

IV. LOW-TEMPERATURE PHYSICS

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A. MAGNETIC DIPOLE INTERACTIONS IN CRYSTALS

Work on this problem has been completed. Curves of magnetization vs. magnetic field at constant entropy have been obtained. A magnetic method of obtaining the absolute temperature has been devised. A detailed report on the results of this study is being prepared and will be published as Technical Report No. 194.

M. B. Prince, M. A. Herlin

B. RESISTANCE MINIMUM MEASUREMENTS

Resistance measurements using the mutual inductance method previously described have been continued. A number of samples of magnesium from various sources have been investigated. All exhibited resistance minima, although the effect was more pronounced in the less pure samples. A sample of magnesium (obtained from the Atomic Energy Commission), believed to be very pure, exhibited a nearly flat resistivity curve in the temperature range of 0.9°K to 4.2°K, though the measurements for this sample were not in the most sensitive range of the apparatus.

The resistivity measurements involve the determination of a real and imaginary component of mutual inductance. The resistivity of the measured sample can be determined from either of these components and the two determinations should agree. Recent measurements on samples of larger dimensions and higher conductivity than those previously investigated have failed to give proper agreement, and the calculations relating the mutual inductance to the conductivity are being refined to include higher order terms. In addition, an exact calculation is being prepared for the case of a cylindrical superconductor of finite length in a uniform axial field to guide further refinements in the conductivity – mutual inductance relations.

Further attempts have been made to grow aluminum crystals. However, the growing technique remains incorrect, especially as regards the growing of crystals from small pieces of chemically pure aluminum. The use of fluxes has been tried, but without success. It is hoped that the furnace can also be used for the growth of magnesium crystals with the use of proper fluxes.

H. E. Rorschach, Jr.

C. THERMOMECHANICAL EFFECT IN LIQUID HELIUM II

Efforts are being made to improve the temperature-regulating device previously

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reported. Coils were wound of 56S aluminum-alloy wire and were substituted for the carbon resistor previously used as a temperature-sensitive element. The superconducting transition temperature was found to be too low to admit their use to date, and a further undesirable effect is the destruction of the superconducting state by the measuring current in the apparatus now in use. A phosphor bronze coil was tried; its resistance also varied with the measuring current. The temperature "wandering" of the bath is believed to be a result of this effect. A need for a constant current power supply and/or larger resistance coils is indicated. At the same time a reduction in the background noise of the electronic apparatus has made it possible to use the carbon resistor with only slightly larger temperature fluctuations than are desired. D. H. Rogers

D. TEMPERATURE AND PRESSURE DEPENDENCE OF THE VISCOSITY OF LIQUID HELIUM

The present investigation has been described in the Quarterly Progress Reports of October 15, 1950, January 15, 1951 and April 15, 1951.

Figure IV-1 shows a cut-away sketch of the viscosimeter chamber in its present form and a block diagram of the associated electronic equipment. The anomalously high damping reported previously was eliminated as expected by a new coil. Preliminary measurements were made at the vapor pressure; the metal pressure chamber was replaced by a glass chamber. Damping of the disk was measured over several hundred periods of oscillation, and the product of viscosity times density calculated on the basis of these data was found to agree qualitatively with previous measurements made at the vapor pressure. The data did, however, show excessive scattering of a systematic

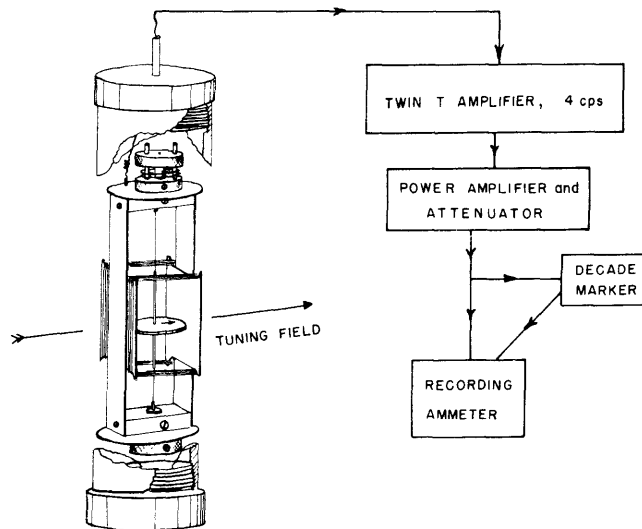


Fig. IV-1
Pressure viscosimeter for liquid helium.

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nature which was found to be caused by erratic operation of the twin-T amplifier: small changes in the characteristics of the very large capacitors employed to accommodate the very low frequency produced systematic drifts in the phase characteristics of the feedback filters and hence of the recorded amplitudes. It was found that the noise level can be reduced considerably by replacing the twin-T amplifier by a low-pass, battery-operated preamplifier comprising only passive filters and enclosed in an effective shield.

This new apparatus has been constructed but no measurements have been made with it.

