DEPARTMENT OF ENGINEERING RESEARCH

UNIVERSITY OF MICHIGAN

ANN ARBOR

Report on

DUST-REMOVAL EFFICIENCY OF SCHNEIBLE MULTI-WASH DUST COLLECTOR

by

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Project Number 1M72

for

CLAUDE B. SCHNEIBLE COMPANY

2827 Twenty-Fifth St., Detroit 16, Mich.

July - December, 1936

The DUST REMOVAL EFFICIENCY of SCHNEIBLE MULTI-WASH DUST COLLECTORS

The purposes of this series of tests were as follows:

1. To determine the dust-collecting efficiency of a Schneible "Multi-Wash" Dust Collector installed to serve Molding Equipment Unit No. 6 in Building No. 70 of the Buick Motor Co., Flint, Michigan. Building No. 70 is one of the important buildings in the large foundry group and the No. 6 molding equipment unit is the newest and of the most advanced design. The dust-collector is nominally rated at 30,000 cubic feet per minute and was designed, manufactured and installed by the Claude B. Schneible Company, 3951 Lawrence Avenue, Chicago, Illinois. It is a heavy-duty, high-efficiency type for handling air very heavily laden with dust and other impurities.

2. To determine the amount of dust in the air at the following locations:

(a) At the breathing-line (nose-level) of each of the two operators at the shake-out of the No. 6 molding equipment unit.

(b) To determine the amount of dust in the air at the position 9 feet behind the two operators at the shake-out on No. 6 molding equipment unit and midway between them. These samples were taken at the breathing-line (nose-level), above the foundry floor.

GENERAL DESCRIPTION of DUST COLLECTOR and CONDITIONS of OPERATION

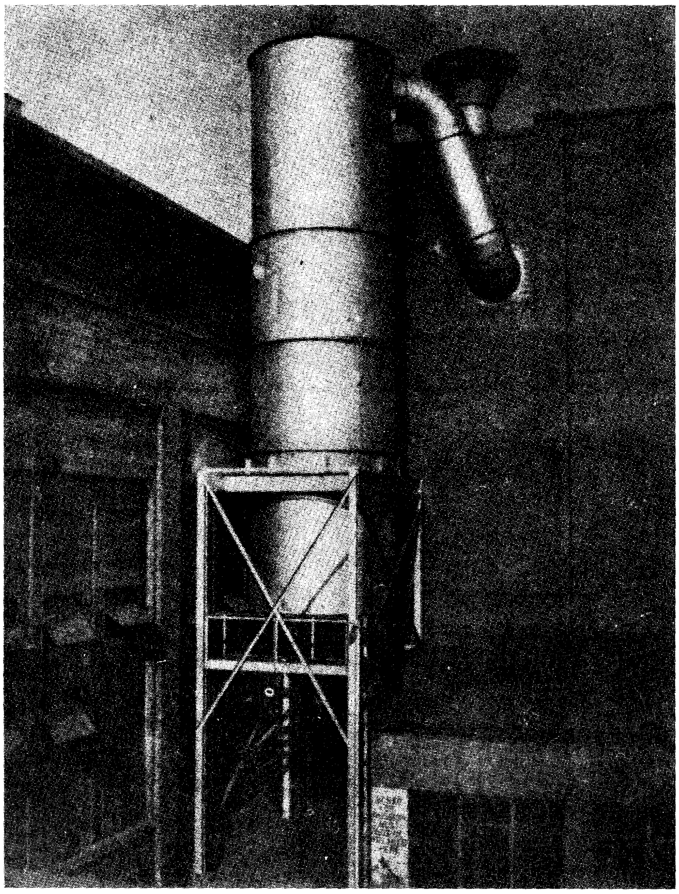


Fig. 1. A 30,000 C.F.M. Schneible Multi-Wash Dust Collector at Buick Motor Company, Flint, Michigan, serving their No. 6 Molding Unit.

Figs. Numbers 1 to 10, inclusive, which follow are descriptive of the dust-collector installation and of the service conditions under which it operates.

Fig. 1 shows the Schneible Multi-Wash Dust Collector on which these tests were made. It is of the heavy-duty type and is rated at 30,000 cubic feet of free-air per minute. It serves the No. 6 Molding Unit which is a thoroughly modern, high-capacity, line-production unit. This includes the shake-out and other devices required in the operation of this unit such as sand-rammers, core-grinders, etc.

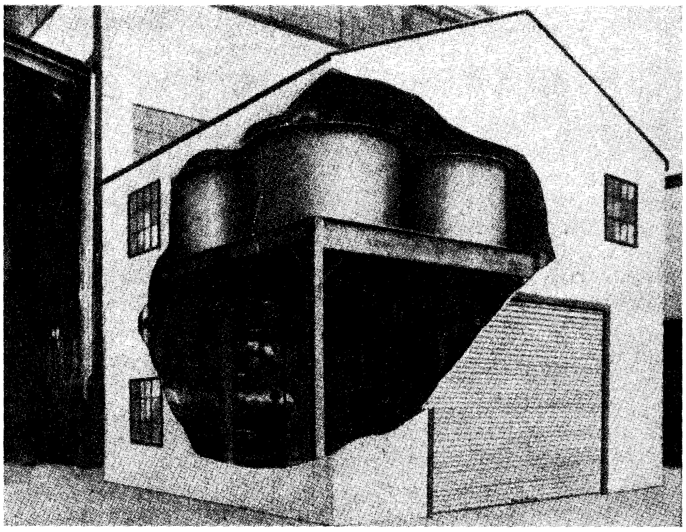


Fig. 2. A Schneible Truck-Type Multi-Louver Dewatering Tank installation at a large Automatic Castings Plant.

