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THE GENEVA CLOUD CHAMBER

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THE GENEVA CLOUD CHAMBER

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### ABSTRACT

A diffusion-type cloud chamber 4-ft. square was designed and built for exhibition at the Atoms for Peace Conference in Geneva, Switzerland.

The necessary thermal gradient in the chamber was established and held by a refrigerator unit.

One external electrical connection and a minimum of maintenance were the chief advantages of this chamber.

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### INTRODUCTION

On April 13, 1955 the Atomic Energy Commission authorized the design and construction of a 4-by-4-ft diffusion-type cloud chamber to be exhibited at the Atoms for Peace Conference at Geneva, Switzerland in August, 1955. The chamber was to be in New York on June 20 for transshipment.

Because the staff of U.S. technicians attending the conference was small, the chamber had to be designed for a minimum of maintenance, as well as for operation by those not familiar with cloud chambers.

The chamber was self-contained, requiring only a 220-v single-phase electrical connection.

## II. CHAMBER CONSTRUCTION

### The Chamber Base

The base for the chamber was constructed of wood. (Figs. 1 and 2) A dural frame carrying the casters, the refrigerator unit, the alcohol pump and alcohol reservoir, and the water pump and water reservoir was bolted to the lower portion of the wooden base. The top of the base was covered with styrofoam to insulate the cold plate.

### The Chamber

The walls of the chamber were made from oak planks, 2 by 1<sup>2</sup> by 7 in., glued and screwed together, then painted with black Tygon. The upper and lower surfaces were provided with two gasket grooves, each for 1/4-in. square rubber gaskets.

The walls were bolted to a 4-ft-square freezer plate purchased from Dean Products Inc.<sup>2</sup> The freezer plate was too thin and wavy to make a good seal, therefore the bolts were threaded into pieces of dural bar stock 1/4 by 2 by 48 in. With the plate thus reinforced, we had no difficulty in making an alcohol-tight seal.

The freezer plate was blackened by an electrochemical anodizing process. The 47-by 47-by 1/8-in. stainless steel anode was suspended from the chamber walls 1/2 in. from the freezer plate. The anode and plate were then covered with an electrolyte composed of an aqueous solution of the following ingredients:

Nickel sulphate ( $\text{NiSO}_4$ ) - 144 gm/l  
 Ammonium Molybdate ( $\text{NH}_4$ )<sub>2</sub> MoO<sub>4</sub> - 30 gm/l  
 Boric Acid ( $\text{H}_3\text{BO}_3$ ) - 22.5 gm/l

An inter-electrode current density of 1 amp/ft<sup>2</sup> was maintained for 6 hr at 86° F or 30° C. The solution was agitated manually.

