The highest temperature current-voltage curve of Fig. 1 resembles those obtained on a gas plasma with a Langmuir probe and can be analyzed on this basis to yield very reasonable values of the parameters. This plasma-like behavior strongly suggests that there are positive ions being generated in the gas below breakdown which neutralize the electron space charge. From the data in Fig. 1 it is also obvious that if this assumption is correct, there are a greater number of ions being generated at a higher temperature than at the lower ones, because the measured electron current rises with increasing temperature.

A possible mechanism for the production of these ions is the thermal ionization of the inert gas at or in the vicinity of the hot filament. In addition, it is probable that some of the high electrical conduction properties of the gas, shown in Figs. 1 and 2, can be partly attributed to the generally low collision cross section for electrons in the inert gases.

A more complete report will be published in the Journal of Applied Physics.

NEW ALLOTROPIC FORM OF He^3†

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The occurrence in solid He^4 of a change in phase from hexagonal closest packing to the face-centered cubic structure[1,2] at a temperature and pressure above 14.9°K and 1100 atmospheres has prompted an investigation of the high-pressure and temperature structure of He^3.

This investigation employed the cryostat and x-ray diffraction arrangement used in the He^4 study.[2] However, because higher pressures were required, the He^3 was solidified in a beryllium cell with a slightly thicker wall. The cell was a cylinder with a 0.8-mm bore and a 0.5-mm wall. The pressure was measured with a Bourdon gauge which was calibrated with a free piston gauge. The temperature was measured with a hydrogen vapor pressure thermometer fastened to the sample cell. A four-stage mercury piston pump designed by Edeskuty[3] was used to compress the gas from 4 psi to the required pressure. The diffraction patterns were obtained with copper and with molybdenum radiation and were photographed on a 4×5-inch flat film placed 5 cm from the sample. During the exposure the cell was oscillated through an angle of thirty degrees.

The He^3 was analyzed with a mass spectrometer. The impurities found were 0.04% He^4 and 0.04% of a mixture of hydrogen isotopes. The remaining 99.92% was He^3.

The sample was first prepared by cooling the cell to the neighborhood of 20°K and then compressing the helium into it at the desired pressure of the experiment. The gas was then solidified by slowly cooling it. The intention was always to have the solid at a temperature and pressure near the melting curve.

It was found that He^3 under high pressure also transforms to the face-centered cubic structure. The data from a diffraction photograph of He^3 at 18.74°K and 1693 atmospheres are listed in Table I. In the table, d is the interplanar spacing found and a_0 is the length of the edge of the cubic unit cell derived from it.

The average cell edge obtained from seven photographs of helium at an average temperature and pressure of 18.76°K and 1690 atmospheres is $a_0 = 4.242 \pm 0.016$ A. This dimension gives a molar volume of 11.50 cc, which is to be compared to 11.54 cc computed from the measurements of Grilly and Mills.[4]

The hcp-fcc transition occurs at a higher pressure than it does for He^4. Where the transition line joins the melting curve has not been deter-

Table I. Data from one diffraction photograph.

hkl	*d* (A)	a_0 (A)
111	2.425	4.200
200	2.138	4.276
220	1.495	4.228
131	1.283	4.255
222	1.221	4.230
		Average = 4.238

mined in this study. It was observed, however, that He^3 at 15.98°K and 1341 atm still has the hexagonal close-packed structure. The cell dimensions and molar volume at this condition are: $c_0 = 4.986$ A, $a_0 = 0.046$ A, $c_0/a_0 = 1.637$, and $V = 12.07$ cc. The computed[4] molar volume is 12.09 cc.

The new phase has been designated the γ phase.

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SIMPLE MODEL FOR THE MAGNETIC BEHAVIOR OF SUPERCONDUCTORS OF NEGATIVE SURFACE ENERGY

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It is well known that for certain superconductors the magnetic field H_c^* required for the complete suppression of the superconducting state considerably exceeds the critical field H_c. Interest in this question has been revived by the discovery that, well below their transition temperatures, exceptionally high values of H_c^* are found for Mo_3Re[1] (≈ 15 kgauss) and Nb_3Sn[2] (> 88 kgauss). While inhomogeneous strains and chemical inhomogeneities in a superconductor are known to influence its behavior, probably owing to a resulting spatial variation of the surface energy of a normal-superconducting boundary, it is the purpose of this Letter to propose a simplified model for the magnetic behavior of a homogeneous strain-free superconductor, in which a spatially independent negative surface energy could lead to large values of H_c^*/H_c.

Suppose that a superconductor of negligible demagnetizing coefficient divides itself, in the presence of a magnetic field H, into thin normal and superconducting laminas, of thickness d_n and d_s, respectively. Let us add to the resulting expression for g, the Gibbs free energy per unit volume,[3] an additional contribution arising from a configurational interphase surface energy, $\Delta' H_c^2/8\pi$. One then obtains

$$g = (H_c^2/8\pi)\left\{-x\left[1-\frac{q}{p}-h^2\left(1-\frac{\tanh p}{p}\right)\right]-h^2\right\}, \qquad (1)$$

where $H_c^2/8\pi$ is the difference in free energy per unit volume between the normal state and the superconducting state in zero field, $h = H/H_c$, $x = d_s/(d_n + d_s)$ is the fraction of the specimen in the superconducting state, $p = d_s/2\lambda$, and $q = \Delta'/\lambda$, λ being the penetration depth of the magnetic field. Equation (1) supposes that the London equation is obeyed in the superconducting laminas, a hypothesis we shall comment on later. As London pointed out,[3] the condition for Eq. (1) to lead to the well-known magnetic behavior of a so-called ideal superconductor is that $q > 1$. Hence $\Delta = \Delta' - \lambda$, the total surface energy usually measured experimentally, is then positive. Pippard[4,5] has suggested that Δ' should be of the order of ξ, the coherence distance in the superconducting state. For pure superconductors, ξ tends towards a limiting value ξ_0 characteristic of the metal; while for very impure superconductors ($l \ll \xi_0$), ξ is of the order of l, the electronic mean free path.[6]

For $q < 1$, corresponding to a superconductor of negative total surface energy, Eq. (1) leads to the existence of two transition fields. For h less than the lower transition field h', given by $h' = q^{1/2}$, one finds $x = 1$ and $p = \infty$, so that here the specimen exhibits a Meissner effect, while for $h > h''$, where h'' is given by

$$q = h'' + (1 - h''^2)\tanh^{-1}(h''^{-1}), \qquad (2)$$

the normal state is stable. For $q \ll 1$, Eq. (2) becomes $h'' = 2/3q$. For intermediate fields the laminar structure is stable, the thickness of the