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TRITIUM HANDLING SYSTEM

B. J. Massey

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Chemistry
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Contract No. W-7405-eng-26

OPERATIONS DIVISION

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DATE ISSUED

FEB 8, 1957

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TRITIUM HANDLING SYSTEM

B. J. Massey

INTRODUCTION

Tritium (H^3), which emits a beta particle[1] with an energy of 0.019 Mev and has a half life of 12.4 years,[1] has been found to have many interesting applications in the fields of biology, physics, and chemistry. A recent decision by the AEC to liberalize its procurement has aroused much interest in research personnel in this isotope.

Many systems for handling and storing tritium have been reported. Each system has certain advantages and, unfortunately, certain disadvantages. The purpose of this report is to describe the system in use at ORNL.

Two items of general interest in handling tritium are personnel safety and isotopic purity. Although tritium has a short biological half life and the human body will tolerate a rather large amount,[2] the ease with which it diffuses through containers and the difficulty of decontamination make it hazardous. Tritium exchanges readily with normal hydrogen (protium), which lowers its isotopic purity. This is particularly of interest when the tritium is stored for long intervals of time in contact with grease or other sources of protium.

EQUIPMENT

The system for handling tritium is mounted in a hood, as shown in Fig. 1, and is constructed of ¼- and ½-in.-OD stainless steel tubing. Containers, or auxiliary systems, may be attached at either of the two outlets shown.

The tritium is stored in uranium[3] which is contained in a small double-walled reservoir shown in Fig. 2. A stainless steel filter is used to prevent uranium dust from entering the system. A Chromel-Alumel thermocouple is attached to the reservoir, which is wrapped with a heating tape. The annular space between the two reservoirs is vented to hot off-gas. This causes a constant flow of air to enter at the top, sweep down the side of the reservoir, and exhaust at the bottom.

The valves used in the system have monel bodies and bronze bellows. The vacuum cut-off valve is of brass construction and has a rubber seat; the portion of the rubber seat exposed to the tritium is so small that the purity of the tritium is only slightly affected.

The pressure measuring devices incorporated in the system include the mercury manometer, shown in Fig. 3, a cathetometer, a thermocouple gage, and an ion gage.

The vacuum pumping system consists of an air-cooled diffusion pump and two mechanical pumps. One of the mechanical pumps is used for roughing down the system, and the other one is a fore pump.

PROCEDURE

Uranium turnings were placed in the reservoir before the top was welded. The system was filled with hydrogen and the reservoir heated to approximately 450°C before sorption was started. Hydrogen was added until there was no pressure decrease. The vacuum system was opened and the hydrogen which is evolved at this temperature was removed. This procedure was repeated once to ensure complete reaction of the uranium. The system was pumped down to a pressure of 1.6×10^{-5} mm Hg with the uranium reservoir held at 450°C. After the uranium was allowed to cool to room temperature, tritium was admitted.

After the uranium has been activated in this manner, it will sorb tritium readily at room temperature. The pressure of tritium in equilibrium with uranium at room temperature is below 10^{-4} mm Hg. One gram of uranium chips is used for each 50 cc of tritium to be stored. This ratio allows for the oxide coating on the uranium and provides an excess of uranium. It is pointed out that no attempt is made to remove the oxide coating from the uranium before it is charged into the reservoir. Uranium oxide does not enter into the reaction between tritium and uranium. In fact, the small amount of air which leaks into the system is removed by the uranium, forming uranium oxide and uranium nitride. The oxide coating does, however, make the initial sorption of hydrogen during activation more difficult.

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[1] S. Kinsman *et al.* (eds.), *Radiological Health Handbook*, p 63, U.S. Dept. of Health, Education, and Welfare (Oct. 1955).

[2] *Ibid.*, p 294.

[3] C. H. Johnson and H. E. Banta, *Rev. Sci. Instr.* **27**, 132 (1956).

