THE DUST HAZARD IN CERTAIN
INDUSTRIES *

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PHILADELPHIA

No health hazard in industry has attracted so much attention, and rightly so, as dust, and yet few exact studies on its nature and quantitative features have appeared. It is not enough to know only that dust has an influence on health, or even what the resultant pathologic conditions are; it must also be shown how these effects are brought about. In order to approach this problem intelligently, it is of prime importance to appreciate certain things about dust itself, and in this communication are presented briefly the results of investigations on the dusts of various industries. These show the number of particles per unit volume of air and their approximate size, the weight and relative mineral content, the influence of relative atmospheric humidity and of exhaust ventilation on these factors, and the amount that reaches the lungs of those exposed.

The dust samples have been collected directly from the air, at the respiration level, by means of the Palmer apparatus,¹ which is now accepted as a standard by the American Public Health Association, and the determinations have been made by the methods of Palmer, Coleman, and Ward,² as modified by Smyth.³ The chief advantages of this apparatus are that it allows a very large volume of air to be sampled, and that it may be operated continuously over considerable periods of time, both these factors greatly augmenting its accuracy. Arens,⁴ in 1894, collected the dust from 200 liters (quarts) of air for his studies; but our results, except where the dust was extremely thick, are based on samples from 200 cubic feet, forty minutes of continuous operation being required for this amount. This period of time is sufficient to allow for ordinary variations in dust production and in the direction and intensity of air currents.

Fig. 1.—Dust collected from the air of the coal grinding room of a cement plant; $\times 100$; appearance after settling in a Sedgwick-Rafter cell; obtained by passing 50 cubic feet of the air through 100 c.c. of distilled water.

STANDARD DUST VALUES FOR PHILADELPHIA

In order to have, as standards, certain dust values with which our results in the industries might be com-

TABLE 1.—RESULTS FROM THE EXAMINATION OF DUST IN
COUNTRY AND CITY AIR

Location	Particles			Weight	
	Number per Cu. Ft.	Percentage Distribu- tion According to Size*			
		1	2	3	Per 100 Cu. Ft., Gm.
Country:					
Outdoors.....	19,600	5	46	49	0.0022
Indoors.....	24,400	4	55	41	0.0054
City:					
Outdoors.....	48,400	2	27	71	0.0078
Laboratory.....	123,800	2	25	73	0.0045
Laboratory.....	150,600	1	24	75	0.0242
Average.....	73,360	3	35	62	0.0088

* In this and the succeeding tables, Size 1 refers to the largest observed particles, averaging about 40 microns in diameter, Size 3 to the smallest ones, averaging about 1 micron, and Size 2 to the intermediates.

pared, five tests were made outside such establishments, as follows: one each in the country and the city outdoors, one in a country home, and two in city laboratories. Table 1 gives the results of these tests, with averages, and these we have accepted as normal values for Philadelphia and its vicinity. Outdoor country air, the most dust-free examined, showed under 20,000 particles per cubic foot with 2.2 mg. of solids in each hundred cubic feet, and indoor country air under 25,000 particles with 5.4 mg. of solids. Outdoor city air contained about twice as many particles as the latter, with 7.8 mg. of solids, and the laboratory air averaged about six times as many particles with three times the weight. A striking difference is seen in the relative proportion of small and large particles when

comparing city with country air, the latter containing relatively fewer of the smallest countable ones. The somewhat low percentage of inorganic material in the laboratory dust resulted partly from an abundance of coal particles which came from a near-by freight railroad and a large power plant stack.

INORGANIC DUSTS

Portland Cement.—In Table 2 are given the results of tests on eleven dust samples from three Portland cement plants situated in the Lehigh Valley of Eastern Pennsylvania. These are averaged as a whole and also by the presence or absence of exhaust ventilation, departments 33 c, 34 c, and 38 r having such ventilation by means of stacks over the conveyors. No other industry gave results so high in either count or weight, the average being almost 7 million particles per cubic foot and over 0.2 gm. of solids in 100 cubic feet. The number of particles in three tests was appalling, two running over 13 million and one over 15 million, and

* From the Clinic for Diseases of Occupation of the University Hospital and from the Laboratory of Hygiene, University of Pennsylvania.

