Rectangular Wilson Chamber with Bilateral Expansion

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Description of a rectangular Wilson Chamber with bilateral expansion, suitable for use with a mass spectrometer.

RECTANGULAR Wilson chambers are now being used more and more to study the composition of cosmic rays. We constructed and prepared a rectangular Wilson chamber with bilateral expansion, intended to investigate the stopping of cosmic radiation particles that pass through the magnetic field of the large mass spectrometer of the Cosmic Ray Laboratory on the Alagez mountain [1].

Rectangular chambers are more suitable for use with a magnetic spectrometer than cylindrical chambers of equal volume, for they permit increasing the light output of the installation. Increasing the light output of the instrument is particularly essential when recording rare phenomena associated, for example, with high-energy nuclear interactions.

To brake and stop the particles, plates made of different substances were fastened horizontally inside the chamber. Since a "shining-through" illumination system was chosen, the only possible expansion was along the longest side of the chamber, i.e., sideways. Locating the expansion apparatus on the side is also advantageous because the cross section of the segment between plates is constant along the expansion direction, even when the plates are tilted relative to the center line of the objectives. A constant cross section prevents gas eddies from forming during expansion.

To prevent eddies from forming inside the chamber when the diaphragm travel is large, we used simultaneous expansion from two opposite sides. Bilateral expansion cuts diaphragm travel in two. In addition, sideways placement of the valves makes them easy to regulate and shields them from the effect of the external magnetic field.

A section through the chamber is shown schematically in Fig. 1. The volume of the chamber is approximately 10,000 cc. The dimensions of the forward window are 230× 380 mm, and the depth is 120 mm. The case is a duraluminum parallelopiped with two transverse apertures for fastening the glasses and the expansion apparatus; the parallelopiped is made of a solid piece to insure more dependable hermeticity. The case is coated on the inside with a thin layer of bakelite to prevent corrosion. The glasses, which are 35 mm thick, are clamped against the case with frames. The joint is made hermetic with rubber gaskets of 4×6 mm cross section placed between the glass and the metal.

Two grids, one movable *8* and one stationary *10*, limit the displacement of the diaphragm *9*, made of rubber sheet 2 mm thick and clamped between the case of the chamber and the case of the expansion apparatus. The moving-grid position, which determines the degree of expansion, is regulated by rotating the supporting bushings *17*; the grids are made to occupy symmetrical positions with the aid of a rigid coupling through shaft *20* and gear trains *2*. The thickness of the diaphragm is so chosen that its inertia does not affect the expansion time noticeably. The openings in the grids are of such diameter, that the degree of expansion is not affected noticeably when the rubber is deflected into the opening by fluctuations in the relative pressure in the expansion apparatus. Expansion was effected by two electromagnetic valves releasing compressed air from the expansion reservoirs. A mixture of 65% ethyl alcohol and 35% water (by volume) was fed to the chamber. The non-condensing gas used was argon, pumped into the chamber to a relative pressure of two atmospheres.

Because of the limited space available under the electromagnet poles, the inside of the chamber had to be photographed from a close distance. Consequently, it was necessary to employ only small apertures to insure depth of focus over the entire volume. The usual techniques for photography at right angles to the direction of illumination at small apertures call for illumination sources of increased power. In the chamber described here, illumination was by "shining through", so that the optical axis of the objective made an angle of approximately 50° with the

[1] A. A. Alikhanian, V. G. Kirillov-Ugriumov, N. V. Shostakovich, and V. M. Fedorov, Dokl. Akad. Nauk SSSR **92**, 255 (1953)

