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DUST ELIMINATION IN THE POTTERY INDUSTRY*

BY EDWARD SCHRAMM

ABSTRACT

Dust counts were made in different parts of a pottery with and without natural and induced ventilation. The hoods installed at the benches of the finishers and setters and the remodeled stoveroom air-circulating system are described and illustrated. The effectiveness in reducing the dust count is given quantitatively.

I. Introduction

There have been two generally recognized health hazards in the manufacture of pottery, one due to the use of lead, the other to the breathing of air containing silica dust. The former is more easily dealt with since in most potteries the use of lead is localized to dipping and glaze making. It has been found that "fritting" the lead, *i.e.*, smelting it into a glass before grinding into the glaze mixture, removes the danger of lead poisoning if the lead silicates or borosilicates are compounded to be only slightly soluble in acids so that they are not readily absorbed by the system. The practice of "fritting" and other precautionary measures have been adopted by many potteries in which lead poisoning is almost unknown today. The dust problem, however, is more difficult; it is a problem not confined to the potteries and in fact is more serious in various other industries. The writer, therefore, was sufficiently concerned with it to undertake an experimental study of conditions in the plant to serve as a guide to remedial measures.

II. Dust Particle Count

In initiating this work, the writer was fortunate in having the assistance of Dr. Leonard Greenburg of the United States Public Health Service. Dr. Greenburg had been instrumental in the development of a convenient and efficient apparatus for dust determinations known as the impinger (Fig. 1).

(1) Impinger In this machine, air is forced at high velocity through a nozzle under water, striking a brass plate, and is broken into many bubbles. Due to the inertia of the dust particles, the impinging serves to free them of the adhering air film so that they are wetted and retained by the water in the flask.

NOTE: A demonstration of the principle can be given with tobacco smoke in an ordinary pipette. If the smoke-laden air be blown slowly through water in a beaker or flask, the smoke can be seen to emerge. If, however, the end of the pipette be placed close to the bottom of the beaker and the smoke-laden air sharply ejected, the extremely fine tobacco smoke particles are absorbed and the air comes through clear.

The impinger machine is provided with a flow meter of the Venturi type which is calibrated against a gas meter. In operation air is sucked through at the rate of one cubic foot per minute and the time of sampling can be varied at will, 15 or 30 minutes being usual. The sample in the flask is diluted to 500 or 1000 cubic centimeters according to the time of sampling; 1 cubic centimeter portions are examined in a counting cell for the dust count at a magnification of 100×, objective and eyepiece each 10×. A factor is used to convert results to the number of particles per cubic centi-

* Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Pittsburgh, Pa., February, 1933 (Materials and Equipment Division). Received February 24, 1933.

meter of air. The remainder of the sample is filtered through a Gooch crucible to give the total weight of dust collected.

(2) Dust Count and Dust Weight To check the technique, two half-hour samples were taken under different atmospheric conditions. These were each divided in two and worked separately giving the results in Table I.

