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DIFFUSION IN METALS

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I. Tracer Studies in Pure Noble Metals

A. Mass Dependence of Diffusion

Work is continuing on a study of the relative rates of diffusion of Fe^{55} and Fe^{59} in silver, preliminary results of which were reported last year. All of the data taken to date are presented in Fig. 1 on a reduced distance plot. The original measurement, which indicated an extremely anomalous mass dependence, is not well substantiated by subsequent experiments. The cause of the discrepancies between the first and later experiments is not well understood at present. The possibility exists that there was excessive evaporation of the iron isotope from the surface of the specimen during the first measurement, but this effect alone would not be expected to explain the large differences. The samples used in the first measurement, when checked a year later, showed no evidence of any isotopic impurity.

The present experimental arrangement, as seen from the scatter in Figure 1, is evidently not sufficiently precise to give an unambiguous answer to the problem under study. The major experimental difficulty enters in precise measurement of the activity of the Fe^{55} isotope which emits only a very weak X-ray that is easily absorbed in the specimen. During the past several months attempts have been made to improve the accuracy of the experiment, particularly in the method of preparing samples for counting. It appears that it will be possible to obtain a highly reproducible counting geometry by electroplating the isotope, with the addition of only a very small amount of carrier, onto a copper planchet. In addition, it is planned to use a differential pulse height analyzer to improve

Fig.1 Relative Rates of Diffusion of Fe^{55} and Fe^{59} in Ag

the counting statistics.

While it is certainly premature to reach any definite conclusions about the mass dependence, the present data strongly indicates that there is at least a classical mass dependence in the diffusion of the slow-diffusing iron in silver, while no mass dependence was found for fast-diffusing Cd^{109} and Cd^{115} in silver, as reported last year. These two results are consistent with the correlation between impurity and solvent atom jumps required by the vacancy mechanism, as described by Lidiard and Le Claire. It is planned to expand the present investigation to a study of diffusion of the iron isotopes in copper. This system should prove exceptionally interesting since, as was previously reported, iron diffuses faster than copper at temperatures near the melting point but slower at low temperatures. Thus one might expect to find a mass dependence at low temperatures which should gradually disappear below the melting temperature.

B. Diffusion of Ruthenium in Silver

At various times during the past several years attempts have been made to measure the diffusion coefficient of ruthenium in silver. In almost all cases the penetration profile was not Gaussian, even at temperatures near the melting point of silver. It was felt that this effect might arise from a possibly extremely small solubility of ruthenium in silver, and consequent build-up of barrier phases. Because of the anomalous results obtained by Mackliet in the diffusion of iron in copper, it was felt important to discover whether or not similar behavior would be noted for ruthenium in silver. The measurements were renewed this year, the major change in technique being a severe restriction on the amount of ruthenium isotope originally plated on the silver crystal. In the current measurements, less than a single atom layer of ruthenium tracer is plated on the silver.

Under these conditions, reasonable Gaussian profiles have been obtained. To date the following diffusion coefficients have been measured:

<u>Diffusion Temperature (°C)</u>	<u>Diffusion Time - Hrs.</u>	<u>Diffusion Coefficient cm²/sec</u>
942	60.5	$2.22 \pm .07 \times 10^{-10}$
916	149.5	$1.6 \pm .2 \times 10^{-10}$
856	724	$3.26 \pm .15 \times 10^{-11}$

These data may be fitted by an Arrhenius equation with an activation energy of about 73 Kcal/mole and a frequency factor of 3×10^3 cm²/sec. These data agree, within errors, with the straight line portions of the previous work.

Unfortunately all of the data so far obtained cover a fairly small temperature range. In order to obtain any reasonable precision in the determination of the frequency factor and activation energy, additional data will be required. Two more specimens are now in diffusion furnaces at lower temperatures. One specimen has been diffusing at 800°C for approximately six months and will be removed for sectioning within the next month. A second specimen at 730°C, which has been diffusing for eight months, will be removed for sectioning sometime during the summer of 1958.

Even with the limited data available, it is obvious that ruthenium diffuses very much slower than the rate of self diffusion in silver, consistent with the predictions of the screening theory and quite unlike the diffusion of iron in copper.