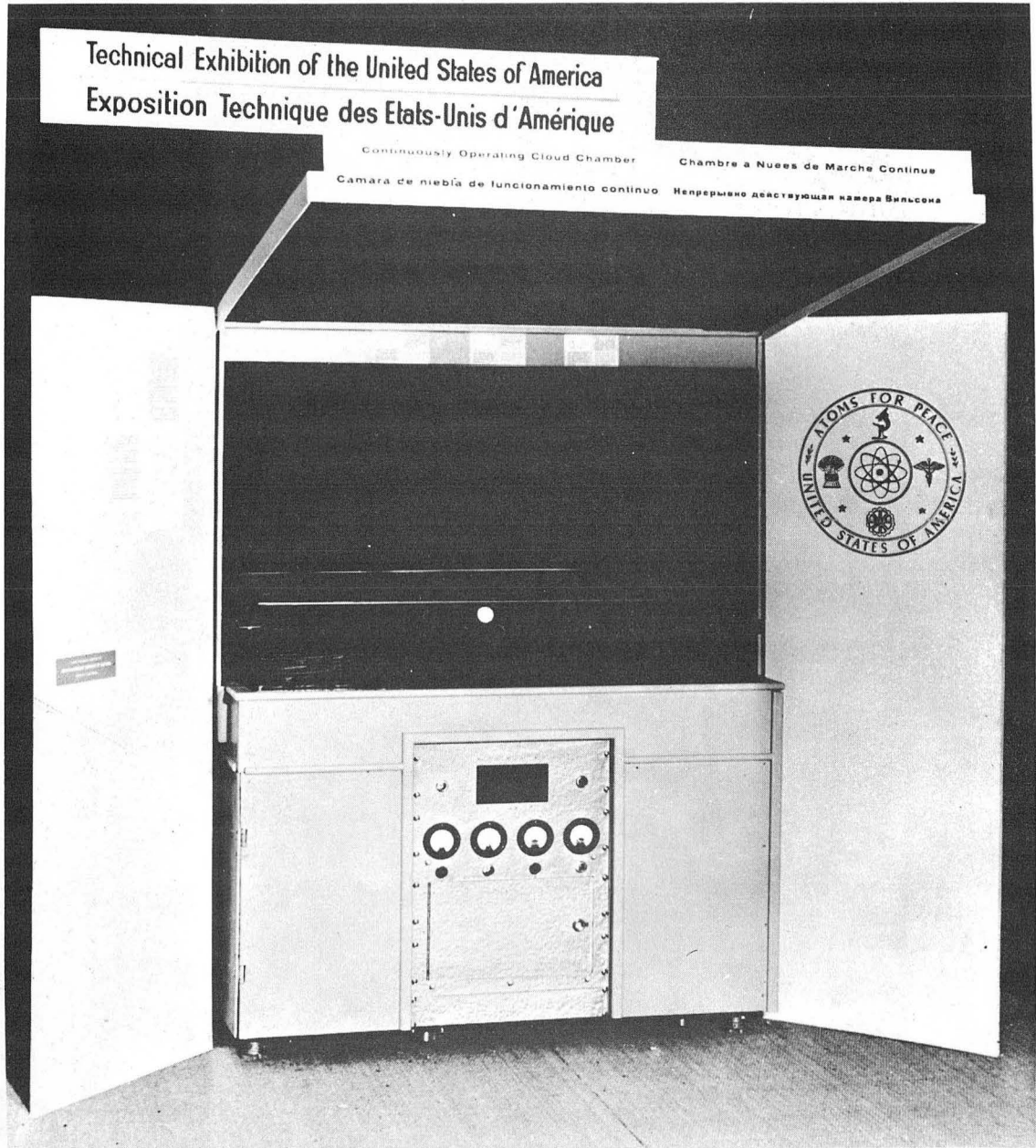
Two-in. dural angle stock was screwed to the top of the chamber walls to provide a clamping frame for the top glass (Fig. 3). A small vent hole was drilled in the upper portion of the chamber wall behind the proposed position of the view-light mirror.

A second piece of glass was placed on a 2-in. -high wooden frame that rested on the top glass. The frame had sponge rubber strips on the top and bottom and carried a grid of nichrome wires, spaced 6 in. apart,

<sup>1</sup> Tygon Paint manufactured by U.S. Stone Ware, Plastics and Synthetics Division, Akron 9, Ohio.