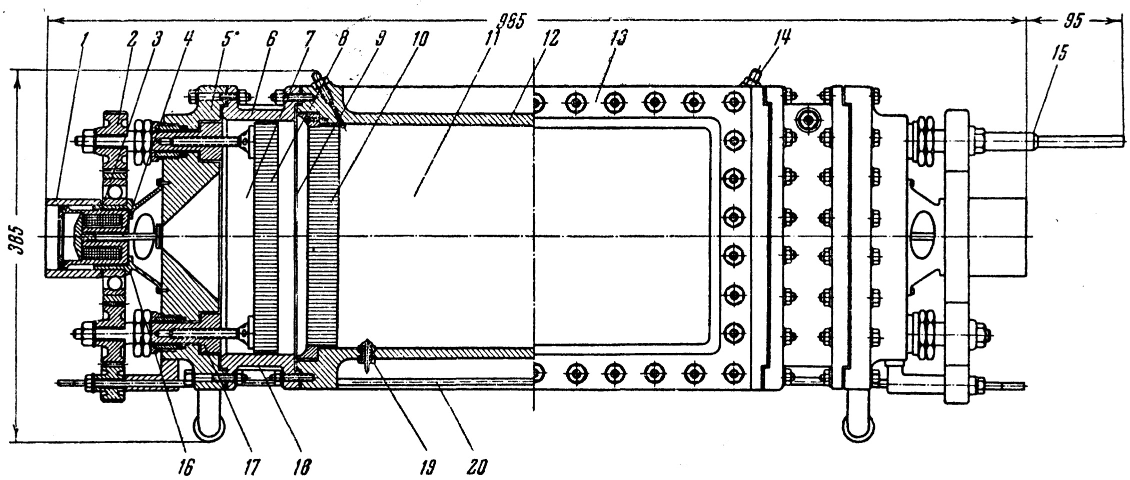

FIG. 1. Diagram of Chamber. *1*– magnetic shield, *2*– gears, *3*– brass cylinder, *4*– valve, *5*–cover of expansion head, *6*— case of expansion head, *7*– expansion apparatus, *8*– movable grid, *9*–rubber diaphragm, *10*–stationary grid, *11*–glass, *12*–case of chamber, *13*–flange, *14*–fitting for filling the working volume, *15*–vernier, *16*—bushing for fastening valve, *17*–mechanism for displacing movable grid, *18*–water jacket, *19*–input point for "clearing" field, *20*–rod connecting the gear trains.

incident light. According to Webb[2], the intensity of the light scattered from the droplet increases considerably as the angle decreases, and is 3-4 times greater at the angle chosen here than at a 90° scattering angle. The photographs were taken at a distance of 650 mm with a stereo camera having a 135 mm base and "Jupiter 12" objectives with $f = 35$ mm. The diaphragm f stop was 11, and the angle between the objective axes was 6.5°. The chamber was illuminated with two IP K-400 flash bulbs. Each bulb was fed by a 48 microfarad capacitor charged to 3.5 kilovolts. The lens system suggested in reference 3 was used to focus the light. The focused beam was so directed to the chamber, that no direct light was incident on the photographic camera lenses (Fig. 2).

Great attention has been paid to temperature stabilization. Water from a TS-15 thermostatic bath is circulated through metallic jackets soldered onto each expansion apparatus. In addition, air of the same temperature is blown through the light-tight boxes. The diagram of the thermostatic regulation (with accuracy to 1°) is shown in Fig. 3. A ratio meter is used for monitoring. The use of several transmitters permits easy monitoring of the temperature in various parts of the chamber.

The chamber is controlled with an electronic circuit devised by Allen[4]. Time delays are effected by differentiating square pulses, formed by blocked multivibrators with cathode coupling. The control circuit also contains a circuit used to control slow expansions. A slow-expansion valve is placed in the main line of the compressed air supply to the chamber. Sixty-five seconds after the main expansion, the valve disconnects the compressed-air supply and connects the expansion volume to the atmosphere. The compressed air escapes through a small-diameter aperture for five seconds, permitting the diaphragm to move away toward the rear, stationary grid. The slow expansion causes the droplets that have not been evaporated by the working expansion to increase in size and to settle on the bottom. This process reduces considerably the lateral fog background during the next working expansion.

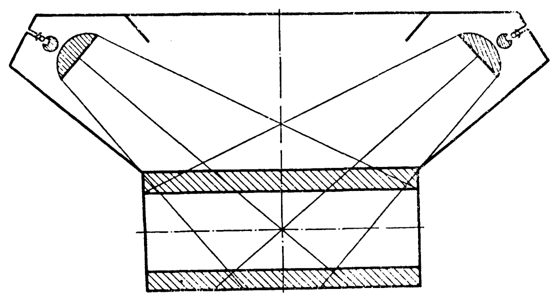

FIG. 2. Illumination box.

[2] C. Webb, Phil. Mag. **19**, 927 (1935)

[3] E. Lofgren, E. Ney and F. Oppenheimer, Rev. Sci. Inst. **19**, 271 (1948)

[4] F. Allen, Rev. Sci. Inst. **19**, 918 (1948)