H. H. Kolm

E. SPECIFIC HEAT OF LIQUID HELIUM

An experimental run was made with the apparatus redesigned as described in the Quarterly Progress Report, April 15, 1951. (See Fig. IV-2). We were bothered by temporary but persistent blocking of the capillary, which made it impossible to condense the proper amount of helium into the inner part of the chamber. In fact one such blocking resulted in the breakage of the chamber. The equipment was rebuilt to eliminate this blocking by condensing out any water vapor present in the helium gas.

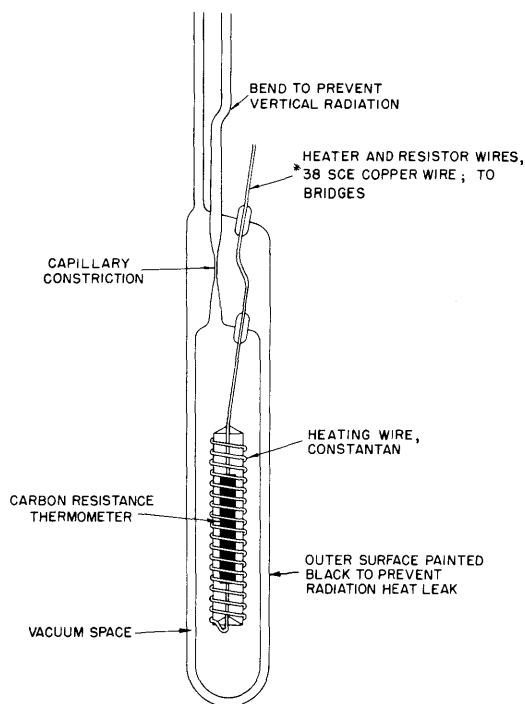


Fig. IV-2

Detail of helium specific heat measuring chamber.

Another run was made in which specific heat measurements were taken at one temperature, 1.27°K. No accurate results were obtained, due to fluctuations in the temperature of the helium bath and the fact that the temperature coefficient of resistivity of the carbon resistance thermometer was not measured. However, an approximate calculation gave a result of the correct order of magnitude for the specific heat of liquid helium at this temperature.

Because of the lack of stability in the temperature of the helium bath it was decided to install an electronic temperature-control system, using a carbon strip resistor as a sensing device, as described by D. H. Rogers in the Quarterly Progress Report, April 15, 1951. The following two runs were devoted mainly to testing this stabilization control. It was found that the stabilizer will hold the outer bath temperature to better than 0.01°, and probably to 0.001°.

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In order to improve the degree of temperature stabilization it has been decided to replace the carbon strip resistor in the stabilization system with a phosphor bronze wire resistor. Further modifications were made in the system for condensing helium into the chamber, including the installation of a charcoal trap to remove air impurities.

G. C. Hunt

F. MEASUREMENT OF SECOND-SOUND PULSE HEIGHTS IN LIQUID HELIUM II

Work has been continued on improving the operation of the electronic equipment designed to measure the pulse amplitudes. The 60-cycle pickup in the high-gain video amplifier has been minimized by reconnection of ground wires and balancing of the remaining signal by feeding 60 cycles of variable phase and amplitude into the grid of one of the earlier stages. The problem of obtaining better linearity of amplification is being approached.

B. Bernstein

G. THE ELECTRICAL RESISTANCE OF COLD-WORKED COPPER

The resistivity of various cold-worked samples of copper was measured from 4.2° K to room temperature for different annealing temperatures. An uncertainty in the measuring system leaves the data as yet inconclusive. However, it was determined that the resistance rise at high temperature is approximately linear, while the ideal resistivity follows a $T^{3.3}$ dependence. The lowering of residual resistance by annealing was also observed.

E. E. Huber

H. PHOSPHOR BRONZE RESISTANCE THERMOMETER

A number of phosphor bronze wires have been tested for resistance change with temperature in the liquid helium region. Some samples with lead deliberately added showed a slight variation, but the best sample was from commercial phosphor bronze wire without special treatment. This wire gives a change of 18 percent per degree, which is sufficiently high for good thermometry. The resistance change is nearly completely destroyed by a magnetic field and by annealing.

J. W. Wright

I. THERMAL CONDUCTIVITY AND SPECIFIC HEAT OF SOLIDS MEASURED BY PULSE TECHNIQUE

To determine the value of pulse techniques in heat measurements we have used pulses of heat to investigate thermal properties of magnesium at liquid helium temperatures. From such measurements one can obtain the dependence of thermal conductivity and specific heat upon temperature. Present effort is aimed at finding geometry and techniques amenable to analysis such that the data taken may lead to quantitative results.

E. D. Harris, S. Waldron

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J. HELIUM LIQUEFIERS

With little maintenance the two liquefiers have been in complete operable condition during all of this period and on several occasions have been run simultaneously. With this sort of operation liquid helium is available at the rate of 8 liters per hour.

R. P. Cavileer