* Read before the Section on Medicine of the College of Physicians of Philadelphia, Dec. 17, 1917.

1. Palmer, G. T.: A New Sampling Apparatus for the Determination of Aerial Dust, *Am. Jour. Pub. Health*, 1916, **6**, 54.

2. Palmer, G. T.; Coleman, L. V., and Ward, H. C.: A Study of Methods for Determining Air Dustiness, *Am. Jour. Pub. Health*, 1916, **6**, 1049.

3. Smyth, H. F.: To be published.

4. Arens, Carl: Quantitative Staubbestimmungen in der Luft nebst Beschreibung eines neuen Staubfängers, *Arch. f. Hyg.*, 1894, **20**, 325.

the lowest count in any of the cement departments was $1\frac{1}{4}$ million. The highest weights were 0.4928 and

TABLE 2.—RESULTS FROM THE EXAMINATION OF DUSTS
IN THE CEMENT INDUSTRY

Index Num- ber	Department	Particles			Weight		
		Number per Cu. Ft.	Percentage Distribu- tion According to Size		Per 100 Cu. Ft., Gm.	Per Cent. Inorganic	
			1	2			3
22 w	Clinker.....	13,560,000	3	39	58	0.4928	87
34 c	Clinker.....	2,394,400	6	54	40	0.2256	88
38 r	Clinker.....	1,872,000	5	20	75	0.0920	70
23 w	Rock.....	9,014,400	1	45	54	0.1332	90
33 c	Rock.....	1,291,200	5	51	44	0.0696	72
37 r	Rock.....	15,524,000	1	32	67	0.3016	85
24 w	Coal.....	4,042,400	3	46	51	0.1240	35
36 r	Coal.....	13,720,000	8	37	55	0.3332	21
25 w	Ball.....	3,244,800	1	41	58	0.0890	78
26 w	Kiln.....	1,641,600	3	46	51	0.0792	65
35 r	Packing.....	8,395,200	2	40	59	0.4736	85
General average...		6,790,900	3	37	60	0.2185	72
Average for 8 depart- ments without ex- hausts.....		8,642,800	3	38	59	0.2533	71
Average for 3 depart- ments with ex- hausts.....		1,852,530	5	40	55	0.1291	81

0.4736 gm. The ratio of small to large particles was between the extremes of country and city air. A comparison of the number of particles with the weights in Departments 35 r, 36 r and 37 r shows that while the numbers increase the weights decrease. This is due to a difference in the specific gravity of the dusts and to differences in the sizes of the particles. The percentage of inorganic matter varied from 21 to 90, the dust from the coal grinding room showing the lowest. The averages for the departments with and without exhaust ventilation show clearly that such exhausts effect both a great reduction in the number of particles and in the weight, and also a slight reduction in the percentage of the smallest sized particles.

Fig. 2.—Dust collected from the air of the rock grinding room of a cement plant; $\times 100$; appearance in Sedgwick-Rafter cell; amount of dust in 50 cubic feet of the air suspended in 100 c.c. of distilled water.TABLE 3.—RESULTS FROM THE EXAMINATION OF DUSTS
IN THE FLINT INDUSTRY

Index Num- ber	Department	Particles			Weight		
		Number per Cu. Ft.	Percentage Distribu- tion According to Size		Per 100 Cu. Ft., Gm.	Per Cent. Inorganic	
			1	2			3
54 e	Ball grinding....	582,400	5	31	64	0.0384	67
55 e	Crushing.....	937,600	3	26	71	0.0464	86
56 g	Ball grinding...	1,120,100	4	36	66	0.0336	76
Average.....		844,040	4	31	65	0.0459	76

Flint.—Three tests were made in two flint mills (Table 3). Unfortunately, the sampling in one mill (54 e and 55 e) was rather unsatisfactory because of a defective electric current, and the results should probably have been slightly higher than here recorded. In this plant the crushing, which was not protected,

generated more dust than the ball grinding, and incidentally the man feeding the crusher was continually exposed. In the other flint establishment (56 g) the crushing mills were enclosed and supposedly protected by strong exhaust suction, but, as sometimes happens,

