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Louis Brookman, Jr., *Business Manager*
L. Moeller, *Circulation Manager*
Harold O. Hayes, *Promotion Manager*

Representatives

New York City
E. Macdonald Bacon
17 West 45th—Room 909
Longacre 3-5260

Detroit
Parker & Tarbell
419 Curtis Bldg., 2842 W. Grand Blvd.
Madison 1540

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Room 1009, 155 Montgomery St.
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The Cement Mill Edition of CONCRETE is edited exclusively for those interested in the manufacture of portland cement and related products.

Its pages are devoted to discussions of plant design, management, operation, production efficiency, chemical research and control, quarry operation, progress and news of the industry.

The Cement Mill Edition also contains all the material published in the corresponding Regular Edition and so provides news of the uses and merchandising of the materials whose manufacture is discussed in the Mill Edition.

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J. C. WITT, *Consulting Editor*
A. C. BAMBERGER, *Assistant Editor*

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DUST-COLLECTING SYSTEMS

Discuss Various Types in Engineering Report

DUST collection in all its engineering phases is discussed in the final report of the committee on the prevention of silicosis through engineering control, presented to the National Silicosis Conference sponsored by the United States Department of Labor. Warren A. Cook, of the Connecticut State Department of Health, Hartford, Conn., is chairman of this committee. The full report has been published by the Department of Labor as *Bulletin No. 21, Part 2.*

A complete dust-exhaust and collection system, the report emphasizes, consists of the following four parts:

(1) Exhaust hoods.
(2) Piping or duct system.
(3) Air-cleaning plant.
(4) Source of suction.

Each of these parts contributes essentially to the smooth working of the whole system, and no part can be used alone. For convenience in presentation, however, the report discusses the four items separately.

Exhaust Hoods.—The design of exhaust hoods has been worked out in considerable detail for a number of applications, while representative velocities which should be attained at the face of the hoods are given in the accompanying table.

If the source of dust is a device such as a tumbling mill, as used in casting cleaning, the mill itself becomes the hood. By keeping the mill under a negative pressure, outward leakage of dust is prevented.

In the case of abrasive cleaning cabinets or rooms, the entire enclosure is ventilated, keeping it under negative pressure, and all of the exhaust air is passed through the duct work to the dust collectors. In order to remove the dust from such devices as mills, cabinets and rooms, it is necessary to provide properly placed openings of suitable size to permit air to flow into the device. Due to the high velocity flow of air, dust and dirt do not escape through these openings when properly designed, but instead are conveyed through the exhaust system.

Exhaust hoods for rotating devices, such as grinding wheels, must overcome the fan action of the rotating wheel in addition to overcoming the energy imparted to the dust particles as they are shot off from the object being ground. Accordingly, the exhaust hood should enclose the wheel so far as is practicable.

A special application of the exhaust hood is the so-called drill-dust trap used extensively in rock-drilling operations. This device consists of a small portable hood through which the drill steel is inserted. Exhaust applied to this hood removes the dust at its source. The drill-dust trap has been shown to be effective in controlling dust produced by this operation.

In designing hoods for jobs for which there are no reliable data, it is advisable to make up light models or experimental hoods and actually try them under practical operating conditions. From the information thus gained, permanent hoods may be designed. A convenient device for testing the efficacy of exhaust hoods is the ordinary flashlight equipped with a focus adjustment. If the plant illumination about the hood is either dimmed or cut off, the flashlight beam, brought into the region of the hood opening, permits a general indication of the accumulation, direction of motion, and speed of travel of dust. The same testing arrangement serves well in exploring elevators, chutes, conveyors, and the like for dust leaks, and thus helps to determine what air volumes must be handled in order to control dustiness.

Piping.—The duct work leading from the exhaust hoods to the dust arrester is made up of such size, shape, and weight as will accommodate the air volumes and dust loads to be handled. Obviously, it is the part of economy to handle as small air volumes at as low velocities as is practical. Velocities must be great enough to carry all of the dust drawn into the piping without settling in the horizontal runs. If the dust is mixed with large materials or with other substances which might injure the fan or arrester, it is advisable to place preliminary separators or traps between the hood and arrester.