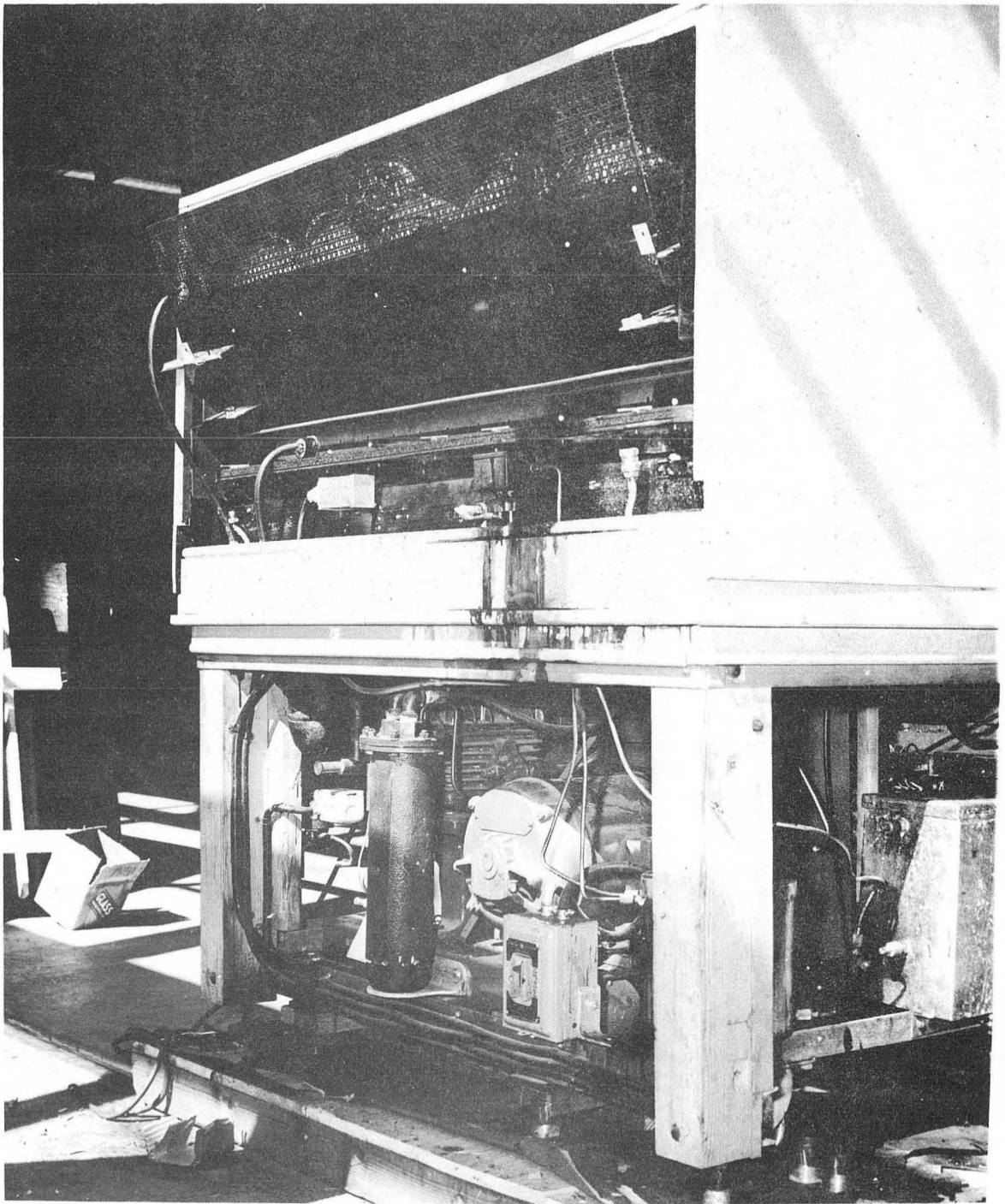
<sup>2</sup> Thermo-Panel Division, Dean Products Inc., 616 Franklin Ave., Brooklyn 38, N. Y.





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Fig. 1. The Geneva cloud chamber.



ZN-1653

Fig. 2. Open oblique view of the Geneva cloud chamber.