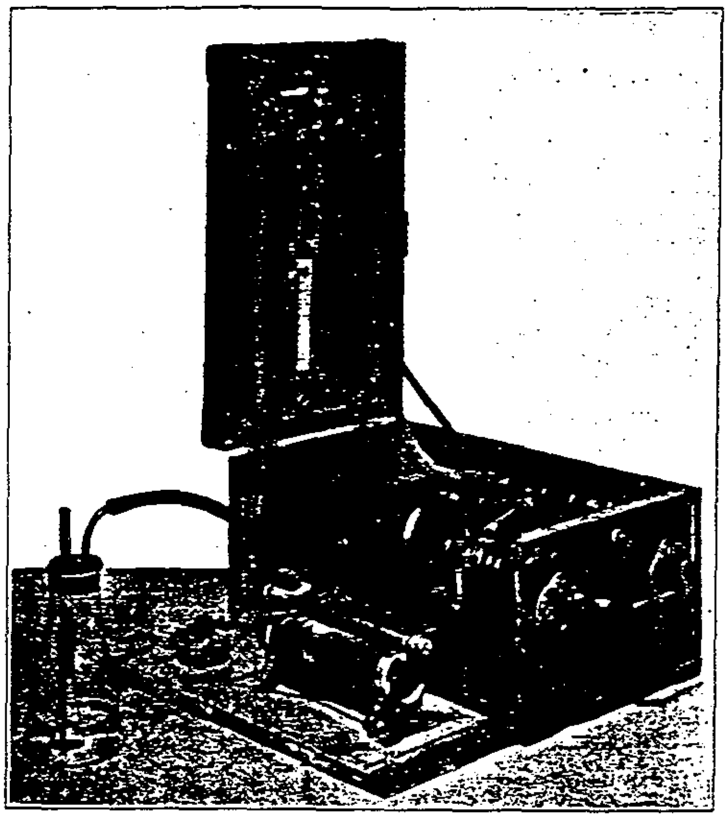

FIG. 1.

TABLE I
CHECK ON LABORATORY WORK

Sample	Dust count per cc. air Total	Over 10μ	Dust weight (mg.)
1a	119	2.3	0.8
1b	125	2.1	0.6
2a	61	1.7	0.3
2b	51	1.1	0.3

As a further check simultaneous samples were taken with two machines, the results being recorded in Table II.

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CHECK

Sample	Machine
1	A
1	B
2	A
2	B
3	A
3	B
4	A
4	B

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(1) Jigger Shop The
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The number of large particles, over 10μ diameter, is not an important fraction of the total, nor are these larger particles important from a health standpoint, so that in later work this observation was omitted. The dust counts are fairly consistent throughout; the checks on the weighings appear less satisfactory but it must be remembered that very small quantities are being considered. With low dust concentrations the counts appear more reliable than the weighings; with high concentrations the case is probably reversed since the counts become more difficult and the filtration and weighing subject to less error. It will be seen in what follows that the counts and weighing are generally in agreement and the double method gives a rough check on the work.

TABLE II

CHECK ON SAMPLING AND LABORATORY WORK

Sample	Machine	Dust count		Dust weight (mg.)
		Total	$>10\mu$	
1	A	244	3.4	3.2
1	B	274	3.5	2.1
2	A	224	4.1	1.4
2	B	228	3.4	1.9
3	A	48		1.4
3	B	54		0.8
4	A	56		0.8
4	B	58		0.8

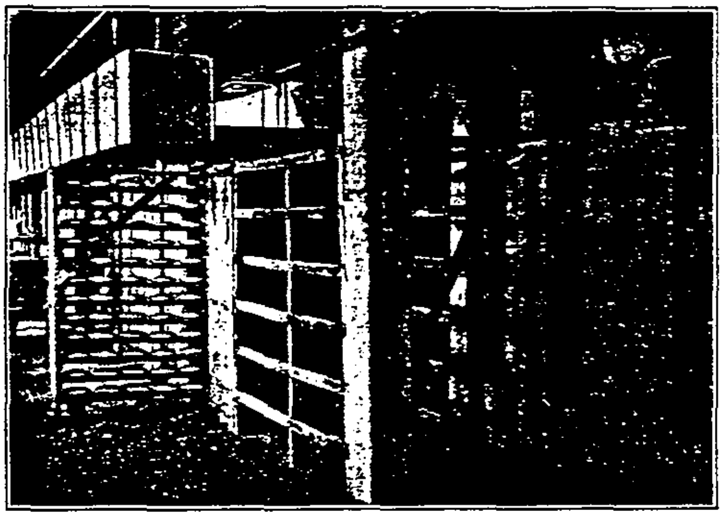

FIG. 2.