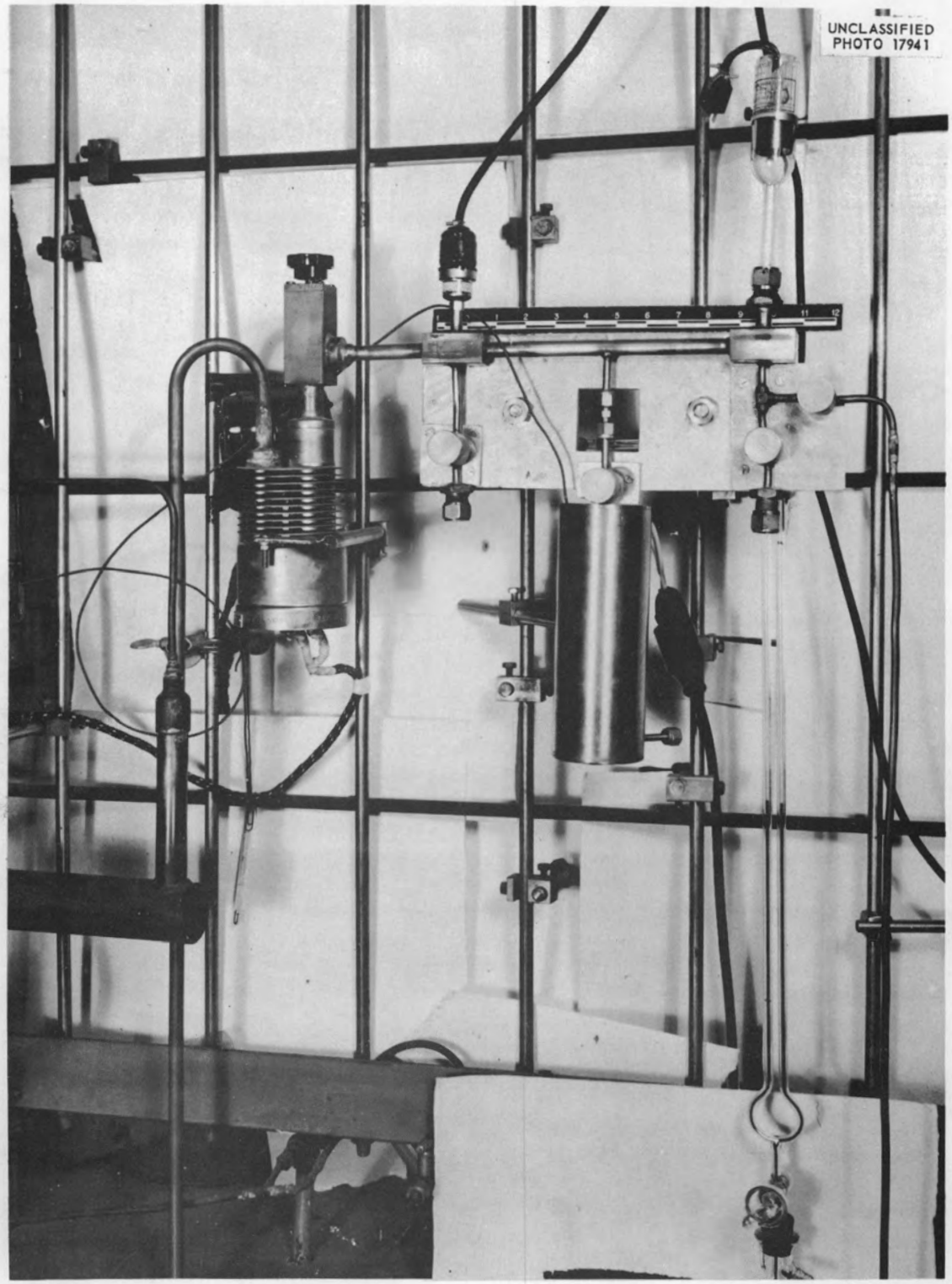

Fig. 1. Tritium Handling System.

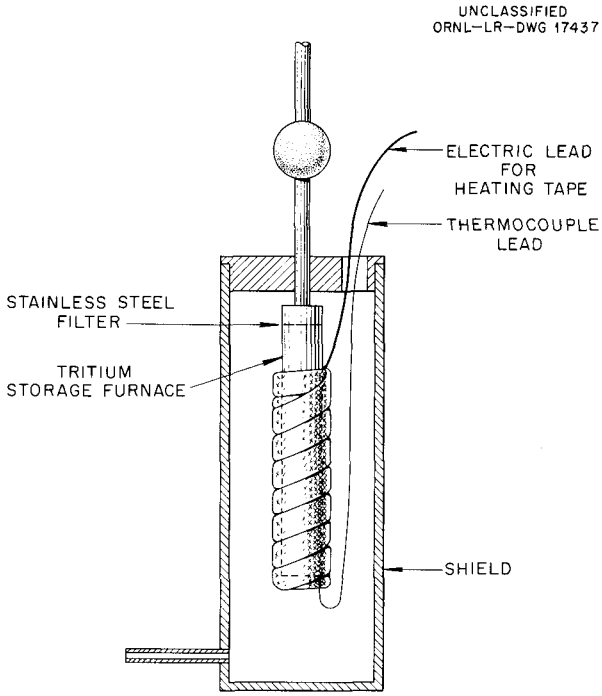

Fig. 2. Uranium Reservoir for Storing Tritium.