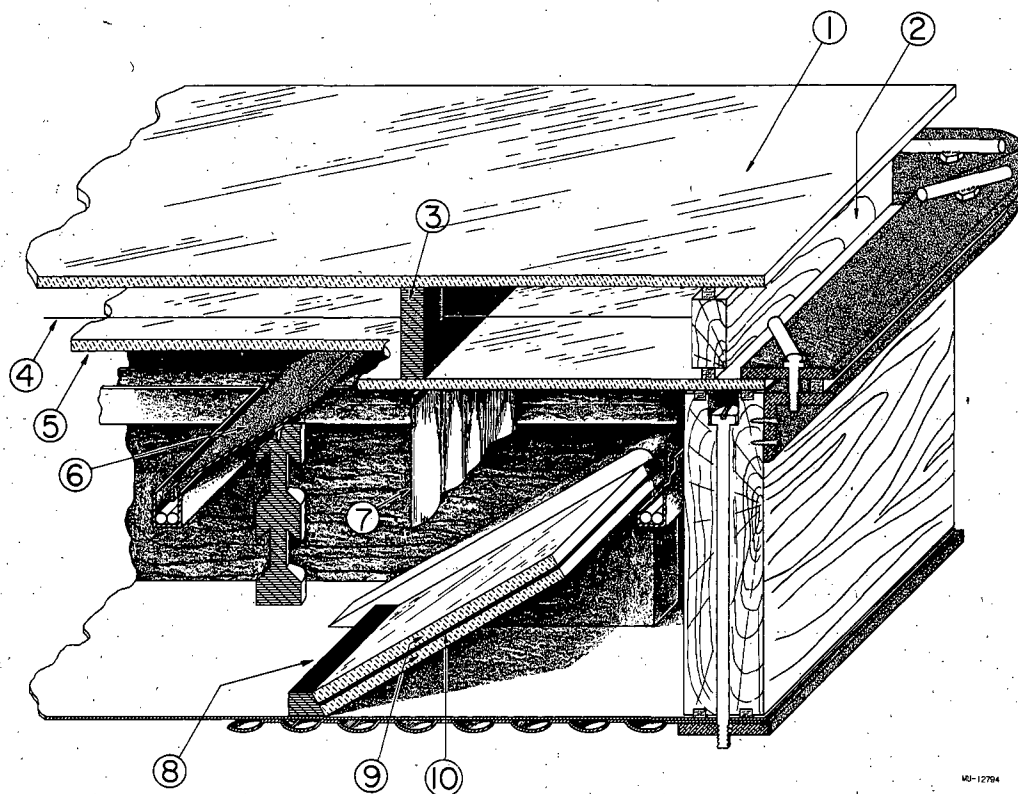


Fig. 3. Cross section of the Geneva chamber.

which heated the volume between the two pieces of glass. The top glass had to be kept hot so as to prevent the condensation of alcohol on its lower surface.

Both the top glass of the chamber and the heat-retaining pane above it were fully tempered glass sold under the trade names Herculite or Tufflex. These glasses had to be able to stand not only physical abuse, but also the rather severe thermal gradients set up by the heating wires.

### The Cooling System

The freezer plate was cooled and held at approximately  $-45^{\circ}\text{C}$  by Freon 22 circulated by a 2-ton refrigerator unit<sup>3</sup> connected to a 2-h.p. 220 volt 50-60 cycle single-phase electric motor. We would have preferred to use a sealed unit for cooling, because the vibration in such a unit is less of a problem, but there were none available that would work on 50-cycle current - (as the electrical supply in Switzerland is 220-volt single-phase 50-cycle all electrical components had to be adaptable to it.)

We wished to make a minimum number of external connections, therefore an air-cooled condenser was used - as the motor fan proved too noisy, it was removed, and four quiet fans were mounted in front of the condenser.

### The Alcohol System

Because a minimum of maintenance was desired, the alcohol supply was recirculated. Unless an obvious major leak occurred, it was necessary only to check the reservoir level once a day. At no time was it necessary to change the alcohol because of poisoning with aerosols.

The centrifugal pump used<sup>4</sup> had a packing gland that leaked from time to time. We had no time to investigate and obtain a similar pump that would be self-sealing, but such a pump would mean a marked decrease in maintenance time and would be preferable to the one used.

The alcohol system consisted of (a) The upper tray system, which was made of stainless steel channel, 1/2 in. wide by 3/4 in. high, welded at corners and intersections to form a square with three cross channels. All channels were interconnected. The trays were supported by six bakelite stand offs, that insulated the chamber from the base.

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<sup>3</sup> Brenner Manufacturing Co. Truck-type refrigerator, Model AT-200 FL. Utica, N. Y.

<sup>4</sup> Centrifugal pump Model D-11, 1/8 H. P. 3450 R.P.M. 110 volts 8g. P.M., Eastern Industries, Chicago, Ill.