III. Shop Studies

(1) Jigger Shop These determinations were begun in the jigger shop. The situation when the work was started may be briefly described as follows: In each unit there were three or four working crews, consisting of a jiggerman, a batter-out, and a finisher. The jigger-

man and batter-out making the ware handled only wet clay. The finisher, usually a girl, removed the dried ware from the molds, trimming, dusting, and arranging it in bungs. Evidently in this set-up, the finishing was the chief source of dust. The stove room for drying ware was at the workers' back and was provided with a series of slides with shelves (Fig. 2). Heat was supplied by a hot-air blast entering the back of the stove room, traveling forward, and escaping between the slides at the front, whence it was supposed to enter an overhead suction duct to be recirculated through the heating coils and stove room. During the summer

TABLE III

CLAY SHOP SURVEY

Shop condition	Description of sample	Dust count	Dust (mg.)
Windows closed, fan on	Shop, early morning (blank)	57	0.1
" " " "	Shop, crew working	132	1.95
" " " "	Stove room	103	0.5
" " " "	Hot-air supply duct	44	0.1
Windows closed, fan off, and stairway screened	Shop, early morning (blank)	43	0
	Shop, crew working	144	2.5
Windows open, fan on	Shop, crew working	97	0.5

months windows were kept open, making the atmospheric condition different from that of the winter period.

The first undertaking was a survey of the actual dust content of the jigger-shop air covering the range of operating conditions. A large number of tests was made (30-minute samples) with the surrounding details noted. The general averages are recorded in Table III.

The data in Table III serve to show the average amount of dust as compared to normally pure air and to indicate the effect of ventilating conditions. The detailed data brought out more clearly than the averages the effect of air currents. Thus in one day there was obtained an appreciable count in the morning with the outside air quiet and a negligible

TABLE IV

DUST TESTS IN CLOSED-OFF ROOM

Conditions of test	Dust count	Dust (mg.)
Early morning (blank)	40	
Ordinary working conditions	156	1.9
Exhaust hoods for finishers	99	1.0
Exhaust hoods and no air escape from driers	60	0.8

count in the afternoon with a sharp breeze blowing through the windows. A reversed effect was obtained by pulling out the stove-room slides, allowing the hot blast to sweep direct into the room. It will be noted in Table III that the hot-air supply duct gave low dust counts and that considerable dust was picked up by the air in traveling through the stove rooms.

Because of the impossibility of eliminating entirely stray air currents in the regular working units, one section of the shop was boarded off to serve as a testing laboratory for further studies in dust elimination. Tests were made daily over a period of a month or more under each of the following conditions: (*a*) ordinary working conditions; (*b*) with special

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New finishing bench; su

(3) Stove Rooms

whole drying system

FIG. 4.

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Anemometer reading
as follows:

exhaust hoods for the finishing operation; (*c*) with special exhaust hoods and with stove-room circulation arranged to prevent escape of hot air into the working room. The general averages are recorded in Table IV.

(2) Separate Finishing Room These experiments clearly indicated the line of attack for eliminating dust from the jigger-shop air. Since the finishing was a main source of trouble, it was decided to reorganize the whole jigger-shop procedure by centralizing that operation in two rooms. This change made it possible and economical to provide adequate suction hoods for the finishers. Details of the finishing hood are shown in Fig. 3 and a battery of hoods in Fig. 4. The following tests made close to the finisher show the efficiency of the system.

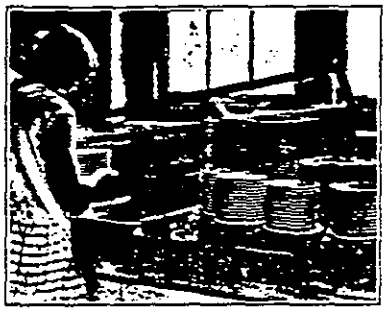


FIG. 3.

