The deviation of the point for specimen 581 from the straight line which fits the rest of the data is not understood at present, but it seems fairly certain that this deviation does not represent experimental error. It is of interest to note that specimen 581 was also exceptional in exhibiting a much broader transition than any of the other specimens. This breadth of transition as well as the unusually large critical field shift shown in Fig. 1 have been observed with excellent reproducibility in two runs between which the specimen was repurified and recrystallized. The only respect in which specimen 581 appears to differ markedly from the others is that it has a relatively broad mass distribution whereas the remaining specimens have their dominant isotopic percentages situated fairly close to M. This anomalous behavior will receive further attention.

Measurements are now being extended down to about 1.2°K to investigate the temperature dependence of the critical field shift. A more detailed account of this work will be prepared when this phase of the measurements has been completed.

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Metallic Transition in Ionic and Molecular Crystals

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EXPERIMENTAL evidence has been obtained that several ionic and molecular crystals under pressures less than 250 000 atmospheres undergo a transition to a metallic state as indicated by their conductivity. The pressure is created by a shock wave generated from a high-explosive system. A decrease in the resistance by a factor of at least 10^6 from the uncompressed to the compressed state is measured by means of pins[1] pressed against the surface of the crystal.

The materials that showed a resistance of less than a few hundred ohms at 250 000 atmospheres were a single crystal of CsI and the following powders which were compressed into pellets to densities near that of the crystal; commercial grade I_2, red phosphorus, and $LiAlH_4$.[2] Teflon and pressed NaCl pellets did not show a substantial decrease in resistance. It is believed that this confirms the validity of the experimental procedure. Another substance, compressed CsBr powder, appeared to have a resistance of the order of kilo-ohms, which might mean that it is in the transition region from an insulator to a conductor. Initially all samples had a resistance greater than 10^8 ohms except red phosphorus, whose resistance was about 5×10^6 ohms.

The high-explosive system is similar to that previously used.[3] This assembly induces a strong plane shock into a series of plates in contact with the high explosive. This series of plates consists of three aluminum plates, individually grounded, and separated by two Teflon plates. This is believed to produce an uncharged shock at the sample. Each sample is pressed against the last plate by two spring-loaded pins. One of these pins is charged to 300 volts while the other is grounded. These pins constitute part of an appropriate RC circuit. A "raster"-type oscilloscope is attached across a resistor of this circuit, so that any discharge can be observed and photographed. The shape of the signal indicates the resistance of the sample. More precise resistance measurements are being worked out.

The pressure is determined from the known equation of state of aluminum[3] by means of an accurate measurement of the velocity of the surface. This is accomplished by a group of seven pins, spaced at 1.5-mm intervals away from the aluminum plate.

An apparent shock velocity is obtained by measuring the time difference between the signal from the pins pressed into the face of the sample and the closure of an additional pin located beside the base of the sample and 0.2 mm away from the surface of the aluminum

TABLE I. Shock velocity (mm/μsec).

Sample	Expt. 1	Expt. 2	Known
CsBr	4.3	...	4.1±0.2[b]
CsI	...	3.8	3.8±0.2[b]
I_2	3.7	3.7	[c]
$LiAlH_4$	5.6	5.5	[c]
P(red)	3.8	4.0	5.0±1.5[d]
NaCl	2.0[a]	2.3[a]	5.9±0.2[b]
Teflon	...	1.6[a]	[c]

[a] These low values indicate that the aluminum plate rather than a shock-induced metallic transition discharged these pins.
[b] Calculated from equation of state experiments performed at Livermore.
[c] Any velocity greater than 2.8 mm/μsec, the measured velocity of the aluminum surface, cannot be the result of the arrival of this surface at the pins.
[d] Estimated from compressibility data, P. W. Bridgman, *The Physics of High Pressures* (G. Bell and Sons, London, 1949).

plate. It is required that the shock velocity obtained from this "transit time" be consistent with one predicted from compressibility data. It should be noted that the pins on the NaCl and Teflon samples eventually discharge also. The timing of this phenomenon easily distinguishes this as being due to the arrival of the aluminum plate itself. Table I compares the results of experiments with known values of the shock velocity.

Further experiments are in progress to try to determine the precise pressure at which the metallic transition occurs for these and other crystals, its temperature dependence, and the nature of any volume change associated with the transition.