At the time of these tests the No. 6 Molding Unit was producing two (2) Oldsmobile cylinder-blocks per minute; a very high rate of production. As shown, the collector is installed outdoors. The outlet from the collector is the inclined duct leading downward through the building wall where it enters the centrifugal suction fan. This centrifugal suction fan discharges into the atmosphere through the exhaust-head shown above the roof.

Fig. 3. The sludge disposal basin for No. 6 Molding Unit at Buick Motor Company's Flint, Michigan Foundry.

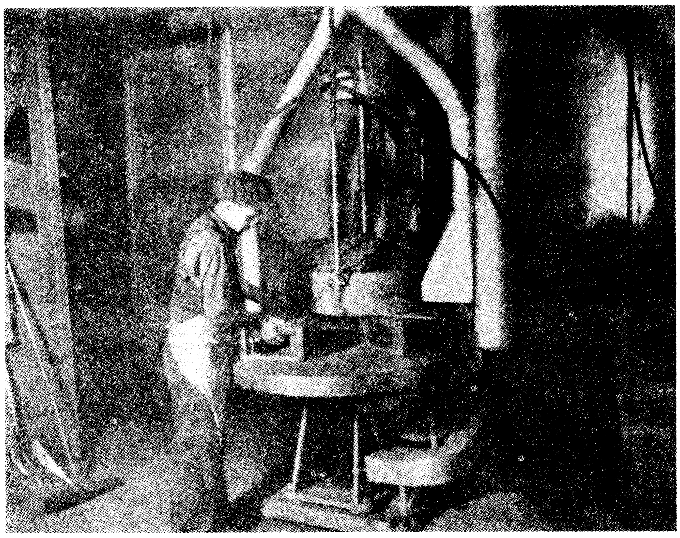


Fig. 5. A Core Finishing Station at Buick Motor Company showing method of ventilation.

Fig. 2 is a view of a Truck-type Multi-Louver Dewatering Tank.

Fig. 3 is a view of a sludge disposal basin.

Fig. 4 is a view at the shake-out on the No. 6 Molding Unit where some of the tests were made.

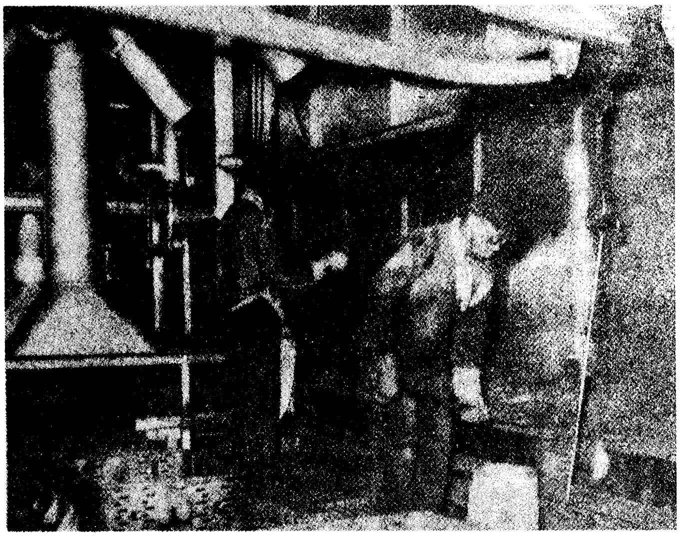


Fig. 4. The Shake-Out on No. 6 Molding Unit at Buick Motor Company where some of the tests described herein were made.

Figs. 5, 6, 7, and 8 are various types of core-grinders. The dust-disposal from these is a very difficult problem and gives some idea of the heavily dust and silica laden air that is passed into the dust-collector.

Fig. 9 shows the compressed-air operated air-ejector which was used to operate the impinger which collected the dust samples taken at the outlet from the dust-collector. The person appearing in this photograph is the writer.

Fig. 10 is a photograph of the apparatus used in making the tests.

Fig. 6. Finishing Cylinder Barrel Slab Cores at Buick Motor Company.

APPARATUS USED IN TEST

The important pieces of apparatus used in these tests are shown in Figure 10, page 4. The conditions under which these tests were made were such that it was not possible to obtain good photographs at the time of the tests, consequently the various pieces of apparatus as used were grouped together and photographed in the Mechanical Engineering Laboratories of the University of Michigan.

