takes into account certain factors, such as the finite mortality of the controls, operative at this extremity of the curve.

In Fig. 1 survival times (solid dots) were calculated by equation (2) to fit the observed survival times (open circles). It should be noted that the agreement is good even in the region of inflection. A detailed analysis of the entire experimental data, a discussion of the theory underlying the development of equations (1) and (2), and a consideration of these results with respect to the literature are included in manuscripts in preparation or unpublished. It is believed that these equations are of general applicability in studies involving the action of compounds, such as sodium metarsenite, that exist in solution in two different forms related by a condition of equilibrium. The good fits obtained by use of these equations support the underlying hypothesis and indicate that the effective concentration is not necessarily the concentration of the poison that is injected into the insect. They also support the explanation that the anomaly represented by the region of inflection is the result of the rate of dissociation of the poison as concentration changes and as the fundamental lethal reaction goes on.

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THE MOTION OF SMALL PARTICLES IN MAGNETIC FIELDS

As reported by Ehrenhaft[1] rotational motions have been observed in a constant vertical homogeneous magnetic field using an electromagnet with the pole pieces immersed successively in ferric chloride, copper sulfate and slightly acidulated water. The material in motion consisted of charged particles and bubbles. The speed of rotation was a function of magnetic field intensity. Polar movements of particles of iron and nickel in a gas were observed in a constant vertical homogeneous magnetic field. These movements occurred both with and against the gravitational field and took the form of spirals, parts of spirals or vertical lines.

The fact that solutions of non-uniform concentration or of different layers of concentration will rotate under the action of an inhomogeneous magnetic field has been noted by many observers. Among these is Urbasch,[2] whose work has been commented on by Drude,[3] and the more recent observations of Kendall.[4]

The authors have repeated the experiments on motions in liquids and gases reported by Ehrenhaft and have performed further experiments to study these phenomena. In these experiments the authors have used solutions of uniform concentration or single particles and a homogeneous magnetic field, as did Ehrenhaft. Unless otherwise stated, all observations were made with a microscope[5] employing dark field illumination. The various liquids were placed in a glass cell and the illumination was directed from either side perpendicularly to the line of observation, being supplied by arc lamps with suitable lenses and cooling cells (see sketch). The microscope was usually fitted with a 3X objective and a 4X ocular, though a wide variety of lenses was available and used.

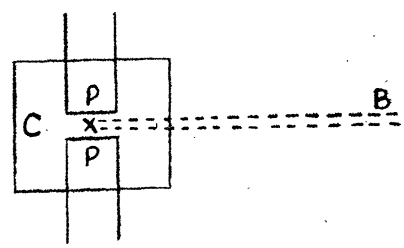

FIG. 1. C—Cell used to hold liquids; PP—Pole pieces; B—Illuminating beam; X—Point under observation. Line of observation is directed perpendicularly into plane of paper.

The electromagnet was constructed in the shape of a rectangle. Three sides of the rectangle, forming a U, had a cross-sectional area of 6 cm^2. The fourth side was completed by detachable pole pieces. On each leg of the U was placed a coil of 9,600 turns of No. 26 B. & S. copper wire. The field could be varied from zero up to 20,000 gausses and was reversible. The coils could be connected singly, in series or in parallel. The current could be varied from zero to two amperes. The separation between the pole pieces was ordinarily from one to two millimeters. The pole pieces were 8 millimeters in diameter. The permanent magnets used were Alnico "Blue Streak" having a total flux of 17,000 to 18,000 maxwells.

In experiments using the electromagnet rotational motions were observed in the following solutions: barium hydroxide, potassium hydroxide, sodium hydroxide, sodium chloride, potassium chloride, sodium fluoride, cupric cyanide, potassium cyanide, 1 per cent. hydrochloric acid, ferrous chloride, ferrous sulfate, ferrous ammonium chloride, ferrous ammonium sulfate, cadmium sulfate, cobalt nitrate, cobalt sulfate, nickel nitrate, nickel sulfate, a suspension of copper in copper sulfate, suspensions of iron, manganese, tungsten, zinc, aluminum, chromium, cobalt, nickel, copper, lead and brass in distilled water, a suspension

1 F. Ehrenhaft, *Phys. Rev.*, 63: 461; 64: 43, 1943; 65: 287, 1944; *Nature*, 3909: 426, 1944.

2, 3 O. Urbasch and P. Drude, *Zeits. f. Elektrochemie*, 7: 114, 1901; 8: 65, 150, 229, 1902.

