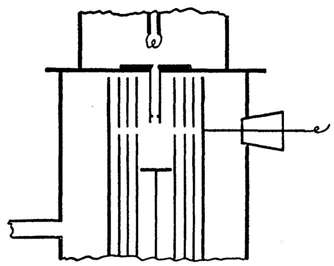

FIG. 12. Apparatus for measuring scattering at 90°.

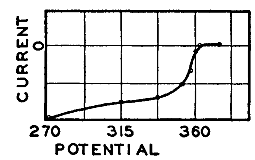

FIG. 13. Current (electron) to the outer cylinder *vs.* potential of the middle cylinder.

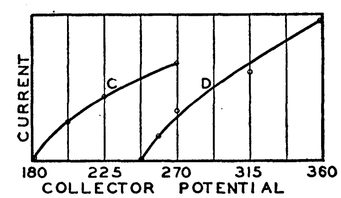

FIG. 14. Positive ion current in second apparatus *vs.* retarding potentials for 270 volt ions (curve *C*) and 360 volt ions (curve *D*) in krypton.

In an attempt to correlate the increased scattering at high voltages with the phenomenon of ionization a comparison of the scattering with the ionization was made. No definite conclusion could be drawn from this comparison but a possible relationship was in evidence.

TABLE II. *Scattering at 90° in the first (column A) and the second (column B) apparatus. Column E gives the number of electrons.*

	Krypton			Xenon			HG	
V	*A*	*B*	*E*	*A*	*B*	*E*	*A*	*E*
90	2.0	2.5	0.0	1.0	1.6	0.0	0.3	0.0
180	1.4	2.2	4.0	2.6	3.2	1.4	3.0	5.0
270	12.3	9.0	6.0	2.6	5.6	4.5	7.4	10.0
360	19.4	11.5	11.0	8.5	9.0	6.0	20.2	20.0

Further work on the scattering curves should lead ultimately to an understanding of the interaction forces between the two particles and a determination of the collision cross sections for the types of collisions which occur.

The author wishes to acknowledge his indebtedness and gratitude to Professor John A. Eldridge for his guidance in this investigation.

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Paramagnetic Measurements at Low Fields with the Rankine Balance

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The Rankine magnetic balance previously reported has been adapted for making paramagnetic measurements at low fields. An analysis of the stability of the balance under these conditions is given. The volume magnetic susceptibilities of gaseous O_2 and of aqueous $NiCl_2$ solutions relative to water are reported, and from these values the relative mass susceptibilities of O_2 and $NiCl_2$ are deduced. The mass susceptibility of H_2O is assumed to be -0.7200×10^{-6}, in terms of which, that of O_2 is 104.4×10^{-6} and of $NiCl_2$ is 33.97×10^{-6}.

IN a previous paper[1] details for the construction of a Rankine balance for measuring magnetic susceptibilities were given. The results of measurements of diamagnetic susceptibilities on mixtures of heavy and light water were reported.

The adaptibility of the Rankine balance for making low field paramagnetic measurements is demonstrated herein, and the results on aqueous nickel chloride solutions and on gaseous oxygen are given.

The equilibrium condition for the Rankine balance is:[1]

$$T+T_0+\frac{\pi m^2 b\kappa \sin\theta}{2x^2}+\tau(\theta+\theta_0)=0, \qquad (1)$$

in which the symbols have the same significance as in the previous paper.[1] For small angular

[1] H. P. Iskenderian, Phys. Rev. **51**, 1092 (1937).

deflections of the beam, T is approximately constant and variations in T_0 may be rendered insignificant if appropriate precautions are taken. Let H_0 and $H_0+\Delta H$ denote respectively the vector magnetic fields of extraneous origin at the north and south poles of the magnet; then, if θ_1 denotes the angle between the increment ΔH and the direction of the beam in its fiducial position, T_0 will be given by $(bm\Delta H \sin\theta_1)$. It is seen that for small deflections of the beam variations in T_0 may in general be appreciable. For stable equilibrium, we must have, in addition to (1), the condition:

$$\left[bm\Delta H\cos\theta_1 + \frac{\pi m^2 b\kappa}{2}\left(\frac{x\cos\theta - 2b\sin^2\theta}{x^3}\right)+\tau\right]>0. \quad (2)$$