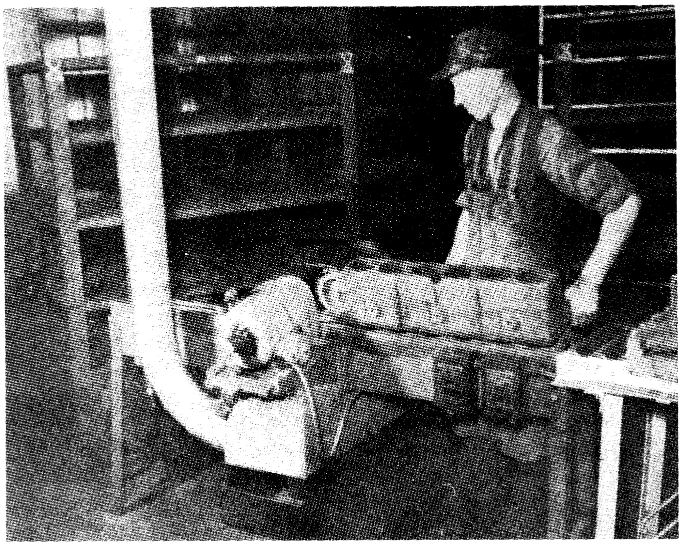


Fig. 7. A core finishing job that creates some of the heavily dust and silica laden air that passes into the Dust Collector.

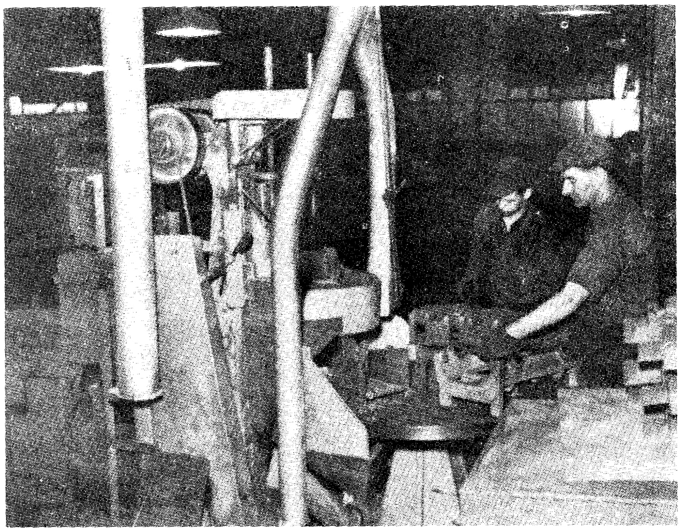


Fig. 8. Another core finishing station that is tied into the Collector System discussed is that shown above.

Item (1) This is a Greenburg-Smith Dust-Sampling Set comprising 10 standard sampling flasks and 3 Greenburg-Smith impingers. The whole group is mounted in the carrying case as shown.

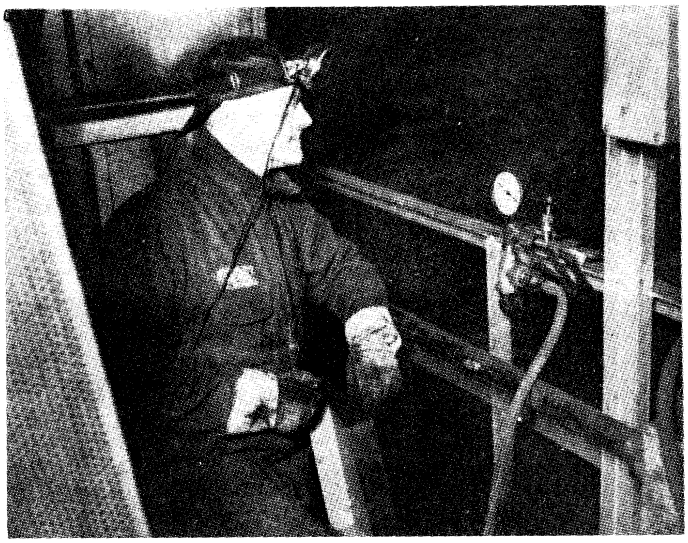


Fig. 9. Hugh E. Keeler with the compressed air operated air-ejector which was used to operate the impinger which collected the dust samples taken at the outlet from the Dust Collector.

Item (2) This is a sampling flask fitted with a Greenburg-Smith impinger which is shown connected by rubber tubing to the calibrated, compressed-air operated air-ejector shown at (3) and to the glass pitot dust-sampling tube shown at (4).

Item (3) This is a compressed-air operated air-ejector, equipped with a calibrated metering orifice. This is used for drawing the dust-samples from the duct through the glass pitot sampling tube shown at (4); then the impinger shown in the flask at (2); then through the metering orifice contained within the ejector assembly.

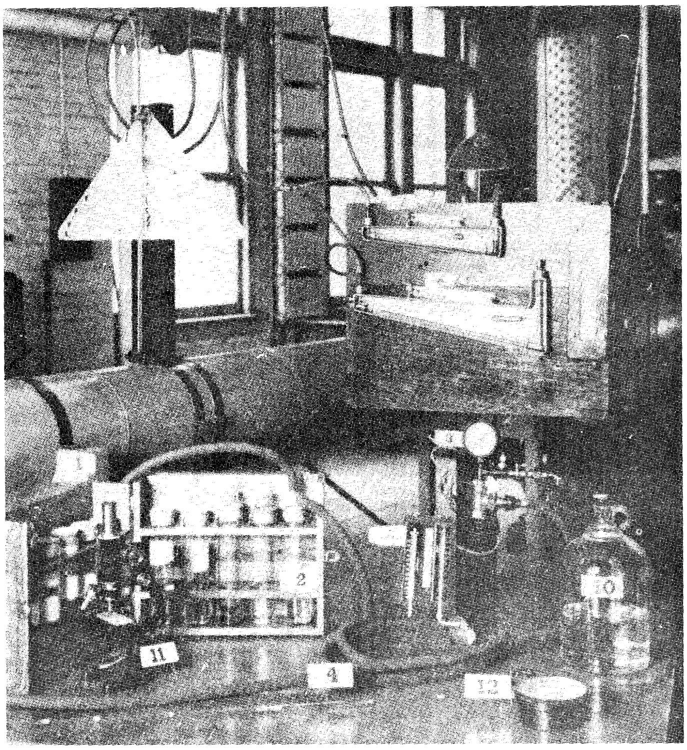


Fig. 10. Photograph of apparatus used in making the tests.