II. Diffusion in Binary Alloys

A. Self-Diffusion in AgCd and AgIn

The program reported last year is now completed. Radioactive tracer diffusion coefficients for both solvent and solute atoms were measured in homogeneous alpha solid solutions of AgCd and AgIn, in the temperature range between 500°C and 900°C. Measurements were made at three different compositions for each of the alloys. In each alloy the tracer diffusion coefficients were found to obey an Arrhenius equation with constant activation energy and frequency factor. The activation energy for diffusion of both solvent and solute atoms decreases monotonically with increasing solute concentration. The frequency factor changes only slightly with composition in all cases studied, showing a small increase with increasing solute concentration in the case of indium diffusion in AgIn alloys, but in the other cases a small decrease with increasing solute concentration.

The experimental data are summarized in Table I together with frequency factors and activation energies for self-diffusion of the various atoms in pure silver, measured previously. The errors given in this table are the standard deviations which were derived from a comparison of the experimental diffusion coefficients for each composition with the best least squares Arrhenius straight line, ignoring possible uncertainties in temperature.

At a given temperature, the diffusion coefficients increase more rapidly than exponentially with increasing solute concentration. In Fig. 2 are summarized the results of the present and past

TABLE I
VARIATION OF Q AND D_0 IN AG-CD AND AG-IN ALLOYS

<u>Diffusion System</u>	<u>(N)_{solute} (atom %)</u>	<u>Q (kcal/mole)</u>	<u>D₀ (cm²/sec)</u>
Ag in pure Ag	0	44,271 ± 81	.442 ± .018
Cd in pure Ag	0	41,687 ± 211	.441 ± .047
In in pure Ag	0	40,801 ± 432	.412 ± .092
Ag in Ag-Cd	6.50	42,607 ± 294	.306 ± .046
	13.60	40,960 ± 233	.234 ± .030
	28.00	37,254 ± 194	.156 ± .019
Cd in Ag-Cd	6.50	40,482 ± 223	.328 ± .039
	13.60	38,605 ± 54	.218 ± .007
	27.50	35,950 ± 205	.253 ± .033
Ag in Ag-In	4.40	42,665 ± 175	.358 ± .032
	12.60	37,401 ± 561	.116 ± .038
	16.70	36,272 ± 399	.183 ± .044
In in Ag-In	4.70	40,303 ± 544	.453 ± .033
	12.40	38,388 ± 215	.566 ± .074
	16.60	36,605 ± 201	.537 ± .064

Fig. 2 SELF-DIFFUSION IN Ag ALLOYS AT 1000°K

measurements of self-diffusion in alloy systems. It is apparent from this figure that a sudden additional increase in diffusion coefficient takes place at high solute concentrations. This presumably arises from the fact that at low solute concentrations the rate of diffusion of a faster-diffusing impurity is rate limited by the jump rate of the nearest neighbor solvent atoms. At high concentrations a given solute atom may have a second solute atom as a near neighbor. In this case the motion of the solute can be decorrelated by another solute jump, as well as by solvent jumps. Then the rate of solute diffusion may be expected to increase rapidly to a value characteristic of the actual solute jump rate. This effect would presumably become important at solute concentrations of the order of the reciprocal of the coordination number. In close packed cubic lattices this should occur for solute concentrations of about 8 atom percent, substantially as observed in Fig. 2.

It should also be noted that since the solvent diffusion rate is relatively enhanced for all solute concentrations, the presence of two solute atoms at adjacent lattice positions must cause an additional lowering of the barrier for jump of the solvent. In this connection it is interesting to observe that the relative enhancement of solvent diffusion, as shown at the bottom of the figure, apparently depends mainly on the nature of the solute, and varies only slowly with concentration, even at high concentrations. The relative enhancement appears to be intimately related to the valence difference between solvent and solute, consistent with previous calculations.

B. Diffusion Under a Chemical Concentration Gradient

Measurements have been made of chemical and tracer diffusion in Ag - α AgCd diffusion couples. Before the specimens are welded together to form the couples, each is electroplated with a thin layer of radioactive tracer atoms (either Ag^{110} or Cd^{109}), so that initially a layer of radioactive atoms is present at the diffusion interface. After diffusion the specimens are sectioned, and the tracer activity and chemical composition are determined for each section. During diffusion there is a chemical concentration gradient at and near the diffusion interface which can influence diffusion of the tracer atoms.

Experimentally, as shown in Figs. 3 and 4, it is found that the tracer atoms spread out in a non-symmetrical fashion, and also the center of gravity of the layer of tracer atoms after diffusion does not lie at the position of the set of 1 mil tungsten wires placed at the original interface before welding. For both Ag and Cd tracer, the center of gravity of the tracer is found to lie on the Cd-rich side of the wires.

