and in some cases may seriously obstruct heating and cooling coils. Dust settles, or is precipitated by heat or air motion, upon furniture, fixtures and walls and the only satisfactory treatment is washing or re-painting. Dust is more difficult to capture than lint, and, obviously, small particles are more difficult to capture than large ones. The air cleaning problem is complicated by the vast difference in size of dust particles, the range of which is shown in Fig. 1, Chapter 10.

Even if the discussion is limited to the range from 0.1 micron to 50 microns, that is, between the smallest particle observable in the microscope and the smallest particle distinguishable to the naked eye, this range is so far outside the usual experience that it is difficult to visualize. If particles could be examined through a super microscope having a magnification of 250,000 diameters, a tobacco smoke particle of 0.1 micron would appear to be 1 in. in diameter, or approximately the size of a golf ball; a soft coal smoke particle 0.3 micron in diameter would appear like a baseball; a ragweed pollen grain 20 microns in diameter would appear 16.5 ft in diameter, while the 50 micron particle, just visible to the naked eye and able to pass through a 270 mesh screen, would appear to be 50 ft in diameter. Picturing this range in particle size from a golf ball to a sphere 50 ft in diameter will emphasize the difficulty of cleaning air or of devising any single test to adequately measure the performance of air cleaning devices under all conditions of service.

As a general rule, the removal of the coarser dust particles and lint from the ventilating air produces tangible results in so far as cleanliness in a house or building is concerned, because much of the finer dust remains suspended in the air and is removed from the building by the circulating air. However, since some of the fine dusts are undoubtedly deposited by means other than settling, such as electrical or thermal precipitation [2,3] and by contact, the ability to remove small particles is desirable in an air cleaner if it can be obtained at not too great a cost.

CLASSIFICATION OF AIR CLEANING MEDIA

Considering the wide diversification of materials and particle sizes to be removed and the varying requirements which have to be met in the field, it is obvious that many kinds of air cleaning devices used cannot be shown satisfactorily in a simple outline. Classifications on three different bases are enumerated as follows:

(A) Principle of air cleaning; 1. Viscous-impingement filters, 2. Dry filters, 3. Washers, 4. Centrifugal devices, 5. Electrical precipitators, (B) Methods of servicing; 1. Automatic, 2. Non-automatic, (a) Throw-away (replaceable elements). (b) Manually cleaned in place (including one type of electrostatic). (c) Removable for cleaning. (C) Classification according to applications; 1. General air conditioning—(a) Central cleaning system, (b) Unit ventilator, (c) Window installation, (d) Warm air furnace, 2. Removal of smoke and fumes from stack gases, 3. Collection of dusts from exhaust systems.

VISCOUS IMPINGEMENT TYPE CLEANERS

The medium in a viscous impingement type filter is usually a fiber pack for non-automatic types or a series of metal plates for automatic self-cleaning types. In either case, the medium is treated with a viscous substance, often an oil or grease, called the *adhesive* or the *saturant*, intended to retain dust particles which come in contact with it. Also, in

either case, the arrangement is such that the air stream is broken up into many small air streams and these are caused to change direction abruptly a number of times in order to throw the dust particles, by momentum, against the adhesive. Several desirable characteristics of an adhesive for air cleaners of this type are: (1) Its surface tension should be such as to produce a homogeneous film or coating on the filter medium, (2) The viscosity should vary only slightly with normal changes of temperature, (3) It should prevent the development of mold spores and bacteria on the filter medium, (4) The liquid should have high capillarity, or ability to wet and retain the dust at all operating temperatures, (5) Evaporation should be slight, (6) It should be fire resistant, (7) It should be odorless.

Various fibrous materials have been used as filtering media in unit filters of the viscous impingement type. These include glass fiber, steel wool, similar *wool* of non-ferrous metals, wire screen, animal hair, hemp fibers, and other materials. In such filters, the medium is often packed more densely on the discharge than on the approach-side in order to increase the dust holding capacity. This results in a selective arrestance of dust with the larger particles nearer the approach face. The arrangement also permits some penetration of lint into (but not through) the filter, so that the amount of lint which can be tolerated on the filter is also increased. Due to plane surface area the viscous impingement type filter, however, may be inferior to some dry types if the air carries a high percentage of lint.

The resistance of air filters obviously increases with the air flow through them. Face velocities of about 300 fpm and resistances in the range from 0.1 to 0.2 in. water, when the device is new and clean, are usual for ventilation system filters. Special filters with low resistances are available for use with gravity warm air furnaces and for other applications where only low pressure is available.

The resistance of these filters increases with dust or lint loading and it is the resistance due to this cause which ordinarily necessitates servicing. The rate of loading obviously depends upon the amount as well as the kind of dust in the air and for this reason periods between servicing cannot be predicted. Manometers are often installed to indicate the pressure drop across filter banks and they serve to indicate when the filter requires cleaning. The pressure drop tolerated differs between operators and system designs. The resistance of a filter bank can be kept desirably low by periodically servicing some but not all of the units in the bank at one time, providing the difference in resistance between the clean and dirty filters is small.

The method of cleaning viscous impingement unit filters differs for different types of filters and kinds of dust. Much dry dust or lint can often be removed by rapping the filter.

Throw-away filters are constructed of inexpensive materials and are designed to be discarded after one use. The frame is frequently a combination of cardboard and wire.

Cleanable types usually have metal frames. Various cleaning methods have been recommended including: air jet, water jet, steam jet, washing in kerosene, and dipping in an oil. The latter may serve both to clean the filter and add the necessary adhesive.

Automatic Viscous Filters

In an automatic air filter, means are provided to remove the dust from the medium mechanically. Automatic filters with moving cloth media