integrated flux shown in Table I, it is concluded that no evidence of radiation annealing is found. The best value for the resistivity change per (electron per cm^2), from five runs, is $(8.25\pm1.2)\times10^{-27}$ ohm cm/(electron/cm^2). This uncertainty in rate of resistivity change is the total absolute uncertainty which includes the uncertainties in the various quantities used to derive ρ_e, the resistivity change per (electron per cm^2). The value of ρ_e measured in this experiment is about 20 times that previously measured by Meechan and Brinkman[4] at liquid nitrogen temperatures.

The simplest model of the electron radiation damage process assumes that one isolated interstitial and vacancy combination is formed in every collision in which a copper nucleus receives more than 25 ev of kinetic energy. The calculated cross section for this process is 44 barns[3] and this, coupled with our measured value of ρ_e, gives a value of 1.88 μohm cm for the resistivity of 1 atomic percent of Frenkel defects. Recent theoretical estimates of this number are given in Table II. Although the agreement with Blatt's value

TABLE II. Theoretical estimates of resistivity for 1 atomic percent of defects (in μohm cm).

Reference	Vacancies	Interstitials	Frenkel pairs
Dexter[a]	0.4	0.6	1.0
Jongenburger[b]	1.3	5.0	6.3
Blatt[c]	0.75–1.0	0.75–1.0	1.5–2.0
Overhauser and Gorman[d]	1.5	10.5	12.0

[a] D. L. Dexter, Phys. Rev. **87**, 768 (1952).
[b] P. Jongenburger, Nature **175**, 545 (1955).
[c] F. J. Blatt, Phys. Rev. **99**, 1708 (1955).
[d] A. W. Overhauser and R. L. Gorman, Phys. Rev. **102**, 676 (1956).

is seen to be quite good, the näiveté of the radiation damage model precludes any choice at this time between the different theories. A number of effects such as multiple displacements and the probability of displacement tend to make the calculation of the number of defects unreliable and it is by no means certain that we are dealing exclusively with isolated interstitials and vacancies. The experiment does, however, appear to be in good general agreement with the simple theory and this is a quite different result than that obtained by using heavy-particle irradiations.[5,6]

We have performed a preliminary series of isochronal and isothermal anneals in the temperature range from 5°K to 80°K. No damage is observed to anneal out below 21°K while 90% has annealed out by 65°K. The maximum rate of isochronal annealing occurs at about 35°K. These results are in qualitative agreement with those obtained in heavy-particle experiments,[5,6] with the exception that considerably more of the damage anneals out in the present experiment. The annealing does not appear to be describable by a single first- or second-order rate equation.

Additional experiments measuring the details of the annealing process and the dependence of the resistivity change on bombarding electron energy are now in progress. We are also attempting to obtain an independent estimate of the defect concentration by measuring the change in lattice parameter by an x-ray diffraction technique. These experiments will be reported in more detail in the near future.

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Nuclear Magnetic Resonance in a Superconductor

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WE have observed the nuclear magnetic resonance in colloidal Hg at temperatures above and below the transition temperature (4.15°K). For $T>3$°K and $H_0>9000$ oersteds, a single resonance (I) appears at the expected frequency for metallic Hg in the normal state. However, for $T<2$°K and $H_0\leqq5200$ oersteds, an additional resonance (II) appears near the proper frequency for a nonmetallic salt of Hg. Since in searches under similar conditions resonance II is not observed in separate samples of the possible impurities $HgNO_3$ and HgS (or in the colloids above the critical temperature), we do not believe that it can be associated with a nonmetallic substance. Rather, the disappearance of II in high magnetic fields leads us to believe that it represents the effects of superconducting material, since the critical field for similar colloids can range from about 5000 to 8000 oersteds.[1]

It should be emphasized that the dc fields usually employed in nuclear magnetic resonance experiments greatly exceed the critical field for macroscopic pieces of Hg. Furthermore, in large pieces of superconductors the penetration of magnetic fields extends through only a small fraction of the volume of the material. However, the use of colloids eliminates both of these difficulties, since, in particles possessing radii a much smaller than the superconducting penetration depth ($\lambda\sim400$ A), the critical fields are increased[1] by an order of magnitude over the values for bulk material. Then, recalling that the penetration depth is much smaller than the rf skin depth for frequencies of a few Mc/sec, one may apply the quasi-static solution of London's equations[2] to show that the penetration of both rf (H_1) and dc (H_0) fields is nearly complete. Reif[3] has calculated the detailed distribution of the dc field within a sphere under these conditions.

To investigate the composite spectrum for a colloidal sample, let us designate by n_a the number of spheres of radius a. Then the total spectrum for all spheres will be a superposition of curves (see Fig. 3 of reference 3), where the maximum intensity of each curve is proportional to an_a and the range of the abscissa for each is proportional to a^2. Note that the number of particles of a given size is more important than their relative volume. In general, an exhaustive count of the several particle sizes must be made in order to determine the probable shape of the spectrum. If observations are made by means of a variable-frequency spectrometer in a fixed magnetic field, the absorption decreases rather sharply toward the high frequencies. The "position" of the line is determined approximately by the point of maximum slope on this high-frequency edge of the line. The uncertainty of this determination is reduced if the very small (<150 A) particles predominate. Furthermore, the edge will appear at slightly lower frequencies for such a distribution.

