The thickness of the helium II film has been measured on an aluminum foil of geometrical area 75 cm^2 and roughness factor 1.3 (as determined from a nitrogen isotherm). The specimen was in the form of a smoothly corrugated foil designed so as to eliminate the possibility of bulk liquid adhering to it. A wire tail 2.7 cm long and 0.005 cm diameter was attached to the bottom of the specimen (see insert of Fig. 1). The measurement made was the determination of the change in the effective weight of the specimen as the liquid helium level (H) is changed from the bottom of the container vessel (H_1) to within a few millimeters of the bottom of the specimen (H_2). The change in weight gives an average thickness over the height of the specimen (7.6 cm). The following data were obtained:

(1) The results of the earlier investigation[1] on the unsaturated film were verified. Close to saturation ($P/P_0=0.9992$), the film is 20 atoms thick.

(2) As the liquid level is raised from H_1 until it touches the wire tail, a film of 55 atoms thick is formed on the specimen. This is independent of height until the bulk liquid touches the tail of the specimen; it is also almost independent of temperature.

(3) Once the liquid level touches the tail of the specimen, the average thickness becomes dependent on height. The variation of this thickness with temperature for various positions of the bulk liquid level in contact with the tail is shown in Fig. 1. In this figure ΔH is the distance of the bulk liquid level from the bottom of the specimen. The experimental points have been connected by straight lines simply to distinguish corresponding data; we consider the thickness to be independent of temperature within our experimental error. If the actual thickness (d) of a helium II film at a height (h) above the bulk liquid level may be expressed in the form

$$d=K/h^{1/n}, \tag{1}$$

where K is a constant, then the measured weight is obtained by integrating this thickness over the height of the specimen. An analysis of our data on this basis gives $n=2.0\pm0.3$ for all temperatures. The value of the constant K equals 295 (for d in number of atomic layers). It is not correct to assume that K gives the film thickness at a height of 1 cm, because expressing our results in this fashion would involve an extrapolation of film thickness well into a region which is not measured in our experiment. We claim only that an integrated form of Eq. (1) with $K=295$ is accurate for the heights measured by us.

Our results for the film in contact with the liquid are more in accord with the data of Daunt and Mendelssohn[3] and of Long and Meyer[4] than with those of Burge and Jackson[5] and of Atkins.[2] It is worth recording that if one averages $d=295/h^{\frac{1}{2}}$ over the heights involved in the Daunt and Mendelssohn experiment, agreement with their values is obtained. The significance of the disparities with the other workers and possible reasons for them will be considered in a subsequent publication. We shall simply record here that we have found a critical dependence of *film thickness* (as opposed to transfer rate)[6] on radiation influx and it is necessary to consider whether the conditions of heat influx are so critical that any measured values of film thickness without an estimate of associated heat influx are of limited significance. Our observation (1) of a film 55 atoms thick when bulk liquid was present but not touching the specimen is interpreted as being due to lack of equilibrium. The heat contact of the film creeping up the wire tail is not present in this case and the film thickness is correspondingly less. An experiment by Daunt and Mendelssohn[7] gave the result that a film under conditions similar to these is only one-tenth as thick as when the specimen is in contact with the bulk liquid. The difference between their 10 percent and our 30 percent is attributed to fine differences in heat influx, and the values obtained have little significance since they refer to a steady state but not to complete equilibrium.

The fact that the maximum film thickness observed at 99.92 percent saturation was 20 atomic layers indicates how steep the isotherm must be in the last 0.08 percent of the saturation axis, assuming the isotherm is continuous to values observed at saturation. There is, however, the possibility that when bulk liquid is present, a film is formed which is much thicker than the extrapolated isotherm would yield.

We have also observed, in agreement with Burge and Jackson,[5] that the film maintains its full thickness to within a few thousandths of a degree of the lambda point. The film just above the lambda point was observed to be between 10 and 15 atoms thick.[8]

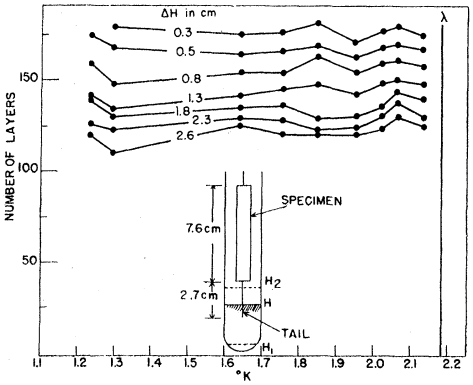

FIG. 1. Average film thickness as a function of temperature for various heights of the liquid level.

I am grateful to Professor E. A. Long, Professor L. Meyer, and Professor J. W. Stout for helpful discussions.

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Velocity of Sound in Superconducting Lead and Tin

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IT has been suggested[1] by Fröhlich that his theory of superconductivity[2] might imply a change in the velocity of sound when a substance becomes superconducting. An unsuccessful attempt to observe such an effect had already been made by Squire[3] but with low sensitivity. It did, however, appear to us desirable to repeat this search with the maximum possible sensitivity, and we have now made measurements on lead and tin.

The apparatus used consisted of an oscillator of 1-Mc/sec frequency feeding a piezoelectric crystal attached at one end of a rod of superconducting material in which standing waves were set up. A crystal at the other end of the rod acted as receiver, and the output was fed through an amplifier to a tube voltmeter. Alteration of the frequency of oscillation or (e.g., by heating or cooling) of the velocity of sound in the rod made the reading of the tube voltmeter go through a series of maxima and minima according as the length of the rod was an integral or half-integral number of half wavelengths. A change in voltmeter reading corresponding to 1/20 of the difference between minimum and maximum was detectable.