TABLE 4.—RESULTS FROM THE EXAMINATION OF DUSTS
IN THE STEEL GRINDING INDUSTRY

Index Num- ber	Department	Particles				Weight	
		Number per Cu. Ft.	Percentage Distribu- tion According to Size			Per 100 Cu. Ft., Gm.	Per Cent. Inorganic
			1	2	3		
63 b	Dry ball grinding	1,066,200	6	34	60	0.0840	100
64 b	Oil grinding.....	90,000	8	21	71	0.0125	92
47 d	Machine shop....	313,600	9	21	70	0.0304	—
Average.....		489,930	7	31	67	0.0433	96

the suction was not detectable, owing to loosened boards in the upper part of the enclosure. The ball grinding drums were enclosed at both mills, as they should be. This dust showed a high percentage of Size 3 particles.

Steel Grinding.—Samples of dust from the emery grinding of steel were taken in a machine shop of a textile mill and in a ball bearing factory, and the results are recorded in Table 4. The most striking fact is the great difference in the figures for the two departments of the ball bearing factory: in the dry grinding department (63 b), where the horizontal emery wheels throw countless particles in every direction and where incidentally the workers have no protection whatever, the figures are high, while in the oil grinding room (64 b), where the process is the same except that the balls run in oil, the

TABLE 5.—RESULTS FROM THE EXAMINATION OF DUSTS
IN THE ASBESTOS INDUSTRY, WITH AVERAGES
SHOWING THE EFFECT OF EXHAUST
HOODS

Index Num- ber	Department	Particles			Weight		
		Number per Cu. Ft.	Percentage Distribu- tion According to Size		Per 100 Cu. Ft., Gm.	Per Cent. Inorganic	
			1	2			3
57 a	Weaving.....	240,800	3	25	72	0.0277	31
58 a	Carding.....	900,800	5	40	55	0.0416	87
66 k	Carding.....	212,800	3	41	56	0.0128	82
65 k	Carding.....	90,400	5	31	64	0.0148	81
59 a	Crushing.....	1,163,200	4	36	60	0.0536	76
67 k	Crushing.....	356,800	7	57	36	0.0456	81
Average.....		494,100	4	39	57	0.0354	73
Average for depart- ments without ex- haust hoods.....		768,300	4	34	62	0.0409	69
Average for depart- ments with ex- haust hoods.....		220,000	5	43	52	0.0226	81

count and weight of the dust is reduced to a twelfth and a seventh, respectively, of the former, these figures being practically those of our standard. This is a strik-

ing illustration of the value of wet processes. The dry ball grinding is the only department of the entire series showing dust composed entirely of mineral matter.

TABLE 6.—RESULTS FROM THE EXAMINATION OF DUSTS IN THE POTTERY INDUSTRY

Index Num- ber	Department	Particles				Weight	
		Number per Cu. Ft.	Percentage Distribu- tion According to Size			Per 100 Cu. Ft., Gm.	Per Cent. Inorganic
			1	2	3		
49 l	Glaze dipping..	152,800	8	41	51	0.0144	38
50 l	Jiggering.....	189,600	4	33	63	0.0120	67
51 l	Kiln.....	249,600	4	33	63	0.0200	64
52 m	Pressing.....	163,200	4	28	68	0.0072	67
53 e	Pressing.....	158,400	4	33	63	0.0084	71
Average.....		182,720	5	34	61	0.0130	60

Asbestos.—Table 5 records the results of six tests in two asbestos fiber weaving mills, the second of which had almost completed the installation of an exhaust system for dust removal. The averages in these two mills show clearly the effect of such dust removal, not only in lessening the number of particles and the weight of the dust, but also in decreasing the percentage of the smallest sized particles.

Crushing is seen to be the dustiest process, and it is also the most difficult to guard properly. The crushing room that did not have a suction system (59 a), with over 1 million particles per cubic foot, ranked next to the cement departments in dustiness, and above any of the steel or flint departments, and the carding room in the same mill (58 a) was not far behind. The percentage of inorganic matter in this dust varied from 31 to 82.