There are several different ways in which the chemical concentration gradient present at the diffusion interface could cause a shift in center of gravity relative to the wires. First, the diffusion coefficient of both tracers increases with increasing Cd concentration, and there is a tendency for the atoms to move in the direction of increasing diffusion coefficient. Secondly, the chemical potential gradient in the non-ideal AgCd solid solution causes Ag to move preferentially toward the Cd-rich side of the interface and Cd atoms toward the Ag-rich region. A third term

Fig.3 Diffusion of Cd^{110} in AgCd Diffusion Couples

Fig.4 Diffusion of Ag^{109} in AgCd Diffusion Couples

arises because the correlation factor is a function of chemical composition. Whether the term is positive, negative, or zero depends on the diffusion mechanism, being positive (i.e. shifts c. of g. toward the Cd-rich side) for an interstitialcy mechanism, negative for a vacancy mechanism, and zero for an interstitial mechanism.

The Kirkendall effect observed in these diffusion couples leads to the assumption that there is a current of imperfections (either vacancies or interstitials) across the diffusion interface. This means that an imperfection is more likely to approach a given atom from one side than from the other, thus adding a fourth term to the expression for the shift in center of gravity. This term is negative for both vacancy and interstitialcy mechanisms and zero for a pure interstitial mechanism. The Kirkendall flow also distorts the crystal lattice in which the tracer atoms are diffusing. This should cause the center of gravity of the tracer to be shifted a distance approximately $1/5$ of the Kirkendall shift.

The fact that the values of the third and fourth terms above depend on the diffusion mechanism suggests that this type of experiment could be useful in determining this mechanism.

Data have been obtained for six Ag- α AgCd couples, using large-grained polycrystalline specimens. The estimated error in the measurement of $\bar{X}$, the shift in center of gravity of the tracer relative to the wires, is ± 4 microns. The tracer measurements can be done very accurately so the only considerable error is in the determination of the position of the wires when the specimen

is sectioned. In one case (Diffusion Couple No. 4) clean cuts were not obtained in the region near the wires, so a somewhat larger error may be expected for this specimen.

By using previously measured values for D_{Ag} and D_{Cd} in AgCd as a function of composition together with the chemical activity data of Herasymenko, a theoretically expected value of $\bar{X}$ has been calculated. In these calculations a vacancy mechanism has been assumed.

Table II gives a comparison of $\bar{X}_{exp}$ and $\bar{X}_{theoret}$, the experimental and theoretical shift in center of gravity.

The term depending on the diffusion coefficient gradient is the largest in all cases and, as pointed out by Le Claire, the fact that this term is larger than the chemical potential term makes it possible for the center of gravity to shift in the same direction for cadmium as for silver. The correlation and Kirkendall flow terms are smaller than the diffusion coefficient and chemical potential terms, but, at least in the cases where cadmium tracer was used, they are not negligible. Very good agreement between the values of $\bar{X}_{exp}$ and $\bar{X}_{theoret}$ is obtained when a vacancy mechanism is assumed. Significantly poorer agreement is obtained when an interstitial or interstitialcy mechanism is assumed. Thus a vacancy mechanism seems indicated.

Measurements on another diffusion couple, in which a large shift in center of gravity is expected, are nearing completion. Preliminary results from this couple lend support to the conclusions mentioned above.

TABLE II
SHIFT IN CENTER OF GRAVITY OF TRACER ATOMS

Diffusion Couple	Tracer	Diffusion Temp. (°C)	Diffusion Time (Sec)	Cadmium Concentration of AgCd Specimen (Atom %)	$\bar{X}_{exp}$ (microns)	$\bar{X}_{theoret}$ (microns)
1	Ag	780	1.75×10^4	27.3	20	18
2	Ag	780	3.62×10^4	27.2	22	24
3	Ag	727	9.98×10^4	27.0	24	28
6	Ag	780	25.88×10^4	15.7	30	26
4	Cd	727	2.65×10^4	26.9	8	16
5	Cd	627	32.98×10^4	27.0	21	22

The contribution to the theoretically predicted value of $\bar{X}$ from each of the five terms discussed above are listed in the following table.

