per unit of time; together with a consideration of such odoriferous operations as may exist in the ventilated spaces, and the purity of the source of air supply. Thus air drawn from near the level of the city streets will require more ozone to maintain the proper concentration, than will air drawn from purer sources. This applies equally to air drawn from the vicinity of stock yards and the like.

Likewise restaurants, smoking rooms, dance halls, and theatres will require a greater quantity of ozone than will schools, offices, etc. Department stores, particularly the basements, due to odors arising from fabrics and other wares, require special consideration. There is also what may be called the "building co-efficient," which includes the length of the duct system, the heigths of the ceilings, and the condition of the ventilating system, whether old and dusty or new and clean, together with the rate of air change, and whether humidity control is provided or not.

In industrial ventilation, where specific contaminants are to be contended with, a knowledge of the concentration and character of the contaminating substances is essential for best results. Ozone is not a cure-all for industrial odors in general, for instance, allyl alcohol vapors, which possess an annoying odor, when subjected to action with ozone, produce the aldehyde acrolein, which is exceedingly irritating, even in very small concentrations. Here harm rather than good will be done. It is best to submit problems of this character to engineers experienced in the use of ozone for definite recommendations.

It has been recommended (Hill & Aeberly, *Heating and Ventilating Magazine*, March, 1922) that sufficient ozone capacity be provided to permit of building up comparatively high concentrations when the building is not occupied. In schools, for example, the ozone equipment should be operated at a capacity to give perhaps 0.01 ppm of ozone when the building is occupied, and after the pupils have left the building, the full capacity of the machine should be used, closing all openings, recirculating the entire amount of air, and building up a sufficient concentration to exert the maximum deodorizing effect throughout the building, the duct work and mechanical equipment.

For general ventilation, under average conditions (85 per cent ventilation), the ozonizer should be of sufficient capacity to provide a concentration of 0.05 ppm of ozone in the fan volume. For 100 per cent ventilating systems a lesser quantity can be made to suffice. A generalization cannot be made broad enough to cover the many special conditions, particularly problems of specific deodorization.

**Determining Required Capacity**

Having chosen the maximum required concentration of ozone, for the purpose in hand, it becomes necessary to calculate the capacity of the ozonizer. There seems to be no agreement, among makers of ozone equipment, regarding the unit of rating for ventilating ozonizers. There are three methods in common use, as follows:

*Parts per Million:* wherein the ozonizer is rated in parts per million (generally by volume) in some specific air volume. At first this may seem a very desirable method for rating ozonizers, as it is simply necessary to state the ppm of ozone, required for the specific CFM of air. Ozonizers so rated, have their ozone meter calibrated in ppm for the specified CFM, and should the fan volume be varied, the meter is liable to become





misleading, as the original CFM may not always be considered when reading it. Consideration of the original CFM, and proportioning to any new CFM, is essential with an ozonier so rated, if accurate knowledge of the concentration employed at any other CFM is desired.

Ozone is generally applied on the basis of ppm by volume, and as there is no existing agreement concerning a standard temperature and pressure at which the ozonizer should be calibrated, this method of rating leaves the actual capacity of the unit open to question, unless the temperature and pressure employed for calibrating is stated. Since weight is unaffected by temperature and pressure, and as ozone is determined chemically, directly in the terms of weight, weight forms a better basis for the rating of ozonizers, and eliminates a number of qualifying factors, together with tedious calculations in ozonizer design.

*Milligrams per Minute:* Ozonizers so rated have their ozone meter calibrated directly in the terms of milligrams per minute, and leave no questions concerning the actual capacity of the unit. Errors of omission are further circumvented by forcing a consideration of all factors, when determining the concentration of ozone in the air of the ventilating system.

The expression ppm, generally means parts per million by volume at room temperature and average barometric pressure, when referred to ozone in ventilation. One litre of ozone at 25 deg. Cent. and 740 mm Hg, weighs 1.9127 grams. Taking these conditions as a basis, the weight of 1 cc. of ozone may be taken as 2 milligrams, yielding a very convenient figure for use, easily remembered, and sufficiently accurate for all practical purposes. The metric system is best employed here, for convenience of analysis and calculations of design, with final conversion into English units for purpose of application. It is on this basis that the following formulae have been derived:

*Formulae for Application:*

CFM = Fan Capacity, cubic feet per minute of air.
mpm = Milligrams of ozone per minute.
ppm = Parts of ozone per million parts of air, by volume, at 25 deg. cent. and 740 mm. Hg.
28,320 = cc per cubic foot.
2 = weight of 1 cc of $O_3$ at 25 deg. cent. and 740 mm. Hg.

Given: CFM and ppm; Find: mpm

$$\frac{\text{CFM} \times \text{ppm}}{10^6} \times 28{,}320 \times 2 = \text{mpm}$$

which reduces to:

$$\frac{\text{CFM} \times \text{ppm}}{10^3} \times 56.64 = \text{mpm} \qquad (1)$$

Given: mpm and ppm; Find: CFM

$$\frac{\text{mpm} \times 10^3}{56.64} \times \frac{1}{\text{ppm}} = \text{CFM} \qquad (2)$$

Given: mpm and CFM; Find: ppm

$$\frac{\text{mpm}}{56.64} \times \frac{10^3}{\text{CFM}} = \text{ppm} \qquad (3)$$

*Ventilating Unit*—The Ventilating Unit (VU) has been created by the author, for the purpose of simplifying the calculations for applying ozone to ventilating systems. It is a compound unit, taking into consideration quantity and time. It is analagous to the horsepower, wherein 33,000 pounds are lifted one foot in one minute. It represents that quantity of ozone necessary to produce a concentration of 0.1 ppm in 1,000 CFM, at 25 deg. cent. and 740 mm Hg.

1 VU = 5.7 milligram of $O_3$ per minute
340 milligrams of $O_3$ per hour

The formulae for its application are very simple:

Given CFM and ppm; Find VU

$$\frac{\text{CFM}}{100} \times \text{ppm} = \text{VU} \qquad (4)$$