Potteries.—Table 6 gives the results of five dust tests in three potteries located in Trenton, N. J. These are the lowest figures shown by any of the inorganic industries, the highest count being under 300,000. The latter (51 l) was in a kiln room where tableware was being packed in saggars with powdered flint, and this packing was done in especially constructed boxes with strong exhaust suction at the rear. With the exception of this one department, there was very little variation in the counts in this industry, though there was considerable difference in the weights. The relatively high weight, in proportion to the count, in the glaze dipping room was due to 8.6 per cent. of lead in this dust, a somewhat lower percentage than in the glaze itself. Calculations show that the workers here inhale at most under 2 mg. of lead a day. The percentage of smallest particles here was somewhat less than in the flint mill tests.

ORGANIC DUSTS

Plush, Blanket and Carpet.—Thirteen tests were made in three divisions of a large textile mill making

silk and mohair plush, woolen blankets, aeroplane wing cloth, and carpets (Table 7). The wool breaking room (33 d) in the carpet factory showed by far the worst organic dust conditions encountered, with 430,000 particles, little less than in the best flint mill test, and with 0.39 gm. of solids, exceeded only by the three highest tests in cement. It so happens also that this dust is peculiarly harmful, because as the raw, unwashed wool is fed to the breaker, much of the dirt from it is blown directly back into the face of the feeder. Another equally harmful dust tested in this mill, which gave a lower count and weight but a decidedly higher percentage of mineral matter, was that in the rag picking room (43 d), where filthy woolen rags of all descriptions are fed by hand into a shredding machine. The shredded material is blown into a supposedly closed room, but the door is left open, allowing the fine shreds and dust to escape into the main room; and furthermore, at intervals, the operative enters the enclosure and brings out the

material by the double armful to bale on the open floor. In so doing he is exposed to much more dust than the results of the test, taken near his station when he is feeding the machine, would indicate. In general, plush mill dusts gave higher counts than carpet mill dusts, but one weaving room (29 d) gave a very low test (under 77,000 particles), little more than one third of the count in the other plush weaving room. Tests in the blanket mill gave remarkably low counts, owing to greater cleanliness and also to the use of wet processes, the bobbins being loaded with steamed thread. Thus again is seen the value of wet processes. All tests in these three mills showed more or less mineral

matter in the so-called organic dust, from 17 per cent. in the wool breaking (33 d) to 68 per cent. in a plush

TABLE 7.—RESULTS FROM THE EXAMINATION OF DUSTS IN THE BLANKET, PLUSH AND CARPET INDUSTRY

Index Num- ber	Department	Particles			Weight		
		Number per Cu. Ft.	Percentage Distribu- tion According to Size			Per 100 Cu. Ft., Gm.	Per Cent. Inorganic
			1	2	3		
29 d	Plush weaving...	76,600	3	41	56	0.0148	68
30 d	Plush finishing...	130,800	6	18	76	0.0180	31
31 d	Plush shearing...	195,600	4	27	69	0.0252	67
32 d	Plush tiger.....	150,400	6	34	58	0.0220	29
40 d	Plush weaving...	208,000	12	11	77	0.0576	44
41 d	Blanket weaving...	48,000	17	37	46	0.0272	41
42 d	Blanket napping...	97,500	13	23	64	0.0160	55
33 d	Wool breaking...	430,000	7	29	64	0.3904	17
43 d	Rag picking.....	110,400	16	22	62	0.0226	45
44 d	Wool carding....	103,400	27	15	58	0.0240	33
45 d	Carpet finishing..	124,800	5	17	78	0.0116	62
46 d	Carpet weaving...	149,600	11	37	52	0.0112	60
48 d	Wool breaking...	112,000	13	24	63	0.0144	22
Average.....		148,950	11	24	65	0.0504	44

weaving room (29 d). Some of the mineral matter in the dust from the weaving rooms is no doubt due to the wear and tear of the machinery.