- (b) An adjustable-level reservoir on the outer wall of the chamber to maintain a constant supply of alcohol to the trays. (See Fig 4.)
- (c) An adjustable drain tube in the base of the chamber to control the alcohol level in the chamber proper. This drain led to the alcohol reservoir.
- (d) An alcohol pump<sup>4</sup> and reservoir.

We found that it was necessary to install a valve on the discharge side of the pump to restrict the flow to the tray reservoir.

As it was necessary to heat the alcohol in the trays, two 1/4-in. o. d. lead-covered soil-heating cables were inserted in each tray. The insulation between the lead sheath and the heating wire is affected by alcohol, therefore all connections had to be alcoholtight.

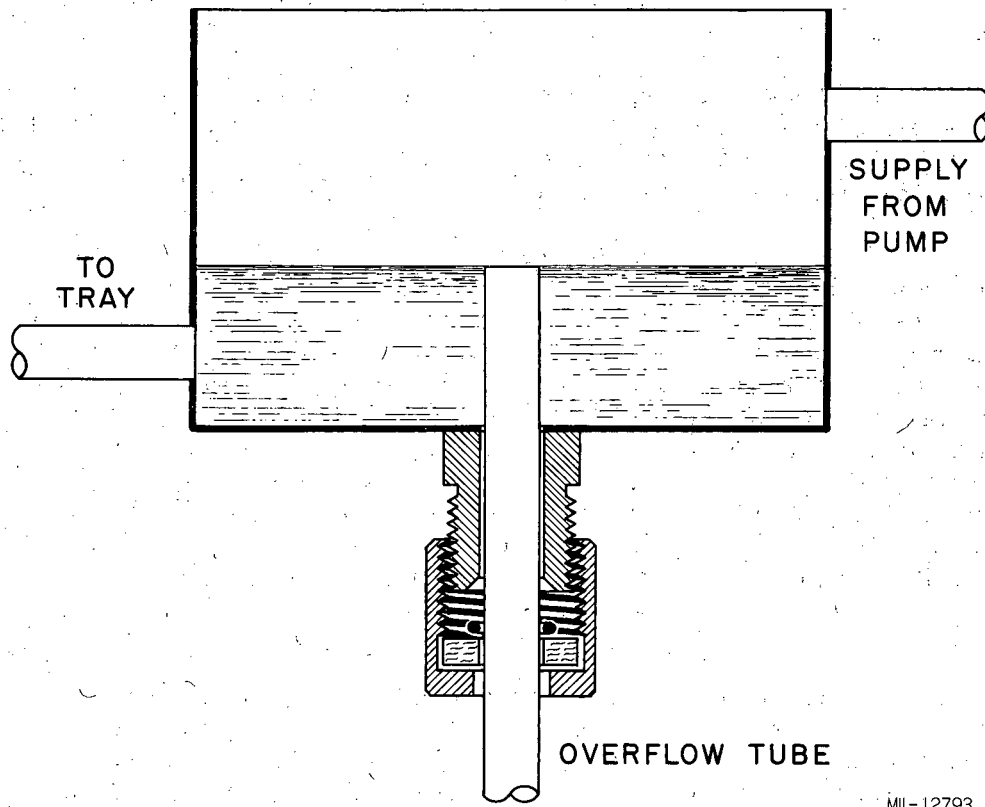
In addition, all the heat had to be confined to the alcohol so that there would be no hot spots causing convection currents of air in the chamber. This was done in the following manner. The cable was cut to length, and copper wires were soldered to the heating element and insulated. These wires were inserted through a 1/4-inch copper tubing tee, which was then soldered to the external lead sheath. A length of lead sheath was soldered to the remaining leg of the tee and to a Kovar seal that was fastened to the chamber wall. The two copper wires were then connected to the 110-volt supply. The trays also acted as the clearing field, and therefore the connection to the clearing-field power supply was made to the external portion of the Kovar seal that was connected to the lead sheath.

#### The Electrical System

All electrical components had to be operable on either 50- or 60-cycle current, for the chamber would have no permanent value if it could not be operated in this country as well as in Switzerland. Several 110-volt components were needed; to avoid the necessity of making extra outside connections, a 220-110 v stepdown transformer was incorporated in the system.