SCHNEIBLE

"Multi-Wash" Collectors

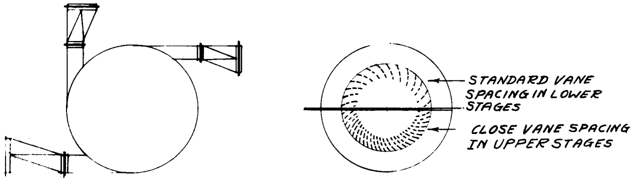
Summary of Special Features for use in the Chemical & Process Industries

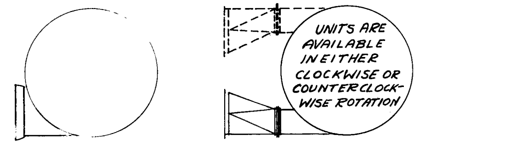
Multi-Wash Collectors may be built either Clockwise or Counterclockwise Rotation; the inlet & outlet may vary to any degree from eachother.

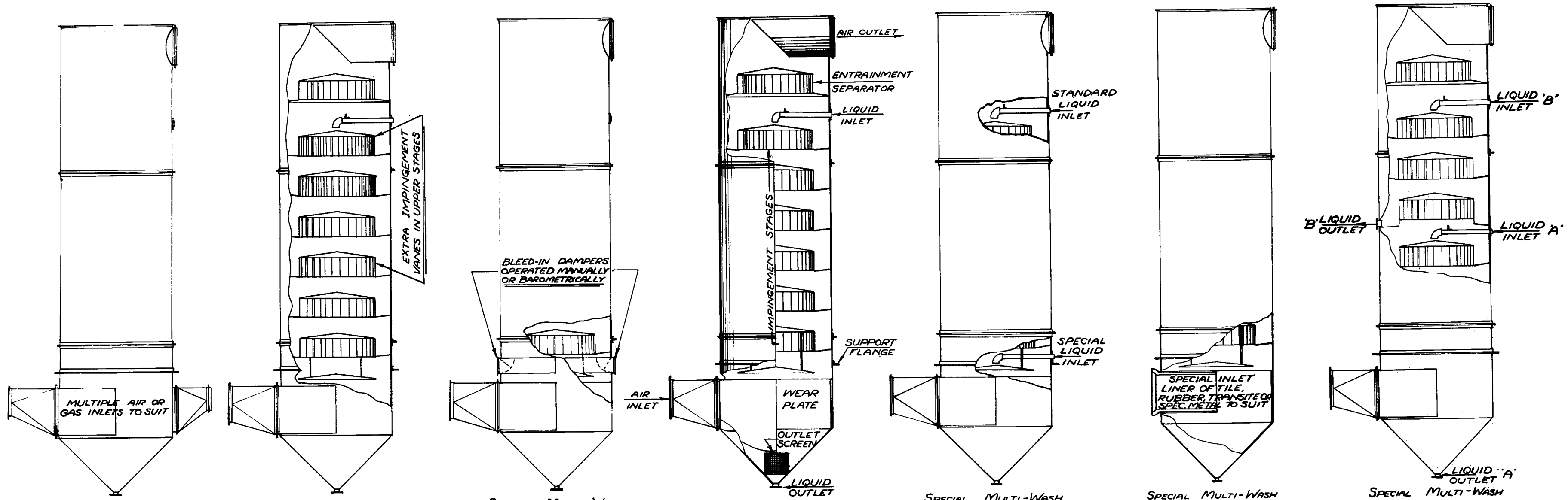
Multi-Wash Collectors may be constructed of any material suitable to your application.

Multi-Wash Collectors may be designed for either induced or positive pressure. In most systems involving the handling of abrasive solids the fans are placed at the collector outlet.

Multi-Wash Collectors may be designed for any number of stages that may be required.







Special Multi-Wash Collector With MULTIPLE INLETS

For use where arrangement makes it desirable to have multiple air or gas inlets.

Special Multi-Wash Collector With VARI VANES

For use where additional impingement surface is required to collect fumes or promote greater contact surface for increase in efficiency on sub-micron solids.

Special Multi-Wash Collector With BLEEDER INLETS

For use where the air or gas volume is variable.
This arrangement provides extra cooling effect in lower chamber.
Where necessary recycled gas may be returned to bleeder inlet to avoid contamination with air.

STANDARD MULTI-WASH COLLECTOR

Standard multi-wash units are used for the collection of dust, fume, condensible vapors, soluble gases, or as a chemical reaction tower where intimate contact between a gas and a liquid is essential.

