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INERT GAS PURIFIER FOR SLAC'S TWO-METER STREAMER CHAMBER*

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Introduction

The streamer chamber at SLAC has two cells (Fig. 1), each 95 inches long, 65 inches wide, and

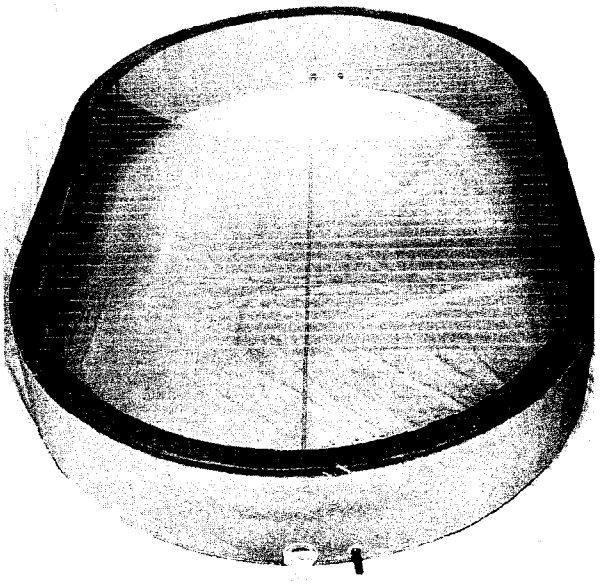

FIG. 1--Gas cell for streamer chamber.

12 inches deep, and filled with a 90% neon-10% helium gas mixture. This gas is contained within the racetrack-shaped walls made of polyurethane and epoxy by some 12 m^2 of 0.002-inch thick mylar. A mylar target tube (1/2-inch diameter, 0.004-inch wall) runs the length of one cell containing H_2 gas at 80 psi gauge.

Gas Purity Required

From observation it was determined that streamers in the chamber are bright and clear when the level of total impurities in the neon-helium gas is below about 0.2%. As contamination increases, the voltage required to produce visible streamers must be increased. At 0.5% the streamers become blurred, and when impurities approach 1% no streamers can be seen.

During design of the chamber it was realized that purging it with neon-helium gas which then was dumped would be expensive. Therefore a chemical purifier was built, in which the used gas flowed over calcium chips at 575°C and then through liquid sodium at 150°C. The calcium extracted all the impurities except hydrogen, and the sodium extracted all except nitrogen.

To conserve the chemicals, the cells were initially flushed with inexpensive CO_2 gas. The CO_2 was then removed, by pumping it through KOH dissolved in water, while neon-helium gas was introduced. At this point the amount of impurities was less than 5%. With fresh chemicals, the purifier reduced the impurities to about 0.25%, which was adequate to obtain streamers.

Contamination Rate in the Cells

In operation it was found that the contamination rate is high when the cells are first filled. After two to three weeks of flushing the cells with neon-helium gas, the rate appears to stabilize at about 0.01% per hour. The principal contaminant by far is nitrogen, followed by oxygen and water.

The diffusion rate through the mylar film was calculated, using E. I. Du Pont de Nemours numbers, to be only about 5% of the measured contamination rate. The additional contaminants come primarily through pinholes in the mylar, either formed during manufacture, or caused by handling during fabrication of the cells. Also, when the chamber is fired, fine metal particles falling from the magnet burn their way through the mylar because of the high voltage used. The resulting small holes are another source of contamination.

The Cryogenic Purifier

Because the measured contamination rate was found to be twenty times the expected rate, the capacity-limited chemical purifier first built was replaced by a cryogenic type. The following reasons led to selection of the cryogenic purifier: (1) Liquid nitrogen is readily available to cool the molecular sieve trap. (2) Reactivating the molecular sieve is quicker and easier than replacing the chemicals. (3) The capacity of the trap is such that all the air in the cells can be absorbed before reactivating the molecular sieve. (4) From a safety standpoint the cryogenic system was more desirable.