TABLE V

DUST TESTS NEAR FINISHER

Conditions of test	Dust count	Dust (mg.)
Old finishing; no suction	228	5.9
New finishing bench; suction	129	1.2

(3) Stove Rooms The dust survey proved the necessity of stopping the air leakage from the stove rooms. Placing the whole drying system under suction was not feasible and accordingly a closed-circuit pressure system was next established. The escape of air was observed by taking anemometer readings at the top and bottom of slides at two points, A and B, at the front of the stove room. The original drier (Fig. 5) with air blast at the back and overhead external suction duct gave anemometer readings as follows:

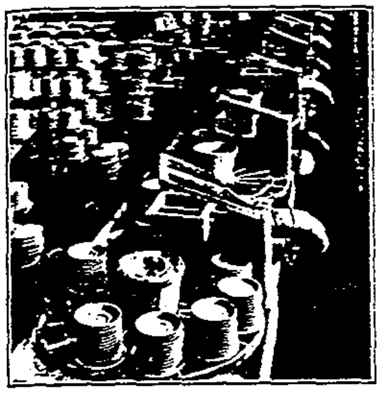


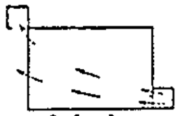
FIG. 4.

A top	A bottom	B top	B bottom
774	715	831	884

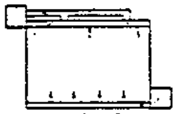
The first modification consisted in closing the main suction duct to the room air while connecting it to the drier by a series of narrow vertical flues placed between the slides. With this arrangement it was possible to reverse the air flow, supplying the blast through the vertical flues and taking the discharge from the back. Anemometer readings corresponding to the above under this system were as follows:

A top	A bottom	B top	B bottom
330	151	198	278 (draft in)

The altered system had two serious defects (*a*) the vertical supply flues constituted an excellent radiator and caused overheating of the shop and (*b*) drying of the ware in different parts of the slide was very unequal. With the same construction, it was decided to return to the air supply through distributing screens at the back, obtaining the following readings:



Old Stove Room Fig 5



New Stove Room Fig 6

A top	A bottom	B top	B bottom
362	181	264	116

This method gave more even drying but there was still excessive heating from the vertical flues.

Further consideration of the problem led to the conclusion that better control over air leakage and at the same time improved drying would be obtained by substituting a rising vertical column for the horizontal air movement. There was very little space available between the slides, but it appeared possible to install a system of narrow horizontal supply ducts in place of the guard rail between the slides at the bottom. The system finally adopted is shown diagrammatically in Fig. 6. The main pressure duct at the back of the stove room supplies air to the system of horizontal ducts whence it rises to a new suction chamber extending across the entire top of the stove room. By providing properly spaced take-offs from this suction chamber an even distribution of air is obtained giving improved drying as well as economies in power and steam. This system has been installed throughout the plant. Typical anemometer readings are as follows:

A top	A bottom	B top	B bottom
215	0	218	0

FIG. 7.

(4) Kiln Placing Rooms The discussion so far has been confined to the jigger shop. In the manufacture of vitreous china tableware there are other sources of dust in the "bedding" or placing operation and in cleaning the ware after the first or biscuit fire. These problems are less acute in most semi-vitreous and in true porcelain plants where a supporting bed is not employed. Flint is the cheapest and most commonly used bedding material, and, unfortunately, silica is the most harmful of the common mineral dusts. This situation has been a source of much concern in England where flint is largely used for bedding bone china.

An interesting discussion is found in a paper by Moore.[1] Two methods of mitigation referred to are (*a*) elimination of the fines from the placing flint, thereby removing the harmful portion, and (*b*) substitution of other

[1] *Trans. Ceram. Soc.* [Eng.], 31, 153 (1932).

materials, especially bone ash and alumina. For a great many years this company has used kaolin instead of quartz for placing. The operation of claying up the bungs of ware is carried out under a hood with strong draft (Fig. 7). Similar precautions are taken in cleaning the ware after the fire (Fig. 8).

