked deterioration in performance is found in raising the pressure from 300 psi to design pressure. A gauge pressure of 525 psi at -40°C is the same density as 42 atmospheres at 0°C . With argon filling, marked deterioration is observed at pressures in excess of 60 psi. In a pion-production experiment carried out at the 184-inch cyclotron, a collimated neutron beam entered and left the chamber through the 12-mil beryllium-copper windows. In current use with the bevatron, a magnetically analysed beam of negative pions at 4.5 ± 0.5 Bev enters the hydrogen-filled chamber through the 3/4-inch-thick stainless steel wall. The beam is one inch high and centered about 1.75 inches above the chamber bottom. About 15 mesons per pulse on an 11-second cycle are the optimum conditions. The data rate quoted in the abstract was obtained by the usual formula with an efficiency factor of 1/2 (less than might be expected, owing mostly to fluctuations in bevatron beam intensity), and is approximately that realized in practice. The delay used before flashing the lights for photography ranges from 0.10 to 0.15 second.

SUMMARY

Experience with the UCRL 36-atmosphere diffusion cloud chamber indicates that the practical upper limit of pressure for a hydrogen-filled diffusion chamber is in excess of 525 psig. A further conclusion is that the all-metal, massive construction required by high pressures, in which the upper pole piece is incorporated into the pressure vessel, and the requirement of a large temperature difference across the sensitive layer may be simultaneously satisfied. A word of caution should be interjected: the problem of chamber illumination is not completely solved; the Astrolite windows deteriorate mechanically with time, and in the present arrangement are used for only four months before being discarded.

ACKNOWLEDGMENTS

Mr. Milton M. Hill, and Drs. Franklin B. Ford, Peter E. Tannenwald, and Harmon W. Hubbard assisted in the design and development of this chamber. Mr. Arnold J. Bermingham did much of the mechanical engineering. Dr. Ralph P. Shutt of Brookhaven National Laboratory has been most generous in making his experience available to us.

REFERENCES

1. Shutt, Revs. Sci. Instr. 22, 730 (1951).
2. Miller, Fowler, and Shutt, Revs. Sci. Instr. 22, 280 (1951); Fowler, Johnson, Shutt, Thorndike, and Whittemore, Revs. Sci. Instr. 25, 996 (1954); Crewe and Evans, *Atomics* 3, 221 (1952); Snowden and Bevans, J. Sci. Instr. 30, 3 (1953); Schluter, Phys. Rev. 96, 734 (1954); Cornelius, Sargent, Rinehart, Lederman, and Rogers, Phys. Rev. 92, 1583 (1953); M. Snowden, Progress in Nuclear Physics III, O. Frisch, ed., Pergamon, London, 1953, p. 1-17.
3. Peter H. Moulthrop, Pion Production by Neutrons on Helium, University of California Radiation Laboratory Report No. UCRL-2858, January 31, 1955; Powell, Maenchen, and Wright, postdeadline paper, Berkeley APS Meeting, December 1954; Wilson M. Powell, Rochester Conference on High-Energy Physics, January 1955.
4. W. M. Powell, Revs. Sci. Instr. 20, 403 (1949).

and 2000-2001

The first part of the report is devoted to a general overview of the situation in the country. It is followed by a detailed analysis of the economic and social conditions. The report also includes a number of tables and charts which illustrate the data. The conclusions of the report are based on the analysis of the data and are presented in the final chapter.