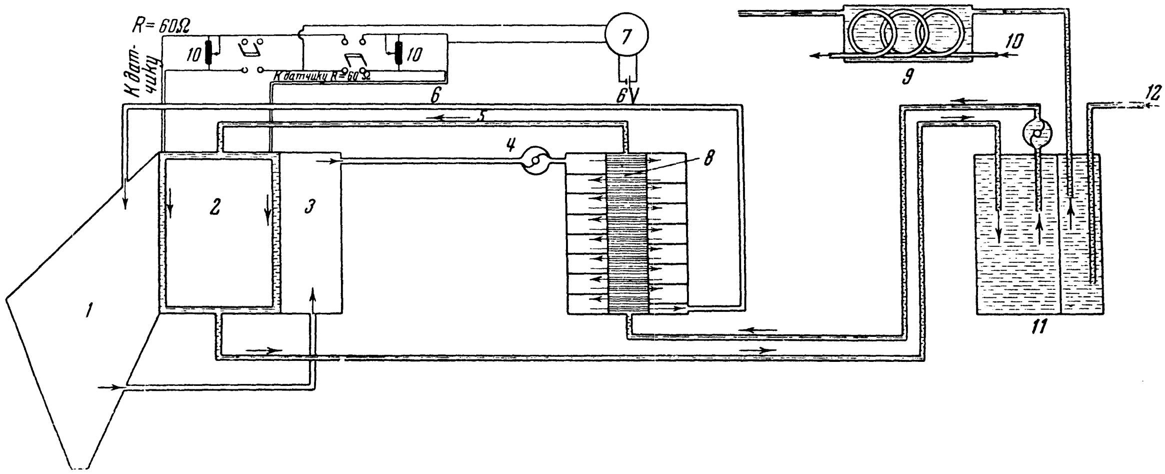

FIG. 3. Diagram of thermostatic regulation. *1* — photographic camera body, *2* - head of chamber, 3 - illumination box, *4* - air blower, *5* - thermostatically-controlled water, *6* - thermostatically-controlled air, *7* - ratio meter, *8* - radiator, *9* - refrigerator, *10* - compressed air for the expansion apparatus, *11* - thermostatic bath, *12* - tap water. The resistances are given in kilohms.

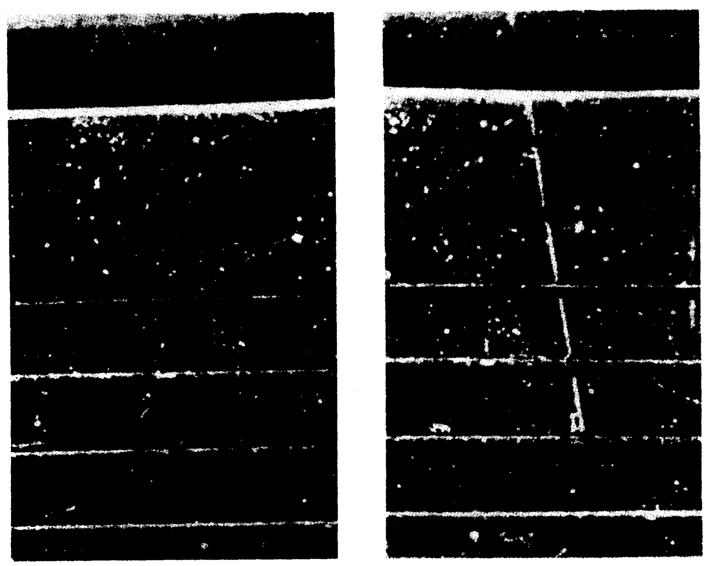

FIG. 4. Photograph of tracks of cosmic particles, recorded in a chamber with bilateral expansion.

Study of the photographs has shown that tracks of the penetrating particles are obtained over the entire volume of the chamber without noticeable distortion. As can be seen from Fig. 3, the illumination is worse in the region adjacent to the grids than in the center of the chamber on the photographs, and the density of tracks of penetrating particles is therefore different in various parts of the chamber. This is easily taken into account when the data are processed. Photographs obtained with the valves operating with a time difference up to 4-6 milliseconds do not differ from photographs obtained with a smaller time difference; this agrees with the results of measurements on the degree of supersaturation as a function of expansion time, reported by Hazen[5].

To increase the intensity of the observed cases of particle stoppage, it is desirable that as many

[5] W. Hazen, Rev. Sci. Inst. **13**, 247 (1942)

plates as possible be placed in the chamber. However, a large number of plates reduces the brightness of the tracks. The best performance was obtained with this chamber when nine plates were used. The sensitive time of the chamber, determined from the number of cosmic particles, recorded at no-field expansion and constant illumination, is 0.2 second. To eliminate the ions produced by extraneous particles passing through the chamber up to the time of the working expansion, an electrostatic field of 30 volts/cm intensity is applied between the plates. The control circuit is capable of removing this field within 10^{-5} second.

The clearest photographs in which both thin and thick tracks are produced without noticeable fog are obtained with type 10-100 or higher-sensitivity "Panchrom" film developed in amidol.

By way of an example, Fig. 4 shows the photographs of the trajectories of a relativistic particle and a proton that is stopped by ionization in the sixth plate.

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102