Fig. 3.—Dust collected from the air of a flint grinding mill; $\times 100$; appearance in Sedgwick-Rafter cell; amount of dust in 200 cubic feet of the air suspended in 100 c.c. of distilled water.

Felt Hat.—Only three tests in a hat factory were made, all in departments handling unfelted fur (Table 8). They show fair conditions, with no very high

TABLE 8.—RESULTS FROM THE EXAMINATION OF DUSTS IN THE FELT HAT INDUSTRY

Index Num- ber	Department	Particles			Weight		
		Number per Cu. Ft.	Percentage Distribu- tion According to Size			Per 100 Cu. Ft., Gm.	Per Cent. Inorganic
			1	2	3		
60 s	Fur cutting....	153,100	2	28	70	0.0160	30
61 s	Fur blowing....	133,600	8	32	60		
62 s	Forming.....	91,360	3	42	55	0.0176	48
Average for the 3 departments.....		126,020	4	33	63	0.0168	39

count, and the decreasing percentage of smallest particles shows the effect of brushing and blowing in cleaning the fur before forming. Lower counts in the

Fig. 4.—Dust from the air of the dry grinding department of a steel ball bearing plant; $\times 100$; appearance in Sedgwick-Rafter cell; the dust of 200 cubic feet of the air suspended in 100 c.c. of distilled water.

brushing and forming departments are doubtless partly due to increased humidity. The highest count is seen in the most dangerous process, fur cutting (60 s),

TABLE 9.—AVERAGE RESULTS OF DUST EXAMINATIONS IN NINETEEN DEPARTMENTS OF SIX CIGAR FACTORIES

Department	Number Studied	Particles				Weight	
		Number per Cu. Ft.	Percentage Distribution According to Size			Per 100 Cu. Ft., Gm.	Per Cent. Inorganic
			1	2	3		
Banding.....	3	25,000	8	46	46	0.0055	55
Packing.....	6	61,600	5	50	45	0.0036	45
Stripping.....	3	90,500	6	40	54	0.0088	30
Hand cigar making.....	2	90,200	8	49	43	0.0075	
Casing.....	1	164,200	2	55	43	0.0086	77
Machine cigar making.....	3	216,500	6	44	49	0.0069	
Stock.....	2	235,000	7	48	45	0.0104	71
Average....	19	102,600	6	47	47	0.0084	56

where the fur is full of dried "carrot" (mercury acid nitrate), this being put on to aid in the felting process, and the dust here is liable to cause mercurial poisoning.

Cigar.—The results of our nineteen tests in cigar factories have been reported elsewhere;⁵ hence only the averages in the different departments are given here (Table 9). While in general these tests show comparatively little dust, yet two counts of over 300,000 particles were made, and one test gave a weight of 0.017 gm. The somewhat high inorganic content of the dust is doubtless due to sand, which is invariably

TABLE 10.—RESULTS FROM THE EXAMINATION OF DUSTS IN THE SILK INDUSTRY

Index Num- ber	Department	Particles			Weight		
		Number per Cu. Ft.	Percentage Distribution According to Size			Per 100 Cu. Ft., Gm.	Per Cent. Inorganic
			1	2	3		
27 q	Weaving.....	109,800	15	2	83	0.0040	60
28 q	Winding.....	64,200	32	3	65	0.0050	40
Average for the 2 departments.....		87,000	23	3	74	0.0045	50

associated with tobacco, and to the wear of the machinery.

Silk.—Two tests were made in a model silk factory, and Table 10 shows that these gave results averaging better than in any other industry, and exceeded only by country air and a few individual tests in cigar factories. This was due to extreme cleanliness and to artificially increased humidity. The inorganic content of this dust averaged 50 per cent.