The procedure for filling a container is as follows:

1. The container is attached to the system.
2. The valve to the roughing pump is opened and the container evacuated to a pressure less than 100 μ Hg.
3. The valve to the roughing pump is closed. The valve to the diffusion pump is opened and the pressure reduced to less than 1 μ Hg.
4. The container is leak tested either roughly by the pressure rise method or more completely by attaching a helium leak detector to the other attachment facility.
5. Mercury is raised in the manometer to an operating level.
6. The uranium trap is heated to 300°C. Pumping is discontinued, and valves are arranged so that the container is open to the uranium trap.
7. Heating is continued until the desired pressure is obtained.
8. The container is closed, the uranium is cooled, and the tritium in the interconnecting tubing is allowed to return to the reservoir.
9. If desired, the container may now be removed from the system.

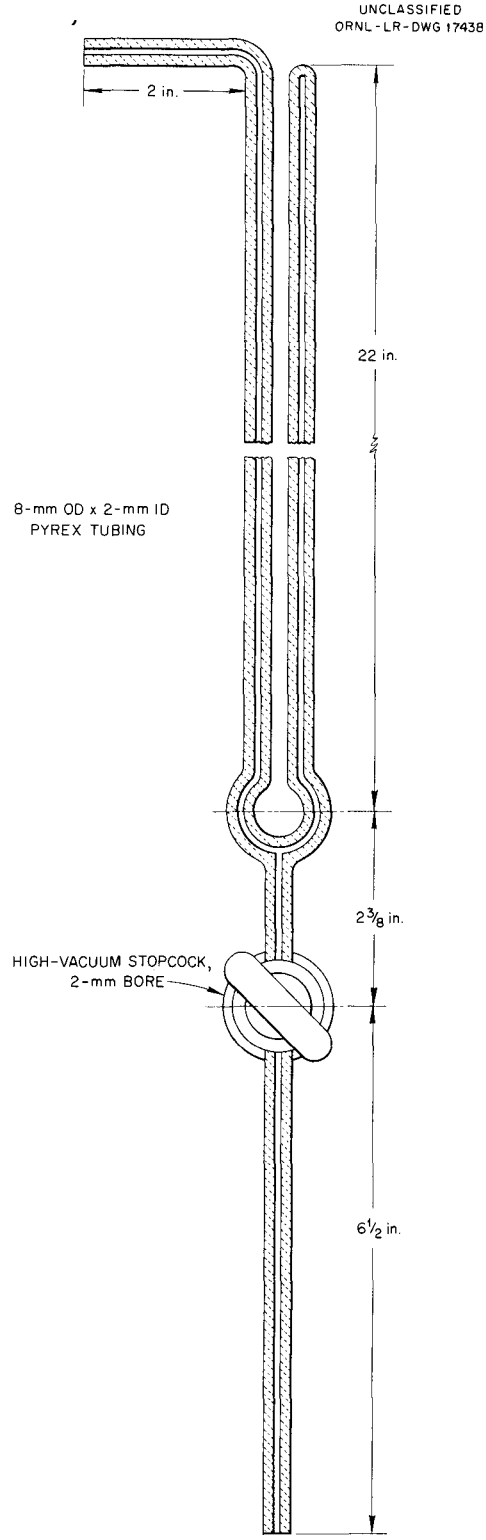

Fig. 3. Mercury Manometer for Measuring Pressure.

DISCUSSION

When the reservoir is heated, tritium diffuses through the stainless steel wall of the inner container. Samples taken of the air around the reservoir with the outer jacket removed indicated that the tritium concentration rose very rapidly to about one-third maximum permissible concentration based on a 40-hr week. This sample was taken inside the hood. Samples taken at the position of the operator's nose showed no increase in tritium concentration, even with the outer jacket removed. When the outer jacket was installed, the tritium concentration inside the hood showed a slight increase during the heating cycle. Urine samples of the operating personnel showed little or no increase over background.

Over a very large range, the pressure of tritium over the uranium is dependent only on the temperature; it is practically independent of the amount of tritium present. This factor simplifies system operation.

Isotopic purity has decreased only a small amount during three months of operation. The assay of the original tritium showed 99.7% tritium against 99.3% at present. No record is available as to the number of operations performed.

The disadvantages of this system are that it cannot be used for handling mixtures of the hydrogen isotopes, inventories are extremely difficult, and it is difficult to handle quantities of less than 10 curies.