All the electrical components had individual switches, but the circuit was arranged so that all the components could be started or stopped from one master switch.

While the chamber was operating it was necessary to heat the top glass to keep alcohol vapor from condensing and spotting its lower surface. This could not be cut off entirely when the refrigerator was stopped, therefore a variac set at a low current value was interlocked with the refrigerator circuit in order to keep the top glass warm at all times.



MIL-12793

Fig. 4. Adjustable-level control for alcohol-tray supply.

### The Lighting System

The chamber was illuminated by five incandescent 300-watt lights.<sup>5</sup> These were mounted in a dural box provided with a blower to remove the excess heat. It was necessary to remove the infrared energy from the light because the heat upset the thermal gradient established in the chamber by the cold plate in the bottom. Directly in front of each light we installed a disk of heat-absorbing glass cut into four adjoining strips. We found that the disks shattered owing to uneven heating, if they were not cut. This still did not remove sufficient heat from the light, therefore a water cell was installed between the light box and the chamber. The water cell consisted of a dural frame 2 in. high with lucite top and bottom. To avoid boiling and evaporation, the water pumped<sup>4</sup> through the cell was first cooled by passing through a few coils of copper tubing placed in the air blast from the refrigerator condenser fans. The water flow was such that any air in the water cell would be removed. Air dissolved in the water formed bubbles under the heating and the rapid flow conditions, and made an interesting but undesirable effect, until sodium nitrite was added to the water to displace the dissolved air. The necessary concentration was found to be about 1 lb of sodium nitrite for 6 gal of water.

The light from the light box was directed into a mirror mounted inside the chamber. The optimum angle of the incident light was determined to be about 30° from the normal to the chamber. Various light shields had to be placed both inside and outside the chamber to eliminate glare, which would detract from the desired contrast in the chamber.

Because all of the mirrors that were tried did not stand up in the alcohol atmosphere, we constructed our own mirror by sandwiching chromium-plated ferrotype plates between two 1/4-inch pieces of glass. This performed very satisfactorily.

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<sup>5</sup> General Electric Type PAR 300/56 NSP

### OPERATION

The following list shows the experimentally determined optimum operating conditions.

1. Chamber bottom - 45° to -50° C
2. Alcohol tray 25° - 30° C
3. Top glass (operating heat) 55° to 60° C
4. Top glass (low heat) 30° to 35° C
5. Clearing-field voltage 28 v dc

When the chamber was operating with the viewing light on, it drew 19 amp at 220 v or 4.2 kw. Without the viewing light the power consumed was 13.5 amps or 3 kw.

All adjustable controls and individual switches were installed behind a panel door and only two main switches were left on the face of the panel. One was the main power switch and the other was the refrigerator power. When the refrigerator power switch was turned to the off position, it not only turned off the pumps and the top glass normal heat, but also turned on the top glass low heat and permitted the refrigerator to pump the Freon to the accumulator, after which the refrigerator would turn itself off. When the refrigerator power switch was turned on, all the circuits were energized and tracks would appear in about 20 min.

The chamber was operated in Geneva for about 2 wks. with only minor mechanical difficulties. It was then stored until November 1955, at which time it was exhibited in New York for three weeks, then stored again.

In March 1956 the chamber was returned to the lab for a routine equipment check, and minor changes were made in some of the electrical circuits. The chamber was then sent to Oklahoma City for a 3-wk exhibition. From Oklahoma, the chamber was sent to Chicago for a 1-yr exhibition at the Museum of Science and Industry.

No major changes or repairs have been necessary since the chamber was first built.



### ACKNOWLEDGEMENTS

The electrical system was designed and built under the supervision of Donald Lundgren. Richard A. Nickerson and his group at the Livermore laboratory electrochemically blackened the freezer plate. The various shops and crafts cooperated fully and produced the necessary fabrications in a minimum amount of time. Without their cooperation, we could not have completed the chamber in the time allotted.

This work was done under the auspices of the U.S. Atomic Energy Commission.