TABLE 11.—SUMMARY OF AVERAGES OF DUST EXAMINATION RESULTS FOR THE SEVERAL INDUSTRIES, GROUPED ACCORDING TO THE INORGANIC OR ORGANIC NATURE OF THE DUST

Inorganic Group							
Industry	Number of Tests	Particles			Weight		
		Number per Cu. Ft.	Percentage Distribution According to Size		Per 100 Cu. Ft., Gm.	Per Cent. Inorganic	
Cement....	11 (2)	6,790,900	3	37	60	0.2185	72
Flint.....	3 (2)	844,040	4	31	65	0.0459	76
Steel.....	3 (2)	489,930	7	31	62	0.0433	96
Asbestos...	6 (2)	494,100	4	39	57	0.0354	73
Pottery....	5 (3)	182,720	5	34	61	0.0130	60
Average..	28 (11)	1,777,970	4	37	59	0.0717	76
Organic Group							
Blanket....	13 (3)	148,950	11	24	65	0.0504	27
Plush.....							
Carpet.....							
Hat.....	3 (1)	126,020	4	33	63	0.0168	39
Cigar.....	19 (6)	102,600	6	47	47	0.0065	56
Silk.....	2 (1)	87,000	3	21	76	0.0045	50
Average..	37 (11)	116,190	6	31	63	0.0201	42
Standard							
Average....	5 (4)	73,360	3	25	62	0.0088	34

SUMMARY OF AVERAGES

Table 11 gives a general summary of the averages for the several industries, grouped according to the organic or inorganic nature of the raw material used. A remarkable uniformity in the percentage of different sized particles in all the tests is observed. It will be seen that the dustiness is much greater in the inorganic class, and that, although the percentage of inorganic material is naturally greater in this group, yet the so-

5. Smyth, H. F., and Miller, T. G.: A Hygienic Survey of Cigar Manufacturing in Philadelphia, Med. and Surg., 1917, 1, 698.

called organic dusts show a mineral content averaging 42 per cent.

EFFECT OF HUMIDITY

In forty instances in which dust tests were made, relative humidity readings were taken at the same time with a sling psychrometer, and Table 12 shows that as

TABLE 12.—EFFECT OF HUMIDITY ON THE SIZE OF DUST PARTICLES

Relative Humidity	Number of Tests	Percentage Distribution of Particles by Size		
		1	2	3
From 35 to 39.....	4	7	36	57
From 40 to 49.....	15	8	36	56
From 50 to 59.....	11	6	34	60
From 60 to 69.....	8	5	33	62
As humidity increases.....		Decreases	Decreases	Increases

the humidity increases the percentage of the larger particles decreases, the minute ones correspondingly increasing. Table 13 shows the effect of increases in humidity in individual industries, indicating, in general,

TABLE 13.—EFFECT OF INCREASES IN HUMIDITY ON THE TOTAL DUST COUNT IN SEPARATE INDUSTRIES

Industry	Number of Tests	Effect on Total Count
Plush.....	5	Irregular
Blanket.....	2	Decreased
Carpet.....	4	Irregular
Cigar.....	9	Decreased
Hat.....	3	Irregular
Pottery.....	4	Decreased
Asbestos.....	6	Decreased

a tendency to lessening of the total dust count. This is naturally more marked with the more hygroscopic dusts.

TABLE 14.—AVERAGE AND MAXIMUM WEIGHTS OF DUST IN THE VOLUME OF AIR INHALED BY A WORKER IN VARIOUS INDUSTRIES, WITH ESTIMATIONS OF THE AMOUNT REACHING THE LUNGS

Industry	Tests	Weight of Dust in Air Inhaled by a Worker		Estimated Amount of Dust Reaching the Lungs	Estimated Number of Years Required to Reach 1 Pound
		Per Day of 8 to 10 Hours, Gm.	Per Year of 300 Days, Gm.		
Portland cement.	Average of 11	0.4559	146.77	45.59	10.9
	Maximum....	1.0644	310.32	106.44	4.7
Carpet.....	Average of 6.	0.1420	42.60	14.20	35.0
	Maximum....	0.7027	210.81	70.27	7.08
Steel grinding....	Average of 3.	0.0861	25.83	8.61	57.0
	Maximum....	0.1599	47.97	15.99	31.0
Flint grinding....	Average of 3.	0.0663	19.89	6.63	60.0
	Maximum....	0.0829	24.87	8.29	60.0
Asbestos.....	Average of 6.	0.0573	17.19	5.73	45.0
	Maximum....	0.1161	34.83	11.61	45.0
Plush.....	Average of 5.	0.0495	14.85	4.95	48.0
	Maximum....	0.1037	31.11	10.37	48.0
Blanket.....	Average of 2.	0.0389	11.67	3.89	
	Maximum....	0.0490	14.70	4.90	
Felt hat.....	Average of 2.	0.0242	7.26	2.42	
	Maximum....	0.0253	5.06	2.53	
Pottery.....	Average of 5.	0.0187	5.61	1.87	
	Maximum....	0.0288	8.64	2.88	
Cigar.....	Average of 18	0.0147	4.41	1.47	
	Maximum....	0.0291	8.73	2.91	
Silk.....	Average of 2.	0.0081	2.43	0.81	
	Maximum....	0.0090	2.70	0.90	