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Further Extension of Microwave Spectroscopy in the Submillimeter Wave Region*

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EARLIER developments in this laboratory led to the extension of microwave measurements through the shortest millimeter waves[1] and into the submillimeter range[2] to wavelengths of 0.77 mm. The present work extends further the reach of microwave electronic methods to wavelengths as short as 0.587 mm. Rotational lines of OCS have been observed with an automatic pen-and-ink recorder through the $J=41\rightarrow42$ transition at 510 457.3 Mc/sec. They have been seen on the cathode-ray scope to wavelengths of 0.685 mm (Fig. 1).

The $J=0\rightarrow1$ transition of hydrogen iodide has been measured in the 0.778-mm region. Table I summarizes the results. Figure 2 is a cathode-ray display of two components of the triplet I^{127} hyperfine structure. The nuclear magnetic coupling constant, C_I, of I^{127} is approximately twice that[1] in DI; the nuclear quadrupole coupling and r_0 are slightly greater than those for DI. The moment of inertia of hydrogen iodide is the smallest to be measured with microwave methods.

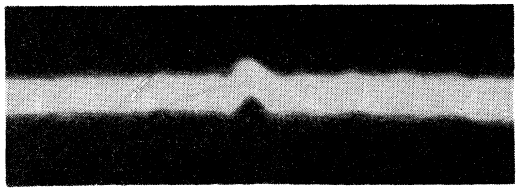

FIG. 1. Cathode-ray display of a spectral line at 0.685-mm wavelength, or 486 184.2 Mc/sec frequency; the $J=35\rightarrow36$ transition of OCS obtained with the 18th harmonic energy from a 2K33 klystron. The line width is about 1 Mc/sec.

Several investigators have studied the infrared spectrum of this molecule. Czerny[3] in 1927 measured pure rotational lines of HI in the 0.1-mm region. The near-infrared value of B_0 by Boyd and Thompson[4] agrees with ours to the four figures which they quote.

The $J=2\rightarrow3$ line of $C^{12}O^{16}$ (Fig. 3) has been measured in the 0.867-mm region at 345 802 Mc/sec. With the multiple harmonic method previously described,[1] the first three rotational lines of CO were seen on the scope together, and their separations caused by centrifugal stretching were measured directly. The stretching constant thus obtained is 0.1888 Mc/sec, in agreement with the value obtained for the lower-J millimeter wave transitions.[5] By further measurements on these frequencies and by measurement of the $J=3\rightarrow4$ line at 0.65 mm, we hope later to improve the accuracy of both B_0 and D_0. The earlier millimeter wave measurements[5,6] on CO have already been used in a preliminary infrared-microwave evaluation of the velocity of light by Plyler, Blaine, and Connor.[7]

The experimental methods and designs of the harmonic generator and detector are the same as those for the earlier work.[1,2] As before, the source of submillimeter wave power is a silicon crystal harmonic generator driven by a Raytheon centimeter wave klystron (2K33). Harmonics up to the 21st were detected. The multiplier crystal was one supplied to us by R. S. Ohl, of the Bell Telephone Laboratories. It was noticeably better for harmonic generation than were the commercial varieties used in the earlier work. We wish to than Mr. Ohl for this considerable favor. For detection we have continued to use sections of crystals obtained from Sylvania Electric Company. Frequency measurements were made with a secondary standard monitored by the 5-Mc frequency of Station WWV.

TABLE I. Observed and calculated frequencies of HI^{127}. $J=0\rightarrow1$, $\nu_0=385\,293.27\pm0.70$ Mc/sec.

Transition $F\rightarrow F'$	Relative intensity	Quadrupole displacement (Mc/sec) first order	Quadrupole displacement (Mc/sec) second order	Magnetic displacement (Mc/sec)	Calculated frequency (Mc/sec)	Observed frequency (Mc/sec)
$5/2\rightarrow5/2$	75	−292.96	0.07	−0.26	385 000.12	385 000.11±0.70
$5/2\rightarrow7/2$	100	91.55	0.05	0.65	385 385.52	385 385.52±0.70
$5/2\rightarrow3/2$	50	256.34	0.09	−0.91	385 548.79	385 548.80±0.70