is also necessary to explain the time lags between the change of potential of the counter wire and the passage of the ionizing ray through the counter.[14] Also our attempts to explain counter phenomena impress us with the lack of information available regarding the mobilities of ions and electrons in high fields. Finally we must make the large reservation that other varieties of counters may not behave in the same manner as those with which we have worked.

In conclusion, we wish to express our great indebtedness to all the members of the Bartol Research Foundation for allowing us the benefit of their discussion and experience on many points.

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[14] C. G. Montgomery, W. E. Ramsey, D. B. Cowie and D. D. Montgomery, Phys. Rev. **56**, 635 (1939); J. V. Dunworth, Nature **144**, 152 (1939).

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Composition of Mixed Vapors in the Cloud Chamber

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The composition of the alcohol-water vapors commonly used in cloud chambers differs from that of the liquid mixtures from which they are produced. This must be considered when ranges or cross sections are to be calculated. Curves are presented for the case of ethanol and water, showing, for various temperatures, the vapor pressure of each constituent as a function of the percent volume of alcohol in the liquid. Attention is called to errors incurred if the cycle of operation is so brief that the vapors do not come up to equilibrium concentration between expansions.

WHENEVER ranges or cross sections are to be determined from cloud-chamber data, it is necessary to know the density and composition of the vapor-laden gas in the chamber at the instant when the ion-trail is formed. Thus we must consider (1) the time required to secure effective equilibrium between the vapor and the liquid on the walls, and (2) the composition of the vapor.

1. Effective thermal equilibrium between walls and gas is established rather rapidly after compression. Kurie[1] found by thermocouple measurements in an 18-cm chamber that the temperature of the chamber gas returned to within 0.1°C of room temperature in 40 to 50 seconds after an expansion or a compression. On the other hand, in large chambers the vapor pressure may remain below equilibrium for a long time. Diffusion is slow and convection depends on temperature gradients in the walls, so we cannot make estimates of general utility, but some idea may be gained from observations of Jones and the writers on the effect of shortening the cycle in a chamber 16 cm×5.7 cm. Conditions are excellent with a cycle approximately 40 seconds long. When the duration of the cycle is cut below 30 seconds, keeping the expansion ratio unaltered, the tracks are not well developed. It is evident that many ions fail to produce droplets, for it is possible to arrange conditions so that only the densely ionized ends of electron tracks are seen. With the cycle duration held at a constant value of the order of 20 seconds, conditions get worse as time goes on so that after 8 or 10 cycles no tracks are seen. This deterioration can be combatted to some extent by increasing the expansion ratio. When the normal cycle and normal expansion ratio are re-established, satisfactory tracks are quickly obtained. There can be little doubt that the short cycle makes the chamber vapor-poor.

2. When a mixture of two vapor-producing liquids is employed, the composition of the vapor is not necessarily the same as that of the liquid mixture. The effect is a large one in the case of the commonly used alcohol-water mixtures and should be taken into account in accurate work.

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[1] F. N. D. Kurie, Rev. Sci. Inst. **3**, 655 (1932); the mechanism of this recovery was elucidated by E. J. Williams, Proc. Camb. Phil. Soc. **35**, 512 (1939).

Here we consider the ideal case, in which we have temperature equilibrium, and equilibrium vapor pressure, before the expansion. It should be remarked that satisfactory track formation is not a proof that these conditions have been attained. For practical reasons we can treat only the case in which there is a considerable excess of liquid in the chamber, so that formation of vapor does not appreciably alter the composition of the remaining liquid and hence the composition of the vapor in equilibrium with it. We assume that in the case of post-expansion tracks, no appreciable condensation has taken place up to the instant of formation of the ion trail, so that the partial pressures of the constituents of the vapor at this instant are calculable from the pre-expansion pressures by dividing by the volume expansion ratio.

The case of methanol and water has been treated by Froemke, Bloomquist and Anderson,[2] and data are available for ethanol-water and normal propanol-water mixtures.[3] Froemke *et al.*, give a curve showing the mol fraction of methanol in the vapor as a function of the mol fraction in the liquid. We shall now deal with ethanol-water mixtures which are of general interest. It is convenient to have the partial pressures as functions of the volume percentage of one of the liquids, measured, of course, before mixing. Since one will ordinarily use 95 percent alcohol, the independent variable may conveniently be the volume percentage of this material. Actually the azeotropic mixture of ethanol and water under a pressure of one atmosphere contains 95.57 percent ethanol by weight, and we used this figure in the conversion from weight percent to volume percent.

Figure 1 shows curves in which the partial vapor pressures of ethanol and water at a given temperature are plotted against the percent by volume of 95 percent alcohol. The solid curves, for 20°C and 40°C, were obtained by direct calculation from the above-mentioned data, while the dotted curves for 30°C were interpolated on the well-supported assumption that over a limited temperature range the logarithm of the partial pressure of a given constituent at a given composition of the liquid is a linear function of $1/T$, where T is the absolute temperature.

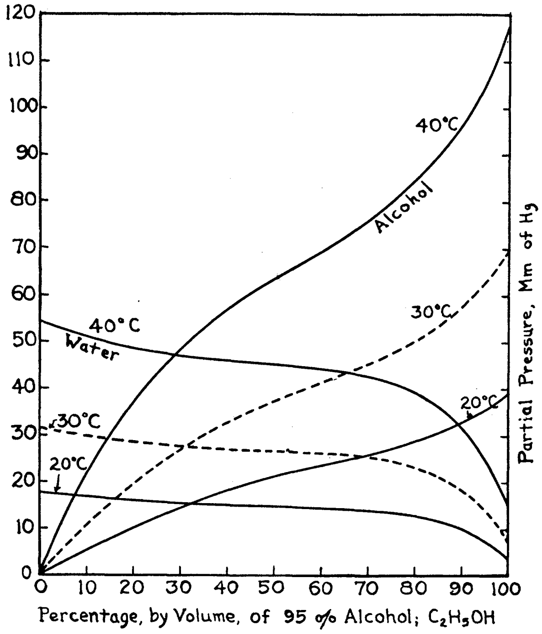

FIG. 1. Partial pressures of water and alcohol as a function of the percentage by volume of 95 percent alcohol.

To show the utility of the curves, let us consider a typical liquid mixture made up with 60 percent, by volume, of the 95 percent alcohol at 30°C. The vapor pressure of alcohol at this concentration and pressure is 42 mm as shown by the graph; whereas, one obtains only 23 mm by multiplying the mol fraction of ethanol by its vapor pressure at this temperature, which would be permissible for ideal mixtures. The absolute magnitude of such discrepancies is smaller for mixtures of normal propanol or isopropanol and water, because of the smaller vapor pressures involved; but since these compounds contain more atoms per molecule, the falsifying effect of using the laws of ideal mixtures should be considered in every case. We shall not give curves for mixtures containing propanols since they are not employed so extensively as the mixtures of ethanol and water.

Vapors containing atoms of high atomic number are sometimes employed in the cloud chamber. If other vapors are present to assist in the formation of droplets, it is necessary to consider their effect in the concentration of such atoms.

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[2] Froemke, Bloomquist and Anderson, Zeits. f. physik Chemie **166**, 305 (1933).

[3] Int. Crit. Tab. **3**, 290–291. These data represent a composite of the results of a number of authors.