WEIGHT OF DUST INHALED AND REACHING THE LUNGS

From our data, calculations were made of the amount of dust in the air inhaled by the various workers in a day. These estimates were based on the assumption of 30 inches of tidal air per respiration, and of 18 respirations per minute, this giving approximately 18 cubic feet per hour. From these results, further

estimations were made of the amount of dust contained in the air inhaled per working year of 300 days, and of the amount that would reach the lungs. Lehmann and his co-workers⁶ found that from 35 to 42 per cent. of inhaled white lead dust reached the lungs, and so we figured on at least one third of the various inhaled dusts gaining entrance. Table 14 gives our calculations based on the average and the maximum tests in each industry, and in a few instances records the time that would be required for 1 pound of dust to reach the lungs. Table 15 gives corresponding results for city and country air. From the former table it will be seen that the average cement worker inhales almost a half gram of dust a day, and that over 45 gm. reach the lungs each year, less than eleven years being required for 1 pound to gain entrance. A worker in the dustiest room inhales over 100 gm. a year, and takes in 1 pound in less than five years. The average carpet mill worker inhales 0.142 gm.

Fig. 5.—Dust collected from the air of an asbestos factory; $\times 100$; appearance in Sedgwick-Rafter cell; the dust of 150 cubic feet of air suspended in 100 c.c. of distilled water.

daily, but the feeder of the wool breaker takes in over 0.7 gm., and the latter would receive a pound in a little over seven years. The steel ball bearing grinder

TABLE 15.—AVERAGE AND MAXIMUM WEIGHTS OF DUST IN THE VOLUME OF AIR INHALED BY AN INDIVIDUAL OUTDOORS AND INDOORS IN PHILADELPHIA, WITH ESTIMATIONS OF THE AMOUNT REACHING THE LUNGS

Location	Tests	Weight of Dust in Air Inhaled by an Individual		Estimated Amount of Dust Reaching the Lungs	Estimated Number of Years Required to Reach 1 Pound
		Per Day of 24 Hours, Gm.	Per Year of 365 Days, Gm.		
Indoors.....	Average of 3...	0.0492	17.96	4.92	100.0
	Maximum.....	0.1045	31.35	10.45	48.0
Outdoors.....	Average of 2...	0.0299	10.92	2.99	
	Maximum.....	0.0503	15.09	5.03	99.0

would take thirty-one years to secure a pound, and in none of the other of these industries would so much

6. Lehmann, K. B.; Saito, Y., and Gfrörer, Walter: Ueber die quantitative Absorption von Staub aus der Luft durch den Menschen, Arch. f. Hyg., 1911-1912, 57, 152.

be taken in during the average working life of an employee. These amounts would be much increased, however, in workers with any form of nasal obstruction, since Lehmann found that in mouth breathing 80 per cent. of inhaled dust reached the lungs. Arens⁴ calculated that a cement worker would inhale 1.12 gm. of dust a day, a foundryman 0.14 gm., a wool worker 0.1 gm. and a schoolboy 0.0024 gm., these figures comparing fairly well with those here reported.