TABLE III

Contributions to Center of Gravity Shift

Diffusion Couple	Tracer	$\bar{X}_{\text{diff. coef.}}$ (microns)	$\bar{X}_{\text{chem. pot.}}$ (microns)	$\bar{X}_{\text{corr.}}$ (microns)	$\bar{X}_{\text{vac. fl.}}$ (microns)	$\bar{X}_{\text{Kirk.}}$ (microns)	$\bar{X}_{\text{theoret.}}$ (microns)	$\bar{X}_{\text{exp.}}$ (microns)
1	Ag	20	2	-1	-1	-2	18	20
2	Ag	26	3	-1	-2	-2	24	22
3	Ag	30	3	-1	-2	-2	28	24
6	Ag	31	2	-2	-3	-2	26	30
4	Cd	45	-22	-4	-2	-1	16	8
5	Cd	57	-24	-6	-3	-2	22	21

$\bar{X}_{\text{diff. coef.}}$ = shift in center of gravity caused by diffusion coefficient gradient.

$\bar{X}_{\text{chem. pot.}}$ = shift in center of gravity caused by chemical potential gradient.

$\bar{X}_{\text{corr.}}$ = shift in center of gravity caused by variation of correlation factor.

$\bar{X}_{\text{vac. fl.}}$ = shift in center of gravity caused by flow of vacancies.

$\bar{X}_{\text{Kirk.}}$ = shift in center of gravity caused by distortion of lattice from the Kirkendall effect.

$\bar{X}_{\text{theoret.}}$ = sum of previous five terms.

$\bar{X}_{\text{exp.}}$ = experimental shift in center of gravity.

The chemical interdiffusion coefficients for AgCd have been determined in the range 0-27 atomic per cent Cd at three temperatures. The experimental values, in most cases, agree to within 15 % with those obtained from Darken's equation, using D_{Ag} , D_{Cd} , and the activities. In the range 0-27 atomic per cent Cd, the thermodynamic factor varies from 1 to 2 1/2. Omission of this factor would result in very poor agreement. The accuracy of the chemical analysis is not as good as that of the tracer analysis, so precise comparisons probably are not justified.

Since Cd diffuses three times faster than Ag in the alloy, a Kirkendall shift is expected. Experimentally it is found that the marker wires move in the predicted direction, toward the Cd-rich region. However, the shifts are small and the accuracy of the experiment does not justify quantitative comparison with theory.

Attempts to measure the Kirkendall shift directly were subject to large errors from edge effects. The position of the Matano interface, as determined from the chemical profile, also was subject to error since the chemical analyses on the small samples used could not be done precisely. In contrast to this, the tracer measurements could be done very accurately, resulting in a very small error in the measurement of the shift in center of gravity of the tracer profile.

III. Effect of Pressure on Diffusion

A. Influence of Hydrostatic Pressure on the Elastic After-effect in AgZn Alloys

During the past year the first experimental apparatus for generation of high pressures has been completed. Experiments have begun on a study of the effect of pressure on stress relaxation in alpha silver-zinc. As shown earlier by Nowick, and largely substantiated by tracer measurements in this laboratory, the elastic after-effect associated with this relaxation process appears to be diffusion limited.

The measurements must be made within the confines of a 1 inch diameter hole inside a heavy steel reactor vessel. The apparatus shown in Figure 5 was constructed for this purpose and appears to give precision at least as good as that achievable with the conventional torsion pendulum method. The material to be investigated is coiled into a helical spring (M). This spring is strained a small amount when the soft iron plunger (P) is raised by the magnetic field of the solenoid (S). A constant strain is assured by a stop which limits the motion of the plunger. The stress required to achieve this constant strain is measured by determination of the minimum current through the solenoid required to keep the plunger just at the position of the stop. By previous calibration with weights it was determined that the actual force exerted by the magnetic field on the plunger is proportional to the square of the current through the solenoid. In this manner, it is possible to measure the relaxation process as a function of time, essentially by determining the minimum stress required to keep the sample at constant strain.

Fig. 5 Apparatus for Measuring Stress Relaxation

The high pressure setup is shown schematically in Fig. 6. Pressure is transmitted to the apparatus through liquid hexane.

The experimental apparatus is contained in a very thick-walled reactor vessel (8 inches O.D. by 1 inch I.D. by 20 inches length); electrical leads are brought in through the bottom closure by means of pipestone seals. The top closure of the reactor vessel is attached to heavy-walled steel tubing which connects the vessel to the pressure measuring device, a manganin gauge, and to the pressure generating unit. The high pressures are generated in an intensifier by a small piston of $5/8$ inch diameter which is pushed by a ram attached to a large piston. The primary pressure is applied by a hand-operated oil pump as shown. The ratio of diameters of the two pistons in the intensifier is such that a pressure of 10,000 psi at the low pressure side produces a pressure of about 10,000 atmospheres at the high pressure side.

