on chains, and are alternately dipped in oil and exposed to the air stream.

Charged-Media Electronic Air Cleaners

The charged-media type air cleaner consists of a dielectric filtering medium, usually arranged in pleats as in typical dry filters. No ionization means are employed. The dielectric filtering medium may consist of glass fiber mat, cellulose mat,

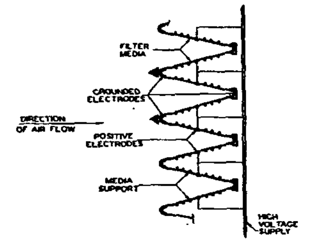

Fig. 2 . . . . Cross-Section Diagram of Charged Media Type Electronic Air Cleaner

or other similar material, and is supported on or in contact with a gridwork consisting of alternately grounded and charged members, the latter usually being held at a potential of 12,000 volts d-c. An intense and non-uniform electrostatic field is thus created through the dielectric medium. Airborne particles approaching the field are polarized and drawn toward filaments or fibers of the media. The general arrangement illustrating this type of filter is shown in Fig. 2.

The precipitator of this type offers resistance to air flow, when clean, on the order of 0.10 in. of water at 250 fpm velocity and, unlike the ionizing type, the resistance of the charged-media type electronic cleaner rises as dust is accumulated on the media. Because of these characteristics the filter tends to equalize the air distribution over the face of the filter. Like typical replaceable-media mechanical filters, the charged-media precipitator is serviced by replacing the filtering medium. The dielectric properties of the media are impaired when the relative humidity exceeds 70 percent.

AIR CLEANER PERFORMANCE AND TESTING

Atmospheric air cleaners are generally rated in terms of the three more critical factors in performance; namely, (1) resistance vs air flow, (2) efficiency or arrestance vs dust load at design air flow, and, (3) resistance vs dust load at design air flow.

Air flow is expressed in cubic feet per minute and is therefore a function of face velocity and filter size. Face velocity is defined as the average velocity of the air entering the effective face area of the cleaner and may be expressed by the equation:

$$V = Q/A \qquad (1)$$

where

V = face velocity, feet per minute.
Q = air flow, cubic feet per minute.
A = effective face area, square feet.

Effective face area is further defined as that area of the filter face inside the enclosing frame, flanges, or seals, but not corrected for any area occupied by any bracing, and retaining or strengthening grid members, located within the enclosing frame.

The rated capacity of general ventilation filters is often based on face velocities in the range of 250 to 520 fpm. Resistance to air flow, measured in inches of water column, at rated capacity, is generally available from the manufacturer (see Catalog Data Section). A suitable allowance must be made in the system design for increase in resistance as the filter becomes loaded with dust. Fig. 3 indicates the range of resistance to air flow found on tests of four unit 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.

The effectiveness of air cleaners in removing a given dust from the air is called efficiency or arrestance. If the efficiency is denoted by E, then algebraically E is given by:

$$E = \frac{D_1 - D_2}{D_1} \qquad (2)$$

where

D_1 = amount of dust per unit volume in uncleaned air.
D_2 = amount of dust per unit volume in cleaned air.

A number of procedures for evaluating air cleaner efficiency have been proposed and are in use. These procedures differ principally in the type of test dust that is used and in the method of measuring the dust content of the entering and leaving air. The numerical value of the arrestance or efficiency of an air cleaner may be different for different methods of test even when the same test dust is used, and is generally different for different test dusts using the same test method. Caution is to be exercised in interpreting published arrestance data, since the test efficiency may be different from that obtained in an actual installation, or in the space being supplied with air.