VARIATIONS IN DUSTINESS

These tests cannot show all the variations that are likely to occur in dust production; but in any study of the dust problem this factor must not be overlooked entirely. Some of our impressions will therefore be recorded. In the dustiest industry included in our survey, cement manufacture, no appreciable variations were suspected except in the packing department. In the flint mills the production was constant in the crushing department, but in the ball grinding department it was greatly increased when the cylinders were charged or emptied; at no time, however, was the air even comparatively free from dust. In the asbestos mills, no appreciable variations were probable. In the pottery kiln room, dust was an appreciable factor only when saggars were being packed or emptied. Elsewhere in the potteries, conditions were more uniform. In the machine shop and the ball bearing grinding room, there were intervals of comparative quiet and of a decrease in dustiness around each machine. Much more variation in dust production occurred in the textile mills and other factories producing organic dusts.

CONCLUSIONS

A study of dust samples taken directly from the air, at the respiration level, of sixty-five departments of twenty-two plants, representing five industries dealing with inorganic and four with organic materials, has given rise to the following conclusions:

1. For a complete understanding of the problem of dust in industry, there must be considered not only its weight, but also the number of the particles, their nature, whether organic or inorganic, and their percentage distribution according to size.

2. The order of the industries studied in regard to dustiness, as determined by weight, was (1) Portland cement; (2) plush, carpet and blanket; (3) flint grinding; (4) steel grinding; (5) asbestos; (6) felt hat; (7) pottery; (8) cigar, and (9) silk.

3. The order as determined by the count of particles was the same except that (1) the asbestos, (2) the plush, carpet and blanket, and (3) the felt hat industries were given lower positions; this was largely due to the presence of fibers in these dusts which it was impossible to include in our counts.

4. The so-called organic dusts were invariably composed of both organic and inorganic materials, and the latter ingredient may account for the harmful influences which have been attributed to certain of these dusts.

5. The organic dusts averaged less than the inorganic dusts both in weight and in count of particles.

6. The percentage distribution of the different sized particles was curiously similar in all the samples, and it may be assumed that approximately half of all dust particles, that are countable by the method here employed, are about 1 micron in greatest diameter, the others ranging up to about 40 microns.

7. Dust removal at the point of production not only greatly decreases air dustiness, but particularly removes the smaller particles.

8. The substitution of wet processes for dry ones effectively lessens air dustiness.

9. Air dustiness varies inversely with relative atmospheric humidity, as does also the percentage of the larger dust particles.

Clinical Notes, Suggestions, and New Instruments

AN UNUSUALLY LARGE VESICAL CALCULUS

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Oct. 30, 1917, a man aged 31, entered the hospital complaining of great pain on urination, with pain over the bladder. The patient had been in this condition for over ten years, gradually getting worse. When he came to the hospital, he could not stand erect on account of the pain.

The man was emaciated, and his face and body were covered with pit marks of old smallpox. A sound introduced into the urethra met at the neck of the bladder a solid, immovable body. This could be palpated 2 inches above the pubes. The urine showed an intense cystitis. An incision

Fragments of calculus.

was made above the pubes almost to the umbilicus and the bladder, which was distended with boric acid solution and opened. A large irregular stone was disclosed which was found to be impacted. Efforts to dislodge it proved fruitless, and finally a hammer and chisel were used to break it into fragments.

An outer shell from three-fourths to seven-eighths inch in thickness was first broken through anteriorly and removed. The nucleus of the stone, 2 inches long, 1½ inches wide, and 1 inch thick, was then removed. The posterior portion of the shell was now dislodged and removed. A mass of small fragments and debris was removed, and the bladder thoroughly irrigated, although a considerable amount of "sand" was adherent to the walls of the bladder and the edges of the wound. A catheter was introduced, and a large rubber tube drain left in the suprapubic opening, the incision being closed in the usual manner.

After thorough drying, the fragments that were recovered weighed 385 gm. It was found impossible to reconstruct the stone, but the accompanying illustration of the fragments gives an idea of its size.

The postoperative history has been uneventful, and at the date of writing (November 21), the suprapubic opening is almost closed. How many stones heavier than this one have been reported?

American Presbyterian Hospital.

Great Nations.—The greatness of a nation is to be judged by the number of the great men it has produced.—Keen.