velocity of the air entering the cleaner, and it is determined by taking the air flow and dividing it by the area of the duct connection to the cleaner in square feet. Cleaners are often rated at a face velocity in the range of 250 to 500 fpm. The resistance of an air cleaner to air flow is usually measured in inches water. The resistances of filters when new and clean and when operated at rated capacity are generally available from the manufacturer (see *Catalog Data Section*).

The ability of air cleaners to clean air is called the efficiency or the arrestance, and may be denoted by the symbol E. The efficiency of an air cleaner differs with the size and nature of the dust on which the cleaner operates. Obviously, large particles and lint are more easily captured than minute particles which are small in all dimensions. The efficiency of an air cleaner, algebraically expressed, is:

$$E = \frac{D_1 - D_2}{D_1} \qquad (1)$$

where

D_1 = amount of dust per unit volume in uncleaned air.

D_2 = amount of dust per unit volume in cleaned air.

Several methods have been investigated for evaluating D_1 and D_2. The particle count method is not used for efficiency evaluation except in investigation of filter performance on specific particles such as pollen or on certain industrial dusts harmful to health. Dust particles can be captured on microscope slides by means of one of the various kinds of impingement devices. The process is useful if an inspection and analysis of dust is desired, but particle counting is not sufficiently precise for evaluating the efficiency of a cleaner operating on a heterogeneous dust.

The weight method of evaluating efficiency has found wide utility and was recognized by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and incorporated in a code [4]. For this test, a known weight of a prepared dust is injected into air supplied to the filter and the quantity of dust in the cleaned air is determined by extracting and weighing the dust from a known volume of the cleaned air. Dust extraction from the air is accomplished by drawing the air through a porous crucible or thimble by means of a high vacuum.

The *dust-spot* or *blackness* test for cleaner efficiency was developed at the *National Bureau of Standards* [5]. The test consists of drawing samples of cleaned air and of uncleaned air through filter papers simultaneously. The ratio of the areas of paper through which the air samples are drawn and the ratio of the amount of air drawn through the papers are adjusted during successive trials to yield spots of approximately equal blackness on the papers. The ratios of the areas and of the volumes of the air samples are then indicators of the filter effectiveness. A special photometer is provided for comparing the blackness or opacity of the papers by transmitted light. For tests of ordinary air filters by this method, a dust is injected into the air stream. The dust consists of precipitated smoke particles from a Cottrell precipitator used in a local power plant for smoke abatement. For tests of electrostatic air cleaners, no dust is added to the air. Tests are commonly made with the dust existing in the air at the location of the installation on a clear day. Some specifications for this type cleaner have required that in dust spots of equal area the downstream spot shall not be any dirtier than the upstream spot when 10 times as much air is drawn through it as is drawn through the upstream

spot. When this condition is met the cleaner is said to have an efficiency or arrestance of 90 per cent or better on atmospheric air.

Dust-holding capacity is defined as the amount of dust which a filter can retain and have a resistance less than some arbitrary value. The term applies only to non-automatic air cleaners. Determination of dust-holding capacity is an objective of each test under the A.S.H.V.E. Standard Code [4]. Curves are obtained during such tests to show the relation between dust load and resistance. Typical curves are shown in Fig. 2. Type A is a dense pack used in bacterium control; Type B is a medium pack used for general ventilation work; and Type C is a low resistance unit, for use where low resistance is the important factor and maximum cleaning efficiencies are not essential.

At the *National Bureau of Standards* two injectors are provided on the air cleaner testing apparatus. One injector is used to contaminate the air stream with Cottrell precipitate, previously described. This dust is used to make both efficiency determination and dust-holding capacity tests. The other injector contaminates the air stream with cotton linters with which lint-holding capacity tests are made. The curves in Fig. 3

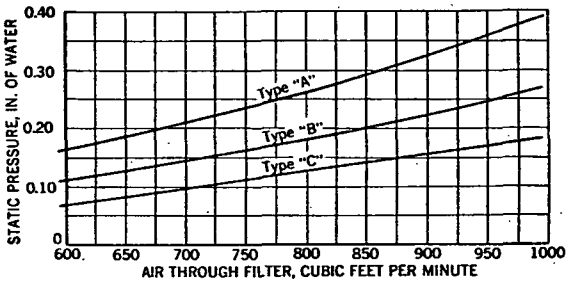

FIG. 2. RESISTANCE TO AIR FLOW OF TYPICAL UNIT AIR FILTERS

illustrate the difference in the characteristics of two filters, one a viscous-impingement type and the other a dry filter with a cellulose fiber medium. The two injectors can be operated either separately or simultaneously. A total dust deposit of 4 per cent cotton linters and 96 per cent Cottrell precipitate gives a deposit on a filter closely resembling those that occur in Washington, D. C.

SELECTION AND MAINTENANCE

For removing fine dust or liquid particles which show no gravitational settling tendency electrical precipitators are highly effective in air cleaning applications. The electrostatic equipment is comparatively expensive to install and maintain. However, in many applications where the cleanest air possible is needed, this expense is justified by the results obtained with properly installed and operated electrostatic air filters.

The advantage of the automatic impingement type filter consists in the small amount of attention which it requires. Such devices are therefore to be recommended where labor is scarce or where reliable and frequent attention to filters cannot be assumed. This type of equipment is not any better in dust arrestance than some unit filters, and it ranks next to precipitators in first cost.