The manganin pressure gauge consists of an unconstrained coil of manganin wire. Pressure is measured by determination of the resistance of the coil, which increases linearly with pressure. The gauge was calibrated by determining the freezing pressure of mercury at 0°C (7640 kg/cm^2).

Before starting a stroke with the intensifier, the system is primed to a pressure of approximately 40,000 psi through the auxiliary priming system. A separator is used to isolate the pump fluid from the high pressure fluid.

To date preliminary measurements have been made of stress relaxation as a function of temperature and pressure in AgZn alloys containing about 30 atom percent Zn. In table IV are recorded

TABLE IV

Relaxation Time (τ) as a Function of Temperature and Pressure

Temp. °C	Run No.	Press. kg/cm ²	τ min.
140.7	58	557	5.8 ₃
	59	551	5.9
	60	540	5.8
	61	539	5.7
	62	757	6.3
	63	1084	6.4 ₁
	64	1520	7.1
	65	7825	17.4
	66	8891	20.4
	67	8786	19.8
	68	8637	19.7
	69	6056	14.0
	70	6010	13.5
	72	4003	9.7
	73	2042	6.9
	74	2042	7.0
	75	654	6.18
	76	654	6.2
	77	632	5.98

Temp. °C	Run No.	Press. kg/cm ²	τ min.
150.6	44	561	2.58
	45	550	2.43
	46	9027	9.4
	47	8924	9.0
	48	8866	8.6
	49	8316	8.1
	50	7306	6.8
	51	6297	6.1
	52	5070	5.0
	53	4049	4.4
	54	3074	3.57
	55	2065	2.95
	56	1204	2.65

130.2	78	608	16.2
	79	608	17.0
	80	7778	51.5
	81	6848	41.6
	82	6767	42.4
	83	6676	41.0
	84	6148	39.2
	85	2831	23.9
	86	2810	23.8

Fig.6 High Pressure Set-up

Fig.7 Relaxation Time as a Function of Pressure

typical values of the time, τ , to the inflection point as a function of pressure for three different temperatures. These data are also shown in Fig. 7. It is apparent that there is a marked dependence of the relaxation time on pressure; the relaxation time increases by more than a factor of 4 for a pressure of 9,000 Kg/cm². The relation between $\log \tau$ and pressure is linear within present limits of accuracy.

Up to now, measurements have only been made over a restricted temperature range, and it is not yet possible to state whether or not the activation energy for the process changes with pressure. In addition, the detailed shape of the relaxation curves suggests that the actual process involves more than one relaxation time. Thus, it is not certain that the time to inflection is a true measure of the mean diffusional jump time. This effect is being investigated further.

B. Energy of Motion of Vacancies in Gold at High Pressure.

Recent work by Koehler, Bauerle, and Kauffman has indicated the possibility of determining the effect of pressure on diffusion in gold. By quenching non-equilibrium concentrations of vacancies into gold wires, Koehler and Bauerle have determined separately the energies of formation and of motion for vacancies in gold. The sum of these energies should be the activation energy for the diffusion of the vacancies and, indeed, their result is in very close agreement with the activation energy for self-diffusion of gold as measured by Okkerse with precise radioactive tracer techniques. Since present techniques in high pressure systems preclude the use of the high temperatures required for tracer measurements, the quenching method offers the possibility of a direct measurement of both formation and motional energy.

The experiment is interesting for further reasons. Bauerle and Koehler found that quenches from various temperatures up to the melting point indicated that more than one process is in effect. At their lower temperature range ($\sim 750^{\circ}\text{C}$) a simple single-vacancy process seemed to explain the results, but as the melting point was reached, annealing rates became faster than exponential. Times for one-half of the vacancies to anneal out decreased from the order of 100 hours to one half hour. The formation of vacancy clusters was set forth as an explanation. More recent measurements show that quench rate affects the annealing process. Thus, by varying the pressure in addition to temperature, it is hoped that more can be determined about the mechanism.