Equations for calculating velocities needed to transport materials pneumatically have been worked out by Dalla Valle and Martin. In practice, it is usual to employ velocities varying from some 1,200 feet per minute for a light, fluffy material like sawdust to 5,000 feet per minute for lead dusts. It must be borne in mind, however, that the concentration of dust in the air stream greatly affects the velocities to be used. Generally, velocities of less than 2,000 feet per minute

A modern Pacific Coast cement mill installation for electrical precipitation of dust

should not be used in duct work. Casting tumbling mills require about 5,000 feet per minute in the branch pipes because of heavy concentration of dust. Grinding and polishing systems generally function properly with a 4,500 feet per minute branch-pipe velocity and 3,600 feet per minute header-pipe velocity. A fair average found in dust-collecting installations is from 3,500 to 5,000 feet per minute. Lower velocities are very apt to allow settling out of dust, while higher velocities entail a needless waste of power. The cross-section area of the header pipes of an exhaust system may be somewhat greater than the sum of the cross-section area of the branch pipes, but in order to reduce friction losses and conserve power this increase in area should not be more than 20 per cent.

MINIMUM AIR VELOCITIES REQUIRED TO CAPTURE CERTAIN INDUSTRIAL DUSTS

Industry	Process	Required air velocity At point of origin	Required air velocity At face of hood	Criterion
Granite cutting	Hand pneumatic tool	[1] 200		Reduced concentration to safe level.
	Surfacing machine	[1] 1,500		Do.
	All tools		1,500	Do.
Paint spraying	Spraying booth		50–200	Do.
Sand pulverizing	Bagging machine	[1] 400		Do.
Quarrying and mining	Horizontal drilling, drill dust trap.	[1] 60		Safe concentration.
Quarrying and mining	Vertical drilling with drill dust trap.	[1] 200		Do.

[1] Feet per minute.

Piping and duct systems should always be provided with clean-out facilities in order that the system may be examined internally and cleaned out when required.

Inertial and Other Primary Separators.—Inertial and other primary dust separators, such as cyclones and other devices, depend for their air-cleaning action on centrifuging out the dust particles by rotary motion or on imparting to the transporting air stream a quick change in direction, accompanied by a reduction in velocity. These devices are probably the oldest of the mechanical dust collectors, and have had a wide use in industry. Their principal appeal has been that they are relatively cheap, are easy to install, and the resistance is usually low, resulting in moderate power consumption. They are furnished by practically every firm engaged in the ventilating or dust-collecting business. In capacity they range from a few hundred cubic feet per minute to many thousands. They are handling dusts of practically every kind and description, and are admirably adapted to exhaust systems from such equipment as woodworking machines, and polishing and buffing wheels. They are the simplest type of collectors made.

It is common practice to install these separators in the line ahead of and as an integral part of the final separator, such as a cloth or bag filter, in order to reduce the load or dust concentration fed to the filter cloths and to remove heavy particles that excessively abrade the blowers, fans, or arresters. However, the preliminary separators of the inertial type can not be relied upon to furnish air sufficiently clean to satisfy hygienic requirements. They must always be supplemented by secondary cleaners whose particular function is the removal of fine particles at high efficiency.

Secondary Separators and Other Types of Arresters.—Dust particles which can not be caught in inertial separators are removed by one of the following methods:

1. Filtration.
2. Scrubbing by water or other fluids.
3. High-tension electric precipitation.
4. Dynamic precipitation.

Filtration.—Industrial air filters handle concentrations of 4 milligrams to 50 grams per cubic meter (0.004 to 50 ounces or 1.7 to 20,000 grains per 1,000 cubic feet) at a velocity of about 0.5 to 10 feet per minute at the filter. In industrial processes with heavy dust loadings, velocities of 3 feet per minute or less are recommended. If the arrester is to operate efficiently, the velocity should never exceed 3.5 feet per minute. The collected dust may have a cash value, which helps defray the operating costs, but usually this dust is worthless and its disposal is something of a problem.

It does not matter whether industrial filters are in the form of flat screens or bags. Many examples of both can be seen today, and either type, when properly designed and maintained, has a high operating efficiency.