The apparatus was thus sufficiently sensitive to detect a *change* in sound velocity of 1 part in 2×10^4.

We examined the effect of allowing a tin rod 15 cm long to pass several times through the superconducting transition in a longitudinal magnetic field at 3.5°K, 3°K, 2°K, and 1.3°K. No significant change in voltmeter reading could be observed.

A similar investigation was made on a lead rod 10 cm long in a longitudinal field at 4.2°K and 2°K and in a transverse field at 3°K. Although a large (but not well reproducible) change in absorption occurred while magnetic flux was penetrating or being ejected, no permanent difference could be observed between the completely normal and completely superconducting states.

It may be concluded from our measurements, therefore, that any change in the velocity of sound of 1-Mc/sec frequency during the superconducting transitions in lead and tin is less than 1 part in 20 000. We were also able to exclude any change in absorption greater than 1 part in 1000.

Although our results fit in well with the very small change (1 in 100 000) to be expected[4] in the static elastic constants, it would be wrong to conclude that no change can be expected in the velocity of waves of frequency closer to that of the main thermal vibrations (10 000 Mc/sec) of the metal. It is also known, of course, that the mean free path of these waves is very different in the two states.[5]

This work was carried out in collaboration with the Physical Institute of the University of Zürich and the new Low Temperature Institute of the Eidg. Hochschule Zürich. We are grateful to Professor Dr. H. H. Staub and Professor Dr. P. Grassmann for their encouragement and interest and for allowing us to use the facilities of their institutes.

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[*] Now at Bell Telephone Laboratories, Murray Hill, New Jersey.

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Microwave Spectrum of DI at 1.5-mm Wavelength

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THE microwave spectrum of the $J=0\rightarrow1$ transition of DI^{127} has been observed in the region of 195 000 Mc/sec. The frequencies of the lines and their assignments are given in the following tabulation:

F	$5/2\rightarrow3/2$	$5/2\rightarrow7/2$	$5/2\rightarrow5/2$
Frequency	$195\,320\pm15$	$195\,152\pm8$	$194\,776\pm8$

The value obtained for B_0, the molecular rotation constant, is $97\,532\pm5$ Mc/sec, in good agreement with the value 97 970 predicted from infrared data on HI.[1] The value for eqQ, the quadrupole coupling constant, is -1805 ± 15 Mc/sec.

The observed quadrupole coupling constant gives information about the bond character of DI. The relationships for ionic character *versus* electronegativity[2,3] indicate that DI is 5 percent ionically bound. This reduces the coupling constant from the free atom value of 2400 Mc/sec[4] to 2300 Mc/sec. The difference between 2300 and the observed value of 1805 Mc/sec can be attributed to a 15 or 20 percent s hybridization of the bond.

The frequencies needed for this experiment were obtained at the eighth harmonic of a $2K33$ klystron, using the harmonic generator and detector described previously.[5] The signal at these frequencies, with a band width of 80 cycles/sec, was approximately ten times noise. A 4000-cycle/sec square-wave repeller modulation was used with a lock-in detection system.

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The Vapor Pressure and Entropy of Liquid He^3

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RECENTLY Chen and London[1] have given an equation for the vapor pressure of liquid He^3 which differs from the equation given by Abraham, Osborne, and Weinstock[2] who had measured this vapor pressure down to about 1°K. One of the consequences of the AOW equation was the need for a transition below 1°K, while this does not follow from the CL equation. It seems to us, therefore, to be worth while to give the reasons why we think that the conclusion of AOW is essentially correct.

The entropy S_0 of liquid He^3 at the absolute zero follows from Eq. (8) of AOW,

$$S_0=(2.0085-C)R\ln10, \tag{1}$$

where R is the gas constant and C is the constant appearing in the vapor pressure equation [AOW, Eq. (3)]; p (measured in mm Hg) is given by

$$\log_{10}p=-A/T+2.5\log_{10}T+C+f(T).\quad [f(0)=0.] \tag{2}$$

At low temperatures the term $f(T)$ is unimportant, and it is thus tempting to plot $\log_{10}(p/T^{5/2})$ against $1/T$ and see whether a straight line ensues. This has been done in Fig. 1. We see that, indeed, the experimental points, which have been taken from Table II of AOW, do fall very nearly on a straight line. Concentrating on the data pertaining to $T\leq2.3$°K we get line II, while a straight line through the higher temperature points gives line I. The equations of I and II are, respectively,

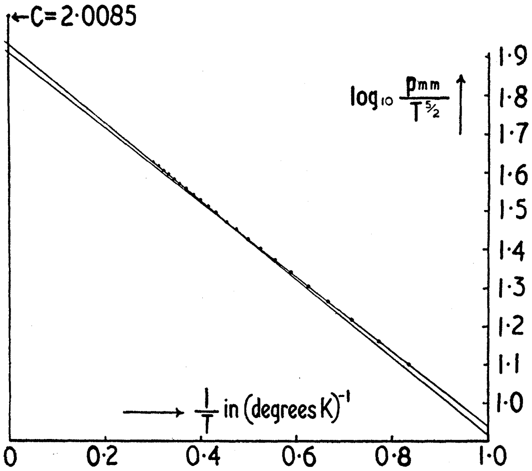

FIG. 1. Vapor pressure of He^3.

$$\text{I:}\quad \log_{10}p=-1.02/T+2.5\log_{10}T+1.934, \tag{3}$$

$$\text{II:}\quad \log_{10}p=-0.97/T+2.5\log_{10}T+1.913, \tag{4}$$