extension being provided with a side connection or Y leading to the interferometer. The result obtained with the Willson apparatus was 101.6 p.p.m. carbon tetrachloride. The results obtained with the interferometer, plotted in Figure 4, average 123 p.p.m., with a minimum of 6 p.p.m. and a maximum of 1096 p.p.m. during the $^1/_2$-hour sampling period.

More than one interpretation of this variation in results is possible. It may be that we have here a true measure of the actual difference between the mean of this series of grab samples and the average obtained from an integrated continuous sample.

At first glance one might say that the difference here of 21 p.p.m. between the two methods is within the experimental error of the interferometer and assume the

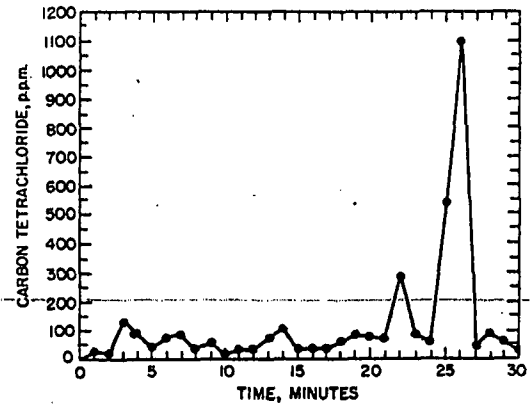

Figure 4. Carbon tetrachloride vapor in air as determined by means of a gas interferometer.

combustion result to be correct. However, although there is a probable error of 20 p.p.m. for one reading on the interferometer, for a series of readings the result obtained is much closer to the correct one, and probabilities are that the combustion apparatus gave slightly low results,[80] especially for the period of time that the concentration was above 500 p.p.m. The correct result may well be assumed to have been 5 to 15 per cent above the combustion results, or between 107 and 117 p.p.m.

The graph is an interesting illustration of another point, that is, of the futility of trying to evaluate a variable exposure by a single, or even a few, random grab samples. To be reliable the grab samples must be taken at frequent regularly spaced intervals. These particular samples represent an abnormal variation in concentration in that the spillage was frequent and variable, with constantly good general ventilation. Under such conditions, if the chief concern is maximum level of con-

[80] F. H. Goldman and C. G. Seegmiller, *J. Ind. Hyg. Toxicol.*, **25**, 181 (1943).

tamination, the industrial hygienist will choose properly spaced grab samples; if toxicity is more dependent upon cumulative exposures, he may prefer the integrated sample.

B. ADSORPTION FOR EVALUATION BY WEIGHT

Many variations of the adsorption method introduced by Greenburg[81] have been proposed by different investigators. The principle is the same in all and the shortcomings are similar. The usual adsorbent is activated charcoal or silica gel contained in convenient weighing tubes. These materials are not selective but readily adsorb most vapors and gases, especially those of high molecular weight. The sample of vapor in air is drawn through the adsorbent at a constant rate, usually 1 liter or less per minute, and after a suitable sample is collected the tube with its contents is weighed. Since practice has shown that variations in weight of silica-gel tubes, and even more so of charcoal tubes, often amount to more than 5 mg. within a 24-hour period as a result of static charges, moisture, and other factors, even though no air has been passed through them, it is obvious that dependable results require samples weighing at least 50 mg. If the sample is collected at the rate of 1 liter per minute, and it is desired to determine the concentration of benzene in the air of a room where the average concentration amounts to 50 p.p.m. (0.16 mg. per liter), it is evident that a sampling time of about 5 hours would be required for dependable results. For higher concentrations this method is more applicable, since less time is required to obtain a sample of suitable weight. Tubes equilibrated for several hours in air of the same humidity and temperature as the atmosphere to be analyzed may be used without filters for removing water vapor and carbon dioxide from the air sampled. However, it is the usual practice in the interest of accuracy to employ such filters wherever they do not alter the concentration of the contaminant. Moskowitz and Burke[82] found it advantageous to have filters before and after the adsorbent. The ones ahead of the adsorbent removed water and carbon dioxide from the air, and the ones following the adsorbent collected water and carbon dioxide lost by the adsorbent as the air passed over it. The adsorption method obviously collects an integrated sample, while it is frequently desirable to follow the changes in concentration in order to obtain information on the height and duration of peak values. The method is applicable to gases and vapors of high molecular weight and moderate toxicity. It must always be borne in mind that many vapors cannot be filtered through drying agents and soda lime without partial or even complete loss within those agents. Since the method warrants an accuracy only to the nearest milligram, weighing usually can be accomplished at any laboratory or in the field. Vapor samples adsorbed on activated carbon or silica gel may also be transported to the laboratory, released by passing heated air through the adsorbent, and the vapor determined by suitable chemical methods of analysis (see also pages 185 and 186).

[81] L. Greenburg, *U. S. Pub. Health Repts.*, **41**, 1516 (1926); W. A. Cook and A. L. Coleman, *Ind. Hyg. Toxicol.*, **18**, 194 (1936).

[82] S. Moskowitz and W. J. Burke, *N. Y. State Ind. Bull.*, **17**, 168 (1938).