When new, all-cloth filters emit some dust in the discharge air, but this leakage soon stops. As dust piles up on the upstream side of the cloth, resistance to air flow increases and less air goes through the system. The rate at which the resistance of a filter cloth builds up depends upon the rate at which particles are deposited upon the cloth. In order to reduce this resistance, it is customary to shake the accumulated dust off the fabric at regular intervals or whenever suitable pressure gages or manometers show that resistance has become prohibitive. Unless the filter manufacturer gives specific directions to the contrary, filter cloths should not be shaken when air is passing through them.

There are few pieces of standard equipment that will deteriorate faster than cloth filters that are neglected. Routine inspection, routine shaking, and routine cleaning out of the units are imperative if the expense of upkeep is to be kept within reasonable limits.

Wet Collection.—It has been common practice for years in power-plant and blast-furnace operation to clean the dust from large volumes of gas by passing the gas through scrubbing or washing devices of various kinds. Such wet collectors, however, have had little application for industrial dust of hygienic interest. Recently new designs of wet arresters have been introduced which cause the dirty air to be impinged against wetted surfaces or which utilize other means of bringing the air into intimate contact with the liquid.

Wet collectors are particularly applicable where much moisture is present in the air being exhausted. One of the most valuable features is that the resistance, which is relatively low, is constant for a given exhaust system, so that the system always functions the same under the conditions for which it was designed. These wet arresters are now beginning to find considerable application in industrial dust collection.

Electric Precipitation.—For the past 25 years high tension electrical precipitation has been applied successfully to the removal of dust, fumes, and mists from air and other gases. The method has many advantages over the other methods discussed, but so far it has not been applied extensively to the solution of the problems with which this silicosis conference is concerned.

Dynamic Precipitators.—This equipment effects removal of entrained dusts by means of a specially designed fan in which the rotating element imparts a centrifugal force to the dust particles up to

1,000 to 1,200 times their specific gravity and thereby separates them from the air stream. Originally these precipitators were designed for the collection of dry dust, but recently the construction has been modified to permit the introduction of water into the dirty air intake, thus extending its application to additional types of dusts. In determining the applicability of this device, consideration must be given to the type of dust to be handled.

Exhaust Fan.—In the interest of economy, it is generally advisable to install the exhaust fan beyond the cloth filters rather than before them. The fan then handles clean air, and abrasion of the blades and housing is minimized. With the fan installed before the arrester any leaks in the arrester case cause escape of dust, resulting in contamination of the atmosphere.

Design of Exhaust Systems.—Other considerations in the design of exhaust systems are:

1. Dampers and gates should be used only for two purposes in the ducts of an exhaust system: (*a*) To balance the system with respect to air flow and then be permanently adjusted; (*b*) to provide fire stops where necessary.
2. Once an exhaust system has been designed and installed for a certain job, additional exhaust outlets can not be added to the original system without reducing the effectiveness of the system and lowering its efficiency—excepting where such additions have been anticipated and the header pipes are sufficient to accommodate them.
3. The number of outlets on an exhaust system should not be reduced and the header pipe flanged off where the branches are removed, unless an amount of air equal to that which the system was originally designed to handle is allowed to flow through the header pipe to the exhaust fan.
4. Several smaller exhaust systems are often preferable to one large system.

Appraisals of Results.—A complete dust-collecting system is designed to handle certain volumes of air measured usually in hundreds or in thousands of cubic feet per minute and to collect certain weights of dust measured usually in pounds or tons per working day. Detailed procedures for testing and measuring air flow in exhaust systems have been published. If the primary purpose of the system is to recover a dust that has a cash value, it may not be necessary or even advisable to exceed an over-all efficiency of 98 or even 95 per cent. If the object in view is to achieve a certain degree of air cleanliness in the work place or in the air discharged from the cleaning system, results are to be measured in terms of the cleanliness of this air. The air volumes handled, the tonnage of dust collected, and even the operating or air-cleaning efficiency of the system are secondary considerations. The engineer must state what degree of cleanliness the system should attain. He should be able to show, in court if necessary, whether or not the plant is being operated according to good modern practice, or preferably according to requirements determined either by competent research, or as prescribed by law or codes.