IV. Medical Aspect

It is not within the scope of the present report to consider in detail the medical aspects of the subject. Much valuable work has been done by

Fig. 8.

the United States Public Health Service, some of which will be briefly reviewed.

Any mineral dust entering the lungs causes the formation of a fibroid tissue reducing the area of effective lung tissue, a condition known as fibrosis. The development is gradual and a long period of years may elapse before marked physiological effects, notably a shortness of breath, become apparent. There is a lowered resistance to respiratory diseases, colds, bronchitis, pneumonia, and tuberculosis. It has been clearly established that silica dust is especially harmful, and the resulting condition is known as silicosis.

It was thought at first that the bad effect of silica was due to the hard character of the mineral. This view, however, is inconsistent with the observation that a still harder dust, silicon carbide, does not produce the same physiological effects, and especially the same susceptibility to tuberculous infection. The specific effect of silica is thought to be associated with its solution and the formation of colloidal silicic acid, which apparently tends to destroy the phagocytes or natural scavenging cells, which normally attack and absorb poison, or tubercle bacilli.

Studies in South Africa and in this country indicate that practically no particles over 10μ diameter enter the lungs, and very few over 5μ, so that the dangerous dust is the finer, microscopic fraction. Particles below 0.1μ are of the order of size of the body colloids and probably harmless in the case of inert minerals. If, however, the chemical theory of the toxicity of silica is accepted, there can be no lower limit to the particle size which will be harmful.

One of the most complete correlations between dust exposure and medical histories is contained in a study of the granite industry by the U. S. Public Health Service.[2] This is particularly interesting since granite dust contains 35% free quartz, about the average content of pottery bodies. Some of the more important conclusions will be quoted from *Health News*, a release of the Public Health Service.

> It was possible, by differentiating occupations on the basis of the amount of dust exposure, to determine within broad limits how much dust of the composition studied can be tolerated by workers without serious deleterious effects. A maximum of dust exposure falling somewhere between 10 and 20 million particles per cubic foot of air is a desirable limit (for dust containing 35% free silica).
>
> Exhaust velocities at the ventilating hoods of 1500 feet per minute served to keep the dust exposure of the operator below 10 million particles per cubic foot of air. The limit established was not found to prevent entirely the occurrence of silicosis, but there seemed to be no particular liability to tuberculosis within this limit.
>
> Case histories of men working in the granite industry brought out the following salient points:
>
> (*a*) The long period of service (20 years or more) before the liability to tuberculosis becomes manifest.
>
> (*b*) The sharp correlation between length of exposure to dust and the prevalence of tuberculosis and also the death rate from this disease.
>
> (*c*) The close relation between the extent of dust exposure and the health of the men.

V. Maximum Dust in Potteries below Dangerous Minimum in Granite Quarries

Conditions in the potteries have never approached, to the knowledge of the writer, those prevailing in granite quarrying as set forth in the foregoing. It is to be noted that a dust count of 10 to 20 million particles per cubic foot is described as a desirable condition. This corresponds to 352 to 704 particles per cubic centimeter. Before the work described in this report was begun, the average dust count in the clay shop was about 150 or less than half the strictest requirement of the Public Health Service. Through the measures described this low figure has again been cut in two. The count of about 130 near the hoods in the finishing rooms is misleading, for nearly all of this consists of kaolin sprinkled on the ware and the equivalent count in terms of 35% free quartz is too low for measurement.

It therefore appears that conditions have been improved to a point

[2] *Public Health Bull.*, No. 187 (1929).

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no longer exists.

(1) Final Report,
Africa, Govt. Printing ar
(2) A. Mavrogorda:
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1922.
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Based on the Study of
[Feb.] (1929).

* The word "phthisis

where the dust hazard formerly associated with the manufacture of pottery no longer exists.

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* The word "phthisis" is here used to mean "silicosis" complicated by tuberculosis

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