HELIUM REFRIGERATOR AND LIQUEFIER

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An investigation at the Massachusetts Institute of Technology, sponsored by the Bureau of Ordnance and later by the Office of Naval Research, of the feasibility of the liquefaction of hydrogen by condensation at one atmosphere on surfaces cooled by helium from an expansion engine, led to the development of the machine to be described. It was completed in 1949 and its performance described in routine reports which were made to the sponsors but not otherwise published. In order to render it a more useful tool in the laboratory, features other than the ability to liquefy hydrogen were incorporated in the design. Helium could also be liquefied, although at a smaller rate than hydrogen. The most notable special feature of the liquefier was the large cold chamber, which could be maintained at any temperature down to the helium level.

A 60-hp compressor provided compressed helium at about 12 atm for driving the refrigerator-liquefier. The assembled machine is shown in Fig. 1, except for the compressor. The cylindrical vessel is 44 in. in diameter and 9 ft tall. There was the customary vacuum jacket, a thin annular heat exchanger of finned tubing, and five expansion engines perched in a semicircle on the inner face of the heat exchanger. The useful part of the cold chamber is at the bottom of the well, a space which is 38 in. in diameter and 18 in. deep with a clear opening to the top, 18 in. in diameter. A detailed sectional view of the heat exchanger is given in Fig. 2. Compressed helium flows in the finned tube, hydrogen in the triangular tubing, and low-pressure returning helium through the finning within the annulus.

One of the five expansion engines is shown in Fig. 3 mounted on a test stand. All five are identical except for the length of the distance piece and the stroke of the piston. Their overall height varied from 2.5 to 6.5 ft. The engines are of the walking-beam type with flywheel, water-cooled brake drum, and centrifugal brake for automatic speed control. The pistons and cylinders are made of nitrided alloy steel. The diameter of the cylinder is 3 in., and the stroke varies from 1.5 to 2.5 in. in the various engines. The engines were spaced along the vertical length of the heat exchanger in such a manner as to secure substantially reversible cooling of the hydrogen stream.

When used as a refrigerator, all five engines were active only during the cool-down period, which lasted from one to three hours, depending upon the required final temperature. Thereafter, one or two of the colder engines could carry the load. Rough temperature control was secured by varying either the speed of the engines or the operating helium pressure.
Fig. 1. 1949 model helium refrigerator-liquefier at MIT.

Fig. 2. Heat exchanger detail.