4 J. Kendall, *Nature*, 3587, 157, 1944.

5 *Ibid.*, footnote 4, page 1.

of aluminum in isopropyl alcohol and numerous other solutions. In many of these solutions dual rotations against each other in the same plane and at the same time were observed. In others this was not observed. Without exception, however, the direction of rotation was reversible with reversal of the field and the speed of rotation was a function of magnetic field strength. Pole pieces of nickel, cobalt and iron were available.

Polar movements in a gas in a constant vertical homogeneous magnetic field were observed. Manganese, tungsten, chromium, nickel, cobalt, copper, aluminum, zinc, lead and brass particles were used. With some metals, such as tin, antimony and bismuth, no movement was observed. Where such polar movements were obtained, all tracks were spirals or parts of spirals.

In another experiment, a suspension of manganese was prepared in a high-grade oil. Spiral tracks of these particles were observed traveling with and against the gravitational field. All these particles moved at approximately the same rate of speed and all terminated their movement on one or the other of the pole faces.

The following experiments were performed using a permanent magnet: Soft iron pole pieces fitted to the permanent magnet were immersed successively in ferric chloride, ferrous chloride, copper sulfate, potassium chloride, sodium chloride, sodium bicarbonate, cobalt sulfate and cobalt nitrate. Rotational motions were observed in each case. Reversal of the magnet reversed the sense of rotation.

At Ehrenhaft's suggestion, the following two experiments were performed: The pole pieces of the permanent magnet were arranged so that only the lower pole was immersed in a solution of ferric chloride. The upper pole was adjusted so that it barely cleared the solution. A rotational motion of the entire liquid was plainly visible without the aid of a microscope. The two pole pieces were then removed and a single soft iron rod was placed across the magnet, a glass cell having been fitted to the center of the rod. This cell was filled with ferrous chloride and a slow rotation of the entire solution was observed. In a variation of the above experiment, the authors immersed the pole pieces in a copper sulfate solution. The rate of rotation was noted and keepers were placed on the magnet. The speed of rotation decreased as the area of the keeper in contact with the magnet was increased.

One of the most beautiful and striking effects was obtained by separating the pole pieces by a distance of about 2 millimeters. A drop of copper sulfate was placed in the gap, the drop filling the entire space between the poles, surface tension causing it to remain in place. The shape of the drop approximated that of an hourglass. The ratio of length to width at the midpoint was dependent on the size of the gap. The entire droplet was observed to rotate. This experiment was repeated using other solutions such as ferric chloride, etc., with like results.

In another experiment, a microscope slide cover glass was floated on a solution of copper sulfate. One pole was immersed in the solution while the other was placed directly above the cover glass. Rotation of the entire solution caused the floating cover glass to rotate.

So far, the motions described have been those of particles in coarse suspension, bubbles and the motion of the entire liquid. The authors next studied the action of a magnetic field on true colloidal suspensions. In these experiments silver nitrate and sodium stearate were used. As before, rotational motions were observed. Large particles formed in the sodium stearate solution experiment and entered the space between the poles of the electromagnet with great speed, depositing on one or the other of the pole faces.

Another set of experiments was performed using the electromagnet and making observations of the action of copper sulfate, ferrous sulfate, ferrous ammonium sulfate, nickel nitrate, nickel sulfate, cobalt nitrate and cobalt sulfate solutions in a magnetic field. When these solutions were placed in a homogeneous magnetic field a slight luminous clouding effect was observed. In every case, this clouding first appeared near the upper pole, gradually dispersing and assuming the shape of a waterspout. Occasionally, striations were observed in the cloud. If copper particles were added to the copper sulfate solution, the copper particles were drawn into the waterspout formation and followed a spiral path down into the narrow portion of the formation.

In experiments using colloidal dispersions of copper, iron, nickel and manganese the dispersion was destroyed by a continued application of a homogeneous magnetic field. The dispersion was observed to gradually become "smoky" and finally disappear. Increasing the power of the microscope to 800X failed to disclose the presence of particles of any size.

The research work thus far has been of a largely qualitative nature. The authors hope to continue their investigations in the field and to make quantitative measurements and also to examine the possibility of a classical theoretical interpretation of the observed phenomena.

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