The two most common methods for evaluating efficiency are: (1) the weight method, in which the weight concentration of dust in the air entering and leaving the filter is measured by some suitable means, and (2) the dust spot test in which the dust content of the entering and leaving air is measured in terms of its ability to stain filter paper. The particle count method is not used for efficiency evaluation, except in investigation of filter performance on specific par-

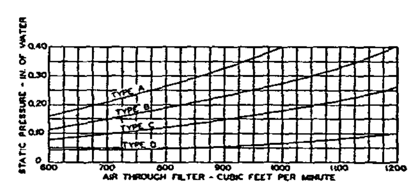

Fig. 3 . . . . Resistance to Air Flow of Four Unit Air Filters

ticles 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.

Among the weight methods that have been used are the Air Filter Institute Code[6] and modifications of the former ASHVE Code.[7] By the latter test method, 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 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 test dust specified in the ASHVE Code is a mixture of coal ash and carbon black.

The Air Filter Institute Code, Section I, specifies a test dust as follows:

"The test dust mixture consists of 72 percent standardized air cleaner test dust, fine (Arizona road dust, fine); 25 percent K-1 carbon black; and 3 percent No. 7 cotton linters (percentages by weight)."

As in the ASHVE Code, the entering concentration (D_1) is determined by feeding a known weight of the prepared test dust. The concentration of dust in the air leaving the filter (D_2) is determined by passing the entire air flow through a high-efficiency filtering blanket known as an absolute filter, the gain in weight of which is measured. Test data and results are presented on standardized forms made available by the Air Filter Institute.

The dust-spot or discoloration method of test for air-cleaner efficiency was developed at the National Bureau of Standards.[8] In effect, this method is based on a comparison of the volumes of air before and after cleaning by the filter that must be drawn through unit areas of suitable filter paper to yield dust spots of equal opacity to transmitted light as determined by means of a photometer. For example, if equal opacities are obtained when the amount of air sampled, per unit area of dust spot, is four times as great for the downstream paper as for the upstream paper, the efficiency of the filter is considered to be 75 percent, since the dustiness of the cleaned air, as measured by change in opacity, is one-fourth that of the uncleaned air. To obtain equal opacities, samples may be drawn at equal rates for equal times through unequal spot areas, or at equal rates through equal areas for unequal times, as best suits the circumstances. Tests may be made with atmospheric air, or with an artificial dust dispersed in the air stream.

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. Under the AFI[6] and the former ASHVE[7] procedures dust-holding capacity is defined as the product of the weight of dust reaching the filter and the average efficiency at a specified resistance and air flow. Dust loading and arrestance determinations are made simultaneously, arrestance and resistance being determined for each increment of feed with the results plotted against weight of dust fed or against accumulated load in the filter.

Dirt-loading measurements are made at the National Bureau of Standards[9] by feeding a mixture of 4 percent cotton linters and 96 percent Cottrell precipitate (by weight) to the test filter. The two ingredients are separately dispersed into the air stream, using two aspirating-type injectors. The measurements show the relationship between the pressure drop and the weight of dirt mixture received at the filter. The curves in Fig. 4 illustrate the difference in the dirt-loading characteristics of two filters, one a viscous-impingement type and the other a dry filter with an extended-surface cellulose-fiber medium, with dust and with lint.

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 resulting residue is disposed of directly to prepare the equipment for further duty. The charged-media type cleaners are less effective than the ionizing type, but are appreciably better than mechanical filters in the matter of small particle collection.

The advantage of the moving-curtain 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. The constant pressure drop of this type of filter is an advantage. The first cost is substantially greater than that of unit filters, and the dust arrestance may not be any higher.

Unit filters constitute the majority of air cleaners now in use, and some choice is possible between the types avail-

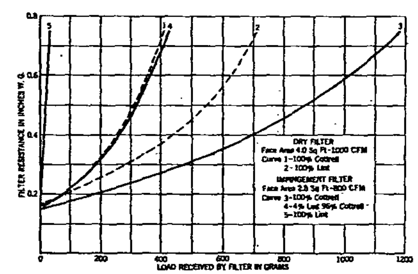

Fig. 4 . . . . Dust and Lint Holding Capacity of Two Filters