ventilated space, by the protection of the equipment in the ventilation system itself, and by providing relatively dust-free air for critical manufacturing processes.

Cleaning devices for atmospheric air are classified by the principle employed to collect dirt particles: i.e. impingement on viscous coated media, filtration through porous media, or electronic air cleaning. In some cases a filter may display a combination of these principles. Each type of air cleaner has certain advantages. There are applications where it is desirable to pass air through a series of two or more different types to obtain optimum results.

AIRBORNE PARTICULATE MATTER

Suspensions of particulate matter in the air are called aerosols and consist of smokes, dusts, mists, and fumes. The characteristics of the aerosols which affect the performance of an air cleaner include particle size, concentration, shape, density, velocity, and surface characteristics. One of the most important of these is size.

The rate of settling of particles varies approximately as the square of the diameter. Particles larger than 10 microns in diameter settle so rapidly that the concentration of such particles decreases rapidly as the distance from the source increases. Particles less than 1 micron in size settle so slowly that the ordinary convection currents prevent sustained downward motion, and consequently such particles remain in the air for long periods.

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 of 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. Consideration of this range in particle size from a golf ball to a sphere 50 ft in diameter will emphasize the difficulty of devising any single test to measure adequately the performance of air cleaning devices under all conditions of service.

The particles in the atmosphere can range in size from less than 0.01 micron up to things which are caught by an ordinary fly screen, such as lint, feathers, and insects. Almost all conceivable shapes and sizes are represented. The material is very commonly soot, ash, soil, lint, smoke, and fumes, but may include particles of almost any inorganic or organic material and even such living organisms as virus, bacteria,[3] and fungus spores.

This wide variety makes it impossible to design one type of cleaner which will be best for all applications. Mechanical filters of the low pressure type can remove large particles effectively. Other mechanical filters can remove extremely fine particles, but may be handicapped somewhat by high pressure drop and cost. Electronic air cleaners have the ability to give high effectiveness on normal atmospheric contamination, with a low operating pressure drop.

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, especially smoke and fume particles, are undoubtedly deposited by means other than settling, such as electrical or thermal precipitation[4, 5] 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.

VISCOUS IMPINGEMENT TYPE FILTERS

The viscous impingement type of filters consist of relatively coarse media constructed of a suitable fiber, screen, wire, mesh, metal stamping or plates, or a combination of medias. The filter may be of the unit type manually-cleaned, the replaceable type, or the self-cleaning type.

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 rate of 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.

Filters designated as high velocity units are also available. In most instances these filters employ a uniform media pack and give best performance at velocities about 500 fpm. Impingement type air filters should hold a substantial amount of adhesive so that the dirt collected by the filter will be retained. The design and construction should also provide a goodly proportion of free space through the media so that high velocities can be used without excessive resistances. The design should assure that the media throughout the thickness of the filter will be effectively utilized