Two colloid samples were prepared as suspensions in albumen and gelatin, respectively. As may be seen in the electron micrographs of Fig. 1, each sample contained spherical particles, the majority of which are less than 200 A in diameter. This sort of distribution would tend to produce a resonance whose "position" is slightly lower in frequency than the corresponding position for a colloid containing a larger proportion of larger spheres. Our measurements of the nuclear resonance absorption indicate that the metallic line shift for superconducting Hg is $\Delta H/H \lesssim 0.5\%$. Reif's result ($\sim 1.5\%$) is for a different particle-size distribution and for lower magnetic fields. In view of the different conditions in the two experiments, the results are not necessarily inconsistent. For normal Hg, $\Delta H/H = 2.5 \pm 0.1\%$.[3,4]

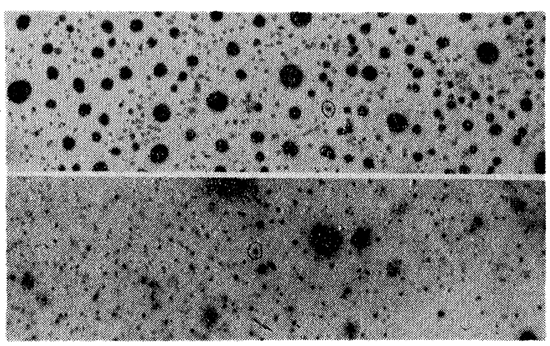

FIG. 1. Electron micrographs of colloidal Hg prepared as suspensions in albumen (top photograph) and gelatin (bottom photograph). The specimens were enclosed in a thin sandwich of SiO before exposure in the electron microscope. In each picture, the circled particle has a diameter of approximately 300 A.

The result is of some significance in considering the electron-nuclear interaction in a superconductor: $\Delta H/H \sim \chi_p P_F$, where χ_p is the spin susceptibility for the Fermi electrons and P_F is the average electronic wave function for s states over the Fermi surface. For a superconductor, the small value of $\Delta H/H$ requires that χ_p or P_F, or both, are considerably smaller than for a normal metal.

The exact value of $\Delta H/H$ is difficult to determine experimentally: (1) the line width in normal Hg is considerable, (2) the shape of the resonance in the superconductor depends on the distribution of particle sizes, and (3) the range of the chemical shifts in Hg is not known.[5] We are attempting to perform experiments with multiple uniform thin films of Pb and Sn. Here the geometry is simpler, the uniformity in sample size will greatly simplify the analysis of line shape, and the widths of the normal lines are smaller.

We are greatly indebted to Mr. R. T. Haines, of the Crookes Laboratories, Ltd., London, for preparing the samples, and to Professor Robley Williams for advice concerning their examination with the electron microscope. We have benefited from conversations with Professor C. Kittel, Professor W. A. Nierenberg, and Mr. A. Mitchell about the interpretation of the experiments. After we had obtained a preliminary result, we learned of Dr. Reif's work. We are grateful to him for discussions of the results.

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Associated Production of Hyperons and K Mesons*

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THERE are now several pieces of experimental evidence indicating definite asymmetries in the angular distributions of Λ^0 and K^0 particles that are produced in association in pion-nucleon and nucleon-nucleon collisions.[1–4] Experimental evidence also exists for asymmetries in the angular distributions of Σ^- and K^+ particles produced in pion-nucleon collisions.[1–4] This note concerns a suggestion for a possible interpretation of these asymmetries in terms of a coupling between pions and K mesons and a coupling between pions and hyperons. These remarks were considered originally in connection with an experiment performed by Osher and Moyer,[5] in which they observed the angular distribution of neutral unstable particles, produced by bombarding a copper target with protons of various energies ranging from 2 to 6.2 Bev. The angular distribution of the K^0 produced in the reaction $p+n \rightarrow Y+K+N$ was fitted with a $\cos^{14}\theta$ in the center-of-mass system, at all energies

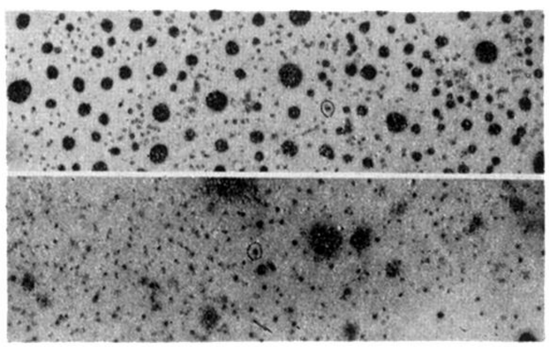

FIG. 1. Electron micrographs of colloidal Hg prepared as suspensions in albumen (top photograph) and gelatin (bottom photograph). The specimens were enclosed in a thin sandwich of SiO before exposure in the electron microscope. In each picture, the circled particle has a diameter of approximately 300 A.