A special type of carbon monoxide indicator[13] for this latter purpose, said to be sensitive to 10 p.p.m. and not affected by altitude and temperature changes, has been developed for sale.

In all types the Hopcalite is subject to deterioration with use and it, as well as the filter for removing organic vapors and water vapor, must be renewed periodically. These instruments are valuable and dependable when properly maintained, but are completely unreliable unless they are serviced by competent men. It is good practice to calibrate them with a known mixture of carbon monoxide and air either periodically or else before each series of tests. Carbon monoxide–air mixtures may be purchased in cylinders; or the air mixtures may be made as required by metering carbon monoxide and air, each through a venturi-type flow meter, into a mixing chamber. Carbon monoxide, with a purity of 98 per cent or better, is readily made by dropping formic acid into heated sulfuric acid and passing the gas through soda lime to remove acid vapors. The carbon monoxide thus generated or carbon monoxide purchased in cylinders may be used to make the desired mixtures.

Flame Safety Lamps. Flame safety lamps that have been approved by the United States Bureau of Mines[14] are satisfactory for the recognition and rough estimation of some combustible gases as well as of atmospheres deficient in oxygen.[15] Obviously they must be used correctly in flammable atmospheres in order to avoid accidental ignition of the atmosphere.[16]

4. Ultraviolet Absorption Devices

Ultraviolet absorption has been used successfully to measure mercury vapor and more or less successfully for trichloroethylene and some other vapors.[18] If this type of instrument can be developed with variable wave length and sensitivity control, it should prove useful for both qualitative and quantitative air analysis for gases and vapors, and especially so in mixtures of unknown composition. In the device for measuring trichloroethylene, light of a fixed wave length in the ultraviolet range is passed through an absorption cell onto a cell sensitive to ultraviolet light. When air containing vapors having an opacity to light of this wave length is passed through the cell, the depletion of transmission is proportional to the concentration of the vapor, providing the atmosphere is free of dust.

The following is a promising variation, involving analysis in the laboratory. Samples of some solvent vapors, collected by drawing the atmosphere through an especially good grade of granulated silica gel at about 1 liter per minute can be

[13] W. P. Yant, personal communication.
[14] J. W. Paul, L. C. Ilsley, and E. J. Gleim, *U. S. Bur. Mines Bull.* No. **227**, 1924.
[15] A. B. Hooker, E. J. Coggeshall, and G. W. Jones, *U. S. Bur. Mines Rept. Invest.*, No. **3327**, 1937.
[16] W. H. Tomlinson, *U. S. Bur. Mines Circ.* No. **7271**, 1944.
[17] T. T. Woodson, *Rev. Sci. Instr.*, **10**, 308 (1939).
[18] V. F. Hanson, *Ind. Eng. Chem., Anal. Ed.*, **13**, 119 (1941).

transported to the laboratory in glass-stoppered bottles, leached out with a small amount of methanol and an aliquot evaluated successfully by means of the Beckman ultraviolet spectrophotometer.[19]

C. COLLECTION IN INDICATOR MEDIUM

Certain contaminants may be collected in scrubbers or impingers containing a liquid medium that by change of color serves as an indicator. By this means a predetermined amount of an atmospheric contaminant may be recognized; it is then only necessary to consider the volume of air that has been sampled up to the time of color change in order to estimate the concentration of the material. The accuracy of such methods is usually within the range of 80 to 98 per cent, depending upon the gas sampled and the efficiency of the scrubber. Although not entirely satisfactory for research work, or for the setting of standards of maximum permissible contamination, these methods are particularly useful in informing the industrial hygienist—in the field—of the order of intensity of contamination and therefore whether control is necessary, and if so, to what extent.

As an example of how this may be used to advantage, without adding an impractical burden of weight to the field equipment, consider the determination of ammonia or acid gases using the midget impinger, with or without special scrubbers, as the sampling device. The sampling rate must be accurately calibrated. The impinging liquid is water with a measured amount of standard 0.01 *N* acid or alkali containing 0.01 per cent methyl red indicator. The standard reagents can be carried in small glass-stoppered bottles and pipetted into the scrubbers as required. The skill of a chemist is required for making up the standard solutions, but any experienced industrial hygiene engineer, exercising ordinary care, can carry out the sampling technique of loading scrubbers in an uncontaminated atmosphere and noting the operating time required to produce a color change in the collecting liquid. The computation for a sampling rate of 2832 ml. per minute is: 1 ml. 0.01 *N* reagent = 0.2445 ml. monovalent gas at 25° C. and 760 mm. Hg pressure,

$$0.2445 \times 1{,}000{,}000 \times \frac{\text{ml. reagent}}{2832 \times \text{minutes}} = \frac{86 \times \text{ml.}}{\text{minutes}} =$$

p.p.m. for gases of one hydrogen equivalent

For gases having two hydrogen equivalents the formula becomes (43 × ml.)/minutes. This has been used successfully for ammonia and most of the common acid gases.

Hydrogen sulfide, sulfur dioxide, and hydrogen cyanide may be determined in a similar manner, employing 0.01 *N* iodine solution and starch indicator. The hydrogen cyanide is collected in a sodium bicarbonate solution containing the iodine. This reaction requires one mole of iodine for one of hydrogen cyanide, since each atom of the molecule combines with an iodine atom:

$$NaCN + I_2 \rightarrow NaI + CNI$$

[19] M. Adams, personal communication.