Special Multi-Wash Collector With EXTRA WATER INLET

For use where high temperatures or unusually heavy dust loads are involved.
The extra liquid at the lower deflector plate serves to cool gases by flash evaporation or flush heavy materials as required.

Special Multi-Wash Collector With SPECIAL INLET SLEEVE

For use where the air or gas entering the unit carries corrosive materials.
The inlet is lined with a corrosion resistant sleeve to protect surfaces not washed with a recirculated neutralizing liquid.

Special Multi-Wash Collector With MULTIPLE LIQUID INLET

For use where multiple contaminants are present requiring two or more liquids as the scrubbing or absorbing medium.
Also recommended where chemical reactions require the use of multiple liquids.

·NO MOVING PARTS - NO WEAR - RECIRCULATION OF SCRUBBING LIQUID - CONSTANT RESISTANCE - POSITIVE ENTRAINMENT SEPARATION - POSITIVE LIQUID DISTRIBUTION -

Item (4) This is a glass pitot-tube used for withdrawing dust-samples from the duct.

Item (5) This is a standard wet and dry-bulb thermometer set for the determination of relative humidities.

Item (6) This is a standard ABC pitot-tube used for determining duct velocities. It is shown located in a duct together with a device for making horizontal and vertical traverses. In the actual tests this device was not used; the horizontal and vertical traverses being made by hand-positioning the pitot-tube.

Item (7) This is an oil-filled slant-gage used for determining velocity pressures in the duct.

Item (8) This is an oil-filled slant-gage used for determining static pressures in the duct.

Item (9) This is an oil-filled manometer used for determining total pressures in the duct.

Item (10) This is a supply of distilled water for use in the sampling-flasks.

Item (11) This is the microscope used for making the dust-count determination. On the stage may be seen an Adams Approved Counting Chamber with Improved Double Neubauer Ruling.

Item (12) This is a Short & Mason, Precision, Aneroid Barometer used for determining atmospheric pressures.

TESTING EQUIPMENT and APPARATUS

The dust samples were collected by means of Greenburg-Smith dust-impingers, together with the necessary compressed air operated air-ejectors and metering orifices. The samples of the dust-laden air were obtained by traversing the inlet and outlet ducts with specially constructed glass pitot tubes.

The inlet-duct was also traversed by means of a standard pitot-tube to obtain data for determining the air quantity entering the Multi-Wash Dust Collector in cubic feet per minute. An adequate quantity of calibrated distilled water was provided.

Dust counts were made in a light field by means of an approved Neubauer Counting Chamber and a magnification of 100 X was used.

Relative humidity at the collector discharge was determined by the usual wet-and-dry bulb psychrometer. Relative humidity at the entrance to the dust-collector was determined by means of a Friez Motor-Driven, Precision, Aspirating Psychrometer. Barometric pressure was determined by means of a Short & Mason, Precision Aneroid Barometer which was carefully checked. All duct pressures were determined by means of calibrated, oil-filled, vertical and slant draft-gages.

Refer to Fig. 10 preceding and accompanying legend for further details of the apparatus used.

METHOD of CONDUCTING TESTS

The testing routine for determining the dust-removing efficiency is described in the following:

The duct system which collects the dust-laden air from the shake-out and from the foundry was studied and a straight horizontal run was chosen as the most suitable place at which to collect the required dust-samples and to determine the quantity of dust-laden air passing into the collector. Two holes, 90° apart were made in this duct so that horizontal and vertical pitot tube traverses could be made in the usual manner. Similar provision was made for pitot-tube traverses in the horizontal duct connecting the outlet of the Multi-Wash Dust Collector with the suction of the centrifugal blower which discharged into the atmosphere.

The diameter of the inlet duct to the collector and the diameter of the outlet duct from the collector were next carefully determined at the locations where the pitot-tube traverses were made. Next the pitot-tubes were marked so that they could be located at the two mid-points of five concentric, annular equal areas on a horizontal traverse and also on a vertical traverse, thus giving a total of 20 points and at which readings of pressure were taken and at which dust-laden air samples were removed from the duct.

Prior to the collection of the dust-samples a traverse of the ducts leading into and out of the collector were made and readings of total, static and velocity pressure were made. From these data the average velocities were determined and also rates of the flow of dust-laden air in the ducts in cubic feet per minute were determined. On the basis of these determined velocities, glass pitot-tube sizes were chosen such that the average velocities of the dust-laden air through them were as closely equal to the velocities of the dust-laden air in the ducts as possible. This was essential in obtaining proper samples of the dust-laden ai in the ducts.

After these determinations ha been made the traverses at the Multi-Wash Dust Collector inlet and outlet were made. The pitot-tubes were left at each station for two (2) minutes so that the total time of dust collection for each traverse was forty (40) minutes.

Two men (four in all) were required to make the traverses at the inlet and two men at the outlet from the collector. Each pitot sampling tube discharged into a Greenburg-Smith impinger type of dust-sampler. The necessary suction for operating each impinger was furnished by a jet-type of air-ejector which was operated by compressed-air from the compressed-air service lines in the foundry. The rate of air-flow through each impinger was determined by means of a calibrated orifice with rounded approach which was incorporated as a part of the ejector assembly. Air pressure gauges on each air-ejector were maintained at a constant value, this value lying between the limits wherein the orifice passed a definite quantity of air. The rate of flow of air through each orifice was carefully checked. Air temperature in the inlet duct at the point of traverse was determined by a high-grade, mercury-in-glass thermometer. Barometric pressure, relative humidity at the collector inlet and relative humidity at the collector outlet were determined as noted previously.

