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OXYGEN LIQUEFIER FOR DEMONSTRATIONS

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THE significance and role of low temperatures in science and engineering increases continuously. However, in so far as we know, lecture demonstrations at which low temperatures and gas liquefaction are attained are practically nonexistent. We describe a small air liquefier, operating with a compressed-air flask. If a flask containing 40 liters of compressed air with initial pressure 150 atm is available, it is possible to obtain within 4 min liquid air in the Dewar of the instrument.

Figure 1 shows a photograph of the liquefier (without the flask). The operating principle of the instrument is based on the use of the Joule–Thomson throttling effect. Figure 2 shows a longitudinal section through the liquefier. Its construction consists essentially of a heat exchanger and a throttling valve, which are placed in an ordinary glass Dewar with inside diameter 50 mm (1—flange; 2—packing gasket of rubber; 3—packing of cotton thread; 4—foamed plastic filler; 5—thin-wall cylin-

FIG. 1. Over-all view of liquefier.

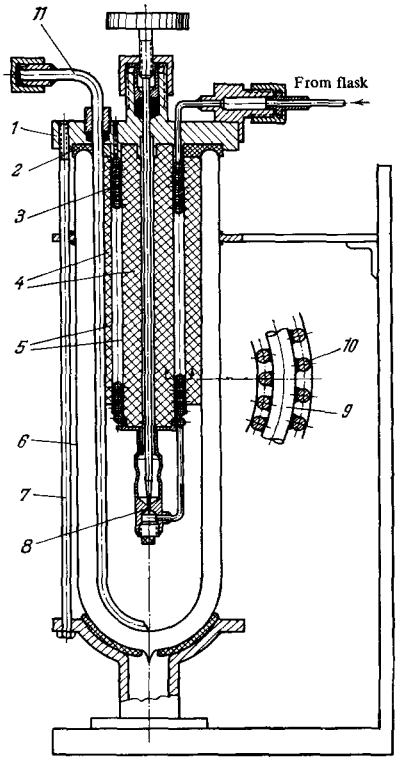

FIG. 2. Longitudinal section through liquefier.

ders of stainless steel; 6—glass door; 7—bolt; 8—throttle valve; 9—heat-exchange tube; 10—rib of copper wire; 11—siphon).

An effective coiled counterflow heat exchanger is made of five ribbed tubes wound helically in one layer between two thin-walled cylinders made of stainless steel. The diameter of the helical winding of the tubes is 30 mm, the total number of turns is 90. The tubes have an inside diameter 0.7 mm and an outside diameter of 1 mm. The ribs of the tubes are made by winding on them a round copper wire which is subsequently soldered to the tube. The wire diameter is 0.5 mm and its pitch is 1.5 mm. The throttle valve is of the usual design with a steel needle blocking an aperture of 1 mm diameter in a brass body.

Compressed air from the flask connected to the liquefier flows through the tubes of the heat exchanger to the throttle valve, is throttled in the Dewar, being cooled thereby as a result of the Joule–Thomson effect, and then returns to the heat exchanger, passing in the space between its tubes, cooling the direct flow, and finally escaping to the atmosphere through an opening in the flange. The accumulation of cold by the heat exchanger gradually lowers the temperature of the direct flow of the gas, and after 3–4 minutes the throttling of liquid air from the valve begins and its gradual accumulation in the Dewar, as can be observed through gaps in it. The instrument has a manometer for monitoring the pressure in the Dewar and a millivoltmeter to measure the thermal emf of a thermocouple inserted in the lower part of the Dewar—to demonstrate visually the cooling process and then the liquefaction. The liquefied air can be forced out from the Dewar through an open siphon by producing pressure in the Dewar by slight flow of air through the throttle valve. For normal operation of the liquefier, pure air is required, containing no moisture, oil, etc. We took compressed air from a commercial nitrogen liquefier, and the instrument operated many times without clogging the heat exchanger. A supply of air in the flask with a capacity of 40 liters with initial pressure 150 atm is sufficient to obtain 150 g of liquid air. The instrument can also liquefy any other gas whose inversion temperature is higher than room temperature, for example, nitrogen or oxygen.

In addition to demonstrating the cooling processes, followed by liquefaction of the gas in the Dewar, this instrument can be used to reveal, by means of the thermocouple readings, the integral effect of throttling from any pressure to 1 atm. To this end it is necessary to keep the siphon open to permit the emergence of the gas from the Dewar, bypassing the heat exchanger. One of the instruments constructed at our Institute is successfully used in the Physics Department of the Moscow State University and at the Khar'kov Polytechnic Institute.