with one another. The conductivity was found to vary approximately as the cube of the temperature; by expressing it in the usual way as $K=\frac{1}{3}\lambda Cv$, the mean free path of the thermal waves was seen to be an order of magnitude smaller than the diameter of the tube. Subsequently de Klerk[2] published some observations roughly in agreement with this work. More recently, however, the theoretical discussions of Landau and Khalatnikov[3] have suggested that at these low temperatures the mean free path should be limited only by the walls of the tube. In view of the preliminary nature of the earlier experiments it was decided to make another determination of the conductivity with the better techniques now available.

The present measurements were made on liquid helium contained in a thin-walled German silver tube of 0.29-mm i.d., to which were soldered two thermometers. Our results, which are shown in Fig. 1, were obtained by the conventional method of supplying heat to one end and observing the temperatures at two points along the capillary.[4] At all temperatures below about 0.6°K the heat flow was accurately proportional to the temperature gradient. Although the magnitudes of the temperature gradients observed varied as much as a factor 10, all the experimental points lie on a smooth curve. We also note that, as a sealed capsule technique[5] was employed, the specimen took several hours to warm up and it was possible to obtain good equilibrium conditions for each measurement.

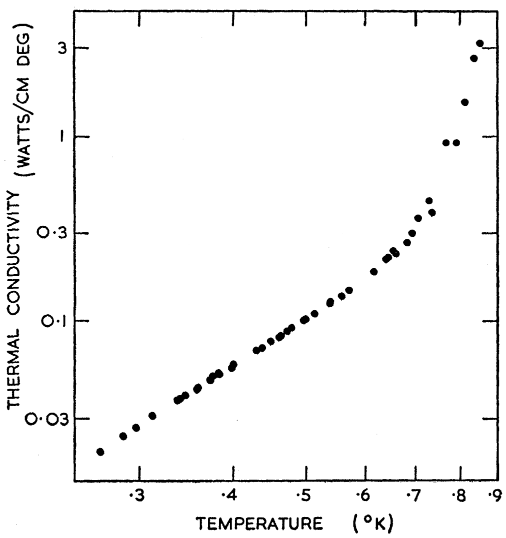

FIG. 1. Thermal conductivity of liquid helium as a function of temperature.

There is a pronounced break in the curve between 0.6° and 0.7° corresponding to the similar break in the specific heat curve.[6] At higher temperatures the heat flows rise very quickly with the temperature and tend towards the values given by Keesom, Saris, and Meyer[7]; we have not examined this region in detail since we may expect a complicated dependence of heat flow on temperature, as observed by the above-mentioned authors at somewhat higher temperatures. Below 0.6°, however, the heat flow is proportional to the temperature gradient and it is clear that the underlying mechanism is quite different. On calculating the mean free path of the phonons, using the values of Kramers, Wasscher, and Gorter[6] for the specific heat and extrapolating the values given by Atkins and Chase[8] for the velocity of sound, we obtain values which are about equal to the diameter of the tube at 0.6° and increase slowly as the temperature falls, being about 30 percent greater at 0.26°. This is quite consistent with the liquid behaving as a continuum whose thermal conductivity is limited by boundary scattering, the increase in mean free path with falling temperature being possibly associated with an increase in the amount of specular reflection at the walls.[9]

Further experiments using a tube of larger diameter are now in progress and a full account of all this work will be published later.

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* On leave from Yale University.

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Melting Curves of Deuterium and Hydrogen

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THERE has recently been considerable theoretical interest in the general behavior of the melting curve of simple substances.[1] Earlier experimental work[2] on the melting curves of hydrogen and deuterium had shown that up to one hundred kg/cm² (the highest pressure to which the measurements on deuterium had then been carried) the melting curves of these isotopes were very accurately parallel, i.e., a displacement of the deuterium melting curve in the direction of the positive pressure axis by about 171 kg/cm² would superpose it on that of hydrogen. It appeared, therefore, of importance to establish whether this phenomenon persisted over a wide pressure range.

For this purpose the melting curve of deuterium was determined up to a pressure of about 2800 kg/cm² and

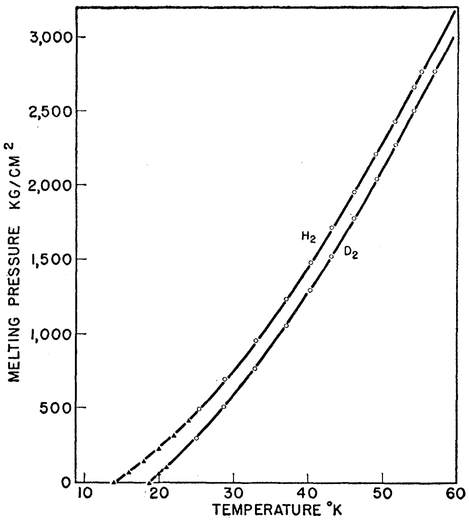

FIG. 1. The melting curves of hydrogen and deuterium. ○ Present measurements. ▲ Previous low-pressure measurements. (See reference 2.)

that of hydrogen was redetermined (in order to obtain a more accurate comparison) over the same pressure range. The method used was that of the blocked capillary.[3] The pressure was determined by means of Bourdon gauges calibrated before and after the experiments against a free piston gauge and the temperature by means of a platinum resistance thermometer. The limits of experimental error were, for the pressure measurements ± 7 kg/cm² and for the temperature ± 0.01°K. The results are shown in Fig. 1 while Table I gives the pressure separation of the two curves for various temperatures.

It is seen that within the experimental error the two curves remain parallel over a pressure range some 27

TABLE I. The pressure separation of the melting curves of hydrogen and deuterium.

Temperature °K	Pressure separation kg/cm²
Present experiments	
25.05	176
28.78	178
32.91	179
37.10	170
40.31	169
43.16	176
46.25	171
49.21	166
51.74	161
54.23	160
56.98	168
Mean pressure separation	= 170 kg/cm²
rms deviation	= 6 kg/cm²
Earlier experiments[a]	
19.00	169.7
20.00	171.1
21.00	172.3

[a] See reference 2.

times greater than that covered in the earlier experiments on deuterium. The striking behavior of the melting curve of these isotopes may be expected to throw light both on the influence of zero-point energy on the melting process and on the nature of this process itself.

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Experimental Evidence for Structure in the Helium II Film*

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FURTHER work on the measurement of the linear velocity of the He II film[1,2] has revealed effects which suggest the existence of structure in the film. The apparatus used is shown schematically in Fig. 1. *BCD*

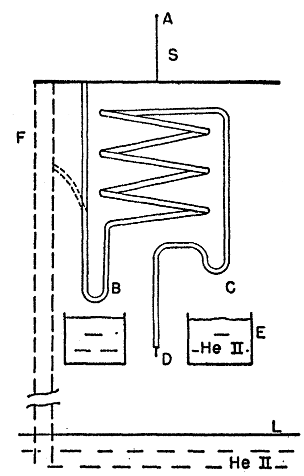

FIG. 1. Schematic diagram of experimental arrangement.

represents a copper wire bent into the shape of a spiral. As shown by the solid lines, this wire extends up from *B* and is fastened to a thin horizontal disk supported by an advance wire *S*. *E* is a small annular reservoir of He II which can be raised or lowered by a mechanism not shown. *L* represents the level of He II in a strip silvered Dewar. Provisions for enclosing the entire structure of Fig. 1 in an isothermal region are not shown.

If the He II in *E* is brought into contact with *B* but not *C*, the film will proceed along the spiral from *B* to *D* and form drops at *D*, since *D* is lower than the level of the liquid in *E*. The time between contact at *B* and the