In appraising the cleanliness of air one's instinct is first to compare it with clean country air (0.1 milligram per cubic meter [0.0001 ounce or 0.04 grain per 1,000 cubic feet]),[1] with city air (0.5 to 2.0 milligrams per cubic meter [0.0005 to 0.002 ounce or 0.2 to 0.9 grain per 1,000 cubic feet]), with the air of a thick fog or haze (1 to 3 milligrams per cubic meter [0.001 to 0.0003 ounce or 0.4 to 1.3 grains per 1,000 cubic feet]), with the atmosphere of an air-conditioned theater (less than 0.2 milligram per cubic meter [0.0002 ounce or 0.09 grain per 1,000 cubic feet]), with the air of any workplace in which adequate dust control is being practiced (less than 10 milligrams per cubic meter [0.01 ounce or 4.3 grains per 1,000 cubic feet]), with some dusty job in which no dust control is being enforced (over 100 milligrams per cubic meter [0.1 ounce or 4.3 grains per 1,000 cubic feet]), and finally with concentrations of inflammable dust which are high enough to furnish an explosion hazard (10 to 50 grams per cubic meter [10 to 50 ounces or 4,000 to 22,000 grains per 1,000 cubic feet]). According to the U. S. Department of Agriculture, concentrations should not exceed from 7 to 10 ounces per 1,000 cubic feet, depending upon the composition, fineness, and other factors.

If such comparisons are to be reliable, the use of a simple measuring technique as described in the report of the subcommittee on determination of concentration and composition of industrial dust, is essential. Results can be given in any of the units listed above or else in numbers of particles per unit volume. It is impossible to convert numbers of particles to weights with any real precision because such conversions require particles of uniform size and shape. In practice, dust particles are never uniform. Approximate conversions, good enough for many purposes, can be made by assuming that 0.7 milligram per cubic meter (0.0007 ounce or 0.3 grain per 1,000 cubic feet) is equivalent to 6,000,000 particles per cubic foot, or, that 1 milligram (0.001 ounce or 0.4 grain per 1,000 cubic feet) contain 300 million particles as sampled and counted by the impinger technique as given in the subcommittee report referred to above.

Summary.—It is unwise to attempt too wide an application of any particular type of final dust separator, whether it be a cloth arrester, a wet collector, or a precipitator. Generally, the manufacturer of the particular device can define its particular uses and limitations. The customer, in turn, should be prepared to furnish reliable data on the physical and chemical properties of the dust to be collected, such as particle size, hardness, hygroscopicity, solubility, and dryness. It is very important that the approximate dust concentrations or dust loadings be given.

The purchaser should demand of the vendor a statement as to the probable performance of the system under definite conditions and should receive detailed instructions as to its operation, upkeep, and repair.

Fundamental requirements relating to the design and operation of exhaust systems in general are presented in a report[2] recently developed by the American Standards Association. This report is of direct use to those designing and operating dust-exhaust systems.

[1] NOTE.—See the following equation:
1 *ounce per cubic foot* = 1 *gram per liter.*
1 ounce per 1,000 cubic feet = 1 milligram per liter.
1 ounce per 1,000 cubic feet = 1,000 milligrams per cubic meter.
1 grain per 1,000 cubic feet = 2.3 milligrams per cubic meter.

[2] Fundamentals Relating to the Design and Operation of Exhaust Systems. Code Z9. American Standards Association, New York, preliminary edition. 1936.

Link-Belt's Interesting Exhibit at New York World's Fair

LINK-BELT Company has arranged an exhibit of exceptional interest for New York's World's Fair. It is arranged to portray in working models, photo murals, and colorful, realistic dioramas and translites, how industry can ease labor's burdens, expedite production and reduce costs, by using mechanical conveying equipment for handling materials from where they are to where they are wanted next.

A dominant central sculptured figure depicts the spirit of power transmission; and various types of driving units are shown in operation. This includes silent and roller-chain drives, three types of enclosed automatically-lubricated speed reducers, and the Link-Belt *P.I.V. Gear* variable-speed transmission for infinitesimally and conveniently changing the speed of machinery, while it is in operation.

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