Physics. — *Methods and apparatus used in the Cryogenic Laboratory.* XXIV. *A cryostat for temperatures between 20.3 and 27.5° K.* By W. H. KEESOM and J. H. C. LISMAN. (Communication N°. 213*f* from the Physical Laboratory at Leiden).

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§ 1. *Introduction.* In 1915 KAMERLINGH ONNES [1]) already emitted the idea of constructing cryostats for pressures some atmospheres above the normal and stated that with hydrogen it is possible to go with such a cryostat from 20° to 25° K. In this paper a new cryostat built after that principle will be described, which we used in measuring the melting-curve of hydrogen [2]) at temperatures above 20.6° K.

From the vapourpressure-curve of hydrogen [3]) it appears that a vapourpressure of 5 atm. corresponds to a temperature of about 27.5° K. In our cryostat the hydrogen boils under a pressure higher than 1 atm. (maximum 4 atm. above atmospheric pressure) so that measurements can be made at temperatures between 20.3 and 27.5° K. For this range of temperatures this cryostat has these advantages compared with the hydrogen vapour-cryostat [4]) that its treatment is easier and temperatures are more constant. The neon cryostat [5]) can only be used for temperatures between 24.6 and 27.2° K.

§ 2. *The apparatus* (Fig. 1*a*). The cryostat proper, *A*, made of copper, has a diameter of about 6 cm, a height of 28 cm, the wall is 2 mm thick. Copper was used because of its great heat-conductivity.

After putting in *A* the platinum thermometers and the measuring apparatus for special investigations, the bottom of the vessel is screwed on and soldered with WOOD's metal.

At *B* the thermometer wires protrude air-tight from the German-silver tube; for this purpose two ebonite pulleys *A* and *B* (Fig. 1*b*) are pressed together by means of the screw *C* and the box *D*. Eight small brass bars *E*, which bear in the middle a double cone and at the ends of which the thermometer wires have been soldered, run through these two ebonite pulleys.

The liquid in *A* evaporates through a German-silver tube; the vapour

[1]) H. KAMERLINGH ONNES, These Proceedings **18**, 507, 1916. Comm. Leiden N°. 147*c*. A cryostat for helium, in which a pressure of $2^1/_4$ atmospheres was maintained over the boiling liquid, was used by MATHIAS, CROMMELIN, KAMERLINGH ONNES, and SWALLOW, Comm. Leiden N°. 172*b*, in measuring the rectilinear diameter of helium.

[2]) These Proceedings, **34**. 598, 1931. Comm. Leiden N°. 213*e*.

[3]) P. G. CATH and H. KAMERLINGH ONNES. These Proceedings **20**, 1155, 1928. Comm. Leiden N°. 152*a*.

[4]) H. KAMERLINGH ONNES and C. A. CROMMELIN. These Proceedings **23**, 1185, 1922. Comm. Leiden N°. 154*c*.

pressure is controlled by means of an oil differential manometer connected with O and regulated by blowing off through the cock R. An open mercury manometer is also connected to this tube at *M*. This manometer is used for the adjustment of the temperature and forms a security against a too high pressure.

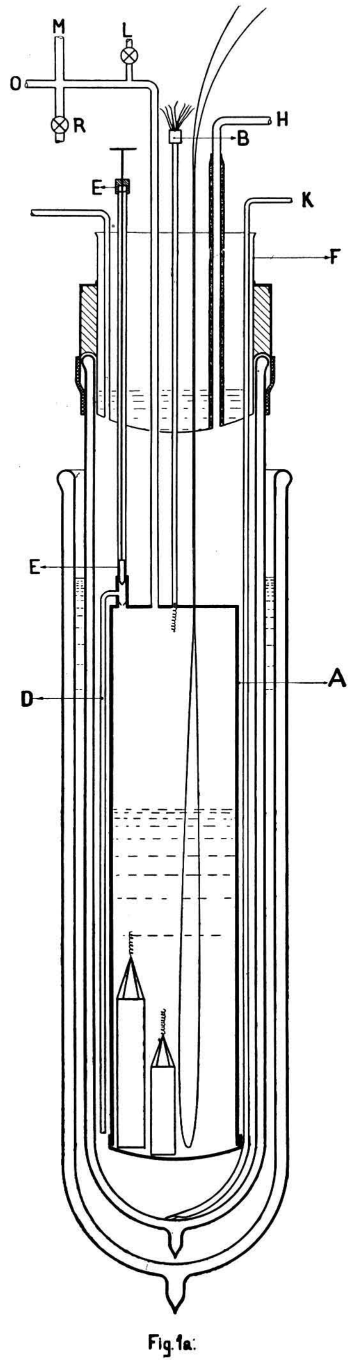

Fig. 1a.

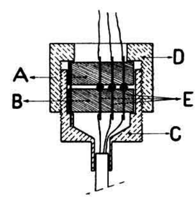

Fig. 1b.

Round the vessel A a DEWARglass for liquid hydrogen is placed, and the whole is immersed in a DEWARglass for liquid air.

The tube D, which can be shut off by the cock E, forms a connection between the vessel A and the inner DEWARglass. The whole is closed at the top by a German-silver vessel F, which is to be filled with liquid air in order to reduce the heat transfer by the tubes (made of German-silver because of its small heat-conductivity); so we are not obliged to take a very long DEWAR-glass.

§ 3. *The experiments.* Before the measurements the apparatus is evacuated thoroughly, because on account of small quantities of impurities, solid at the temperature of liquid hydrogen, the cock E should get immovable.

The outer DEWARglass and the vessel F are filled with liquid air; some time after that, the inner DEWARglass is filled with hydrogen through the tube H; this glass being filled up the vapour exit tube is pinched and the fillingtube H is connected to a flask with compressed hydrogen.

Cock E being open hydrogen gas is admitted from the flask, and under an additional pressure of 10 cm mercury the liquid hydrogen runs through the tube D into the vessel A. The hydrogen now evaporates through the cock L (near the cryostat) and a wide tube. The drop of the hydrogen level in the hydrogen DEWARglass enables us to conclude whether the vessel A is full. Then the cocks E, R and L are shut. Meanwhile the hydrogen, left in the glass, runs out by the tube K, which is put in connection with the gas-holder.[1]) The pressure in A then increases; the required pressure being attained it is kept constant by blowing off through R. However, the liquid in A has not yet reached the temperature, corresponding to the pressure; therefore a small quantity of hydrogen from the flask is led round A, after some 15 minutes the corresponding temperature is reached and can be kept sufficiently constant. After about half an hour again the liquid hydrogen level reaches the top of the thermometer; measurements are terminated then.

It appears that one filling of the cryostat gives us half an hour to make measurements at one temperature. Because the contents of the cryostat is rather small, it is necessary to use a short platinum thermometer, in order that the level of the evaporating liquid reaches the top of the thermometer as late as possible. In our experiments on the melting curve of hydrogen (Fig. 1*a* shows the high pressure capillary in A) we therefore used *Pt* 64, which is about two times shorter then *Pt* 24, and calibrated the first against the latter.

We render our cordial thanks to Mr. G. J. FLIM, chief of the technical staff, for his intelligent help in the construction of the cryostat, and to W. L. NEUTEBOOM, technician 1st class at the cryogenic laboratory, for his valuable aid in the experiments.

[1]) In order to reduce heat transfer to the vessel A one could still evacuate this glass. For our experiments this was not necessary.