Measuring techniques are essentially those developed by Kauffman

and Koehler. The fact that the residual resistance is altered in proportion to the amount of vacancies quenched in is used. The extra quenched-in resistance is measured by comparing the sample (in the form of a 16 mil wire) with an unquenched dummy in a simple bridge arrangement. Equal currents are passed through each arm of the bridge, while differential voltages across specimen and dummy are measured with a microvolt potentiometer. Quenching is achieved by passing an electric current through the sample until the desired temperature is attained and then dropping it into a water bath. The apparatus has been so designed that the specimen and dummy remain attached to the plug of the pressure vessel during all operations, eliminating the possibility of different contact potentials which might arise if leads had to be broken and resoldered between runs.

However, several difficulties remain. There are still contact potentials as the leads must be brought through the plug via steel cones. The bridge arrangement should cancel out any such effects to a great degree, and the fact that the pressure vessel is in a bath whose temperature can be controlled to $\pm .005^{\circ}\text{C}$ should further reduce such effects. One other difficulty cannot be so easily reduced. Since the residual resistivity is small compared to the thermal part at room temperature, measurements are normally carried on at liquid nitrogen temperature. Since the high pressure fluids would freeze at such temperatures it is not possible to use this procedure in the present experiment. For this reason, a factor of 5 in sensitivity will be lost. However, Bauerle had to carry out his most important measurements at room temperature and experienced little difficulty with them.

Energy of motion will be measured by quenching the specimen at atmospheric pressure, placing the apparatus in the pressure vessel, applying pressure, and then immersing the vessel in the constant temperature bath. The fact that very little annealing occurs at room temperature permits these operations to be carried out without losing a significant amount of vacancies. Since annealing times are so long for low temperature quenches, warm-up time of the pressure vessel will be negligible although it may become appreciable for the shortest anneals. Annealing rates at two different temperatures are necessary to determine the motional energy. Again, times to adjust the temperatures will be appreciable only for the shortest runs.

In order to measure energy of formation the quenches will have to be made at pressure. Several possibilities have presented themselves, but their practicality will not be apparent until the apparatus has been completed. The most promising method seems to be that of pulse heating. No method requiring extended heating or heating of the pressure vessel are feasible since the steel would be annealed. Preliminary measurements should be underway by early fall.

C. Ionic Conductivity as a Function of Pressure and Temperature.

It is well known that ionic conductivity in the alkali halides occurs by diffusional motion of positive and negative ions. Thus a measurement of electrical resistivity may be interpreted directly in terms of diffusion coefficients. In studies of diffusion in metal systems, a fairly consistent correlation has been found between the rates of diffusion and the magnitude of the small shear modulus of the solid. While metals generally exhibit a small change in shear modulus with pressure, fairly large changes have been observed for salts. In some cases (e.g. KCl, RbCl) the small shear modulus is even found to decrease with increase in hydrostatic pressure. Thus the study of diffusion in salts as a function of pressure should be extremely valuable in pinpointing the possible correlation between elastic behavior and diffusion in solids. The only previous measurements in this field are those of S. W. Kurnick, who studied ionic conductivity in AgBr as a function of pressure. Since diffusion in this system presumably occurs by an interstitial mechanism, rather than by vacancies, his results are not directly applicable to metal systems.

The present investigation will be concerned with measuring both impurity and intrinsic conductivity in the alkali halides, where a vacancy mechanism is presumably operative. From an instrumental viewpoint this study poses some serious problems. The electrical leads to the high pressure system must be brought in through pipestone pressure seals, which offer a parallel resistance of at most a few megohms. Therefore, it will probably not be possible to measure a

sample resistance much in excess of this limit. Thus, if measurements are to be made in the intrinsic range, fairly high temperatures will be required. Apparently it will be possible to reach temperatures of approximately 400°C with external heating of the high pressure chamber by use of special "red tough" steel. It is planned to include a small heater inside the high pressure chamber in order to reach sample temperatures of 450 or 500°C . There is some question at present as to whether the silicone oils used for transmitting pressure will remain stable under these extremes of temperature and pressure. Even at temperatures of 500°C considerable precision will be required in the resistivity measurement. It is planned to use a General Radio Type 716C capacitance bridge for this measurement.

If this arrangement is successful, it should be possible to measure intrinsic conductivity in the lithium halides, and possibly impurity conductivity in the sodium and potassium halides. Since the impurity conductivity presumably depends only on the energy for motion of divalent ions with associated impurities, it may be possible to separate the effects of pressure on the energy for formation and motion of vacancies.

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