Description

The replacement purifier is shown in Fig. 2. To avoid negative pressure in the cells and to keep the mylar from touching the wire electrodes, the pressure is maintained between 0.01 inch and 0.08 inch of water gauge. Two pressure-sensitive switches operate two solenoid valves on the pump unit of the purifier. If the pressure in the cells becomes too high, solenoid valve 18 opens and dumps gas into the atmosphere; if the pressure becomes too low, solenoid valve 19 opens and make-up gas from a cylinder enters the system.

The system was made so that it is easy to leak check. The molecular sieve traps were made of aluminum. Stainless steel hoses and copper tubing were used almost entirely throughout the system except next to the cells and the pump unit where plastic hoses were used. The

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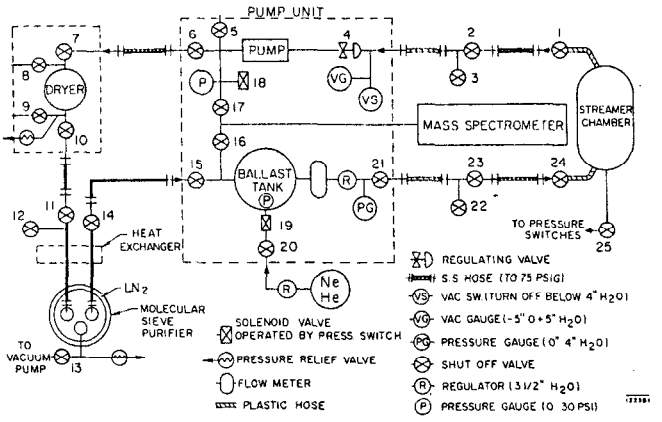

FIG. 2--Flow diagram for cryogenic neon-helium purifier.

size of the tubing and hoses varies from 0.5 inch to 2.5 inches in diameter.

Larger chemical reactors using calcium and sodium have been built and could be substituted for the liquid-nitrogen-filled trap shown in Fig. 2. These may be necessary for future operation if gases which condense at liquid-nitrogen temperatures are used.

Operation

The regulating valve upstream of the pump is used to control the pumping speed. To avoid damage to the cells, the vacuum switch turns the pump off in case the pressure goes below -4 inches of water gauge.

The pump is a 3/4-hp piston pump located inside a gas-tight box. The suction side of the pump is open to the box. The discharge is through a pressure relief valve and then out of the box. The purpose of the box is to avoid gas leaks between the pump and the environment. The pressure relief valve is set such that no components in the purifier can be over-pressurized.

From the pump unit the gas goes through a dryer, a cylinder containing a Linde-type 13X molecular sieve about 10 inches in diameter and 24 inches tall. It can be baked and has a safety pressure relief valve. Following the dryer is a 12-inch diameter cylinder 40 inches long which has an internal baffle and is filled with the same molecular sieve as the dryer. The baffle forces the gas to go to the bottom on one side of the cylinder and back up again on the other side. (A tube was initially used to lead the gas to the bottom of the trap, but gases would freeze in the tube and stop the flow.) The cylinder sits in a Dewar half-full of liquid nitrogen when operating. Heating elements are wrapped around the sieve container and it can readily be baked-out. Through a heat exchanger, the gas leaving the cold molecular sieve is heated by gas going in. Next, the gas goes to the ballast tank on the pump unit. From there it passes through a flowmeter and a pressure regulator before returning to the cells.

The molecular sieve material is reactivated by baking at 500° F for two hours, the last half-hour under vacuum.

Results

In an experiment lasting 10 weeks, two sets of cells were used. The cells were fired at a rate of about once a second continuously except for three days shutdown every two weeks. The molecular sieve was baked every shutdown. With a flow rate of 2000 liters/hr of neon-helium through the cells, the total amount of impurities was maintained at less than 0.1%, a level which permitted good streamers. Hydrogen which theoretically diffused into the gas from the target at a rate of 240 cc/day was removed quickly enough so that the amount present was not detectable over general background on a mass spectrometer.

During the 1500 hours of operation, three million liters of gas went through the purifier. Six cylinders each containing 200 ft^3 of neon-helium gas were used at a cost of about $2000. Thirteen thousand gallons of liquid nitrogen were consumed at a cost of about $2100. The total operating cost was therefore only $4100 for purifying three million liters of gas.