In order that the balance have a high sensitivity the magnitude of the expression in (2) should be a minimum.[1] Then, for making paramagnetic measurements over a wide range of susceptibilities, it is essential to reduce the second term in (2) to a minimum by setting the cell at an optimum orientation relative to the beam when the latter is in its fiducial position.

In the present balance, the optimum value of θ is approximately 29° corresponding to $x=1$ cm and $b=2$ cm. It was found that for volume susceptibilities of the order of magnitude of 10^{-6} the second term of (2) was small compared with the first. The improved sensitivity of the apparatus which results from such an optimum orientation of the cell could not be fully utilized in the present arrangement on account of lack of high stability of the suspension due to accidental disturbances. Electrostatic shielding of the test cell from the magnet improved the performance of the apparatus.

Volume susceptibility measurements at field strengths of about 40 oersteds and at room temperatures were made on oxygen and aqueous solutions of $NiCl_2$. The mean of nine independent measurements on oxygen at 20°C is 0.139×10^{-6} with an average deviation from the mean of 0.001×10^{-6}; the corresponding value of $\chi_M T=0.979$ is in good agreement with the theoretical value[2] of 0.993, considering that the oxygen tested was tank oxygen, which probably contains some diamagnetic impurities. This value also agrees well with the results of other investigators:[3] 0.983 (Curie), 0.970 (Onnes and Oosterhuis), 0.975 (Soné), 1.001 (Bauer and Piccard), 1.021 (Wills and Hector), 0.979 (Lehrer), 1.002 (Woltjer, Coppoolse and Wiersma).

[2] Van Vleck, *Electric and Magnetic Susceptibilities*, p. 266.

TABLE I. *The magnetic susceptibility of aqueous solutions of $NiCl_2$.*

ρ_l	C	$-\kappa_l/\kappa_w$	$\kappa_l\times10^6$	$\chi_l\times10^6$
1.0380	0.04105	1.0161	0.7302	0.7034
1.1005	0.1014	4.287	3.081	2.800

The results of measurements on $NiCl_2$ solutions at 20°C are given in Table I.

In the first column are contained the measured densities of the solutions, in the second, the corresponding concentration by weight of $NiCl_2$ determined from data contained in the *International Critical Tables*. In the third column are listed the observed ratios of the volume susceptibilities of the solutions to that of water. The volume susceptibilities shown in the fourth column are calculated from these ratios and the assumed value for water at 20°C, $\kappa_w=-0.7186\times10^{-6}$. The last column gives the mass susceptibilities of the solutions and is calculated from the data of second and fourth columns with the formula, $\chi=\kappa/\rho$.

The mass susceptibility of $NiCl_2$ is computed from the observed mass susceptibilities of the solutions on the assumption that the constituent susceptibilities are additive. Based on the above figures the values are 33.95×10^{-6} and 33.99×10^{-6} respectively, for the solutions containing 4.105 percent and 10.14 percent $NiCl_2$. Similarly, assuming the validity of the additivity law for the Ni^{++} and 2 Cl^- ions in the $NiCl_2$ solutions, the calculated average value of the mass susceptibility of the nickel ion is 75.71×10^{-6}. The corresponding magnetic moment of the nickel ion is 16.0 Weiss magnetons, which is in good agreement with the values obtained by others.[4]

In conclusion the writer gratefully acknowledges his indebtedness to the physics department of Columbia University for the use of the apparatus.

[3] Stoner, *Magnetism and Matter*, p. 342.
[4] Reference 3, p. 327.