cleaner differs with the size and nature of the dust on which the cleaner operates. The efficiency of an air cleaner, algebraically expressed, is

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

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 inspection and analysis of dust are desired, but particle counting is not sufficiently precise for evaluating the efficiency of a cleaner operating on a heterogeneous dust.

A weight method of evaluating efficiency was described in a former code of the AMERICAN SOCIETY OF HEATING AND AIR-CONDITIONING ENGINEERS and incorporated in a code.[6] 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.

Caution is to be exercised in interpreting published air filter arrestance data, since the test efficiency may be somewhat higher than that which will be obtained in an installation with respect to the ventilated space.

The *dust-spot* or *blackness* test for cleaner efficiency was developed at the *National Bureau of Standards*.[7] The test consists of drawing samples of cleaned air and of uncleaned air through filter papers simultaneously. One such test apparatus consists of a means of drawing samples of air simultaneously through two filter papers, one on each side of a light chamber. The intensity of light from a single bulb passes through these papers and falls on two photo-cells. The cells are connected to the same galvanometer and if the light falling on one cell decreases faster than the light falling on the other, the galvanometer moves off the zero position. The flows of air through the filter papers are kept in such ratio as to keep the galvanometer on the zero position, showing that the papers are becoming dirty at equal rates. The ratio of the sampling rates is then an index to the efficiency of the filter under test.[7] Actual atmospheric contamination is commonly used as the basis of test.

The *National Bureau of Standards* has also used prepared dust and lint in its air cleaner testing apparatus, two injectors for contaminant being used. 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 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.

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 fixed type air cleaners. Determination of dust-holding capacity is an objective of each test under the former A.S.H.V.E. Code.[6] Curves are obtained during such tests to show the relation between dust load and resistance.

Fig. 4 indicates the range of resistance to air flow found in tests of four unit air filters. Type A is a dense pack used in bacterium control; Type B is a medium pack used for general ventilation work; Type C is a low resistance unit, for use where low resistance is the important factor and maximum cleaning efficiencies are not essential; and Type D is a high-velocity viscous-impingement filter.

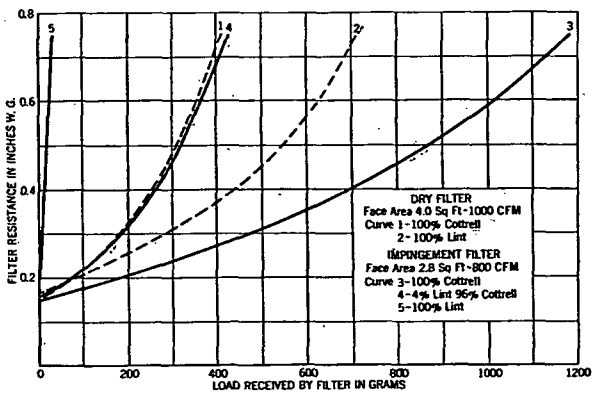

FIG. 3. DUST AND LINT HOLDING CAPACITY OF TWO FILTERS

SELECTION AND MAINTENANCE

To evaluate filters and air cleaners properly for a particular application, two factors should be carefully weighed: (1) the degree of air cleanliness required and (2) disposal of the dirt after it is removed from the air. These factors affect initial costs, operating costs and the extent of maintenance that will be required. Savings that accrue through reduction in housekeeping expenses, protection of valuable property and equipment, ability to carry on dust-free manufacturing processes, improved working conditions, and even health benefits should be credited against the cost of installing and operating an adequate system. The capacity and physical size of the unit required may emphasize the need for self-cleaning features. Operating costs, predicted life, and efficiency are more important than first cost, because air cleaning is a continuing process.

While electronic air cleaners have a higher first cost, they exhibit very high efficiencies in cleaning atmospheric air, due largely to their ability to remove fine dust which shows no gravitational effect. They are equally effective on coolant oil mists from high speed cutting and grinding machines. System resistance remains unchanged as dirt is being collected, and the