All distilled water used in the impingers and for subsequent dilution of samples was subjected to a control count. The method of making the actual dust-counts has been described previously.

Analyses of the samples collected in the impingers were made for quantity of total solids and for quantity of silica; (SiO_2). These quantitative determinations were made in the Chemical Laboratories of the Department of Engineering Research of the University of Michigan.

It is worthy of note that during these tests the No. 6 Molding Equipment Unit was operating at a very high rate of production and was turning out two (2) Oldsmobile cylinder blocks per minute.

RESULTS of TESTS

TABLE No. I

1.	In Duct at Entrance to Dust-Collector	In Duct at Discharge from Dust Collector	At Shake-out; Facing Wall; Breathing-Line; Left-Hand Operator. No. 6 Molding Unit	At Shake-out; Facing Wall; Breathing-Line; Right-Hand Operator. No. 6 Molding Unit	Facing Wall; 9 ft. behind Operators at Shake-out; Midway bet; At Breathing-Line Above Foundry Floor. No. 6 Molding Unit
	Col. A	Col. B	Col. C	Col. D	Col. E
2. Average total pressure; inches H_2O	−1.912	−5.97	—	—	—
3. Average static pressure; inches H_2O	−2.592	−6.59	—	—	—
4. Average velocity pressure; inches H_2O	0.601	0.62	—	—	—
5. Barometer; inches hg	—	—	29.410	29.410	29.410
6. Dry-Bulb; F°	129.0	72.0	75.5	75.5	75.5
7. Wet-Bulb; F°	—	71.0	60.5	60.5	60.5
8. Relative humidity; per cent	—	95.0	41.1	41.1	41.1
9. Air Velocity; feet per minute	3322.4	—	—	—	—
10. Air per minute; cubic feet	28.994	—	—	—	—
11. Millions of dust particles per cu. ft. of air	2976.4	11.02	1.51	5.04	7.57
12. Total solids per cu. ft. of air; grams	0.021171	0.000341	—	—	0.000354
13. Total solids per cu. ft. of air; lbs.	0.000047	0.0000008	—	—	0.0000008
14. Total silica (SiO_2) per cu. ft. of air; grams	0.010910	0.000038	—	—	0.000042
15. Total silica (SiO_2) per cu. ft. of air; lbs.	0.000024	0.00000008	—	—	0.00000008
16. Silica (SiO_2); per cent	51.53	11.19	—	—	11.76
17. All other solids; per cent	48.47	88.81	—	—	—
18. Fan speed R.P.M.	444	444	444	444	444
19. Motor speed R.P.M.	1164	1164	1164	1164	1164

DISCUSSION of TESTS

In conducting these tests every effort was made to obtain truly average dust-samples and likewise every effort was made to obtain truly average dust counts.

It is of interest to note the high-dust removal efficiency, based on number of dust-particles of 99.7%.

It is also of importance to note the great decrease in the *ratio* of silica content by weight in addition to its great drop by weight after passing through the collector. Before passing through the collector the silica (SiO_2) is 51.53% by weight of the total solid material and after passing through the collector the silica (SiO_2) has dropped to 11.19% of the total solid material that has passed through the collector.

This is a point of much importance.

Attention is particularly directed to the results appearing in Table No. 2 on page seven.

RESULTS of TESTS

TABLE No. 2

The principal test results given below are all expressed in terms of air at the conditions in the foundry which were:

Barometer=29.410 inches of mercury
Dry-bulb temperature=75.5°F.
Wet-bulb temperature=60.5°F.
Relative humidity=41.1%

	Col. A	Col. B	Col. C
1. Location	In Duct at Entrance to Dust Collector	In Duct at Discharge From Dust Collector	Facing Wall; 9 ft. Behind Operators At Shake-out; Midway between; At Breathing-Line Above Foundry floor. No. 6 Molding Unit
2. Millions of dust particles per cu. ft. of air	3294.9	11.11	7.57
3. Total solids per cu. ft. of air; grams	0.023436	0.000344	0.000354
4. Total solids per cu. ft. of air; pounds	0.000052	0.0000008	0.0000008
5. Total silica (SiO_2) per cu. ft. of air; grams	0.012077	0.000038	0.000042
6. Total silica (SiO_2) per cu. ft. of air; pounds	0.000027	0.00000008	0.00000008
7. Silica (SiO_2) in per cent; by weight	51.53%	11.19%	11.76%
8. All other solids in per cent; by weight	48.47%	88.81%	88.24%
9. Total solids per cu. ft. of air; grains	0.364000	0.005600	0.005600
10. Total silica per cu. ft. of air; grains	0.189000	0.000560	0.000560
11. (Item 9)—(Item 10) per cu. ft. of air; grains	0.175000	0.005040	0.005040
NOTE:—1 pound=7000 grains			

Dust removal efficiency based on number of dust particles= $\left(\frac{32949 - 11.11}{3294.9}\right) \times 100\% = 99.7\%$

TABLE No. 3

All values below estimated by means of ruled counting grids:

	Col. A	Col. B
1. Location	In Duct at Entrance to Dust Collector	In Duct at Discharge from Dust Collector
2. Percentage of particles between 10 and 15 microns; longest dimension	1	Negligible
3. Percentage of particles between 2 and 10 microns; longest dimension	35	15
4. Percentage of visible particles below 2 microns; longest dimension	64	85

1 Micron = 0.001 millimeter.

COMMENTS ON THE FOREGOING TEST
by the
ENGINEERING DEPARTMENT
of the
CLAUDE B. SCHNEIBLE COMPANY

The U. S. Public Health Service in its Bulletin No. 187, July, 1929, defines the probable safe condition with reference to air-borne dust as one in which the concentration of dust particles measuring 10 microns or less, in the greatest dimension, does not exceed 20 million per cubic foot, and that the free silica (quartz) concentration shall not exceed 25% to 35%.

The Code of the Industrial Commission of Wisconsin states that the Commission, its advisory committee, employers and scientists have agreed on a tentative figure of 15 million countable dust particles under 10 microns in longest dimension with free silica content of 35 per cent in a cubic foot of air as determined by United States Public Health Service technique. Variations in free silica content will make proportional inverse changes in this standard. In the case of practically pure silica the permissible dust count would be 5,250,000 countable particles. By countable particles is meant those particles within the range of size from 2 to 10 microns in the longest dimension. Dust particles smaller than 2 microns in the longest dimension are not ordinarily countable. Dust particles larger than 10 microns in longest dimension do not ordinarily reach parts of the body where they can produce injury.

In the study made, the air at the inlet to the Dust Collector showed a total dust concentration of 3,294,900,000 particles per cubic foot made up of particles in the following size groups:

Particles measuring in excess of 10 microns	1%
Particles measuring between 2 microns and 10 microns	35%
Particles measuring less than 2 microns	64%

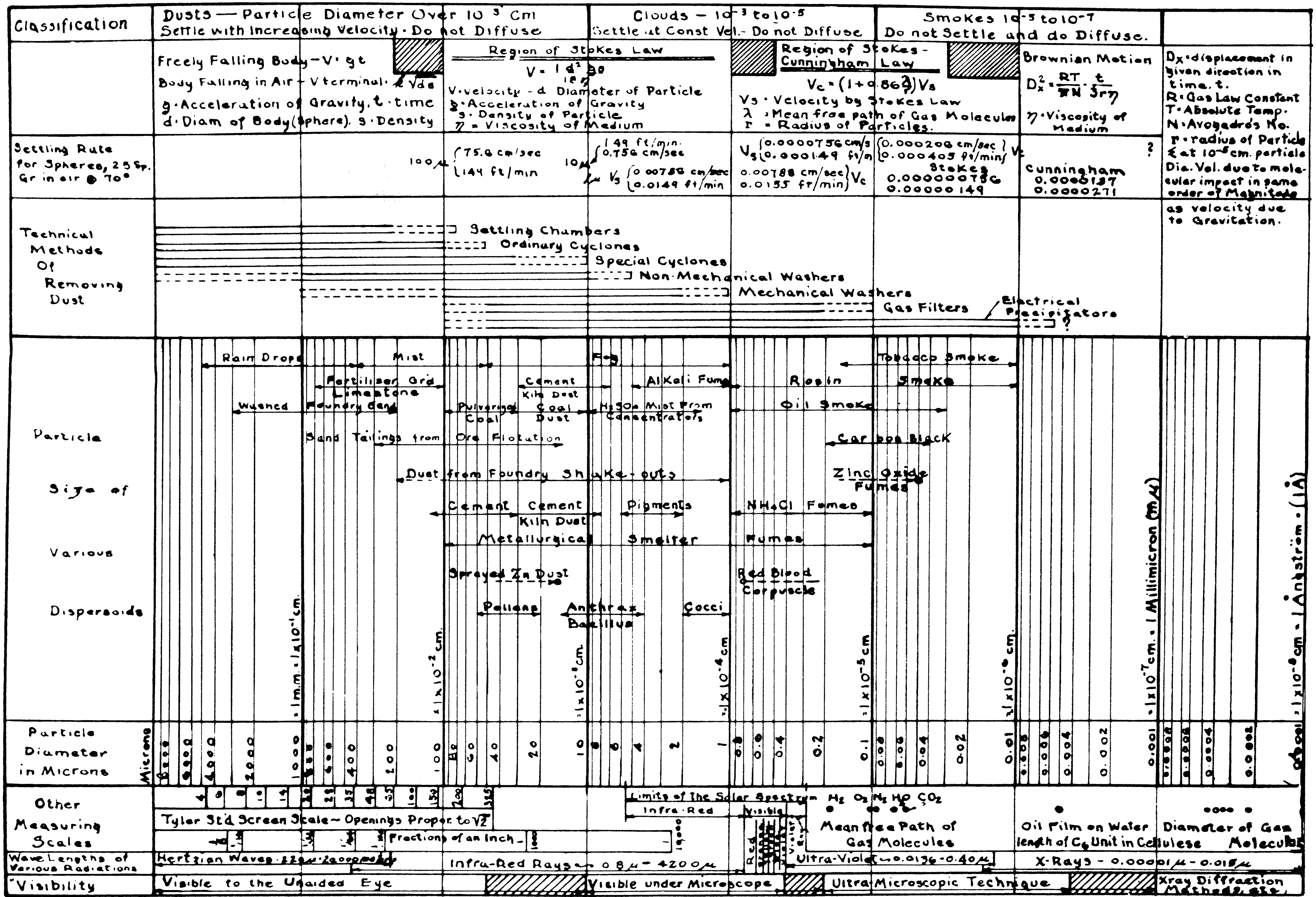
Further analysis of this dust showed it to contain in excess of 51% silica.

