ticles in separators, either gravitational or centrifugal, thus preventing clogging and overloading of the filters or precipitators used for the fines. Air cleaning devices for this purpose must meet the severe conditions of temperature and corrosion while handling large air volumes at low power and labor costs.

## SEPARATORS

In addition to the air cleaning devices previously mentioned, the following are common types available for application to the removal of stack gases.

### Gravitational Settling Chambers

The larger dust and gas particles will settle out from air if time and space are provided. Since the settling rate is constant, the required time of retention of the air in a gravitational settling chamber varies directly with the distance through which the particles must fall before reaching a retaining surface. Horizontal plates placed parallel with the air flow are effective and introduce negligible resistance. Air velocities should be selected so that the settled dust will not be redispersed, and for this reason baffles or constrictions producing increased velocity or turbulence should be avoided.

Relations between time of gas passage, distance of fall, and size of particles removed can be calculated from Fig. 1 in Chapter 4. With a forward air velocity of 50 fps passing between horizontal 14 ft shelves placed 3.3 in. apart vertically, particles of 100 microns, which settle at the rate of 59.2 fpm, will all have time to settle through the 3.3 in. vertical distance and reach the shelf while the air is passing along the shelf. Due to redispersion, actual operation would be much less favorable except at low air velocities.

Simple settling chambers consist of large spaces through which air velocities are decreased to one or two feet per second and in which dust particles fall into hoppers. In proper design, the inlets and outlets are placed and baffled so as to cause minimum turbulence, and the collected dust is protected from eddy currents.

### Centrifugal Separators

The force causing settling can be increased many times that of gravitation by giving the air a whirling motion and introducing centrifugal force. The settling rate then becomes dependent upon the peripheral air velocity and the radius of curvature as well as upon the other factors.

In centrifugal and cyclone separators, air is introduced tangentially into a vertical cylinder and passes out from the center of the top. The gas velocity and curvature of the cylinder cause whirling which throws the particles to the surface. In the simple centrifugal type, the particles slide down the surface and are removed through a hopper in the cone bottom. In the cyclone type, they are thrown through slits in the periphery and collect in a second outer cylinder where the air is nearly static and there is little chance for redispersion.

Assumptions regarding streamline flow and turbulence make general calculations of centrifugal settling rate quite involved and rough. Their





range of usefulness is indicated in Fig. 1 of Chapter 4. They have wide application in connection with industrial operations such as grinding, screening, combustion, etc., but have little or no effect upon the finer particles.

Small diameters give smoother stream lines and larger centrifugal forces for the same power consumption, so that several small units in parallel are to be preferred to one larger one.

## INDUSTRIAL FILTERS

In principle and practice the industrial dry filters are similar to those used for general ventilation, the latter being a development of the former. Bag filters up to 2.5 ft in diameter and 30 ft long, hung vertically, are fed through a header, allowing gas to pass out through the sides of the bag and retaining the dust particles on the inner surface. Depending on the nature of the cloth or mat filtering medium, retention of fines can be very high if gas velocity is low, about 0.5 to 3 cu ft per square foot per minute. The collected dust particles themselves aid in agglomerating and retaining others. Periodic shaking, with the fans off or reversed, at intervals of a few hours drops the excess dust into a lower header or hopper for removal.

Readily removed filters built in small sections in which filter media can be replaced are of distinct advantage where deterioration is rapid. Various styles of construction are available which combine quick interchangeability and large filtering area per square foot cross-sectional area. Use of several independent units in parallel is important for the reconditioning of each unit separately. Both continuous and intermittent shaking and sweeping devices remove excess dust and maintain a low resistance.

## ELECTRICAL PRECIPITATORS

For removing fine dust or liquid particles which show no gravitational settling tendency, electrical precipitators are highly effective in air cleaning applications. In this system of air cleaning the particles are first ionized in a region where they acquire an electrostatic charge. The separation of the particles is then accomplished by passing the air between parallel plates where the dust particles are attracted to grounded collecting electrodes. The electric field holds them to this electrode unless a high critical redispersing gas velocity is exceeded. Particles are shaken down by either periodic mechanical or hand rapping.

The materials of construction for the apparatus may be selected to meet nearly any required conditions of temperature and corrosion. The discharge electrodes are usually of metal in the form of wires or edges placed equidistant between collecting electrodes either in the form of hollow pipes or plates. By properly choosing the type of electrodes the generation of oxides of nitrogen may be practically eliminated.

Voltage requirements depend primarily upon the electrode spacing and the gas conditions or particle nature. The maximum field intensity is limited by the arcking voltage for the particular conditions. The discharge electrode should be negative because with this charge higher voltages may be carried without arcking.