Now, let us examine the air leaving the Dust Collector. The total number of particles per cubic foot is 11,110,000, all of which measure 10 microns or less in the greatest dimension and not only has the number of particles been reduced by 99.66%, but the silica content has been reduced by 99.67%.

This reduction of dust concentration has rendered what was a particularly hazardous dust concentration to one which to the best of our knowledge is practically harmless, and one which compares quite favorably with the atmospheric dust conditions in many of our big cities.

In 1936, the U. S. Public Health Service in its Bulletin No. 224 entitled "Atmospheric Pollution of American Cities for the Years 1931-1933," we find that the average dust concentration in fourteen cities studied was 23,078,110 particles per cubic foot; the range being between 42,871,000 and 9,581,000.

It will be seen from this that the air leaving the Multi-Wash Collector contains far less dust than the average city air.


Classification
Dusts — Particle Diameter Over 10⁻³ Cm
Settle with Increasing Velocity - Do not Diffuse
Clouds — 10⁻³ to 10⁻⁵
Settle at Const Vel. - Do not Diffuse
Smokes 10⁻⁵ to 10⁻⁷
Do not Settle and do Diffuse.
Freely Falling Body — V = gt
Body Falling in Air — V terminal
g = Acceleration of Gravity, t = time
d = Diam of Body (Sphere), s = Density
Region of Stokes Law
V = velocity - d = Diameter of Particle
g = Acceleration of Gravity
s = Density of Particle
η = Viscosity of Medium
Region of Stokes-Cunningham Law
Vs = Velocity by Stokes Law
λ = Mean free path of Gas Molecules
r = Radius of Particles
Brownian Motion
η = Viscosity of Medium
Dx = displacement in given direction in time, t.
R = Gas Law Constant
T = Absolute Temp.
N = Avogadro's No.
r = radius of Particle
at 10⁻⁵ cm. particle Dia. Vel. due to molecular impact in same order of Magnitude as velocity due to Gravitation.
Settling Rate for Spheres, 2.5 Sp. Gr in air @ 70°
75.0 cm/sec
144 ft/min
1.49 ft/min
0.756 cm/sec
0.00756 cm/sec
0.0149 ft/min
0.0000756 cm/s
0.000149 ft/m
0.00788 cm/sec
0.0155 ft/min
0.000206 cm/sec
0.000405 ft/min
Stokes
0.00000075
0.00000149
Cunningham
0.0000137
0.0000271
Technical Methods Of Removing Dust
Settling Chambers
Ordinary Cyclones
Special Cyclones
Non-Mechanical Washers
Mechanical Washers
Gas Filters
Electrical Precipitators
Particle Size of Various Dispersoids
Rain Drops
Mist
Fog
Tobacco Smoke
Fertilizer Grd Limestone
Cement Kiln Dust
Alkali Fume
Rosin
Smoke
Foundry Sand
Pulverized Coal
Coal Dust
H₂SO₄ Mist From Concentrators
Oil Smoke
Sand Tailings from Ore Flotation
Carbon Black
Dust from Foundry Shake-outs
Zinc Oxide Fumes
Cement
Pigments
NH₄Cl Fumes
Metallurgical
Smelter
Fumes
Sprayed Zn Dust
Red Blood Corpuscle
Pollens
Anthrax Bacillus
Cocci
1 mm. = 1 × 10⁻¹ cm.
1 × 10⁻² cm.
1 × 10⁻³ cm.
1 × 10⁻⁴ cm
1 × 10⁻⁵ cm
1 × 10⁻⁶ cm.
1 × 10⁻⁷ cm. = 1 Millimicron (mμ)
1 × 10⁻⁸ cm = 1 Ångström = (1Å)
Particle Diameter in Microns
Microns
8000
6000
4000
2000
1000
800
600
400
200
100
80
60
40
20
10
8
6
4
2
1
0.8
0.6
0.4
0.2
0.1
0.08
0.06
0.04
0.02
0.01
0.008
0.006
0.004
0.002
0.001
0.0008
0.0006
0.0004
0.0002
0.0001
Other Measuring Scales
Tyler Std Screen Scale ~ Openings Proper to √2
20
28
35
48
65
100
150
200
325
Fractions of an Inch
Limits of the Solar Spectrum
Infra Red
Visible
Ultra Violet
H₂ O₂ N₂ H₂O CO₂
Mean free Path of Gas Molecules
Oil Film on Water
length of C₆ Unit in Cellulose
Diameter of Gas Molecules
Wave Lengths of Various Radiations
Hertzian Waves
Infra-Red Rays ~ 0.8μ - 420.0μ
Ultra-Violet ~ 0.0136 - 0.40μ
X-Rays - 0.00001μ - 0.015μ
Visibility
Visible to the Unaided Eye
Visible under Microscope
Ultra Microscopic Technique
Xray Diffraction Methods, etc.